Dottorato di Ricerca in "Recupero dei Contesti Antichi e Processi Innovativi nell'Architettura"
XXIV Ciclo Coordinatore del Dottorato: Prof. Giuseppe De Giovanni

ARCHITECTURAL DESIGN IN THE DIGITAL ERA

identifying computer influences and new expressive trends in current architecture

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AREA 08 - SSD ICAR14 - Composizione architettonica e urbana

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PRESENTATION

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This dissertation belongs to a new category of scholarship that addresses architectural issues in a recognizably modern framework that represents the wider social, technological and historical backgrounds of our digital era. Not so long ago, the computer was an exclusive toy for an academic and technological elite of researchers and developers jealously guarding an expensive technology and its applications, and restricting it to their internal preoccupations. Especially on low-tech areas such as architecture, this made the computer a mysterious, enormously promising but ultimately underperforming and unknown tool. The area that became then known as computer-aided architectural design (CAAD) represented a powerful consolidation of two main ambitions: to computerize drawing and to automate design. Consequently, much of CAAD research and teaching focused on matters technical and technological but even more and of a higher profile were methodical approaches, usually of a proscriptive nature, that produced designs, often of a questionable quality. This mixed bag of methods and techniques contained a lot that is best forgotten but also some genuine gems that provided useful insights into the nature of architecture, as well as powerful tools that improved design performance.

In the 1990s the popularization of the computer brought this situation to an abrupt end: when every professional could afford decent computer hardware and software, there was little need for guidance by an elite. Anyone could use a computer in architecture and quite soon practically everyone did. Despite the liberating effect of this major change, architecture did not improve through computer use; on the contrary, much of the knowledge developed in CAAD was forgotten, as new users were predominantly preoccupied with basic stuff such as drawing. The computer remained an expensive, underperforming additions to the architects' tools, replacing the drafting table and calculator but still primarily used to produce drawings and other documents on paper. The reaction of the CAAD community did not improve matters either: most of CAAD education became training into the use of commercially available software with little insight into the methodical underpinnings of such software and its relationship to architectural design. On the other hand, research remained focused on internal priorities and preoccupations, often jumping from bandwagon to bandwagon, but still producing noteworthy ideas and tools that nevertheless seldom managed to cross over to practice.

Thankfully, as this dissertation suggests, it turned out that it was just a matter of time (or possibly of a couple of generations) before the potential of the computer and much of the CAAD legacy were re-discovered and moreover widely applied in practice. The dissertation is based on the analysis of a surprisingly large number of prominent buildings that would not have been possible and in many cases even conceivable without the computer. They not only make use of drawing and modelling software to describe and specify novel forms but also involve compositional concepts and techniques developed in CAAD. Quite predictably they exhibit a high repetition of popular devices and notions but also a wide spectrum of what is available in various combinations and with variable results. The analysis suggests that the current state of the art is certainly promising of greater morphological variety and indicative of changes in architectural composition too.

One arguably worrying note is that much of what is encountered in terms of digital influences in the analysed buildings appears to derive primarily from the software used to design them. Traces of methodical CAAD approaches are evident in a minority of cases and are inevitably complemented by other elements from the current repertory of digital features, procedures and primitives. Still, this may indicate a natural order of progress: from fundamental to applied research and development and from there to end use, with a few forming the avant-garde that transfers fundamental research results to practice quite early. On the other hand, this also may suggest absence of a coherent framework for the application of computer tools in architectural design, which may reduce the effectiveness and robustness of the transition from morphology to composition, as suggested in the dissertation. It may be so that current frameworks do not suffice for our new purposes but without one digital tools may degenerate into an incoherent and insignificant bag of tricks with no real meaning to architecture.

One of the primary virtues of the dissertation and the emerging tendency it represents lies in its comprehensiveness. This applies to the historical aspects too and their relationships with the evolution of the general framework of digital design, including indirect, yet untraced relationships that nevertheless seem to hold water. Such wider historical backgrounds enrich understanding of how we have come to the choices popular today from several, complementary viewpoints. Hopefully this line will further develop in research that will follow this dissertation.

Delft, 07.01.2014

Introduction

Research problem

Design computing has a long history of implicit and explicit attempts to redefine architectural design. Driven by the dual ambition to digitize design representations and to automate design processes, it has produced an extensive supply of methods and techniques for a variety of design tasks, from the production of a floor plan layout to online remote collaboration and to parametric definition of building components.

Since the commercialization of the first CAAD (Computer Architectural Aided Design) software for our profession in the '80s, initially born to *aid* the production of *drawings*, software has progressively begun part of designer's tools. Despite at first the undoubted advantage resided in the representation power, above all to manage three-dimensional shapes, after some years of experimentation it was clear that software aided the expression of architects' creativity.

After about fifteen years of experimentation, everyone agrees that digital tools are currently used in architectural practice and that the effect of their use is rather evident on the formal and aesthetic configuration of some buildings. It is not any doubt that we are inside a revolution of methods, processes, thinking. Nowadays we could talk of *Post-Digital Age*, because the first effects of this revolution are strongly evident on global scale. The architecture is very much a synthesis between the virtual, the actual, the biological, the cyborgian, the augmented and the mixed (Spiller, 2009).

Today we have to reflect about the changes that architecture has undergone and is undergoing, in order to understand the real results and meanings of more than ten years of digital experimentation in the construction industry. As Antoine Picon said: «we are now past these initial reactions of enthusiasm or concern. The question is no longer whether the digital technology is a good or bad thing for design; it is rather about the direction architecture is taking under its influence» (Picon, 2010).

Literature background

The scientific community did not rest indifferent to the huge explosion of new digital tools and their application in architecture. Indeed, since the first years of introduction of IT in architecture, the problematic was analyzed in several books, papers, dissertations, exhibitions. Moreover there was the birth of the first CAAD associations, as eCAADe (Education and research in Computer Aided Architectural Design in Europe) in 1983, ACADIA (Association for Computer Aided Design in Architecture) in 1981, CAAD Futures in 1985, etc., with the main aim to organize annual conferences where to share knowledge about architectural software and experimentations with digital tools. Even if the main contribution was given by academia, also practitioners and representatives of software developers (like Autodesk®, Bentley®, Dassault Systèmes®) have participated to the congresses, mainly in order to take advantage of the most interesting studies which could become parts or add-on of their software.

During the initial phase, prior researches were focused on the augmented three-dimensional representation potential (Baer et al., 1979), on the cognitive activities of designing with digital means (Mitchell, 1989), on the new possibility to interconnect design, construction and industry, probably as natural prosecution of *Structuralism* (Kroll, 1985), on the design methodology modifications (Cross, 1984, Schön, 1983).

In the subsequent years we have assisted to a dominant trend of new kind of architect and researcher, primarily devoted to push-up the new digital capabilities on the research of figurative solutions and procedural ways not yet explored before the advent of IT (Lynn, 2004, Van Berkel et al., 1999, Balmond et al., 2007). In parallel we have looked at some buildings that undoubtedly were affected by this digital feeling, such as the Möbius House by Un Studio, the HtwoO pavilion by NOX and, obviously, the Guggenheim Museum in Bilbao by Frank O. Gehry, who showed to entire world what Architecture can yet communicate, in terms of novelty, artistic expression, capacity to influence positively a degraded context.

Then, after ten years of digital revolution, in the early 2000's it was begun to reflect about the state of art in the current architectural scenario. At first with the *Architecture in the Digital Age* book (Kolarevic, 2003), a collection of essays written by several researchers, practitioners, theorists; then with the publication of *Architecture's New Media* (Kalay, 2004), where, with a smart approach, the author relates many concepts interesting digital (and not) architectural design, such as design process, communication, problem solving, evaluation, trying also to predict a future outline.

In this sense, also the 2006's special edition of Design Studies about Digital Design reports several interesting researches and points of view. In particular, the classification about *models of digital design* proposed by Rivka Oxman (2006) seems particularly shareable and marks a starting point for future research in this field.

At the same time, other authors have spoken about digital design, but with points of views probably more critical and sceptical. Among the main critics directed to research on digital design, on the one hand the excessive clarity in the explanation of the process, on the other the lack of considering the other tasks, such as design content, designer and design context and last, but not least, the poor relationship between researches in digital design tools and experimentations and their effects on real architectural practice (Dorst, 2008).

It seems that there is an absence of researches about the existing relationship between technical developments and design thinking, between tools and conceptual strategies, about the connections of these matters with the actual buildings, which, on the contrary, show marked digital influences.

Research hypothesis, questions and goals

The main hypothesis is that the triumphal entry of computing in architectural design has produced a real revolution in architecture, so that we have assisted to the birth of several expressive trends. Then, main goals of the research have been to answer to the following questions:

- Can we identify the extent and scope of digital influences on real architectural designs? Indeed, despite various claims in academic publications, software publicity, manifestos and architectural criticism, it is unclear what these influences entail and what evidence we have for their existence and significance. It seems that it is generally assumed not only that we are able to recognize these influences and their effects but also that we all agree as to their existence, nature and manifestations. However, upon closer inspection it becomes evident that the main reason for recognizing digital elements in a design is the designers' or some critic's say-so.
- Following the objective identification of digital influences in a design, we should be able to identify their origin, too: do they derive from academic research and education or are they products of general computer literacy or specific architectural software training?
- In this scenario, what is the role of composition?
- Why is architectural expressivity changing?
- Why there is a huge diffusion of buildings with curvilinear morphologies?
- Finally, are we able to identify some transverse trends in which to classify digital influenced architectures?

These questions are central to the role of design computing in architecture, but also point out research goals and directions that may be absent in current research. Answering to these questions has the aim to develop a comprehensive overview about the effects of digital technology entry in architectural scenario, not by focusing just on procedural and technical part or, on the contrary, on general and prejudicial opinions, emerging either from critical or enthusiastic studies, but by linking the knowledge about digital technologies with morphology, composition and design thinking.

Research methodology

To achieve these goals, we need first of all a coherent and comprehensive overview of elements derived from design computing, so that we can unambiguously identify them in architectural designs. Then we have to apply it to real designs so as to verify its adequacy and, when this is done, to examine how these elements appear and are used in practice and what is the linkage with geometry and composition. Finally we must consider how digital influences contribute to a new way to intend architectural design and its formal expressions.

Identifying the above digital influences in a single design is quite useful for the refinement of the framework, i.e. the definition of the repertories and the clarification of the specific forms that their members may assume in a design. This can be done in either top down or bottom up fashion. We have opted for the bottom-up approach: identify instances of the digital elements in existing designs, linking them with morphological, compositional and conceptual matters, without attempting to complete the spectrum with additional instances. This agrees with the critique by Dorst (2008) and stresses not the supply but the actual usage and, through that, the possible demand for digital methods and techniques and ultimately their significance in architectural design. It is a deductive methodology, based on the following steps:

1. Study of each project
2. Observation of main features
3. Classification, according with criteria previously defined
4. Analysis of the results

For a real bottom-up analysis, in order to clarify how much CAAD software have contributed on the emergence of several *digital trends* with precision and overview, we have avoided *opinions* (either from academia or from practice) and focused instead on the actual *products* of practice, analysing sixty recent buildings clearly related to digital methods or techniques. The analyses were conducted in a uniform, objective manner and collected in a database, developed with Microsoft Access®, which allows a wide variety of queries on the identified features and where the collection of data, the classification of projects on the basis of predefined, objective parameters, and, above all, the interrelations between two or more parameters, permit us to understand the role of digital means in current architecture

Research Relevance

The study of this dissertation is principally dedicated to architecture students and practitioners. Indeed, given that the use of digital tools in architecture is already pervasive and that it will continue to increase, there will be new degrees of complexity for those who approach each architecture problem.

There is an high risk that the extreme freedom of formal expressions guaranteed by software can conduct architects to forget to fully investigate each problem-to-solve and to focus just on a search of *form for form's sake* (Tschumi and Cheng, 2003). In this sense, since there has been a lack of a comprehensive overview, that actually shows each designer's thinking, the reason of formal choices, we have to pay attention that practitioners and students could simply copy *beautiful forms*. Therefore, having a study, which explains the relationship between tools and abstract criteria, techniques and design thinking, could help them in the comprehension of what is actually happening in architectural design. Moreover, also lecturers of Architectural Design or History of Architecture could find this study useful for architectural education, not only for teching technical developments or how to obtain forms, but rather than on why and how it is possible to *mise-en-scene* a particular idea or concept with the use of appropriate tools and methods.

Structure of dissertation

The dissertation is organized in three parts, which correspond to the different phases in which this research was articulated:

Part 1 - State of the Art.

- Chapter 1. *The evolution of the architectural shape from Post-war period to the XX century's end.* Since this thesis has the aim to analyze digital influenced architectures, in order to understand which are the main trends and to figure out how much CAAD software has effectively contribute to the birth of these tendencies, it was necessary to begin this treatise with a briefly historical overview, that focuses on the architectural expressivity evolution from the Post-war until the XX century's end.
- Chapter 2. *Trends and computer tools to create architecture shape.* Since the thesis deals with digital technologies, we need to know what these instruments are and what we can do with them.

Part 2 - Analysis.

- Chapter 3. *Multi-case analysis and database*. In this chapter will be explained in greater detail the methodology of analysis, the organization and structure of the database and the theoretical framework, which gives consistency to the analysis.
- Chapter 4. *Case-studies*. In this chapter we can observe the whole casuistry, as was analyzed through the database. Each case sheet was produced directly from the database. Hence, it is possible to verify the analysis done and examine a collection of *digital* architectures.
- Chapter 5*. Queries*. In this chapter it is explained the mechanism to create the queries that serve to interrogate the database in order to get the results and to quickly visualize them.

Part 3 - Interpretation.

- Chapter 6. *Results and discussion*. In this chapter we will discuss each single result coming from the analysis, with the purpose to understand how much software were actually used in the design process and which can be the most prevalent trends, with respect to digital technologies.
- Chapter 7. *Conclusions. A rational overview on digitization of Architecture in the last 15 years*. In the last chapter we will deal with the real conclusion of the dissertation. Given that the goal was to understand which are the most dominant trends of current digital-influenced architecture, we will propose a classification of these tendencies, in which we could subdivide our casuistry.

Finally, the dissertation is accompanied by two appendices.

- Appendix I, *Interviews with Dutch designers*. There are presented a series of interviews with Dutch designers, done during the research period carried out at Delft University of Technology, in which they discussed about the application of new digital methodologies in design practice and how their approach, both methodological figurative, have changed accordingly.
- Appendix II. *Glossary.* It is relative to the individual categories of the database, where it is then given a definition of all the parameters of each category, helpful in order to understand the analysis done and to justify the choices made.

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Summary in Italian
Inquadramento e struttura della ricerca

Problematica di ricerca

La ricerca propone una riflessione sull'architettura contemporanea in funzione del ruolo sempre più preponderante che le tecnologie digitali hanno assunto all'interno del processo progettuale. L'introduzione dei computer nel panorama dell'architettura ha prodotto una rivoluzione nei metodi e nei processi progettuali che contribuiscono alla generazione della forma architettonica

Sin dalla commercializzazione del primi programmi CAAD (Computer Architectural Aided Design) negli anni '80, inizialmente nati per assistere la produzione dei disegni, i software sono progressivamente diventati parte degli strumenti di progetto. Nonostante, in un primo momento, l'indubbio vantaggio risiedeva nel potere rappresentare e soprattutto gestire le forme tridimensionali complesse, dopo alcuni anni di sperimentazione divenne chiaro che il software aiutava ed aumentava le possibilità degli architetti di esprimere al meglio la propria creatività.

Dopo circa quindici anni di sperimentazione, più o meno tutti concordiamo sul fatto che gli strumenti digitali sono attualmente utilizzati nella pratica architettonica e che il loro effetto è evidente nella configurazione formale ed estetica di alcuni edifici. Non vi è alcun dubbio che stiamo vivendo una rivoluzione di metodi, di processi, di pensiero. Oggi potremmo addirittura parlare di *Era Post-Digitale* (Spiller, 2009), perché gli effetti di questa rivoluzione sono marcatamente evidenti nello scenario architettonico globale.

è necessario oggi riflettere sui cambiamenti che l'architettura ha subito e sta subendo, al fine di comprendere gli effetti ed i significati reali di più di dieci anni di sperimentazione digitale nell'architettura. Come afferma Antoine Picon (2010): «abbiamo superato le prime reazioni di entusiasmo o preoccupazione. La questione non è più se la tecnologia digitale è una cosa positiva o negativa per la progettazione, ma piuttosto è necessario capire quale direzione l'architettura sta prendendo».

Ipotesi e obiettivi della ricerca

L'ipotesi posta alla base della ricerca è che l'introduzione dei software CAAD all'interno della pratica professionale architettonica abbia prodotto una rivoluzione non solamente di metodi e processi, ma anche e soprattutto nel linguaggio architettonico. Pertanto obiettivi della ricerca sono stati:

- identificare la portata e l'estensione delle influenze digitali su progetti di architettura realizzati;

- comprendere che ruolo assume la composizione e come nasce la forma architettonica dopo l'introduzione dei nuovi strumenti digitali per la progettazione;
- comprendere perché e in che modo il linguaggio dell'architettura sta cambiando e quanto di questo cambiamento sia stato frutto della progressiva *digitalizzazione* dell'architettura;
- comprendere, inoltre, quanto di tutto ciò è frutto degli influssi digitali e quanto, invece, deriva da considerazioni di altra natura (culturali, estetiche, filosofiche);
- identificare alcune tendenze trasversali dell'*architettura digitale*.

Queste domande sono fondamentali per il ruolo assunto dal *digital design* nell'architettura contemporanea, ma sottolineano anche obiettivi e indicazioni che possono essere assenti nella ricerca attuale. Raggiungere gli obiettivi prefissati ha lo scopo finale di poter essere in grado di sviluppare una panoramica completa sugli effetti dell'ingresso delle tecnologie digitali nello scenario architettonico, non concentrandosi solo sulla parte procedurale e tecnica o, al contrario, su opinioni talvolta entusiastiche, talvolta critiche e pregiudizievoli, ma collegare le conoscenze sulle tecniche e metodologie di progettazione digitale con aspetti più propri dell'architettura, come morfologia, composizione e teoria del progetto.

Metodologia e fasi di ricerca

La ricerca è stata condotta, in una prima fase, attraverso un approfondito studio bibliografico della letteratura scientifica di riferimento, individuando alcuni filoni di ricerca che sembrano essere poco studiati o addirittura assenti ed in cui questo lavoro di tesi si inserisce.

Successivamente, nella seconda fase, il lavoro di analisi critica è stato portato avanti attraverso lo studio di sessanta casi, scelti tra architetture di riconosciuta qualità, realizzate negli ultimi quindici anni e in cui l'influsso degli strumenti digitali sia fortemente evidente. I casi di studio sono stati analizzati e classificati secondo una rigida e logica struttura teorica sviluppata, composta da diverse categorie e parametri, che consente di evidenziare aspetti singoli e generali. Si è scelto di collezionare le informazioni relative ad ogni caso in un database sviluppato con il software Microsoft Access®, che ha facilitato, oltre all'immagazzinamento dei dati, anche lo sviluppo di una struttura logica coerente tramite cui analizzare ogni caso, sviscerandone ogni aspetto. Pertanto, dopo aver reperito tutte le informazioni generali, come *nome dell'edificio*, *progettista*, *data*, ecc., si è proceduto a classificare ogni architettura rispetto a considerazioni di tipo morfologico - definendo, ad esempio, se la configurazione formale prevalente è *curvilinea* o *rettilinea*, quali sono le *primitive* usate per la composizione del progetto, ecc. - considerazioni relative poi anche alla composizione architettonica e alle strategie concettuali da cui ogni architetto è partito per lo sviluppo del progetto.

Ci si è, quindi, avvalsi di un metodo essenzialmente deduttivo, ossia basato sull'analisi di una ampia casistica selezionata sulla base di criteri ben precisi, facendo poi una *decostruzione* di ogni architettura, dissezionandola nei suoi singoli aspetti. L'utilizzo di questa metodologia di ricerca è stato necessario per cercare di ridurre al minimo la possibilità di essere condizionati da pregiudizi e, in definitiva, per fare in modo che l'analisi di un fenomeno così complesso fosse la più obiettiva possibile. La volontà precisa è stata quella di non effettuare una ricerca semplicemente teorica, in cui si parlasse dei singoli fenomeni che hanno riguardato gli influssi digitali sul'architettura contemporanea in termini generici, citando e descrivendo sommariamente qualche architettura, ma ci si è voluti focalizzare sugli effettivi *prodotti* della pratica professionale.

Nella terza fase di lavoro, quindi, dopo aver impostato una serie di *query* attraverso cui interrogare il database, si è lavorato sull'analisi dei risultati ottenuti. Le *queries* consentono, infatti, di mostrare dati come la prevalenza assoluta nelle singole categorie - ad esempio, analizzando tutti i casi, qual è la morfologia più ricorrente? E la primitiva maggiormente usata? - e inoltre è possibile filtrare i dati prendendo in considerazione altri parametri e, quindi, intrecciando i diversi aspetti fra loro - ad esempio, è possibile mostrare, all'interno degli edifici a configurazione curvilinea, quali sono le primitive maggiormente usate, ecc. Le analisi quindi hanno consentito di produrre anche una serie di grafici e tabelle riepilogative che aiutano a comprendere criticamente i risultati ottenuti e come l'influsso della tecnologia e della cultura digitale siano pervasive nella progettazione architettonica contemporanea, definendo, infine, come riportato nel capitolo conclusivo, una serie di tendenze trasversali in cui è possibile interpretare l'*architettura digitale*.

Struttura della tesi

La tesi è strutturata in tre parti, che corrispondono alle differenti fasi di ricerca.

PARTE I - LO STATO DELL'ARTE.

- Capitolo 1, *The evolution of the architectural shape from Post-war period to the XX century's end*. Poiché questa tesi ha lo scopo di analizzare le architetture influenzate dall'usodegli stumenti informatici e dalla cultura digitale al fine di comprendere quali sono le principali tendenze e capire quanto il software CAAD ha contribuito efficacemente alla nascita di queste tendenze, è stato necessario cominciare questo trattato con una breve storia panoramica, che si concentra sull'evoluzione espressività architettonica dal dopoguerra fino alla fine del XX secolo. Partendo, dalla crisi dell'*International Style* del dopoguerra, ci è focalizzati sulle sperimentazioni formali dell'architettura, analizzando il lavoro di *innovatori* come Pier Luigi Nervi, Eero Saarinen, Frei Otto e molti altri, ma anche sulle architetture dell'utopia prodotte negli anni '70 dagli Archigram, da Friederich Kiesler, ecc., che hanno considerevolmente influenzato i principali protagonisti dell'*architettura digitale.*
- Capitolo 2, *Trends and computer tools to create architecture shape.* Prima di poter analizzare gli effetti delle sperimentazioni digitali sull'architettura, abbiamo bisogno di conoscere quali sono questi strumenti e cosa possiamo fare con i diversi tipi di

software. Pertanto, dopo una breve storia sulla nascita dei programmi CAAD, si sono analizzate le tipologie di software esistenti, spiegando gli usi principali e le tecniche di progettazione prevalenti.

PARTE II - ANALISI

- Capitolo 3, *Multi-case analysis and database*. In questo capitolo viene spiegata in maggior dettaglio la metodologia di analisi utilizzata, sia dal punto di vista teorico, che da quello pratico, definendo come è stato progettato, organizzato e strutturato il database al fine di poter garantire analisi obiettive e coerenti.
- Capitolo 4, *Case-studies*. Qui vengono raccolti tutte le schede dei singoli casi. In questo modo è possibile comprendere meglio la metodologia di analisi portata avanti attraverso il database, infatti ogni scheda è stata prodotta direttamente dal programma. È quindi possibile verificare l'analisi fatta ed esaminare un vasto repertorio di *architetture digitali.*
- Capitolo 5, *Queries*. In questo capitolo viene spiegato il meccanismo, sia dal punto di vista pratico che da quello teorico, per creare le *query* che servono per interrogare il database, al fine di ottenere i risultati e di poterli velocemente visualizzare.

PARTE II - ANALISI

- Capitolo 6, *Results and discussion*. In questo capitolo parleremo di ogni singolo risultato proveniente dalle analisi fatte attraverso il database, con lo scopo di capire quanto gli strumenti digitali sono effettivamente utilizzati nel processo di progettazione, e, di conseguenza, cosa ciò ha prodotto in termini di morfologia, composizione, concetti. Si arriva dunque a definire quali possono essere le tendenze prevalenti, rispetto alle tecnologie digitali.
- Capitolo 7, *Conclusions. A rational overview on digitization of Architecture in the last 15 years*. L'ultimo capitolo contiene l'effettiva conclusione della tesi, una panoramica critica delle tendenze più significative dell'architettura contemporanea, prodotto degli influssi digitali, presenti sia dal punto di vista strettamente strumentale, che da quello culturale. Viene quindi proposta una classificazione originale di queste tendenze, in cui ci è sembrato opportuno suddividere la nostra casistica. La trattazione è accompagnata anche dai profili dei progettisti protagonisti di questa rivoluzione.

Infine, la tesi è corredata da due appendici.

- Appendice I, *Interviews with Dutch designers*. Vengono riportate integralmente una serie di interviste fatte a progettisti olandesi, durante il periodo di ricerca svolto presso la Delft University of Technology, in cui si è discusso dell'applicazione di nuove metodologie digitale nella pratica progettuale e di come il loro approccio, sia metodologico che figurativo, sia cambiato di conseguenza.
- Appendice II. *Glossary*. Viene riportato un glossario relativo alle singole categorie del database, in cui viene data, quindi, una definizione dei parametri di ogni categoria, al fine di aiutare la comprensione dell'analisi svolta e motiva le scelte effettuate.

Destinatari della ricerca

Lo ricerca effettuata è principalmente destinata a studenti di architettura e professionisti. Infatti, dato che l'uso degli strumenti digitali in architettura è già pervasivo e addirittura continuerà ad aumentare, ci saranno nuovi gradi di complessità per chi si approccia ad ogni singola problematica di architettura.

Vi è, quindi, un elevato rischio che l'estrema libertà delle espressioni formali garantita dagli strumenti informatici possa condurre gli architetti a dimenticare di indagare a fondo ogni problema da risolvere per concentrarsi solo su una ricerca della *forma fine a se stessa* (Tschumi and Cheng, 2003). In questo senso, dal momento che c'è stata una mancanza di descrizione e approfondimento dello scenario attuale nella letteratura scientifica e nelle riviste di settore, che riportano spesso solamente opinioni entusiastiche e critiche, tralasciando di approfondire la posizione concettuale di ogni progettista, la ragione delle scelte formali effettuate, è necessario prestare attenzione al fatto che i professionisti e studenti, spesso con uno specifico background tecnico sull'utilizzo dei software, possano semplicemente copiare *belle forme*.

Pertanto, l'avere uno studio che spieghi il rapporto tra strumenti e criteri astratti, tra tecniche digitali e teoria del progetto, potrebbe fornire un possibile quadro di lettura e quindi aiutare a comprendere ciò che sta effettivamente accadendo nella progettazione architettonica. Inoltre, anche i docenti di Progettazione Architettonica e Storia dell'Architettura potrebbero trovare questo studio interessante per poter arricchire l'insegnamento attuale di una problematica ancora non sufficientemente indagata sia dal punto di vista progettuale che da quello storico, travalicando i meri aspetti tecnici e focalizzandosi invece su come possa essere possibile *mettere in scena* una propria idea progettuale astratta anche attraverso l' utilizzo di metodi e strumenti digitali appropriati .

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PART I

state of the art

CHAPTER 1
The evolution of the architectural shape from Post-war period to the XX century's end

History of architecture teaches us how tight is the relationship between innovation and changes in architectural expressivity and design through the centuries. These innovations may occur in the own territory of architecture, e.g. with the introduction of new materials or building technologies, or, instead, they may be classified within disciplines external to architectural subject, but which can have considerable repercussions on it.

This is very evident if we look at the modifications occurred into architecture during the XX Century. Gradual but significant changes, in expressivity and aesthetics and in conception of architectural space and its organization, derived from a combination of influences, from innovation in materials (Frampton, 2007), e.g. concrete, metal profiles, studies on the prefabrication, to the social questions - as the new composition of social classes and, thus, necessity to give a house to working class, which brought to studies about *existenzminimum* (Mumford, 2002) and have produced new dynamics of urban transformation (Frampton, 2007).

In recent years trend of contemporary architecture seems to take advantage of the innovations occurred in the field of science and technology in the broadest sense. About this, Ignasi de Solà-Morales (1997) says that: «having abandoned the discourse of style, the architecture of modern times is characterized by its capacity to take advantage of the specific achievements of that same modernity: the innovations offered it by present-day science and technology. The relationship between new technology and new architecture even comprises a fundamental datum of what are referred to as avant-garde architectures, so fundamental as to constitute a dominant albeit diffuse motif in the figuration of new architectures».

Looking at the second half of XX Century, it is undeniable that technological developments, especially those happened in Electronics, played a fundamental role on architectural experimentations and shape evolution. The Philips Pavilion (Xenakis, 1992), designed by Le Corbusier and Iannis Xenakis for the 1958 World Exhibition in Brussels (Pluvinge, 2008), shows an unusual conformation, derived by complex acoustic calculations to guarantee the best sound experience. Indeed, they put on scene a new way to listen to music through the spatial articulation of building shape, which probably was the first multimedia architecture born to advertise the highest technological level guaranteed by Dutch brand.

In the current scenario, where the concept that best expresses and embodies the sense of our time is *complexity*, at all levels, from the international political scene to the historical events that have marked recent years, e.g. 11 September 2001 or the economic crisis of the Western world and the quick growth of the East economies, also Architecture cannot be longer be through criteria such as *rationalism* or *simplicity*. In a world in constant flux and ever more interconnected, the discipline of architecture takes advantage of the new and modern digital tools, suitable to express the values, needs, icons, complexity of our time because they embody the most significant and substantial transformations happened in the international society and culture.

But, in order to understand the cultural background underlie digital revolution, first of all we need to further deepen the historical happenings in architecture since the Postwar period. Then, we will be able to comprehend the generation of that fertile climate which has permitted that *new digital architecture* would have had such a claim into architectural public.

1.1. Post-war: between needs to rebuild and International Style's crisis

The first period after the Second World War is characterized by several aspects at the same time. First of all, the analysis of huge damages caused by war, especially to European cities, pushed all Governments to plan a rapid reconstruction, above all thanks to the availability of funds from U.S. Secondly, from the cultural point of view, the countries in war in the years 1939-1945 represented antithetical institutions and ideals. At the end of the War, totalitarian regimes collapsed in the looser nations, while in the winner ones politic and social contrasts increased. Borders among technique, politics and morale became even more undistinguished and labile (Benevolo, 1997).

Fig. 1. Allegoric vignettes by C.B. Purdom from the book *How should we rebuild London?* (1945).

In Architecture this was translated in a completely different climate. Before of the War there was an interesting international debate about the future of our cities and architectural *style*, also testified by the organization of CIAM congresses. In the Post-war it seemed unnecessary to discuss about architecture, because the main need was how to reconstruct and, above all, how to do it as soon as possible (Fig. 1).

The war left an absence of meaning in architecture, because architects founded their style, values, beliefs on technological progresses and ideals (machine, speed, automation), which, finally, conducted to devastation, because the new weapons of mass destruction were exactly a product of that technology. So, where to start again? On what values to base the new architecture and reconstruction?

The first choice was to base reconstruction on a new idea to conceive the city, mainly in an urban way, basing it on the whole debate of the first XX Century decades, recovering concepts as *delocalization*, to solve congestion problems in the centres, *green belt*, *outer ring*. In that scenario, architecture was perceived as *necessity* (Saggio, 2010), necessity to satisfy needs and to fulfil function, with a less interest on aesthetics, on style, on relationship with what remained of cities. Exactly in that period, Le Corbusier built the Unitè d'habitàtion in Marseille (fig. 2), a new residential housing building constructed in *béton brut*[1], with several types of apartment, from simplex to duplex, which marked the beginning of trend that historians called Brutalism (Banham, 1966).

Fig. 2 - The Unitè d'habitàtion in Marseille by Le Corbusier.

The *Unitè*, with the stylistic use of rough concrete, and also the publications of *Manière de penser l'urbanisme* and *Le Modulor* (Le Corbusier, 1946, 1950) determined a strong impact on architecture in that period. The extreme functionalism which defined the spaces, the zeroing of language, intended as ornament and formalism, reduced into minimal terms, the use of brutality of concrete; everything was mouthpiece of the new aspiration ethical responsibility, shared by many architects in those years (Saggio, 2010).

The term 'Brutalism' was coined by Hans Asplund, who provocatively described his friends and colleagues Edman and Holm «neo-brutalists» (Banham, 1966). The absence of decoration and the design of building with the unique criteria of *function* marked the tendency of European architects and practitioners. If we look at the parts of our cities designed and built in that period, often without a predefined planning, it is strongly evident the architectural reference to the brutalist trend.

But besides architecture of *necessity*, without language, almost without identity, some architects began to design disengaging from rationalist canons and trying to experiment with form.

1.2. The reaction to Modern Movement and the destruction of the Style from '50s to '80s.

Modern thinking in architecture has found its crisis point in the mid-twentieth century when the international style has spread everywhere, generalizing constructive schemes, spatial and urban planning, with no respect or connection to local cultures. The obvious matrix of this model was a logocentric thinking, outside history, against which later it would be born different forms of resistance and criticism, especially in between '60s and '70s.

This opposition was translated mainly in form of new ways of geometrical expressions, on one hand linked to new structural and technological developments which stimulated designers experimentations, on the other hand regarding a new idea of the future and how to interpret it in a formal key. Main goal of these investigations was to find viable alternatives to the spatial model based on the right angle and to the trilithic structure beam-column. The geometric search during '60s and '70s, largely innovative, challenged the current architecture of International Style through specific spatial and geometrical experiments; but all these experiments had also several theoretical frameworks where they can be placed. We have to note that historians often disagree to each other because everyone tends to classify projects developed in the same years within different categories.

For this research, it is not important which category to use or how to gather and classify projects, but it is fundamental to show the evolution of architectural expressivity after the first reaction to international style. We need to understand this composite scenario of '50s-'70s, where we are not anymore allowed to talk about language or style for architecture, because it was changing in several directions at the same time, experimenting with three-dimensionality of forms or with eclectic compositions. Instead, we need to focus on the aspects that will be strongly present on the new developments given by digital revolution. Therefore, this treatise will be articulated in chronological order, but with a particular slant, selecting what is thought to be the proto-phase of digital experiments with architectural shape.

1.2.1. New frontiers of concrete: Saarinen, Nervi, Candela, Scharoun, Utzon

The reaction to Modern Movement and Brutalism was expressed in terms of new experimentations on architectural shape, conducted by pioneer architects and engineer who took advantage of the new possibilities allowed by building technologies - new patents, studies on reinforced concrete and pre-stressing, availability of increasingly resistant steels and concretes - and also of the studies on complex and analytical geometry, which served as test-bed to create new unusual three-dimensional configurations.

At the same time and in different part of world, projects by Eero Saarinen, Pierluigi Nervi, Felix Candela, Hans Scharoun, Jørn Utzon, became new architectural avant-gardes and icons of that time. These architectures are all characterized by strong expressive qualities, which attract public (Gössel and Leuthäuser, 2005). The work of these architects tried to bridge the gap of monumentality, identity, representative power, which were main prerogatives of architecture over the centuries, left by the anonymity and functionalism of International Style. It seems necessary now to attention some of these projects.

Eero Saarinen, a Finnish architect who prevalently worked in U.S. with his collaborator Charles Eames, designed several public buildings in the early '60s. Among his projects, we found airports, terminals, stadiums, which denote a strong need to be representative and buildings that want to be viewed. Architectures have often a curvilinear envelope, almost always derived from a parabolic solid, and the interior spaces are treated and articulated as a fluid spaces; the most evident case is the TWA Terminal of New York Idlewild International Airport (Fig. 3), designed with the goal to experiment not only with form, but with the whole spatial configuration. About this project and its design concept, Saarinen declared: «We wanted passengers passing through the building to experience a fully-designed environment in which each part arises from another and everything belongs to the same formal world» (Gössel and Leuthäuser, 2005).

Fig. 3. Eero Saarinen, TWA Terminal in New York Idlewild International Airport (1956-1962).

Also the works of Pier Luigi Nervi, a structural Italian engineer, were devoted mainly to push to the limit the beauty of construction, in order to create grandiose spaces. If the forms are less unusual than Saarinen ones, the structural solutions are brave and amazing at the same time, thanks to a sort of structural ornament, beyond the purely technical factor, that makes unique conventional spaces, as in the Palazzetto dello Sport in Rome (Fig. 4-5).

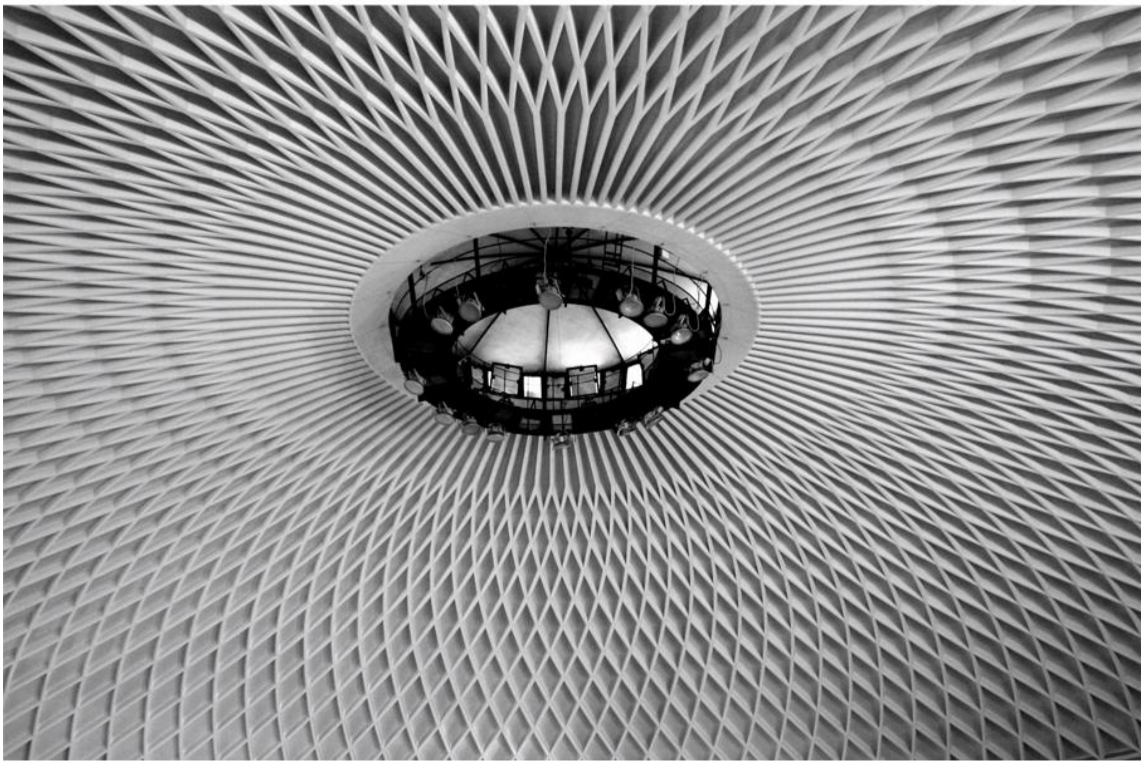

Fig.4-5 Pier Luigi Nervi, Palazzetto dello Sport in Rome (1958-1959).

In this phase of constant experimentation with form, when the relationship between architecture and mathematics becomes even closer, it is notable also the work of Felix Candela, a Spanish architect who practiced prevalently in Mexico. In particular, studies on reinforced concrete and on analytical geometry allowed him to conceive architectures as the *Los Manantiales Restaurant* (Fig. 6), which has a unique white envelope, result of the intersection of eight hyperbolic paraboloids. Experimentations with shapes derived for analytical geometry were a permanent feature in his whole work, starting from the end of '50s.


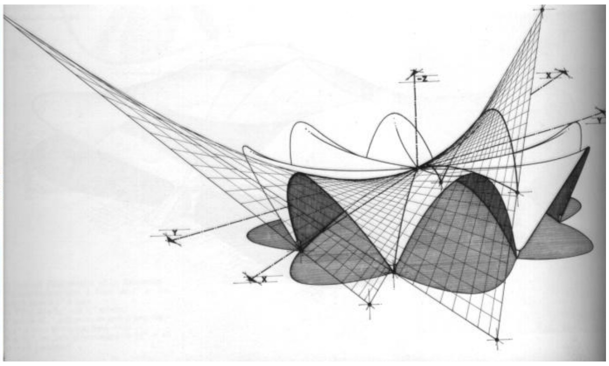

Fig. 6-7. Felix Candela, Los Manantiales Restaurant in Xochimilco, Mexico (1957-1958).

To complete this overview about formal experimentations in between '50s and '60s, we have to examine works of Hans Scharoun and Jørn Utzon. At the same time but in different places, these architects dealt with the design of two entertainment buildings, the *Philarmonic* in Berlin and the *Opera House* in Sidney. The theme of designing a space for the music have always stimulated architects to find often unusual formal configurations, in order firstly to find the best solution to acoustic needs and, secondly, to create new icons for those cities. In this case, Utzon turned out even to realize a new symbol for the entire country, with the several elliptical shells of the covering that mark the whole Sydney bay (Fig. 8). Indeed, about him, Frank O. Gehry, among judges in 2003 when Pritzker Prize was assigned to Utzon, declared that he: «made a building well ahead of its time, far ahead of available technology, and he persevered through extraordinarily malicious publicity and negative criticism to build a building that changed the image of an entire country» (Hawthorne, 2008).


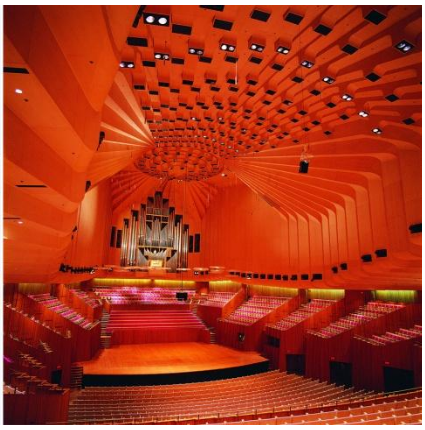

Fig. 8-9. Jørn Utzon, Sydney Opera House (1957-1973).

Regarding instead to Berlin Philarmonic, Scharoun created a new kind of space for the music, where the acoustic is perfect and the formal result absolutely new, thanks to a solid with several sides, placed in different directions, connected through a complex curvilinear roofing (Fig. 9).

Fig. 10-11. Hans Scharoun, Berlin Philarmonic (1957-1973).

1.2.2. Domes and three-dimensional coverings. The experience of Fuller, Otto, Le Ricolais.

Beyond three-dimensional projects developed with concrete, other designers experimented also with steel structures and glass coverings, taking advantage of natural progressions in steel and glass industry that allowed the use of new building technologies. Above all, we are talking about tensile structures, that were constructions of elements carrying only tension and no compression or bending. These buildings were realized through a complex bind of structural cables, which could be in mild steel, high strength steel (drawn carbon steel), stainless steel, polyester or aramid fibres. A tensile membrane structure is most often used as a roof, as they can economically and attractively span large distances. Last, but not less important, tensile structures allowed realization of novel forms, unusual and brave, where structural engineers could try new geometrical solutions.

Despite the Russian engineer Vladimir Shukhov was the first to develop practical calculations of stresses and deformations of tensile structures, shells and membranes and also Antoni Gaudì used the concept in reverse to design a compression-only structure for the Colonia Guell Church, the first interesting formal solutions are to attribute to Richard Buckminster Fuller.

Fuller was not only an engineer, but also an architect, systems theorist, author, designer, inventor, and futurist. He intended his whole life like a test bed to become a pioneer in thinking globally, exploring principles of energy and material efficiency in the fields of architecture, engineering and design. His attention to sustainability principles is combined with the nascent ecological thinking and it affects a very wide circle of people, from the group of avant-garde artists from New York, to hippie counterculture and American alternative culture, from the composite English architectural framework close to the journal *Architectural Design*, to a series of architects from different countries (including many Israelis) primarily interested to the static and geometric spatial re-foundation of Fuller's synergetic geometry (Fuller and Applewhite, 1975). This geometrical theory, called *tensegrity*, since the compressive forces are isolated within a system that works in tensile, starts from the critical reading of Euclidean geometry and of the Platonic solids to finally introduce the geodesic triangulation, which inspired the famous Fuller's domes. He had the opportunity to design and build these well-known structures when, after several failures in his professional life, he decided to dedicate his work to experimentation and he realized projects of geodesic domes while he was working for Black Mountain College in North Carolina. Then, the U.S. government recognized the importance of his work, and employed his firm *Geodesics, Inc*. in Raleigh, North Carolina to make small domes for the Marines. Within a few years there were thousands of these domes around the world.

For the World Exposition in Montreal in 1967 it was asked to Fuller to design the U.S: pavilion (Fig. 12-13), which was a geodesic structure by of steel and acrylic cells, 76 metres in diameter and 62 metres high, built with triangular and hexagonal elements (Gössel and Leuthäuser, 2005). But, at the same exposition, it is notable also the German pavilion, designed by Frei Otto and Rolf Gutbrod, which testifies that this kind of structures were becoming very popular all around the world.

Fig. 12-13. Richard Buckminster Fuller, U.S. pavilion at '67 Montreal Expo.

Frei Otto made his mark with a number of impressive ultra-modern and super-light tent-like structures using new materials. The German architect studied at the Technische Universität, Berlin, and, as a postgraduate student researching sociology and urban form at the University of Virginia, he visited the leading-edge US studios of Erich Mendelsohn, Ludwig Mies van der Rohe (both German emigres) Eero Saarinen, Richard Neutra, Charles and Ray Eames and Frank Lloyd Wright. The whole work of these architects became a strongly important figurative reference in his design, despite he had a pronounced trend towards light structures than heavier ones, like Mendelsohn or Saarinen. Frei Otto along with Gunther Behnisch collaborated to design the 1972 Olympic Stadium in Munich, Germany. With the Olympics having already been held in Berlin in 1936, Otto and Behnisch took the second Olympics games in Germany as an opportunity and a second chance to show Germany in a new light. Their goal was to design a structure that would emulate the games motto *The Happy Games*, as more of a whimsical architectural response that would overshadow the heavy, authoritarian stadium in Berlin. Then, the lightness of tensile structures seemed them the best to express ideals of the new Germany, which wanted to show to the entire world that there was an epochal counterpoint and that all the horrors of Nazism would have occurred nevermore.


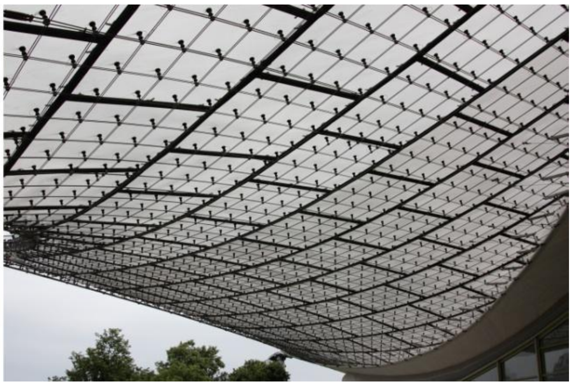

Fig. 14-15. Frei Otto, Olympiapark in Munich (1968-1972). Photos taken by Author.

To do this, he based his esthetical research mainly on the relationship between architecture and nature. Indeed, from the early 1970s he began fusing forms found in the nature with modern building techniques and computer logistics. His book *Biology and Building* (Helmcke and Otto, 1971) examined ways in which the lightweight sandwich construction of bird skulls could be applied to architecture; a further volume, published in the subsequent year, dealt with the strength and beauty of spiders' webs. Starting from this, Otto thought about the possibilities to stretch man-made structures to such limits with such economical use of material. And finally, with Olympic stadium in Munich, he tried to realize a light and transparent structure, made, as usual in this kind of works, with steel cables and large sweeping canopies of acrylic glass, that wanted to re-interpret the Alps skyline, visible on the background of Munich's landscape. After about 30 years, the Olympic Stadium would become an interesting reference point for the Viennese studio Coop Himmelb(l)au, which had to design a new representative building for BMW (the later BMW Welt), placed on the opposite side of the Olympiapark.

1.2.3. The return of ornament: Postmodernism

On the other side with respect to the organic trends, much more focused on the structural matters, since the Post-war another trend was born as an opposition to Modern Movement: we are talking about what historians have defined *Post-Modernism*. There is no predefined definition about what post modernism is, this because it was a general tendency, not only belonging to architectural scenario, and in a moment not well defined the word begun to be used to indicate a certain formal and cultural detachment, a refuse of precedent happenings (Harvey, 1995). Postmodernity in architecture is said to be heralded by the return of wit, ornament and reference in response to the formalism of the International Style. The functional and formalized shapes and spaces of the modernist style are replaced by diverse aesthetics: styles collide, form is adopted for its own sake, and new ways of viewing familiar styles and space abound. Perhaps most obviously, architects rediscovered the expressive and symbolic value of architectural elements and forms that had evolved through centuries of building which had been abandoned by the modern style.

One of the protagonists of this movement was certainly Robert Venturi, who worked with Denis Scott Brown, by redefining architecture's tasks starting from a sociologic interpretation of visual communication (Gössel and Leuthäuser, 2005). The publication of their *Learning from Las Vegas* (1972) rediscovered the value of vernacular architecture and its communication with the human, who, in turn than before, see architecture from the road and, then, it is attracted by commercials and symbols immediately recognizable. By analyzing what was happening along the most congested and popular roads or highways, architecture rediscover his semantic value, with the intrinsic idea that it has to communicate a message. Then, e.g. the eclectics interest returned on the façades replacing the aggressively unornamented modern styles, but combining it in new manners and often attributing intense colours to the elements, with the use of non-orthogonal angles and unusual surfaces, which has to immediately cause attention. Influential early large-scale examples of postmodern architecture are Michael Graves' Portland Building in Oregon and Philip Johnson's Sony Building (originally AT&T Building) in New York City, which borrows elements and references from the past and reintroduces colour and symbolism to architecture (Fig. 16-17).


Fig. 16-17. Michael Graves' Portland Building (1982) and Philip Johnson's Sony Building (1984) in New York City.

The move away from modernism's functionalism is well illustrated by Venturi's adaptation of Mies van der Rohe's famous maxim *Less is more* to *Less is a bore* (Venturi, 1966). The final aims of the movement was to make possible that architecture can express its own diversity, communicating meanings with ambiguity and sensitivity for the building's context. Then, the actual architectural production is visually very different, with respect with each architect's style, including the use of sculptural forms, ornaments, anthropomorphism and materials which perform trompe l'oeil. These physical characteristics are combined with conceptual meaningful characteristics, as in the well known projects of SITE Projects Inc. and Charles W. Moore and Associates (Fig. 18-19). The extreme freedom of expression opened by Post Modernism, will have considerable repercussions on later architecture, as we will explore in this dissertation.

Fig. 18-19. Natch Showroom of Arden Fair Shopping Center in Sacramento by SITE Projects Inc. Piazza d'Italia in New Orleans by Charles W. Moore.

1.2.4. Utopias and new visions of the future

While architecture was experimenting with new courageous forms or conceptual composition, another trends of that years was the conception of several visionary projects, which had the aim to explore a new idea about future.

Indeed, *visionary architecture* is the name given to architecture which exists only on paper or which has visionary qualities. While the term 'visionary' suggests the idea of an idealistic, impractical or Utopian notion, it also depicts a mental picture produced by the imagination. These architectural drawings on paper allow insight of the unusual perception of the worlds that are impossible to visit every day, except through the visual dramatization of the designed, imaginative environment (Walker, 1992). There are also two meanings that are derived from both terms 'imagination' and 'imaginary,' meaning unrealistic and impossible, and the other the ability to deal creatively with an unseen reality.

Archigram was an avant-garde architectural group formed in the 1960s and based at Architectural Association, with Peter Cook, Warren Chalk, Ron Herron, Dennis Crompton, Michael Webb and David Greene among its main components. The works of Archigram had a Futurist slant, being influenced by Antonio Sant'Elia's works, and their aim was to explore some possible ideas of future, as we can see in the high-scale projects Plug-in-City and the Walking City (Fig. 20), where they designed some futuristic structures figuring out a future, which figurative references were the space missions of that years (Archigram, 1999). The success of these missions became the measure of future contingence and the form of space capsule was a pattern for day-life objects. Therefore, also Archigram's work began to deal with themes like housing in a futuristic way, as testified by the *Air House Exhibition Project* in 1964.

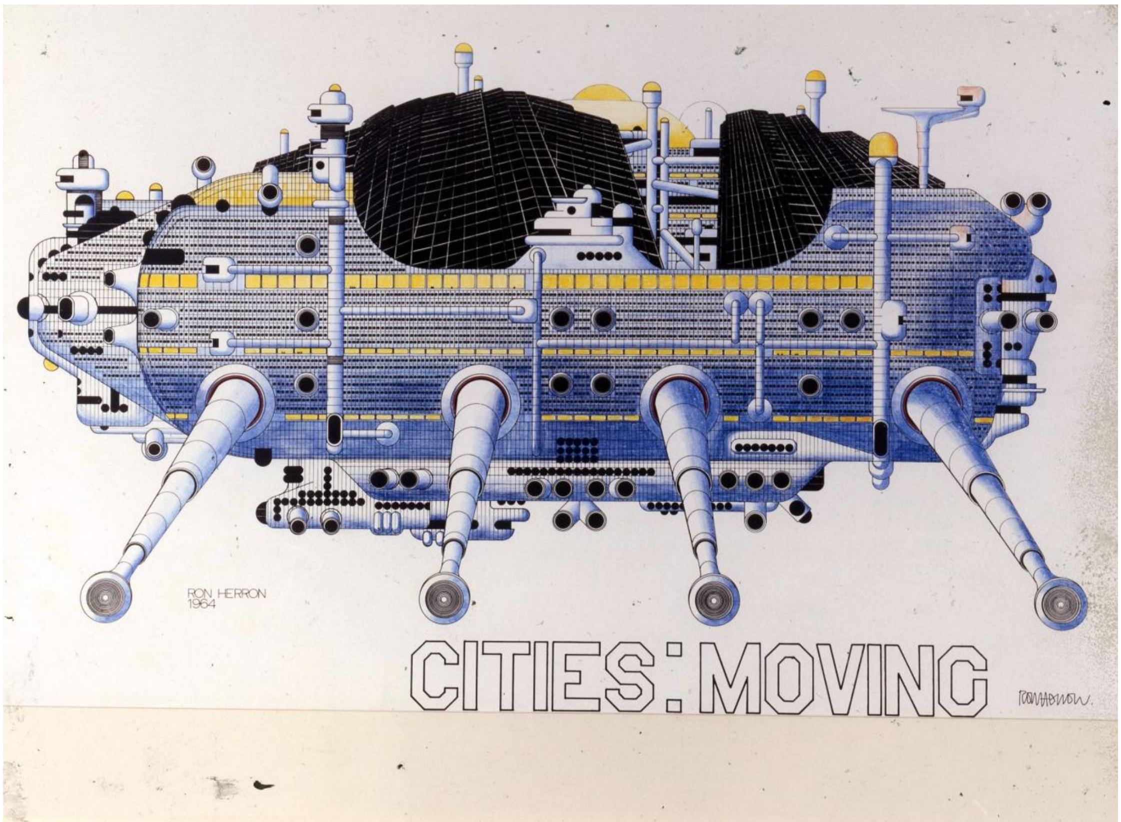

Fig. 20. Archigram, *The Waliking City*, 1964.

Some ideas related to the *House of the Future* were also developed by Friederich Kiesler, who dealt with the design an *endless house*, a project where the each point of the surface crosses and crosses again, endlessly (Fig. 21). This project remained on paper, even if Kiesler built a physical model of it. We have also to mention the visionary expressionist artist and architect Hermann Finsterlin, who played an influential role in the German expressionist architecture movement of the early 20th century and was able to regenerate his work during the explosion of visionary architecture movement in the '60s.

Finally Lebbeus Woods, considered the main exponent of Radical Architecture and recently died, since the '70s dealt with the design of systems in crisis: the order of the existing was confronted by the order of the new. His designs are politically charged and provocative visions of a possible reality; provisional, local, and charged with the investment of their creator (Woods, 1997). The vision about the future is dramatic, the scenarios imagined are influenced by a strong presence of metal materials, as opposition to an old fashion, as tangible effects of war disasters (Fig. 22).

The influence of visionary architecture, especially on a generation of architects who were studying in that period, was profound and their ideas about future would have begun the basis of certain expressive trends, with the difference that the project would have been actually realizable.

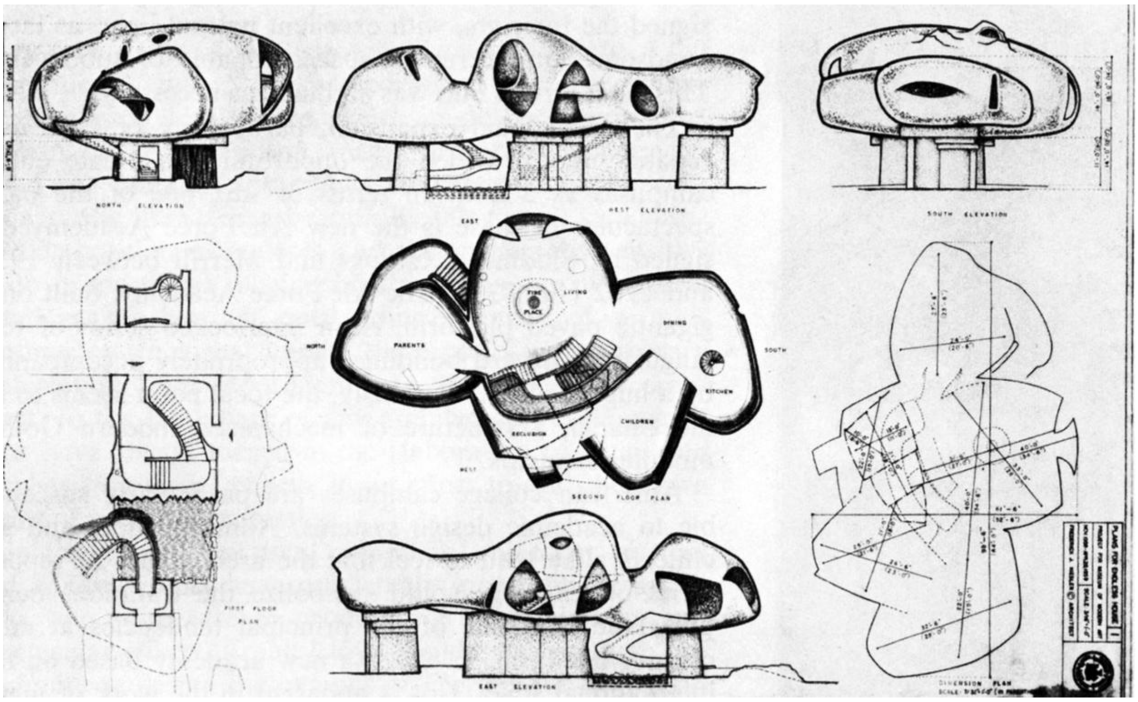

Fig. 21. Friederich Kiesler, *Endless House*, 1959.

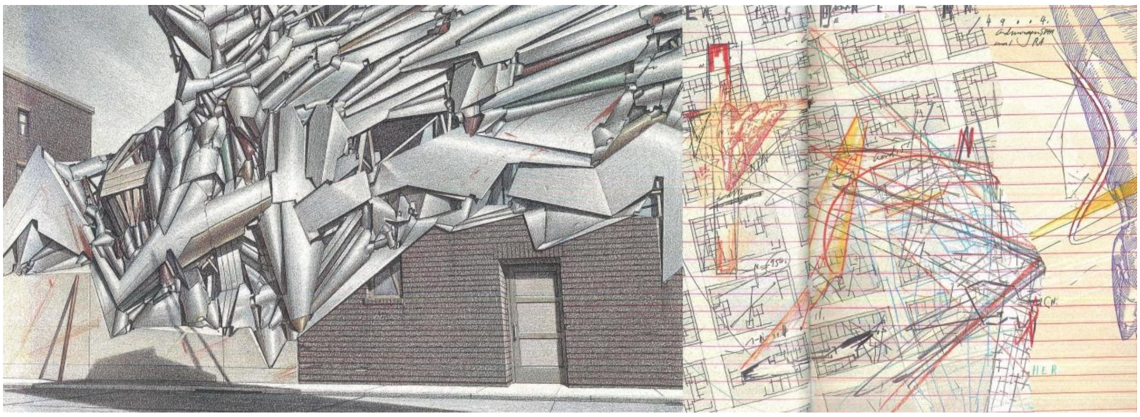

Fig. 22. Lebbeus Woods, *Radical Reconstruction*, 1997.

1.3. The end of century: Hi-Tech and Deconstructivism.

The end of the XX century was characterized by the emergence of two figurative styles, whose conception was totally opposite: while the Hi-Tech has is basis on the technological developments in construction industry, the Deconstructivism starts from a philosophical movement. Like Brutalism, Hi-Tech buildings reveal their structure on the outside as well as the inside, but with visual emphasis placed on the internal steel and/or concrete skeletal structure as opposed to prior exterior concrete walls. In buildings such as the Pompidou Centre, this idea of revealed structure is taken to the extreme, with apparently structural components that serve little or no structural role. In this case, the use of structural steel is a stylistic or aesthetic matter (Fig. 23-24).

Fig. 23-24. Pompidou Centre in Paris, by Renzo Piano and Richard Rogers.

Architectures were built mainly in North America and Europe. The main content is that the technological kind of construction, mostly with steel and glass, is expressed in a formal independent way to gain own aesthetic qualities out of it. The first proper example are the 860-880 Lake Shore Drive Apartments by German architect Ludwig Mies van der Rohe in 1951 and architects like the British architects Norman Foster, Richard Rogers, Michael Hopkins and Nicholas Grimshaw, the Italian Renzo Piano, and so on, are direct descendents of this way of working. With the improved technological developments these architects evolved their way to work, detaching from rational configurations and going towards more complex forms, obtained with lattice shells structures in a way previously traced by the '60s heroes (Buckminster Fuller, Frei Otto), mentioned in section 1.2.2.

Influenced by the theory of *Deconstruction*, which is a form of semiotic analysis, *Deconstructivism* trend is characterized by fragmentation, interest in manipulating a structure's surface or skin, non-rectilinear shapes which appear to distort and dislocate elements of architecture, such as structure and envelope. The finished visual appearance of buildings that exhibit deconstructivist concepts is characterized by unpredictability and controlled chaos. Deconstructivism came to public notice with the 1982 architectural design competition for the Parc de la Villette in Paris, especially for the proposal made by Peter Eisenman with the French philosopher Jacques Derrida (1997) and Bernard Tschumi's one, and also for the Deconstructivist Architecture exhibition organized by Philip Johnson and Mark Wigley at the MoMA in New York in 1988.

The main channel, from deconstructivist philosophy to architectural theory, was through the influence of the philosopher Jacques Derrida and his collaboration with Peter Eisenman, who drew some philosophical bases from the literary movement. One of the main presupposition is that architecture is a language capable of communicating meaning and of receiving treatments by methods of linguistic philosophy. The dialectic of presence and absence, or solid and void, occurs in most of deconstructivist projects, as the Libeskind's ones (Fig. 25-26). However, the initial developments started from an interpretation of Derrida's thinking in a key purely formalist, insomuch most common operations were cuts and disconnections, even if, after a while, the trend begun to be associated also to plastic forms. Nowadays deconstructivists expressions are still part of architectural scenario and have become part of digital-influenced architecture, insomuch borders between the two tendencies are not well-distinguishing.


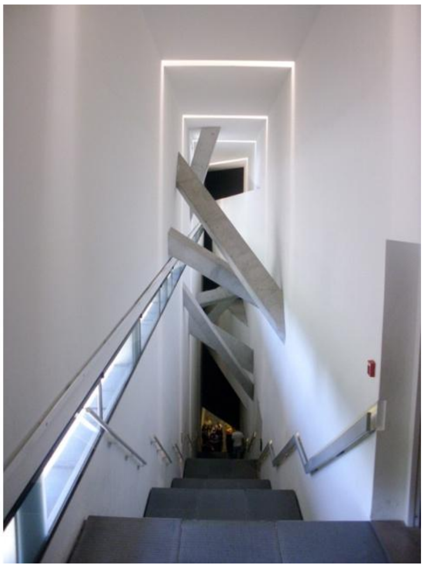

Fig. 25-26. The Jewish Museum in Berlin Daniel Libeskind (2001).

1.4. The advent of the computers. Pioneering attempts of digital design in the '90s

The innovation that changed the landscape of contemporary architecture is undoubtedly related to the birth of the computer technologies. In the next chapter, we will explore how CAD software was born, the birth of first commercial programs, which kinds of models are allowed by the new computer applications and which contribution can they guarantee to architectural practice. For this stage of analysis, it seems fundamental showing the first real effects of the use of computer in architecture, reporting architects opinions and showing some first *digital* projects.

At the beginning of the '90s the CAD software began to enter into architectural practice. In the first period their contribution was only related to the potential of representation. The screens of computers were used as a paper sheet, designing and drawing in a traditional way.

However, the next step was to understand that the potential of the CAD was not related only to the architectural representation, but also to the ability to control and manage the design. The use of CAAD programs has undoubtedly expanded the representation possibilities of the architectural object. It has also triggered a revolution in design methodology linked to the possible experimentation of the architectural space.

One of the innovations using the digital processing tools is the continuity of the design and construction phases. The software available does not allow only the representation, but also the independent creation of complex shapes, never imagined because not fully representable (Colajanni et al., 2006). In fact, before the advent of digital technologies the conception of architectural shape was mainly based on the principles of Euclidean Geometry. The design might be arisen by composition and synthesis of basic geometrical shapes, because they were easily controlled by whole knowledge possessed at that time. The actual modelling software offers the ability to handle complex shapes in three dimensional space, a place where we can virtually represent the real physical space.

While many architects have introduced the new software in their design practice, trying to exploit the instrumental opportunities offered to improve the productivity of their work, the others have pushed these possibilities on the research of expressive solutions not yet explored with the traditional tools of representation.

Hani Rashid and Lise Anne Couture of Asymptote explain the evolution of their design practice since the introduction of information technology until the most recent achievements: «When we first acquired a computer, around 1992, we weren't quite sure what to do with it. At first it only seemed useful for flattening drawings - an expensive paperweight […] Once we saw some of the potentials, we realized that creating a fly-trough was the last things we wanted to do. At that point, the computer became a powerful tool for us to extend various set of issues that we were already exploring in predigital media - video and films, for instance - mainly those issues related to understanding and experimenting with new aspects of space and architecture». (Rashid and Couture, 2003)

Among the first experiment we obviously find the HtwoO pavilion by NOX (Fig. 28) and the Möbius House (Fig. 27) by Ben van Berkel and Caroline Bos (UNStudio), where one of the classical topological surfaces such as the *Möbius Strip* has been manipulated to create a surface which boundaries between interior and exterior are made by an envelope without solution of continuity or breaks between the opaque and transparent elements. What makes attractive this architecture is not the complexity of form, but the record on the shape of the structure and the relationship that are developed internally and externally with the context, integrating functions and circulation.

After these pioneer projects, the triumphal entry of computing in architectural design became evident; everyone is able to recognize that something is changed and that new expressivities are derived from software use.

Fig. 27-28. The Moebius House by UNStudio in Het Gooi, Netherlands and the HtwoO Pavilion in Neeltije Jans, Netherlands by NOX.

Notes

1) *Béton brut* (raw concrete) is architectural concrete left unfinished or roughly-finished after pouring and left exposed visually. The imprint of the wood or plywood formwork used for pouring is usually present on the final surface.

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CHAPTER 2
Trends and computer tools to create architecture shape

2.1. The history of CAD: from the birth to the current 3D modelling software.

The invention of the first electronic calculators, the prototypes of today's computers, can be dated in 1945, when John von Neumann began the development of ENIAC, (Electronic Numerical Integrator And Calculator, completed in 1946 (Russell and Norving, 2010). In subsequent years, the research conducted by IBM and the American University of Dartmouth led to the production of machines that could manage and process an increasing number of information and data.

We owe to Ivan E. Sutherland the first proto–application can perform drawing functions. Sketchpad, a software that experienced new forms of interaction between operator and computer by using a light pen and a CRT monitor, was developed into the Sutherland's PhD thesis in 1963 (Fig. 1). In the abstract of the Ph.D thesis publication, Sutherland wrote: «the Sketchpad system uses drawing as a novel communication medium for a computer. The system contains input, output, and computation programs which enable it to interpret information drawn directly on a computer display». Initially the software was not designed for architecture, indeed «it has been used to draw electrical, mechanical, scientific, mathematical, and animated drawings; it is a general purpose system» (Sutherland, 1980). *Sketchpad* is considered the precursor of the CAD (Computer Aided Drafting) software, that will be further enhanced to come to the current CAAD (Computer Aided Architectural Design) programs.

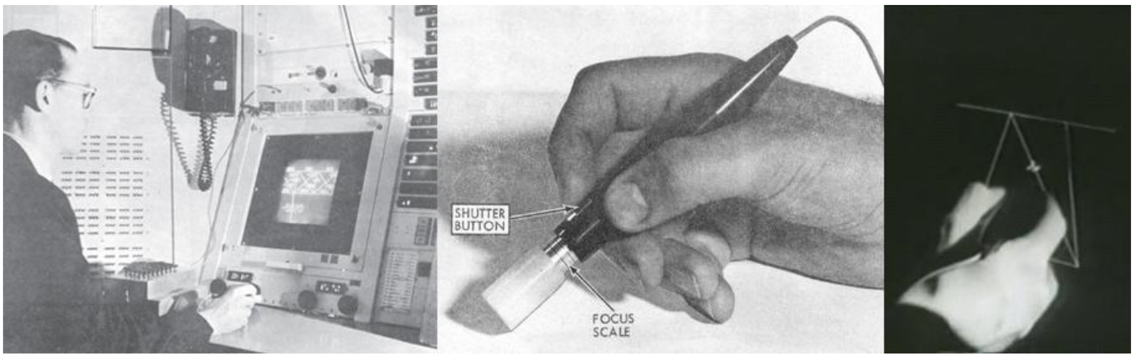

Fig. 1. *Sketchpad* in use (credits: I. E. Sutherland).

The first commercial applications of CAD occurred in the biggest companies operating in the automotive, aerospace and electronic field, because only the large corporations could have computers able to perform the calculations. Great company projects have been the software DAC-1 (Design Augmented by Computer) in 1964 at General Motors, GRAPHIC 1, design developed by Lockheed and Bell, UNISURF 1971 software, developed by Bezier at Renault factory, used to design the car body and accessories (Farin et al., 2002). Between the '60s and the '70s, there was the development of Intergraph software within IBM, the thicker industry in computer science at that time. The Intergraph IGDS platform was developed in 1974 and later absorbed by Bentley Systems®, becoming the first version of the popular software MicroStation® in 1984.

In 1968 Donald Welbourn thought of the possibility of using computer to solve the problems of creation of the forms designed through it, assuming they can be directly interfaced with the CNC machines to produce all the shapes virtually conceived. Initial work was sponsored by Ford, but finding money to support the development was a constant problem for Welbourn. When he became director of the Wolfson Cambridge Industrial Unit in 1971, he convinced the Pye Foundation to support the work of T. H. Gossling, member of the same Industrial Unit, to develop a model that combined the software and actual realization. In 1972 he was able to develop two machines with three axes that could help the manufacturing industry and that was directly interfaced with CAD software: the work done by the CAD widened also to the manufacturing field, resulting in the birth of the CAM, Computer Aided Manufacturing (Welbourn, 1983).

Throughout the 1970s, the CAD industry grew from virtually zero to a billion dollar hardware and software business. One area where university research played a significant role in the evolution of the CAD industry was in geometric modelling, both in regards to surface geometry and solids modelling. The earliest CAD systems simply handled two-dimensional data, emulating traditional drafting practices. The initial transition to three dimensions was done using wireframe geometry – points in space and the lines connecting these points. Solid objects and surfaces were defined simply by lines that represented the edges of the geometry. Without additional information, it was not possible to generate shaded images of wireframe objects nor could hidden lines be removed without manual intervention. Obviously, better methods were needed (Weisberg, 2008). During the 1970s in US academic research a lot of work was done on the study of curvilinear configuration. The Syracuse University Ph.D. candidate Ken Versprille worked on the definition of rational B-splines and he is credited by many people as being the developer of NURBS, Non-Uniform Rational B-Splines (Versprille, 1975).

Surface modelling technology was driven by the automotive and aircraft industries since manually defining and manufacturing sheet metal parts for these vehicles was becoming increasingly time-consuming and costly. Indeed, in 1977 Marcel Dassault and his team reached the aim of controlling the three-dimensional solids by using an interactive program, considered the precursor of CATIA (Computer-Aided Three-Dimensional Interactive Application). In 1979 Mike Muuss, almost at the same time with respect of the work on Dassault's CATIA, introduced the three-dimensional modelling within the world of CAD: BRL-CAD software was a platform developed in the U.S. Army Ballistic Research Laboratory and publicly released for the first time in 1984[1] (Fig. 2).

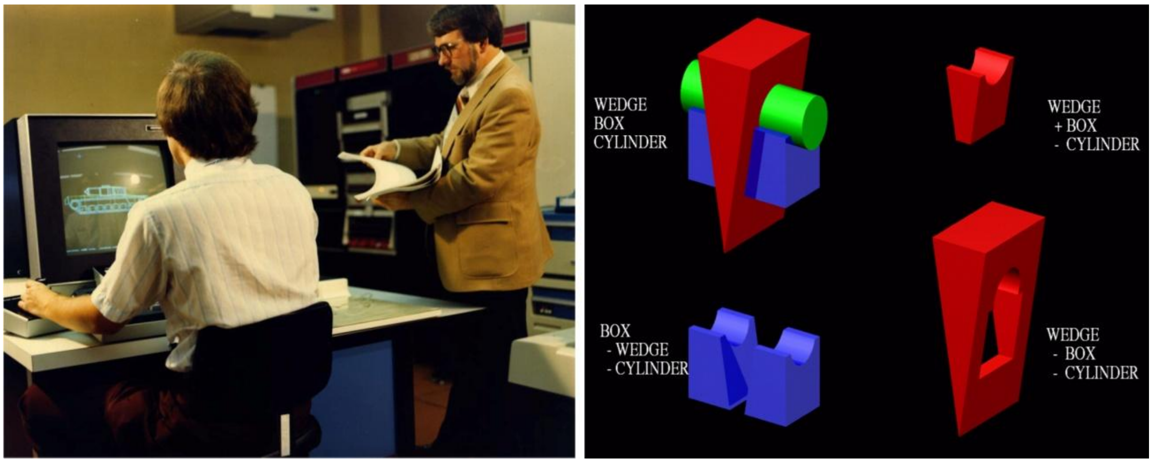

Fig. 2. Mike Muuss working in with BRL-CAD, that allowed some basic software operations, in the early 80's.

In the early '80s, the computer became a cheaper machine and therefore more accessible, not only prerogative of huge companies. The most immediate consequence was a gradual extension of the areas of application of the software.

In April 1982, John Walker founded Autodesk with the idea of creating a CAD program (AutoCAD) accessible for everybody, allowing the use of virtual design also in the construction industry, at the commercial cost of 1.000 $. The birth of AutoCAD and the consequent development of software for personal computers was the impetus for the application of virtual design in almost all areas of industry, including the building industry. Moreover, as the price of CAD systems came down, modifications in how they were used began to occur. While many organizations continued to operate inside CAD departments, other began to disperse systems into their design and manufacturing organizations. Instead of providing sketches to a professional CAD operator, design engineers were trained to do this work themselves. In Architecture this was translated in the possibility of fully drawing and, above all, experimenting the representation potential of CAD software.

In the early 90's the CAD software, with the birth of several commercial programs, was commonly used into the architectural and engineering studios, as well as within industries, but their contribution was only related to the potential of representation, making faster the drawing process and unnecessary the *old* set squares. However the next step was to understand that the potential of the CAD was not related only to the architectural representation, but also to the ability of controlling and managing the design. Indeed, these programs allow the operative continuity of design and construction phases and do not permit only the representation, but also the independent creation of complex shapes, never imagined before because not fully representable (Colajanni et al., 2006).

2.2. Three-dimensional modelling and new design trends.

In the contemporary architectural design, different digital approaches are opening new fields of research, both conceptual and formal. The architectural morphology seems to be focused on the emergent and adaptive properties of the shape. The forms digitally represented do not appear designed using the logical–creative methodology of the traditional design, where the project is put on paper after the initial intuition, in a continuous going back and forth to verify the goodness of the studied solutions. They are thought through computational media, which enables the designer to view the changes in real–time, giving back a complete overview. You do not work longer for watertight compartments or individual graphic scripts, that must be related to the others as in the traditional dialectic plan – elevation – section, but you can have the total control of the project, selecting from a range of endless possibilities the one that seems the most appropriate.

One of the main tasks, reported by several papers in the last years, regards the design decision-making in digital domain (Christiaans and Almendra, 2010, Dorta et al., 2008, Ball et al., 2010). Indeed, the conception of each design is changed by the use of software because there is a different way to explore forms, concepts, space. Most of the times, the software used implies a reduction of the design time: on the one hand, if this is a considerable advantage due to the parallel control of all design documents, before individually drawn, on the other, it can be risky. Indeed, the speed of the project definition could lose the reflective time, that allowed the designer to mature the project idea with a greater awareness of the whole operation.

In this dynamic context, the emphasis shifts from the production of forms to the process which lead to a final shape, searching for the novelty of the form itself, as Leonardo Benevolo stated (2008). Nowadays digital design is begun clearly linked to the different software used to the architectural conformation. But in this open scenario of the available programs and their specific properties and functions, different trends were born, depending on the type of design software chosen and its interaction with designer.

In particular, the classification about *models of digital design* proposed by Rivka Oxman (2006) seems particularly shareable and marks a starting point for future research in this field. In particular, the author recognizes four components of digital design, *representation*, *generation*, *evaluation* and *performance* and distinguishes digital design models for architecture in:

- *CAD models*, that represent the evolution of paper-based representation and design;
- *Formation models*, where the designer starts from the new augmented capabilities in digital representation;
- *Generative design models*, where the operator sets up the algorithmic structure of design, imposing constraints and parameters;
- *Performance models*, based on the optimization of one or several parameters;
- *Compound models*, that could see as a combination of precedent tasks, as in the current BIM software programs.

These models, which identify different approach in digital design, differ significantly. Then, given that this dissertation analyzes how architectural expressivity has changed under the digital influence, it seems necessary to describe these models, by starting from Oxman's categorization, to understand their use in architectural practice and to be able to recognize their presence by analyzing each project.

2.2.1. CAD Models

CAD Models are the oldest example of digital models: they are the closest to paper-based design, since the actual computer screen is intended as a paper sheet. Indeed, these models are commonly used for controlling graphical representations of digital objects. Oxman subdivided the category in *descriptive* CAD and *generation-evaluation predictive* CAD.

The first generations of computer-aided design systems were characterized mainly as being *descriptive* through employing various geometrical modelling/rendering software. The common use of traditional descriptive CAD has been so far in manipulating the graphical representations of digital objects (Oxman, 2006). Today CAD technologies enable also data flow between digital and physical objects. By means of using various digital material processing techniques, data can be transferred from digital models to physical objects and vice versa, such as translating physical objects into digital models, which is called *reverse modelling*, a common technique born in military industry and used e.g. by F. O. Gehry (Chikofsky and Cross, 1990).

The *generation-evaluation predictive* CAD are used in evaluative analytical processes, e.g. related with cost estimation, structural behaviour, and environmental performance. They are used to integrate advanced construction level modelling and evaluation software. This kind of CAD helps to support collaboration among different design team groups, such as combinations of architects and engineers. However, in this kind of models, generation is not explicit. Generation, representation and evaluation take place consequently, not simultaneously. They are not directly linked, which means any change and modification in digital model requires a re-evaluation. CAD descriptive software are programs like AutoCAD®, MicroStation®, VectorWorks® (Fig. 3).

2.2.2. Formation Models

Formation models are emergent in digital design, where the centrality of traditional concepts of paper-based representation are no longer valid for explaining methodological processes and design thinking associated with digital production of architectural projects. What is undoubtedly changed is the role of representation in design conception: while in CAD models it was based on the digital composition of figures and shapes, formation models are based on abstract criteria, which generates the form. This way of conceive architectural design is forging new bases for design thinking, with an emerging design theory that has transformed the concept of *form* into the concept of *formation*. The use of dynamic concepts in digital design helps creating a new definition for the role of the representation itself.

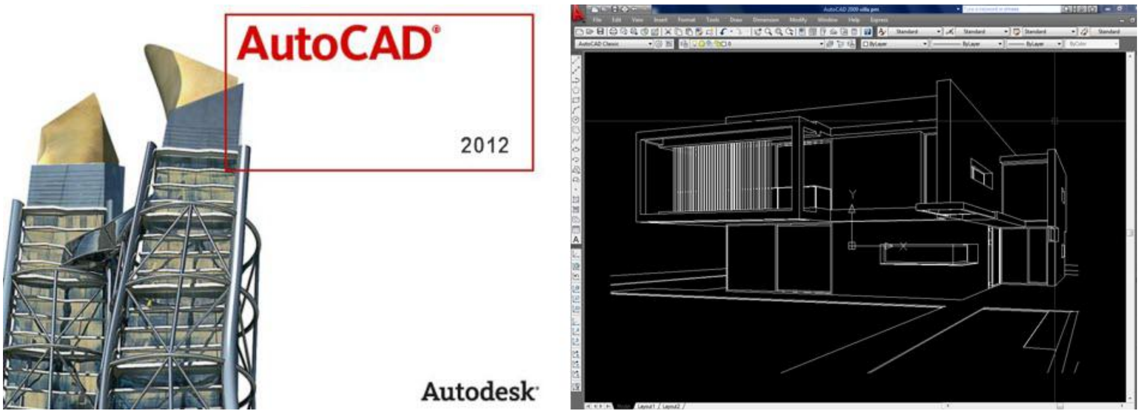

Fig. 3. Logo and main interface of Autodesk AutoCAD® 2012 during the design of a house.

In formation models, digital techniques are used in the generation of form and shape. In contrast, CAD models are only used for representation and data flow. Designer operates the non-deterministic logic of form generation process along with digital techniques, such as scripting and parametric design. The designer becomes a digital *toolmaker* for form generation (Oxman, 2006). Oxman has also subdivided formation models in three other sub-classes, *topological*, *associative* and *dynamic* models.

2.2.2.1. Topological models

The reconsideration of traditional geometry, towards non-Euclidean geometry and the concepts of topology, has contributed to the exploration of new formal possibilities. The new forms obtained through these tools are experimenting new geometries, as reported in the wide casuistry selected in Jane and Mark Burry's book (2010).

Topology is the mathematical study of shapes and spaces and particularly it is the study of the relational structure of objects rather than of their geometry. It studies the properties that are preserved under continuous deformations including stretching and bending, but not tearing or gluing. Therefore topological structure can be defined in a variety of geometrically complex forms, as reported by Emmer (Emmer, 2004). Obviously these properties of form can be easily managed through the software use.

Indeed, the use of NURBS (Non-uniform rational basis spline) Surfaces, which are functions of two parameters mapping to a surface in three-dimensional space. The shape of the surface is determined by control points. Moreover, design tools like *loft*, *sweep*, *smooth*, that now are current available in most of CAD software, allowed the management of these complex surfaces. In addition, beyond solely creating complex surfaces, these tools permit the deformation of existing shapes or primitives, with the aim to create unusual and never-seen forms. In the early 2000s, the popularity of topological control of architectural space helped to create a new figurative language, with also a new terminology for architecture, like *blob*, *folds*, *hypersurfaces* (Lynn, 1998, Van Berkel et al., 1999, Oosterhuis, 2003). We will explore these trends in the next chapters.

2.2.2.2. *Associative models (parametric design)*

Associative design is based on parametric design techniques Associative Geometry, that is used in the majority of parametric tools. It is based on spatial, geometric and topological relationships and properties, which characterize the architectural form. With the conventional CAD models is quite easy to create an initial model, modelling the different parts and linking them together thanks to elements like *snaps* (Woodbury, 2010). Making changes to a model can be difficult. In fact, changing one dimension may take many other parts to change, requiring a manual rework. The parametric tools are effective in controlling the various parameters and their correlation. Changing a parameter automatically involve others, because their relationship does not change, providing the designer with a total control of project and all changes that are taking place.

The parametric approaches represent the symbol of change, insomuch some architects publicly have declared their favour to parametric design. Patrik Schumacher, principal at Zaha Hadid Architects, have developed the *Manifesto of Parametricism*, publicly discussed in several lectures and published in different paper and his books (Schumacher, 2009, Schumacher, 2012). Indeed, rather than creating the project solution through direct manipulation, as in conventional instruments and in topological models, firstly the designer establishes relationships between the parties and their connection, later he conceives the project using these relationships and changes them, by observing and selecting the produced results. The system takes care of keeping the shape consistent with the pre-established relations and thus increases the ability to explore the project ideas, reducing the reoperation in case of modification.

Parametric design depends on the relationships definition and on designer's willingness and ability to consider the definition phase of the rules as an integral part of the design process. From the beginning of the design stage it requires that designer has to take a step back, compared to the direct design, and focus on the logic that ties the project together. The definition of relationships is a complex act of creative thinking. These are strategies and skills, some new, some more familiar to designers. Geometrical rules can be also set on the basis of the design conception. This way to proceed is typical of some add-on programs like Grasshopper® for Rhinoceros®, where you have to set an algorithm before to go on with your design (fig. 4).

2.2.2.3. *Dynamic models*

In the dynamic models, the designer does not interact directly with a complex form or with a rule that has to define final configuration, as we saw in *topological models* and *associative* models, but rather with a motion-based approach.

The morphing, which literally means *metamorphosis*, is a technique born in the film industry and is one of the first digital effects that have been developed. It consists of a fluid, gradual and seamless transformation between two different images, which can be objects, people, faces, landscapes, creating an animation. Before the advent of morphing into the cinema field, the most effective method to show the transformation of one image into another was the dissolve: this technique was used to obtain a gradual overlapping of the final image on the starting one, up to total replacement. However, it had a limit that was much more evident as the two images had different contours, since dissolve is not allowed to obtain effective deformation between the one and the other.

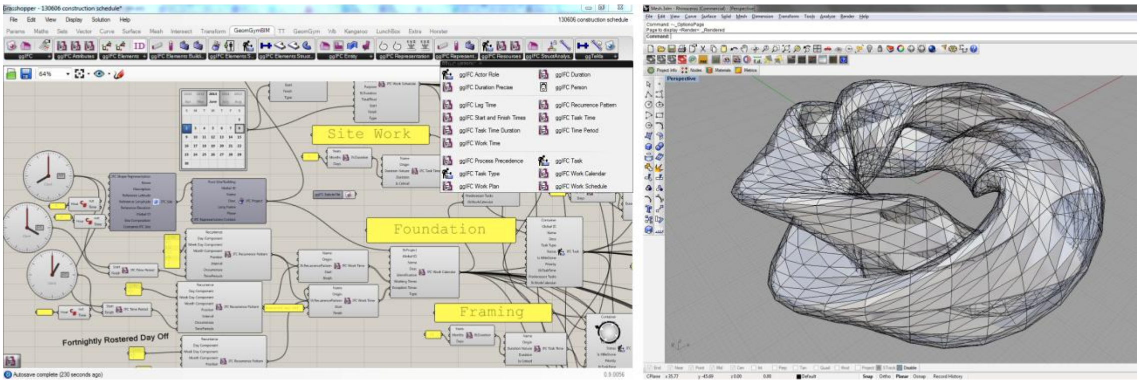

Fig. 4. The interface of Grasshopper®: on the left the definition of the alorithm, on the right the form produced.

The ability to generate images and animations through the exclusive use of the computer was born in the second half of the '60s and later perfected and used with good results only from the mid-80s onwards. The first experiment took place in 1988 movie *Willow* by Ron Howard, produced by Lucasfilm®, but the greatest technological contribution that has given popularity to morphing technique, was in the *Terminator 2* movie by James Cameron, produced in 1991, where the technique was used in many scenes (Fig. 5).

Fig. 5. Screenshot of Terminator 2 movie by James Cameron, where robots are realized with morphing.

In the three-dimensional modelling this gradual transformation takes place between 3D entities, allowing you to transform an entity into another through gradual steps. It is a complex animation, where parameters that define location, dimensions, physical characteristics of the object are replaced with other parameters, with the possibility of obtaining an almost infinite conformations and morphological transitions. The morphing technique is based on the concept of target, which is the temporal stage of the form and is associated to a channel, which records and imposes a defined stage to the form itself. Through the selection of two or more destinations, you determine which are the key steps that the shape must make in its transformation. The morphing uses initial, intermediate and final configurations as key moments, which, if interpolated, produce a single continuous deformation, creating a fluid and indeterminate form. There were many architectural applications, such as those by Peter Eisenman, who has used this technique in his design methodology traditionally linked to the concept of diagram and grid (Fig. 6).

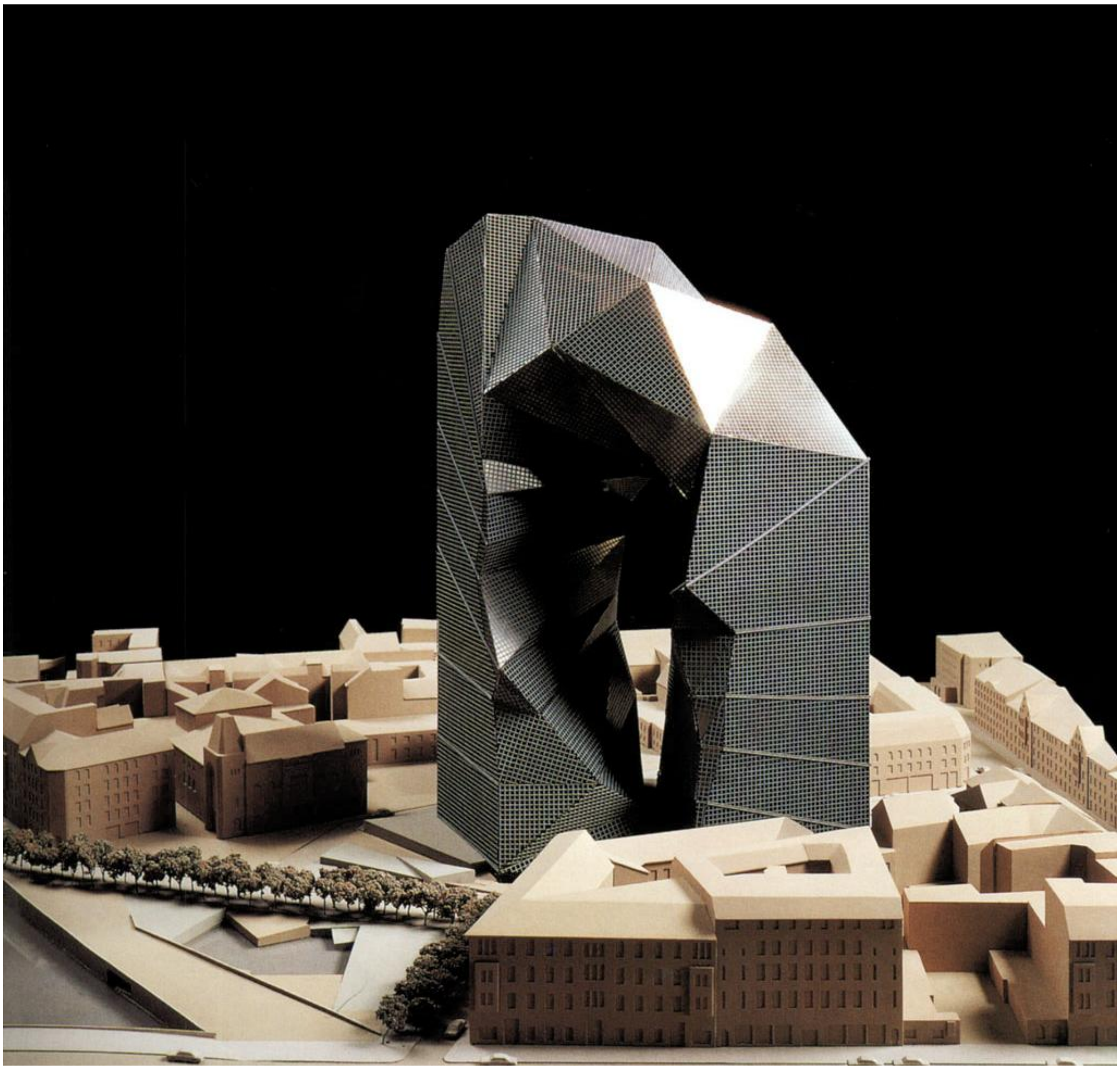

Fig. 6. Peter Eisenman, Max Reinhardts Haus, Berlin (1992), designed with morphing technique.

2.2.3. Generative Models

By contrast, in generative design geometrical aspects of structural relationships are defined; however, formal qualities are not defined. This formation prevents explicit formal representation in the conventional sense of visual design thinking. Generative design models create computational mechanisms for formalized generation processes in contrast to formation models, here the designer interacts with and operates the generative mechanisms.

The Generative Design is a design method in which the output – that can be images, architectural models, animations – is generated by a set of rules or by an algorithm. It is an innovative approach to the architectural design, in which *dynamic process* and *interaction* are the main keywords.

Initially generative methodologies were not born for architecture, but for other fields such as Art, Graphic Communication (commercials, posters), Product Design. Subsequently, the understanding of the great possibilities opened up by this methodology has made it a formal configuration tool that can also be used in architectural design. The designer participates interactively, changing the generative features of architectural object and verifying the results of real–time changes. The immediacy of the modifies allowed the exploration of numerous scenarios and the evaluation of different alternatives.

A Generative Design system has typically a design scheme, a tool to create variations, an instrument to choose the most desirable output and it is based on two fundamental concepts: *logical process*, which is reconstructed using algorithms within the design schema, and *constraints*, which are placed in order to give limited solutions to the program. The common element in the Generative Design methodologies is the concept of *rule*. It can be born from simple operations executable on the geometric figures in which an architectural shape can be broken down, such as rotation, translation, scale (Shape Grammars), or from the mechanisms that regulate the development of biological systems (Evolutionary Algorithms), that will be explained later.

In the terminology of Thomas Kuhn (1996), the Generative Design offers a changing paradigm for the design process (fig. 7). The designers does not longer need to consider the building as a static structure, subject to actions that manipulate it. The conceptualization provides a set of interacting components, that in turn generate new products with special and original properties. In a first rough analysis, it may seem a risky approach, which leaves very little freedom to the designer and too arbitrariness to the machine. In reality, everything is decided by designer, from the rule to the constraints, from the process until the final choice between the various solutions proposed by the software. If anything, the risk is related to designer himself and his ability to evaluate the best choices and find suitable solutions.

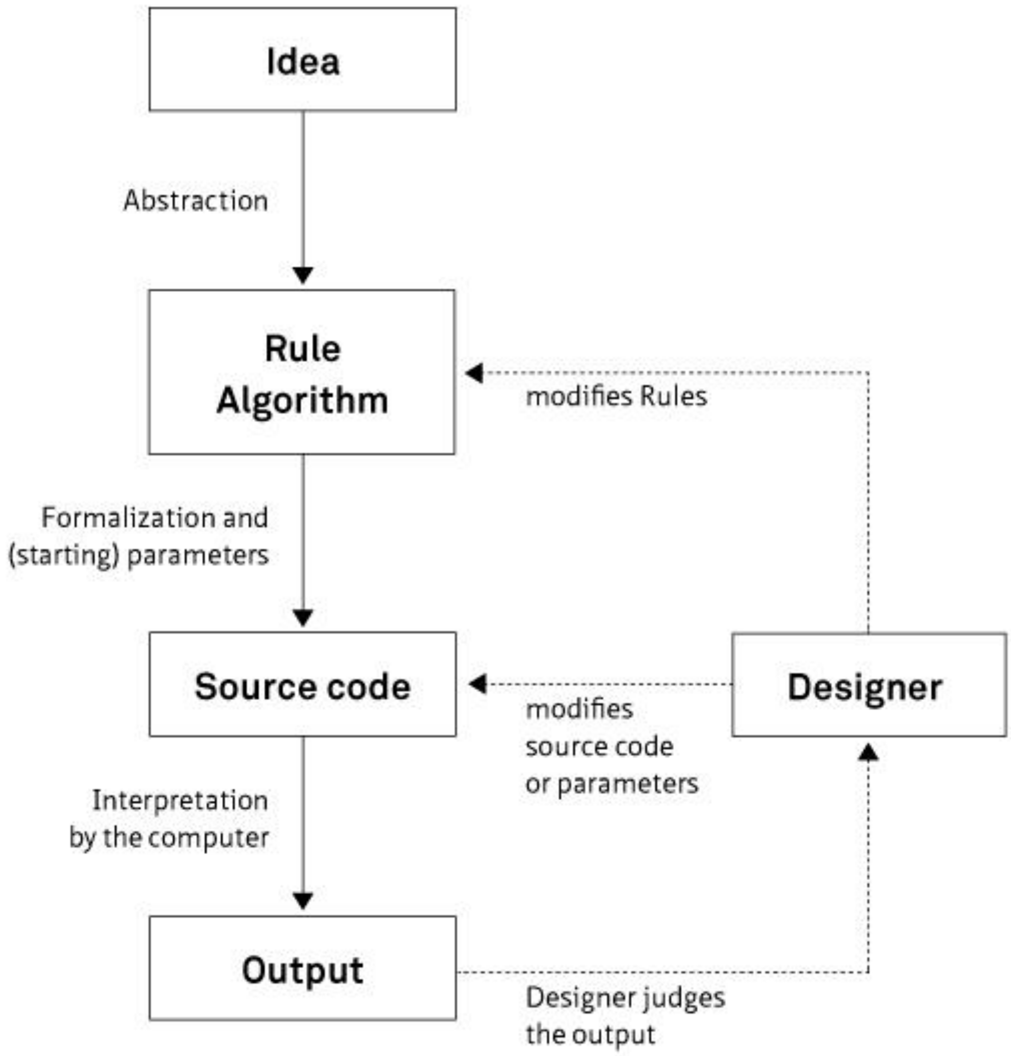

Fig. 7 – Scheme of design process through *Generative Design*. Source Bohnacker et al. (2009).

2.2.3.1. Properties of Generative Design

The criterion of formal generation is inspired by nature (evolution of the species, synthesis of the best features, ability to adapt to the environment). The properties attributed to natural systems are, therefore, applied and also reported to digital systems.

- *Ability to generate complexity*. The components interaction of a given complexity generates aggregates with much higher behaviour and/or complexity. These aggregates can interact among themselves generating new aggregates of sophistication and complexity even higher, creating between them a dynamic hierarchy (McCormack et al., 2004). A similar example in nature could be identified in the complex multi-cellular organisms, in which the combination of the smallest element, the atom, can create an ecosystem. So e.g. in architecture a building could be the result of the aggregation of simple forms, creating a high level of formal complexity.

- *The complex and interconnected relationship between organism and environment*. The organisms not only evolve and adapt to their environment, but their presence and number can influence and change the environment. In architecture, this is a well-known process: the project does not arise only on a blank sheet of paper, it is confronted with a real and physical environment and it will impact on that environment just by changing it, creating new flows and hierarchies between the parties, acting on the way of life of habitants. Therefore, even in Generative Design Systems the context plays a fundamental role in the choice of variables and constraints to be included in the algorithm design.
- *The ability to generate new structures, behaviours, results or reports*. It introduces the concept of novelty: the quality of being new, original and different from anything else before it. Artists and designers are always looking for something new, the opposite of which is a copy, something already seen, in a continue and spasmodic search for originality. The generative systems have the potential to give rise to genuinely new properties, which usually do not fall in the expectations of the designer, with consequent results not provided. This raises the question of control of the project, a problematic issue for generative design, especially if the designer is used to organize the results in a predictable way.

2.2.3.2. Shape Grammars

Grammar-based approaches involve the specification of a mapping between a character string and the artefact or its components, which have be designed. The characters of the string are taken from an alphabet of possible characters, which also can directly represent the elements of the artefact in the design phase. Alternatively, they can specify instructions for the generation of a building.

The concept and development of this approach start from the wording of the Shape Grammar made by Stiny and Gips (1972). It is a general formalism that allows the manipulation of simple geometric entities to generate complex shapes. More precisely, according to the wording provided by Stiny (1980), each Shape Grammar is based on:

- a vocabulary of shapes and definition of spatial relationships;
- rules, consisting of operations of scale, rotation, translation, reflection.

One of the first experiments in architecture was to develop a digital model of some Palladian villas, by using shape grammars (Stiny and Mitchell, 1978).

In architecture, this technique can work to create generative processes that involve the entire building and parts of it, such as the facade and the window arrangement, or replicable structural components. One form is generated from one or more initial forms, by recursively applying predetermined rules. The process of shape generation ends when the rule cannot be applied anymore. Over the years several variations of shape grammar were born. The most frequent use is related to the creation of pattern, such as different types of coating that start from one or more elements and reiterate them automatically, creating automatic and randomized façades (Fig. 8).

Fig. 8. Study of a randomized facade, by using ParaCloud GEM® software.

2.2.3.3. Evolutionary Algorithms

The evolutionary systems (Fig. 9) are based on the simulation of natural selection process by taking the evolutionary model of nature as a generative process of architectural form and reproducing it through the computer (Frazer, 1995). This technique has found wide application in digital animation and computer graphics, but also in architectural, industrial and engineering design (Bentley, 1999).

The technique depends on the specification of a parameterized model that allows a wide variety of possible interesting results for the designer. In cases where it is required a very specific purpose, the algorithm must also be sufficiently extended insomuch to be able to include a response to the issue that satisfies the imposed design constraints (McCormack et al., 2004). The structure of an evolutionary algorithm is constituted by:

- Population of individuals, that represent the candidate solutions, identified as a set of random parameters.
- Display of individual parameters by the designer, who can choose from a variety of visual solutions among those offered.
- Operators of transformation, which produce a new population from the original parameters, implementing the concept of inheritance.
- Selection of the optimal configuration, which will be the best possible since it is the one obtained by the selection of the best starting features.

Alternatively to display of the various parameters and the consequent choice of a solution, there are *fitness* functions, which can be directly encoded by the designer, who assigns a value to each parameter. E.g. in the case of the design of a care, where the purpose is a lighter design by using a cheap set of wheels. This fitness function is encoded in the evolutionary system and the computer, regardless from further human input, the algorithm evolves towards the desired result always by using wheels with previously defined features. This kind of function is actually usable as long as the parameters to be considered are quantitative - functional. It remains impossible to quantify, categorize, simply reduce the aesthetic value to a function, requiring a constant human interaction.

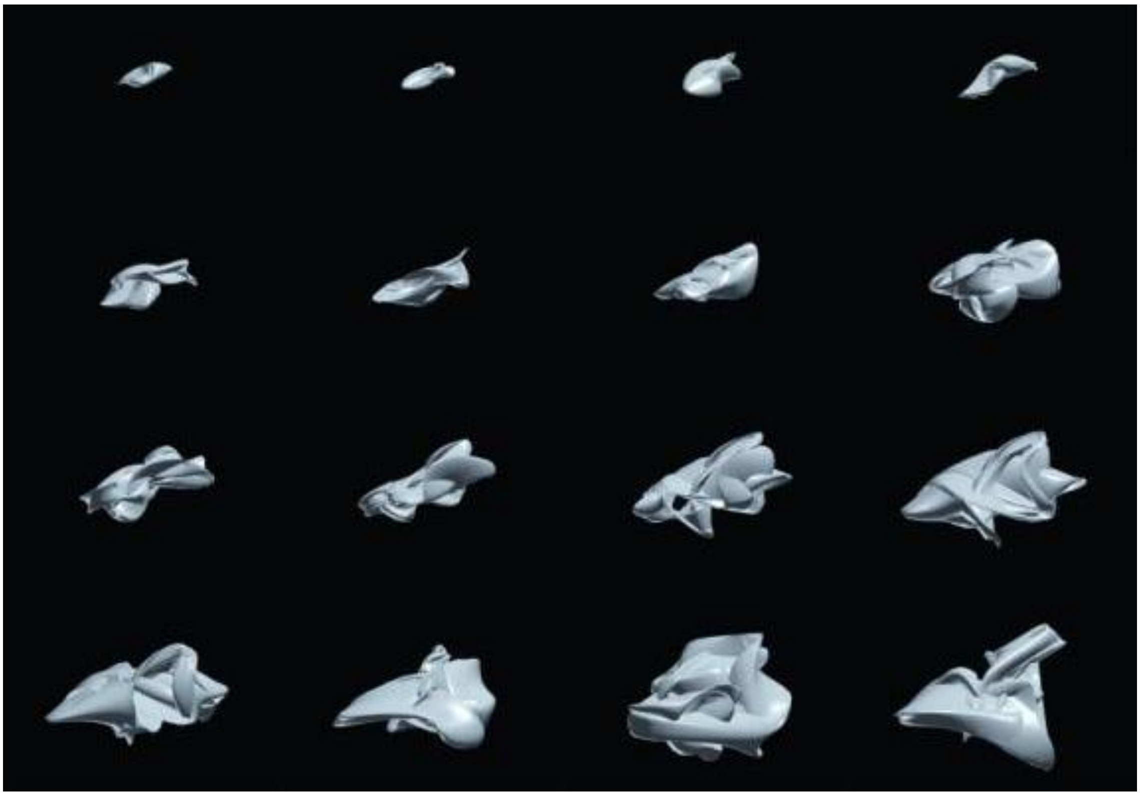

Fig. 9. *Interactivator:* Networked Evolutionary Design System by John Frazer (1995)

2.2.4. Performance Models

The performance–based design is an architectural trend born without the advent of digital technology in *strictu sensu*, but that has taken advantage of the new instruments developed in the last decade, putting them to serve the project.

The idea on the basis of this methodology is that the project can arise by the consideration and the optimization of one or more parameters selected, according on the purpose that you want to achieve. Somehow, the concept of performance–based design is different, depending on if we put it in technical–scientific context or in a broader field. The parameters to be optimized may be several: you can choose to give priority to the structural, the climate – environmental. But also the procedural and social aspects, those related to the flows – of people, of mobility and transport systems – can be quantified, optimized and intervene into the design process.

With the advent and the development of numerous architectural software, we have programs and plug–in, able to implement tools to ensure the performance optimization. This then becomes a guiding principle of the project and the shape derives from the best possible configuration.

The digital tools, that intervene on the performance of buildings, can act in different ways. For example, you can start from a primitive or a predefined shape, result of the creative input of designer, and modifying and deforming it to satisfy the parameter. This approach was defined *Performance-based formation models* in Oxman's classification (2006). The *performative* software may intervene after, optimizing multiple selected parameters and changing the original shape, maintaining some invariants chosen by the designer, such as the topology of the envelope or the faces number of the object. In this way, it is determined an interesting dialectic between designer and tools, where the first will always have the total control of the operations and the possibility of choosing endless configurations modifying the original idea, or take action on the parameters. In contrast to this attitude, the project can be born in a generative way from the imposed parametric constraints and then you can work with their variation (*Performance-based generation models*).

The current interest seems to point to the possibility of considering variables to ensure the sustainability of buildings and putting them on the basis of design idea. The resulting architectural shape is the one that provides the best environmental performance guaranteed by orientation, arrangement of openings, choice of materials, building systems for low energy or with a cost-benefit ratio in favour of an overall saving. This attitude seems to be shared by Hi-Tech pioneers such as Norman Foster & Partners, Nicholas Grimshaw, Renzo Piano, who have introduced the concept of performance in their projects.

E.g. the New London City Hall by Norman Foster has been designed with glass coating to have high visibility from the outside and to express the openness of the democratic processes to visitors. In the subsequent development of the envelope configuration, Foster takes the solar radiation as environmental parameter reference: starting from the digital model of a sphere, by changing the characteristics of solar radiation and by acting appropriately on the control points of the surface, he has achieved the shape that optimizes energy performances (fig. 10). The Swiss Re Tower by Foster focuses on the structural parameter, as the aerodynamic shape allows wind to flow around the construction, in order to minimize wind loads on the structure itself. The three-dimensional spiral shape that is repeated throughout the height of the building has been modelled to generate pressure differences that favour the flow of air currents (fig. 11).

2.2.5. Compound Models

Compound models represent a class of future paradigmatic digital design, that has important potential implication for future design media. Compound models are based on integrated processes including formation, generation, evaluation and performance (Oxman, 2006). We can interpret Oxman definition, by including in this classification BIM.

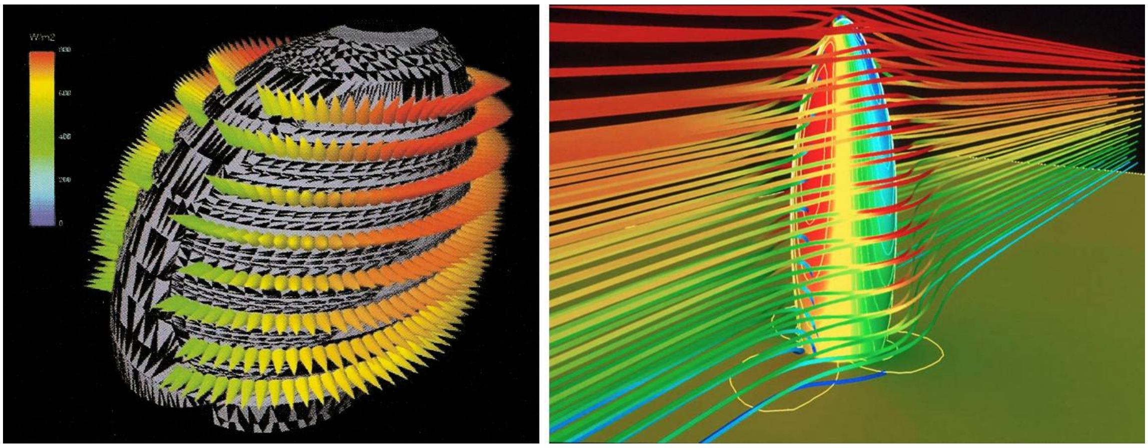

Fig. 10-11. Performance models generated for Swiss Re and London City Hall buildings, by Foster & Parters.

BIM is a new method of drawing in which the project is being developed through a process of creating and managing the information model of the building. This information may be related to the entire life cycle of the structure, from the design phase until the use and maintenance, through the construction.

The term BIM also identifies the new generation CAAD software like AutoDesk Revit®, ArchiCAD®, Bentley Architecture® (fig. 12), which are not limited to the design of simple graphical elements – lines, circles, arcs – but you can directly draw the building components. When you start designing, the software will ask if you are tracing a wall, a structure, a door or a window, it will ask the parametric components of each object, from the point of view both of the geometry and of the materials. With this kind of model, we have the whole information regarding the project. At any time you can choose the level of detail and the information that you want to know: you can extrapolate an architectural plan or obtain a constructive section. The building and its components are consistent in size, specific location, building characteristics, because every object is defined only once, with the consequent advantage of eliminating many mistakes due to the difficulty to control all the aspects of a building.

The development of these programs has greatly speeded up the operations of design, calculation, analysis and drawing in the great studios because they provide the ability of interaction between the various teams – planners, structural engineers, plant designers – involved in the same project (fig. 13). They allow these professionals to cooperate with a significant decrease of the problems related to the consistency among the parties and a considerable saving of time. On the one hand, the BIM has proved a very useful tool to manage the executive phase, on the other one, there is the risk of having little freedom in the design phase, creating an excessive 'standardization'. In fact, although it is possible to imagine endless new solutions, the designer can move only within forced schemas.

For this reason this type of programs is associated with others, generative or performative.

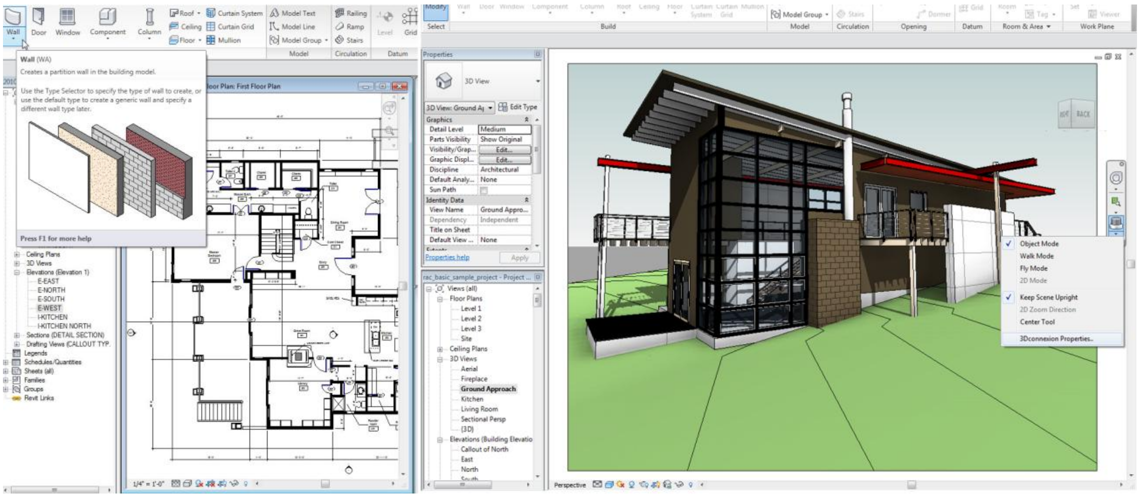

Fig. 12 – Interface of AutoDesk Revit.

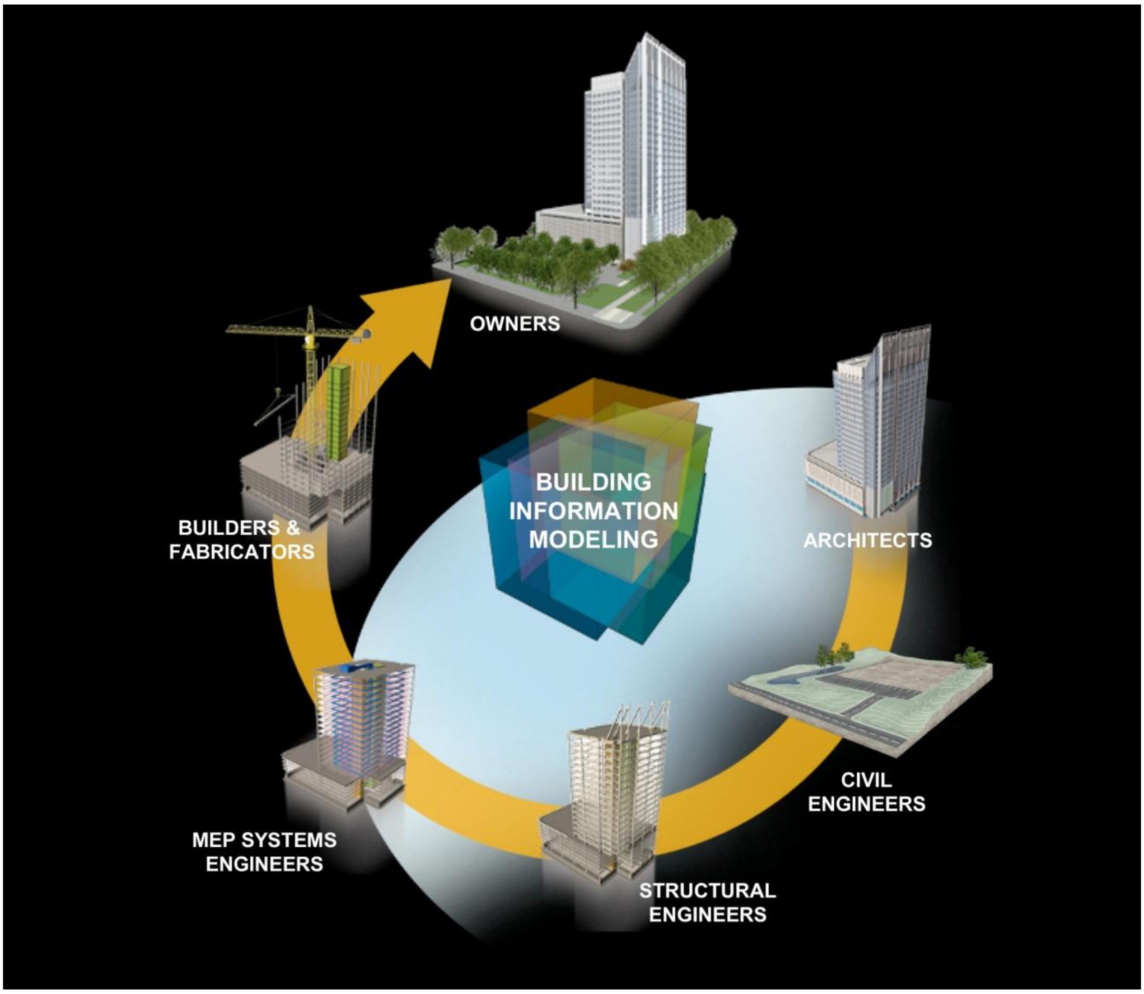

Fig. 13. Scheme of design cicle with BIM.

Considerations

In this wide and diversified landscape, these trends don't constitute areas of expertise independent and closed to the others. Within the international offices, they are often used in conjunction in order to obtain a design conscious, complete and deepened in all its parts. The tendency of the largest software houses for the Architecture is to make the programs permeable and interfaced to each other. In this way the design process appears as a fluid operation, in fully becoming, where the key feature, guaranteed by the computer, is to always have the total control of the action, starting from the initial sketch to the morphological configuration, from the architectural language until the constructive detail.

Notes

1) BRL-CAD has become an open source project in December 2004 and is available as a free download on the site <http://brlcad.org/>.

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PART II

analysis

CHAPTER 3
Multi-case analysis and database

3.1. Introduction

As seen in previous chapters, design computing has a long history of implicit and explicit attempts to redefine architectural design. Driven by the dual ambition to digitize design representations and to automate design processes, it has produced an extensive supply of methods and techniques for a variety of design tasks, from the production of a floor plan layout to online remote collaboration and to parametric definition of building components. The traditional point of view, as we have just seen in the Chapter 2, has been to approach these as different *models of digital design* corresponding to different components of digital design – representation, generation, evaluation and performance: *CAD models* that represent the evolution of paper-based representation and design; *formation models*, where the designer starts from the new augmented capabilities in digital representation; *generative design models*, where the operator sets up the algorithmic structure of design, imposing constraints and parameters; *performance models*, based on the optimization of one or several parameters; *compound models*, that could see as a combination of precedent tasks, as in the current BIM software programs (Oxman, 2006). This is a point of view from the supply side, representing the preoccupations as well as the evolution of design computing with little reference to matters beyond the direct capabilities of digital means.

A more critical point of view considers digital design from the side of demand (Dorst, 2008): while not underestimating the achievements and significance of academic research and commercial development, digital methods tend to be rather simplistic and quite prescriptive in their attempt to capture and express specific computational aspects. This can be detrimental to other aspects, often peripheral in design computing but central in design practice, such as the content and context of a design, and consequently strain the relationship between academic research and practice, and diminish the value of the former for the latter. In fact, commercial software has arguably had a greater influence on the computerization of architectural practice than academic research and teaching.

Given the current state of development in digital media, we could be justified to talk about a *Post-Digital Age* (Spiller, 2009) because the effects of more than ten years of digital experiments in design practice are strongly evident in contemporary architecture. This also agrees with the reflection that, having passed the fist reactions of enthusiasm or concern, we need to understand what direction architecture is taking under the influence of digital media (Picon, 2010).

Hence the goal of this research, as clarified in the *Introduction*, has been to identify two things. The first is the extent and scope of digital influences on real architectural designs. Despite various claims in academic publications, software publicity, manifestos and architectural criticism, it is unclear what these influences entail and what evidence we have for their existence and significance. It seems that it is generally assumed not only that we are able to recognize these influences and their effects but also that we all agree as to their existence, nature and manifestations. However, upon closer inspection it becomes evident that the main reason for recognizing digital elements in a design is the designers' or some critic's say-so. Following the objective identification of digital influences in a design, we should be able to identify their origin, too: do they derive from academic research and education or are they products of general computer literacy or specific architectural software training? This question is central to the role of design computing in architectural education but also points out research goals and directions that may be absent in current research.

To achieve this goal, we need first of all a coherent and comprehensive overview of elements that should be attributed to design computing, so that we can unambiguously identify them in architectural designs. Then we have to apply it to real designs so as to verify its adequacy and, when this is done, to examine how these elements appear and are used in practice. Finally for this stage of the research, we must consider how digital influences contribute to architectural design, either as a coherent methodical and technological component or as a diffuse network that either dominates or supports a design approach.

3.2. Methodology of analysis

Identifying the above digital influences in a single design is quite useful for the refinement of the framework, i.e. the definition of the repertories and the clarification of the specific forms their members may assume in a design. This can be done in either *top down* or *bottom up* fashion. Top down means the production of an extensive, possibly exhaustive series of examples for each digital element and use the results, properly classified and clustered, as templates for identification. Such a series can be produced by observing designs, collecting relevant occurrences and probably augmenting the results with plausible, possible and probable variations. An alternative is to use a generative system that produces all variations algorithmically, as in e.g. rectangular arrangements and shape grammars. We have opted for the bottom-up approach: identify instances of the digital elements in existing designs, without attempting to complete the spectrum with additional instances. This agrees with the critique by Dorst (2008) and stresses not the supply but the actual usage and, through that, the possible demand for digital methods and techniques and ultimately their significance in architectural design.

For a real bottom-up investigation of digital influences on architectural design with precision and overview, we have avoided opinions (either from academia or from practice) and focused instead on the actual products of practice: we have analysed sixty recent building that are reputed to relate to digital methods or techniques. we have chosen to work with acknowledged digital designs of important buildings. The analyses were conducted in a uniform, objective manner and collected in a feature-based structured case base that allows a wide variety of queries on the identified features. This method allows us to identify digital influences in current architecture with clarity and consistency so that we can not only describe but also explain the state of the art.

3.3. The database

To make easier our analysis, it was chosen to collect all the information related to these buildings in a database so as to ensure consistency: all buildings are analysed in the same manner and the results are described in the same terms. This also promotes the refinement of the individual features and criteria used in the analysis towards a comprehensive descriptive framework. The use of a database has several positive aspects: firstly it gives us the advantage of using a great combinatorial system, that allows us to figure out the existing relationships among several elements, to visualize them and, at the end, to interpret the results; secondly, organizing information in a database forces us to think in a different way, less vague but, on the contrary, according with a rigorous logical scheme, where everything is related to each other, with the possibility to explore the endless existing combinations between one or more parameters.

3.3.1. Articulation and construction of the database

To build our database, designed with Microsoft Access®, it was needed to have a series of information very well organized. Then, the main operation was to establish a series of tables, which are the most basic building block in every database because they hold the data that we need to save and to analyze.

By opening the software, we can quickly create a new database and suddenly we can observe it produced a main table. At this point we can choose to have different types of visualization, which determinate different logical levels of abstraction.

- *Datasheet view*. It shows our data. Datasheet view is similar to a spreadsheet — it displays data in rows and columns, which respectively are the *records* and the *fields*. In Figure 1, we can see a datasheet of our final database, with all the parts labelled.
- *Design view*. In the first part of our work, this kind of visualization is the most important, because we have to *design* our database, to impose the relationships among sub-tables, if there are any. Here we do not see any data, instead it is possible to define and edit field names, specify the type of data that each field holds and to also provide a field description. Design view also contains field properties, more advanced ways to define fields, and helps make sure that data entry is accurate. In Figure 2, it is shown the main structure of our database.

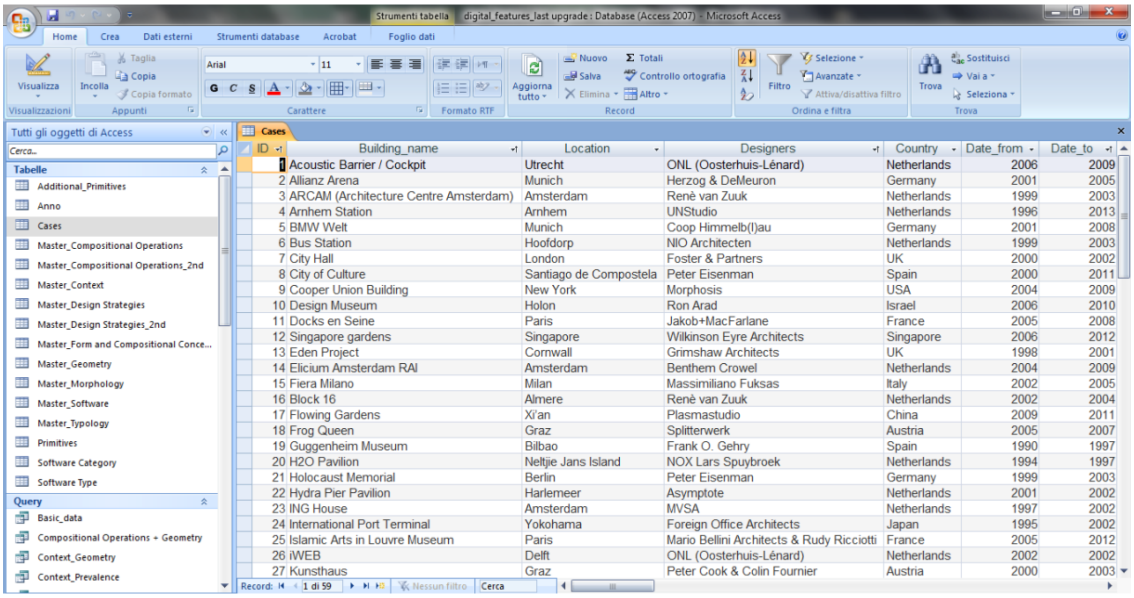

Fig. 1. Datasheet view of the database

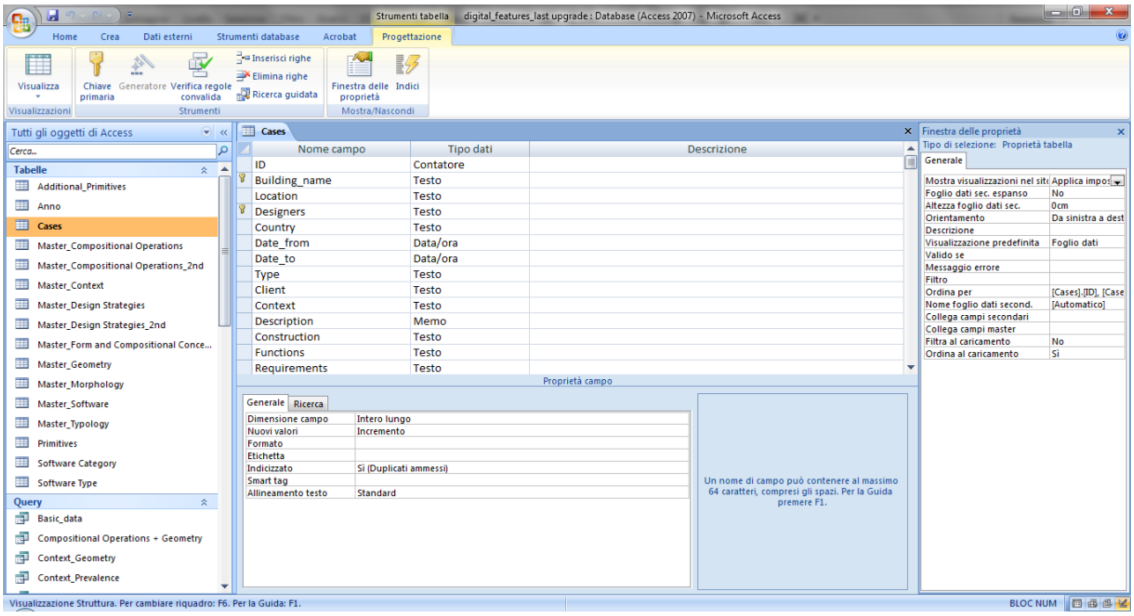

Fig. 2. Design visualization of the database.

For our database design we have opted for the design view, in order to have the right cognition of the information we wanted to collect, even if it is obviously possible to further add other fields. Indeed, design view is recommended you know a lot about the type of data you put in the table — and you want the fields you create to be designed for the data you have to put into them (Simpson et al., 2007).

After the creation of a main table, it is necessary to define fields. Each field stores one category of data, e.g. text, dates, memo, etc. The definition of fields can be done by using field templates, by defining each field in Table Design view or with a combination of all these methods. Since normally a database is thought to store data, like quantities, numbers, addresses, and so on, our database is relatively simple. Indeed, most of the fields are classified as simple text, because we need to describe our cases. Moreover, we can type a description of the field in the Description column, to remember which kind of information are stored in that field and how you intend to use it. Also when we design a table, Access® asks us to define a *primary key* among all the fields, that uniquely identifies each record.

In some cases when we need not to simply put records in each field, but, just because e.g. we are dealing with a something which is recurrent and we want instead to pick a record among predefined parameters, we have to refer the field to another table, as we will now explain.

3.3.2. Tables, sub-tables and relationships

In order to make our database as useful as possible and to enter data consistently, we need to create a *lookup field*, which provides the user with a list of choices, rather than requiring users to type a value into the datasheet. It could think of it as adding a field from an existing table to our main table. Access uses the field from the other table to create a drop-down list of products. Moreover, lookup fields enable you to keep your database small and the data entered accurate and consistent. Storing values for your drop-down list in a table gives you much more flexibility if you want to modify the list or store additional information about the values.

To create a lookup field, firstly we need to create the reference table of that field: e.g. if we are dealing with the field *context*, we create the table *Context*, which have a primary field where there are all the parameters I want to visualize and pick in the main database (old city, inner city, etc.) and in another field there will be the description of each record, which then will become part of the Glossary in Appendix II. After that we need to impose the relation between these tables through the *lookup wizard*, which considers some steps. Firstly you have to select the reference table, then the field of that table you want to contain the drop-down list. Finally the wizard will ask us if we want to *allow multiple values* or not, which means that in the main table we can visualize a *forced selection* or a *multiple choice* (Fig. 3).

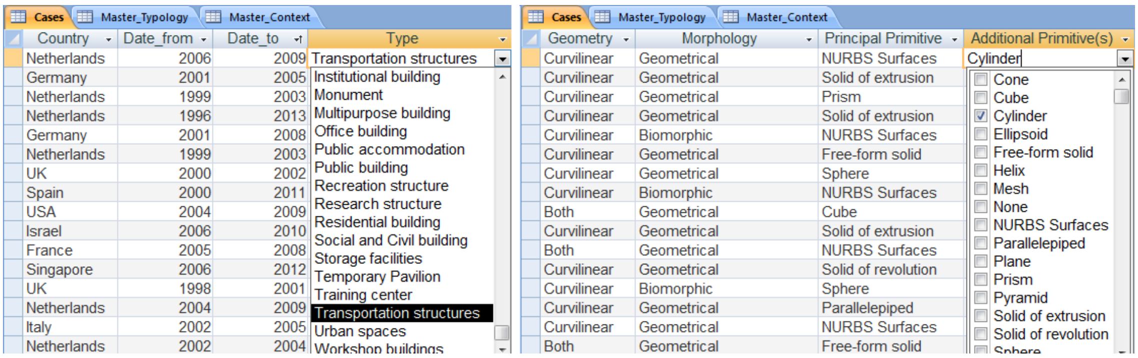

Fig. 3. Example of forced selection and multiple selection.

If everything is well-defined, by looking at field properties we find this SQL command line, that means that tables are correctly linked, so that relationship has made:

SELECT [Table_Name].[Field_Name] FROM Table_Name

Access® is a relational database-management system, born to simulate the real-world which is obviously featured by one-to-many or many-to-many relationships between pieces objects and, consequently, data. When information is spread across multiple tables, the data must always "link up" correctly and we need to verify its *referential integrity*. We can do it visually through the *relationships* tool of the database, which shows all the links between the parts (Fig. 4). Beyond to understand if our software framework is well-organized, it also give us a unexpected awareness of our theoretical scenario, by showing all the logical links that we have previously defined.

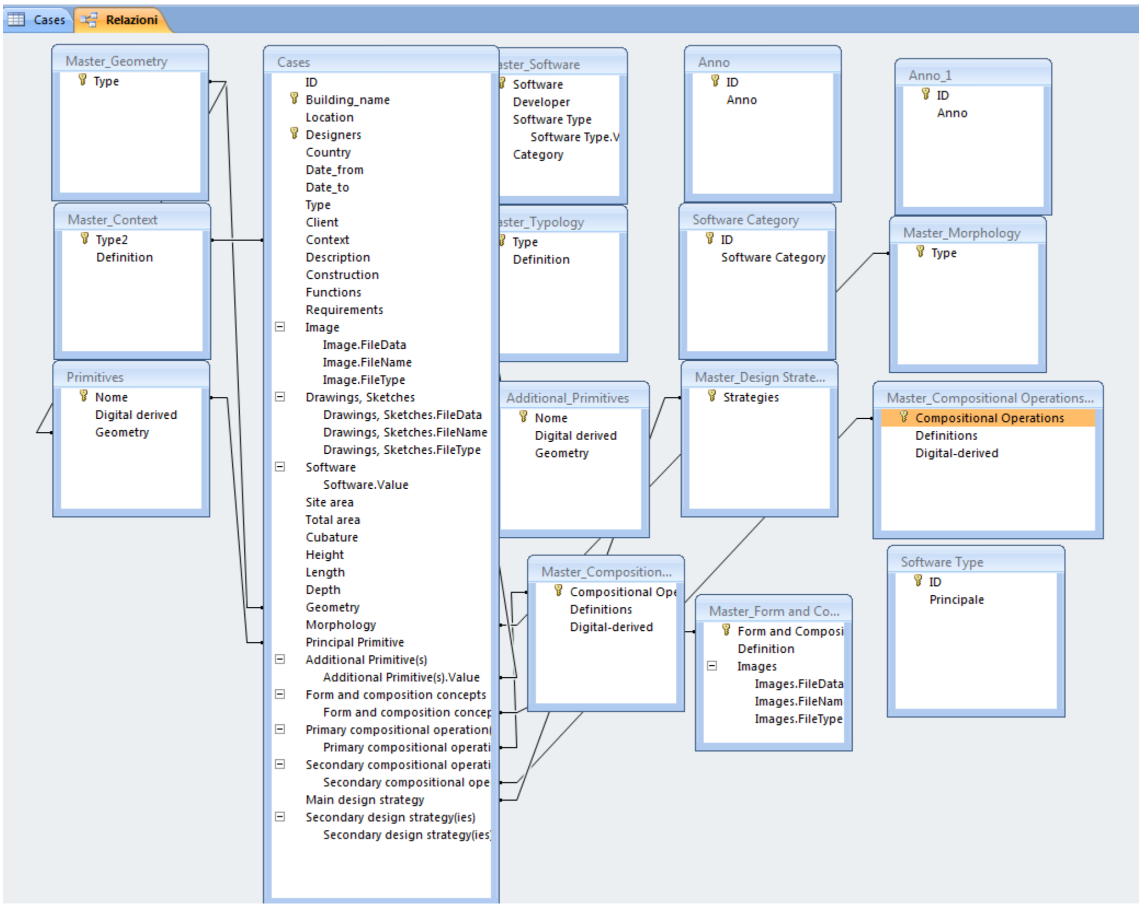

Fig. 4. Relationships among several tables in the database.

3.4. Theoretical framework: the database logic and levels of analysis

3.4.1. Descriptive part: simple data collection

After structuring the main interface of the database, each single case-study was analyzed through the definition of several categories, which contribute to describe the project. The first part of data collection (Tab. 1) contributes to identify and describe each building, through several categories as i.e. *building name* and *designer(s)*, settled up as primary keys, until *Location* (city), *Country*, *Date from* and *to*, *Client*, *Type* and *Context*, which both refer to the *Art & Architecture Thesaurus* (Getty)- that will be described in the section 3.4.4 - macro-categories of *single built work by type*, ordered respect with *function*, and *built complexes and districts by location or context* (Tab. 2).

Category/ Field	Field type
Building name	Text; primary key
Location	Text
Designer(s)	Text; primary key
Country	Text
Date from	Date
Date to	Date
Type	Lookup field; table *Type*; forced selection
Client	Text
Context	Lookup field; table *Context*; forced selection
Description	Memo
Pictures	Attachment
Drawings	Attachment
Site area	Text; number; m^2
Total area	Text; number; m^2
Cubature	Text; number; m^3
Height	Text; number; m
Length	Text; number; m
Depth	Text; number; m

Table 1. Case study description: fields and values.

The description is completed by the pictures and design drawings and by the dimensional data (site area, total area, cubature, height, length, depth). In parallel, it was developed a glossary of all terms, with the aim to consult it quickly and easily when you work on each case-study.

For a better overview about *Context* and *Type,* please refer to the Appendix I.

3.4.2. Morphological and Compositional analysis.

After this first descriptive part, we deal with the real analysis and close examination of the cases, that now we are going to conceptually explain. Even though whether an architect uses computers in a significant manner is primarily a matter of declaration and reputation, digital influences in a design are often easy to detect in the overall form, as well as in some critical parts such as the building envelope. They may indicate use of digital means to solve specific problems, e.g. represent complex geometries, or design actions constrained by the use of digital tools, e.g. frequent use of particular geometric primitives or operations. In many cases, the computer is used to facilitate representational and design actions, e.g. model complex surfaces that tend to be hard to specify by hand and may require more information than what is available in conventional orthographic projections. Other elements clearly belong to the computational domain, like NURBS surfaces. In all cases, however, the choices and effects of digital means are often discernible in the design as unmistakably as e.g. classical or modernist morphological elements.

Context	Type
Old town	Agricultural structure
City center	Cerimonial structure
Inner city	Commercial building
Central business district	Communication structure
Urban area	Exhibition building
Urban fringe	Industrial structure
Rural area	Information handling facilities
Industrial Area	Entertainment structure
	Institutional building
	Monument
	Multipurpose building
	Office building
	Public accommodation
	Public building
	Recreation structure
	Research structure
	Residential building
	Social and Civil building
	Storage facilities
	Training center
	Transportation structures
	Workshop buildings
	Urban spaces

Table 2. Context and Type categories.

The search for digital influences in a design is consequently based on formal and representational repertories offered by digital means, grouped under two main categories, *general characteristics* and *local features*. The former contain two groups: the *overall geometry* of a design, which can be either rectilinear, curvilinear or hybrid (both); and *its general morphological tendency*, which can vary from geometric and biomorphic to anthropomorphic and zoomorphic.

Local features have a wider scope, especially as new digital methods and techniques continuously add to them. They comprise three complementary groups, the first of which contains the geometric primitives used in a design: cones, cubes, cylinders, freeform solids, NURBS surfaces etc. In this group the dual role of digital means becomes quite evident: at least some of these primitives are not bounded by computational environments; it is simply their definition and manipulation that becomes significantly easier and more reliable with digital means. Other primitives are inconceivable outside computational environments either because they emerged in relation to computation or because they are mathematically or geometrically hard to implement and control.

The other two groups of local features refer to relationships and manipulations in a representation comprising such primitives. Formal concepts cover local, general, bilateral and multilateral relationships such as alignment, axiality, horizontality, symmetry, verticality etc. These underlie the arrangement of primitives in a design but are not limited by them: they are discernible as patterns and coordinating devices that may be quite indifferent as to the elements they apply to (Arredi, 2006). In digital representations such formal concepts are often expressed as constraints.

Finally, *operations* like Boolean, folding, revolution, rotation and repetition serve two related purposes: firstly, the implementation of formal concepts, e.g. as in the use of reflections and translations to create symmetric forms; secondly, the transformation of primitives so as to produce generally more complex forms. The effects of these operations arguably determine most of the cues that allow us to recognize digital influences in a design, e.g. a Boolean combination or the adaptation of a mesh. While there repertories were initially compiled in a bottom-up manner by observing designs and correlating their features to the capabilities of digital design environments, there is also substantial support from literature, especially in some studies about the theoretical conception in architectural design, conducted through the observation and analysis of morphological features related to digital instruments (Evans, 1995), (Liu and Lim, 2006), (Oxman, 2008), (Wong, 2010). The overall structure of the repertories and the definition of their members derives from the *Getty Art & Architecture Thesaurus* (Getty), in an attempt to add lexicographic consistency to the description of digital designs.

The analysis of designs concerning these repertories can be done in two complementary ways, *syntagmatically* and *paradigmatically* (Van Sommers, 1984). Syntagmatic analysis refers to the sequence of actions by which different primitives, concepts and operations are entered in the design. Syntagmatic aspects can be of great value in computational and algorithmic studies (e.g. in shape grammars) but they are also difficult to detect in the final design and in many cases only loosely related to design thinking, as there can be various sequences of actions by which we arrive at the same results. Consequently, syntagmatic analyses tend to reveal more about contextual factors, including a designer's understanding of digital means.

Paradigmatic analysis focuses on the elements of the design, in our case primitives, concepts and operations, their existence and interrelationships without reference to temporal precedence or such mental hierarchy. This allows us to identify traces and effects of digital means in design representations, with the obvious exception of prescriptive algorithmic techniques like shape grammars. The economy and effectiveness of paradigmatic aspects made this analysis a safe starting point for this research.

3.4.3. Categories and classification

The analytical part, both in morphology and composition, is split up in two parts: firstly we have to analyze the taxonomy of each project, through the overall recognition of its *Geometry* and *Morphology* with a forced selection (Tab. 3).

Geometry	Morphology
Rectilinear	Biomorphic
Curvilinear	Antropomorphic
Hybrid (both the precedents)	Zoomorphic
	Real-object
	Geometrical

Table 3. Taxonomic analysis with respect to the overall geometry and morphology.

Furthermore we identified the *Geometric Primitives* on the basis of each design, which, as we said in the previous section, are clearly identified as digital or not and, moreover, it is established which kind of geometry is associated to these (Tab. 4).

About primitives, we have distinguished two different levels, first and secondary. *First Primitives*, which are the first geometrical starting point of the designer and where it is possible to choose among the several parameters, as reported in Table 4, with a forced selection, so that the primitive detected is one and unequivocal; you cannot pick both parallelepiped and sphere, because always one is prevalent on the other. For this reason we have admitted the level of *Secondary* or *Additional Primitives*, the other solids which participate to the geometrical composition; in this case it possible choosing more parameters (Tab 4).

Following we had to map which operations and concepts are associated to the single case, as we can examine in Table 5. Regarding to the *Operations* it was obviously indispensable understand and take note of those are born essentially in the computational domain, as i.e. folding, mesh, smooth, loft, etc. We have considered two levels, as in the case of Primitives, because, even in this case, we can recognize which operations clearly were dominant in the definition of architectural overall shape (first level) and which, on the contrary, were used only to refine the concept (second level); moreover in both levels we can have a multiple choice among the several parameters.

On the other hand, at level of *Concepts*, we cannot give a hierarchy to that we have detected, we cannot say that e.g. *alignment* is in a higher-level with respect to *balance*. In fact, in that case, we should deal with that syntagmatic level we choose to abandon in favour of the paradigmatic one. Our analysis is based on observation of facts and on a widest possible casuistry. Furthermore, even in the Concept category is allowed the multiple choice. For a better understanding of the logical structure and the subdivision of the categories, please refer to the Appendix I, where e.g. *Concepts* are referred to some examples to architectures from all over the world and in every historical period.

Primitive	Digital-derived	Geometry
Cone	No	Curvilinear
Cube	No	Rectilinear
Cylinder	No	Curvilinear
Ellipsoid	No	Curvilinear
Free-form solid	Yes	Curvilinear
Helix	No	Curvilinear
None	Not applicable	Not applicable
NURBS Surfaces	Yes	Curvilinear
Parallelepiped	No	Rectilinear
Prism	No	Rectilinear
Pyramid	No	Rectilinear
Solid of extrusion	Yes	Both
Solid of revolution	No	Curvilinear
Sphere	No	Curvilinear
Tetrahedra	No	Rectilinear
Torus	No	Curvilinear
Wedge	No	Rectilinear

Table 4. Primitives: digital derivation and geometry.

3.4.4. Getty Art & Architecture Thesaurus

The Art & Architecture Thesaurus (AAT) is a controlled vocabulary used for describing items of art, architecture, and material culture. It comprises around 34,000 concepts, including 131,000 terms, descriptions, bibliographic citations, and other information relating to fine art, architecture, decorative arts, archival materials, and material culture. The AAT contains generic terms, such as "cathedral," but no proper names, such as "Cathedral of Notre Dame." The AAT is used by, among others, museums, art libraries, archives, cataloguers, and researchers in art and art history.

The AAT project began in the late 1970s in response to the gradual automation of records by art libraries, art journal indexing services, and cataloguers of museum objects and visual resources. Automation required consistency in cataloguing as well as more efficient retrieval of information; a controlled vocabulary was a solution to both these problems. In 1983 the Getty Trust took over editorial responsibility and the AAT offices were placed to the Getty's Los Angeles headquarters in order to better coordinate with two other similar Getty projects, the *Union List of Artist Names* (ULAN) and *Getty Thesaurus of Geographic Names* (TGN) soon after its publication (Getty).

Form and Composition concepts	Compositional Operations
Alignment	Align
Articulation	**Boolean (digital)**
Asymmetry	Break
Axiality	**Bulging (digital)**
Balance	Copy
Complexity	Divide
Contrast	**Extrusion (digital)**
Disproportion	**Folding (digital)**
Frontality	Interrupt
Gesture	**Loft (digital)**
Harmony	**Mesh (digital)**
Horizontality	Move
Linearity	**Offset (digital)**
Monumentality	Overturning
Obliquity	Repeat
Plasticity	Retract
Proportion	Revolution
Rythm	Rotation
Scale	Scale
Simmetry	Slicing
Simplicity	Sliding
Unity	**Smooth (digital)**
Verticality	**Stretch (digital)**
	Sweep (digital)
	Taper
	Tilt
	Translation

Table 5. Form and composition concepts and compositional operations. About operations it is clearly mapped those are digital-derived.

The AAT was published in 1990 and 1994 in both print and electronic form. By 1997, the size and frequency of updates made hard-copy publication unfeasible and the decision was made to publish via a searchable online Web interface and in data files available for licensing. The online Web interface is freely-accessible from any computer connected to the Internet. Final editorial control of the AAT is maintained by the Getty Vocabulary Program.

The AAT is a hierarchical database and the conceptual framework of facets and hierarchies in the AAT is designed to allow a general classification scheme for art and architecture. The framework is not subject-specific; for example, there is no defined portion of the AAT that is specific only for *Renaissance painting*. Terms to describe Renaissance paintings will be found in many locations in the AAT hierarchies.

The vocabulary is also The AAT is a faceted classification system, that allows the assignment of an object to multiple characteristics (attributes), enabling the classification to be ordered in multiple ways, rather than in a single, predetermined, taxonomic order. A facet comprises clearly defined, mutually exclusive, and collectively exhaustive aspects, properties or characteristics of a class or specific subject (Wynar and Taylor, 1992) and contains a homogeneous class of concepts, the members of which share characteristics that distinguish them from members of other classes. For example, *marble* refers to a substance used in the creation of art and architecture, and it is found in the Materials facet. *Impressionist* denotes a visually distinctive style of art, and it is found in the Styles and Periods facet (Fig. 5).

The facets are conceptually organized in a scheme that proceeds from abstract concepts to concrete, physical artefacts.

- *Associated Concepts.* This facet contains abstract concepts and phenomena that relate to the study and execution of a wide range of human thought and activity, including architecture and art in all media, as well as related disciplines. Also covered here are theoretical and critical concerns, ideologies, attitudes, and social or cultural movements (e.g., beauty, balance, connoisseurship, metaphor, freedom, socialism).
- *Physical Attributes*. This facet concerns the perceptible or measurable characteristics of materials and artefacts as well as features of materials and artefacts that are not separable as components. Included are characteristics such as size and shape, chemical properties of materials, qualities of texture and hardness, and features such as surface ornament and colour (e.g., strap work, borders, round, waterlogged, brittleness).
- *Styles and Period*. This facet provides commonly accepted terms for stylistic groupings and distinct chronological periods that are relevant to art, architecture, and the decorative arts (e.g., French, Louis XIV, Xia, Black-figure, Abstract Expressionist).
- *Agents*. The Agents facet contains terms for designations of people, groups of people, and organizations identified by occupation or activity, by physical or mental characteristics, or by social role or condition (e.g., printmakers, landscape architects, corporations, religious orders).
- *Activities*. This facet encompasses areas of endeavour, physical and mental actions, discrete occurrences, systematic sequences of actions, methods employed toward a certain end, and processes occurring in materials or objects. Activities may range from branches of learning and professional fields to specific life events, from mentally executed tasks to processes performed on or with materials and objects, from single

physical actions to complex games (e.g., archaeology, engineering, analyzing, contests, exhibitions, running, drawing (image-making), corrosion).

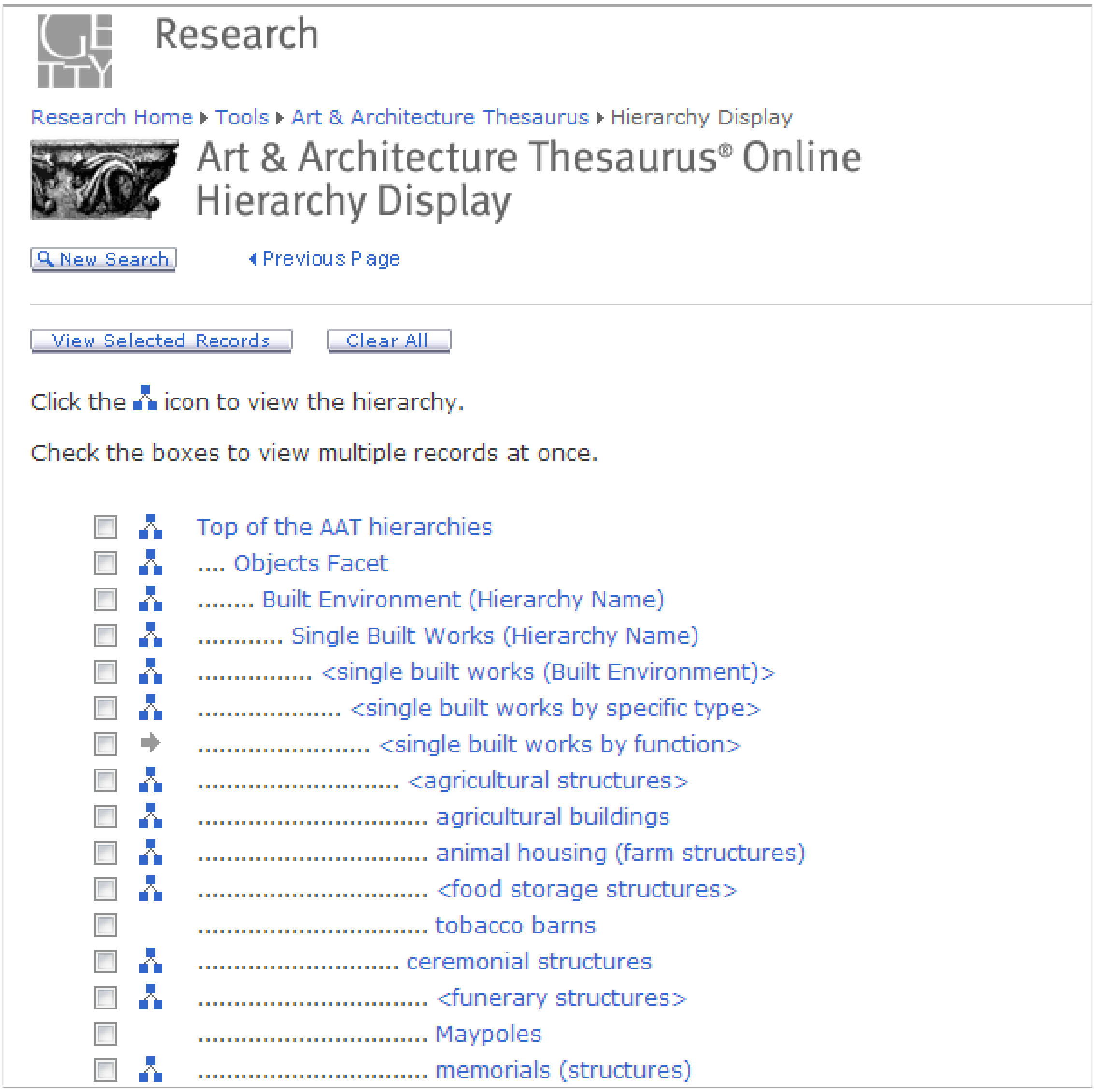

Fig. 5. Example of the hierarchical organization of Getty Art & Architecture Thesaurus, applied to building type.

- *Materials*. The Materials facet deals with physical substances, whether naturally or synthetically derived. These range from specific materials to types of materials designed by their function, such as colorants, and from raw materials to those that have been formed or processed into products that are used in fabricating structures or objects (e.g., iron, clay, adhesive, emulsifier, artificial ivory, millwork).
- *Objects*. The Objects facet is the largest of all the AAT facets. It encompasses those discrete tangible or visible things that are inanimate and produced by human endeavour; that is, that are either fabricated or given form by human activity. These

range, in physical form, from built works to images and written documents. They range in purpose from utilitarian to the aesthetic. Also included are landscape features that provide the context for the built environment (e.g., paintings, amphorae, facades, cathedrals, Brewster chairs, gardens).

Homogeneous groupings of terminology, or *hierarchies*, are arranged within the seven facets of the AAT. A broader term provides an immediate class or genus to a concept, and serves to clarify its meaning.

3.4.5. Design Strategies: classification and explanation

At first we have defined a vocabulary of the current architectural trends derived by the use of digital technologies. Each category was described, deepened and explained in all specific aspects. Then each architecture was then classified according these several categories, that now we will discuss in more detail. Some buildings may have more than one classification. The aim was to understand which are the most common trends, if several ways of designing are recurrent in the architectural practice, if they interact each other and with which results. The categories identified are the followings.

BLOB

The term Blob (Binary Large OBject) assumes different connotations depending on the specific context in which it is used, but in general, it represents a *mass without form and consistency*. Greg Lynn was the first to associate the word with architecture coining the term *Blobitecture* or *Blob Architecture*, referring to those buildings digitally designed that have an organic, a bulged shape, as an amoeba (Lynn, 1998). The shapes are defined through special algorithms implemented within CAAD programs, in order that the shape evolves depending on the pressure applied from outside on the surfaces and modifying the algorithms consequently (Fig. 6-7).

GRID

Traditionally it is a Cartesian structure that generates static and rational shapes. Grids are transversal elements, always present in the history of architecture. In our time the term is inextricably linked to the concepts of net, connections, network and sharing. The introduction of the IT made it possible working on the grids in a different way: they are no longer a rational and rigid design tool, but become an instrument for designing forms and spaces unpredictable and changeable (Fig. 8-9). "*Laying down a grid*" - variously modified and deformed - *"should be a mapping of the possible, not a restraining order. [...] At any instant it can be pulled apart and shifted dramatically, [...] fixed one moment, vanish and refigured in the other"* (Balmond et al., 2007).

Fig. 6-7. The Kunsthaus (2003) in Graz by Peter Cook and Colin Fournier and the Son-O-House (2004) in Eindhoven by NOX Lars Spuybroek.

Fig. 8-9. The Holocaust memorial (2003) in Berlin by Peter Eisenman.

FLUIDITY

The term was defined for the first time in scientific field as that physical magnitude, inverse of the viscosity. With the advent of the digital age, the concept of fluidity extends to computing, becoming a key-word. The computer single particle is not a physical quantity, but rather an electrical pulse capable of providing and transferring data. In the contemporary landscape scientific discoveries and technological innovations are changing the same idea of nature and the Architecture reflects, with its proposals, the formalisms of science and technology. Curved figures, as spirals, waves, liquid crystals, become a precise figurative reference for the contemporary architecture (Fig. 10-12).

FLOWS

Looking at the constitution of contemporary society, it is immediately apparent that itself, compared to a few decades ago, is dominated by a constant flow of people, information, mobility systems. *"Not a flow - such as motorway or the phone - but the juxtaposition of a variety of flows, is the first finding that the reality where we live is made up of meshes that add interconnections"* (Costa and Solà-Morales, 1996). Contemporary architecture has taken the flows as a starting point of the design. The movement of the users inside the space has generated a widespread trend of designers in creating free spaces, not rigidly structured: it is the user who creates the architecture, choosing to freely move inside it. There is no more a rigid concept of exterior and interior; the architecture is the result of the movement and is destined to be container of human activities (Fig. 13-14).

Fig. 10-12. Les Docks en Seine in Paris by Jakob+MacFarlane.

Fig. 13-14. The BMW Welt by Coop Himmelb(l)au in Munich.

DIAGRAM

In architecture it is usually thought of as *"graphic tool"* (Bijlsma, 1998), that is the translation of a series of possible relationships between the parties in a drawing, but it can't be attributed either to the type, nor even to a sketch. The term derives from Greek *dià* (through) and *grámma* (something written). Although it is usually made up of points, lines and surfaces organized in two-dimensional patterns or three-dimensional models, it may include data, legends, text, and then relate different aspects at the same time, crossing data, connecting functions and needs. Digital diagrams become an operational concept tools, design tools as well as a means of reading (Fig. 15-16).

PATTERN

In architecture and design generally it indicates the repetition of a geometric graphic motif on a plane. The buildings can communicate through their materiality, the articulation of joints, the different types of surface, the different materials. Even though the current fascination with the aspect of facades has turned image into fetish, the reconsideration of physical and material qualities of architecture has nonetheless gained a new prominence in the contemporary tectonic tradition. Software programs with shape grammars allow the design of patterns, starting from a set of elements previously defined and repeating them with imposed or random schemes (Fig. 17-18).

Fig. 15-16. The Mercedes Benz Museum in Stuttgart by UNStudio.

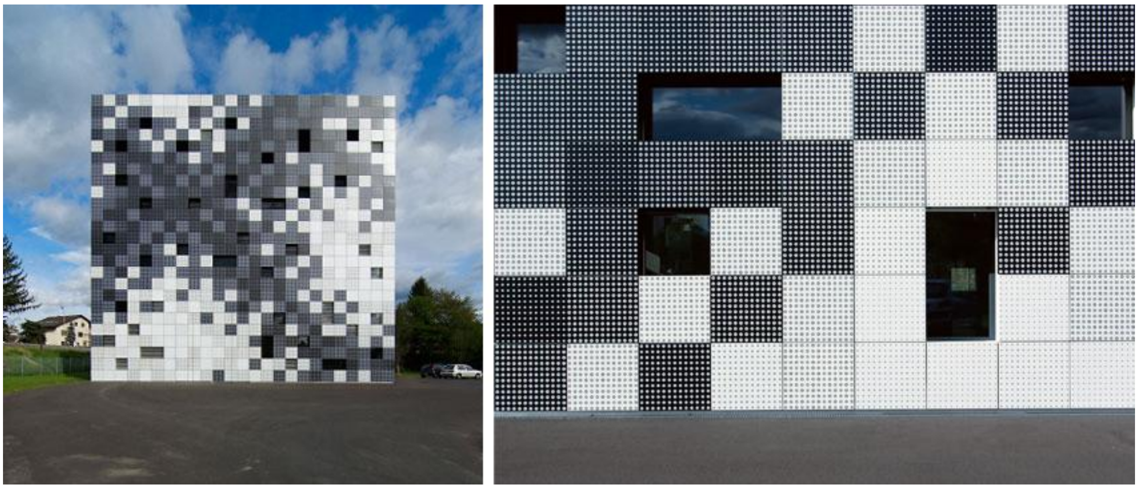

Fig. 17-18. Frog Queen in Graz by Splitterwerk.

ARTISTIC FACT

One of the major trends, due to the introduction of information technology in architecture, is the growing interest as much in the formal outcome rather than in the process that gives life to the project. For artistic fact we mean those buildings designed as if they are works of art, which increase infinitely the category of sculpture. The borderline between architecture and sculpture becomes increasingly ephemeral and undefined because certain works of art, such as those by Anish Kapoor, become part of the architecture of the city. On the other hand, more and more artists are implicated in the creation of the architecture, while some architects carry out art installations (Fig. 19-20).

DECONSTRUCTION

The term enters into the history of Western philosophy with the writings of Jacques Derrida, from which arises the movement of *Deconstructivism*. Derrida didn't intend to create an *-ism*, indeed it was contrary to place the deconstruction within a philosophical movement, as was then happened, involving Art and Architecture. From a superficial reading of Derrida's thinking in key purely formalist, in recent years new forms were born, trying to dematerialize architecture, through disconnections, cuts, rotations, offsets (Fig. 21-22).

Fig. 19-20. The Guggenheim Museum in Bilbao by F. O. Gehry and Anish Kapoor's Cloud Gate in Chicago.

Fig. 21-22. The Cooper Union building in New York by Morphosis.

FOLDED SURFACES

The concept of folding is introduced in architecture with the publication of the text of the French philosopher Gilles Deleuze, *The Fold. Leibniz and the Baroque* (Deleuze, 1993). The main contribution concerns an alternative view of the concept of space (Fig. 23-24). For centuries the architectural space has been designed according to the Cartesian model, in which each point is identified by fixed coordinates that allow to represent the objects through elementary geometric shapes and to frame precisely their position in relation to the context. This rational and linear vision of space has certainly practical advantages because it simplifies, distinguishes, orders. Some architects, like Eisenman, identify this new model with the topological surfaces, geometrical entities that, as the surface of the ground, they are continually modelled, deformed, folded (Galofaro and Eisenman, 1999).

MATHEMATICAL DERIVATION

Architectural space is intimately linked to numbers and proportions, from antiquity to the present day. Before the advent of digital technology, the mathematics used in architecture was simple arithmetic, made by proportional relationships and Euclidean geometries. Digital technologies allow us to manage and design forms, whose mathematical relationships couldn't be controlled only with Euclidean geometry. Within this category you can find those projects where the formal configuration comes from the work of mathematicians, for example, the Moebius strip; the topological surfaces, where the intrinsic properties of figures remain even when the surface is subjected to deformation; from everything that arises by fractals, where a geometric object is repeated throughout its structure in the same way on different scales. In addition, we have inserted also all those projects conceived through scripting operations, or by defining an algorithm that generates the form (Fig. 25-26).


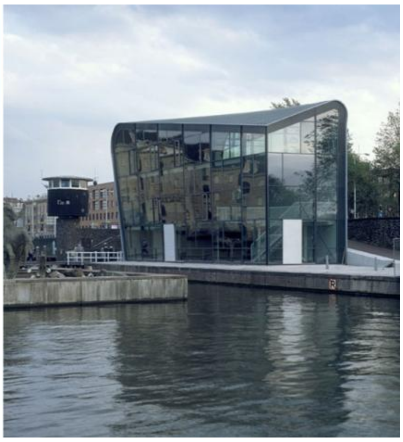

Fig. 23-24. ARCAM Museum by Renè van Zuuk


Fig. 25-26. The MINI Opera pavilion in Munich by Coop Himmelb(l)au.

NATURAL DERIVATION

Intimately connected with the mathematical derivation, there are those projects derived from the nature, both the buildings having clear figurative references in natural forms, both the projects derived from the evolutionary processes in nature. The study of natural systems requires access to an information system so complex as to be inaccessible to human cognition and can be decrypted only with the aid of computer. On the other hand, information technologies allow to generate the form through computation, setting the logic of natural systems - for example the genetic code or biological systems - generating a series of possible scenarios. The project is obtained by combining the best basic conditions (Fig. 27-28).

PERFORMANCE

The performative approach to the project wasn't born with the advent of digital technology *stricto sensu*, since the goal is to optimize one or more parameters. With the advent of the information technology new lines of research were born: in fact the new software for architecture allows the creation of autonomous forms, arising from the optimization of different parameters. You can choose to focus on the structural, the climatic - environmental, but also the social and procedural aspects, and many others. In parallel, the final shape can be achieved also due to the modification of a primitive initial, for example a sphere, a cube, a parallelepiped, modifying it, deforming it by successive approximations, until it reaches the best possible configuration (Fig. 29-30).

Fig. 27-28. The Olympic stadium in Beijing by Herzog & De Meuron

Fig. 29-30. The Swiss RE Headquartes in London by Foster and Partners and the Singapore Gardens by the Bay by Wilkinson Eyre Architects.

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CHAPTER 4
Case-Studies

4.1. Selection and inclusion criteria

The case-studies were chosen from the high end of contemporary architecture, they are buildings well known in the academia and among practitioners and experts. Each case was selected on the basis of the following criteria:

- High-quality buildings, as testified by publication in international journals and reviews. Moreover, this difficult selection among projects published more or less everywhere on architectural magazines was carried out also taking in consideration the claim or publicity earned among not-experts and simple users. E.g. the construction of buildings like the maXXI Museum in Rome or Stedelijk Museum extension in Amsterdam had generated diffuse polemics on newspapers, critics from public, apologies from municipalities and institutions and so on.
- Only built work. We have chosen not to include designs that exist only on paper, because we cannot explore their relationship with the environment or evaluate i.e. the tectonic aspects, the real congruence between design and construction. Furthermore, many projects remained on paper seem often like a funny ideas or games, rather than something that can be actually built, because designers don't deal with many design and construction problems.
- Designs where the influences of digital tools and culture are strongly evident. during the selection and inclusion phase it will be watched at many projects, examining also the design drawings and the representation used. Indeed, many conceptual schemes show immediately what is digital-derived and what is not, if the projects was thought only using three-dimensional modelling or algorithmic computing or rather if they were derived from sketches or traditional diagrams. It is important to focus on the first part of the design process, even because, as Louis Kahn said, «*in the preform - in the beginning, in the first form - lies more power than in anything that follows*» (Kries et al., 2012).
- Projects realized in the last fifteen years, starting from the first pioneering attempts at digital experimentation in architecture, such as the pavilion HTwoO by NOX / Lars Spuybroek or the Möbius House by UNStudio.
- Buildings from all over the world. We strongly think that current digital influences on architecture are not related to a specific geographic area. On the contrary, the effects of digitization on the evolution of architectural shape are evident on global scale.

- No specific building type. As in the case of global scale, digital influences on current architecture are not dependent on the type or specific functions accommodated in the building. We can trace digital derivation both in a house and a museum.

As a result, the selection does not represent a specific tendency or approach but gives an adequate impression of what is being currently applied in architecture. Moreover, being prominent buildings, they receive more than enough publicity and through that they can influence more architects both in terms of features used but also as implicit indications of what digital design entails. Recent prominent architecture has always been a major influence on both practicing architects and students but design computing with its emphasis on supply tends to make only incidental use of such opportunities.

4.2. Cases list

Building Name	Designer(s)	Location	Country	Dates	
1. Acoustic Barrier/Cockpit	ONL (Oosterhuis-Lénard)	Utrecht	Netherlands	2006	2009
2. Allianz Arena	Herzog & De Meuron	Munich	Germany	2001	2005
3. ARCAM (Architecture Centre Amsterdam)	Renè van Zuuk	Amsterdam	Netherlands	1999	2003
4. Arnhem Station	UNStudio	Arnhem	Netherlands	1996	2013
5. Auditorium Parco della Musica	Renzo Piano	Rome	Italy	1994	2004
6. Block 16	Renè van Zuuk	Almere	Netherlands	2002	2004
7. BMW Welt	Coop Himmelb(l)au	Munich	Germany	2001	2008
8. Bus Station	NIO Architecten	Hoofdorp	Netherlands	1999	2003
9. Casa da Musica	OMA Rem Koolhaas	Porto	Portugal	1999	2005
10. City Hall	Foster & Partners	London	UK	2000	2002
11. City of Culture	Peter Eisenman	Santiago de Compostela	Spain	2000	2011
12. Cooper Union Building	Morphosis	New York	USA	2004	2009
13. International Conference Centre	Coop Himmelb(l)au	Dalian	China	2008	2012
14. Design Museum	Ron Arad	Holon	Israel	2006	2010
15. Docks en Seine	Jakob+MacFarlane	Paris	France	2005	2008
16. Eden Project	Grimshaw Architects	Cornwall	UK	1998	2001
17. Elicium Amsterdam RAI	Benthem Crowel	Amsterdam	Netherlands	2004	2009
18. EYE Film Museum	Delugan Meissl	Amsterdam	Netherlands	2009	2012
19. Ferrari Museum	Shiro Studio, FutureSystems	Modena	Italy	2004	2012
20. Fiera Milano	Massimiliano Fuksas	Milan	Italy	2002	2005
21.Flowing Gardens	Plasmastudio	Xi'an	China	2009	2011
22. Frog Queen	Splitterwerk	Graz	Austria	2005	2007

Building Name	Designer(s)	Location	Country	Dates	
23. Guggenheim Museum	Frank O. Gehry	Bilbao	Spain	1990	1997
24. H2O Pavilion	NOX Lars Spuybroek	Neltjie Jans Island	Netherlands	1994	1997
25. Holocaust Memorial	Peter Eisenman	Berlin	Germany	1999	2003
26. Hydra Pier Pavilion	Asymptote	Harlemeer	Netherlands	2001	2002
27. ING House	MVSA	Amsterdam	Netherlands	1997	2002
28. International Port Terminal	Foreign Office Architects	Yokohama	Japan	1995	2002
29. Islamic Arts in Louvre Museum	Mario Bellini Architects & Rudy Ricciotti	Paris	France	2005	2012
30. iWEB	ONL (Oosterhuis-Lénard)	Delft	Netherlands	2002	2002
31. Kunsthaus	Peter Cook & Colin Fournier	Graz	Austria	2000	2003
32. Leonardo Glass Cube	3Deluxe Graphics	Bad Driburg	Germany	2004	2007
33. Liwa Tower	ONL (Oosterhuis-Lénard)	Abu Dhabi	UAE	2008	2011
34. Maison Folie	NOX Lars Spuybroek	Lille	France	2001	2004
35. Maxxi	Zaha Hadid	Rome	Italy	1998	2010
36. Mediacite	Ron Arad	Liegè	Belgium	2006	2009
37. Mercedes Benz Museum	UN Studio	Stuttgart	Germany	2001	2006
38.Metropol Parasol	J. Mayer H.	Seville	Spain	2004	2011
39. Metropolitan Opera House	Toyo Ito	Taichtung	Taiwan	2009	2014
40. MiCo Milano Convention Center	Mario Bellini	Milan	Italy	2008	2012
41. MINI Opera 21Space	Coop Himmelb(l)au	Munich	Germany	2008	2010
42. Moebius House	UNStudio	Het Gooi	Netherlands	1993	1997
43. Mur Island	Vito Acconci	Graz	Austria	2003	2003

Building Name	Designer(s)	Location	Country	Date	
44. Nardini Research Centre	Massimiliano Fuksas	Bassano del Grappa	Italy	2002	2004
45. Olympic Stadium	Herzog & De Meuron	Beijng	China	2002	2008
46. Opera House	Zaha Hadid	Guaghzhog u	China	2003	2010
47. Orange Cube	Jakob+MacFarlane	Lyon	France	2005	2010
48. Paul Klee Museum	Renzo Piano	Bern	Swizerland	1999	2005
49. Porsche Museum	Delugan Meissl	Stuttgart	Germany	2003	2009
50. Sarpi Border Checkpoint	J. Mayer H.	Sarpi	Georgia	2010	2011
51. Selfridges Store	Future Systems	Birmingham	UK	1999	2003
52. Singapore gardens	Wilkinson Eyre Architects	Singapore	Singapore	2006	2012
53. Son-O-House	NOX Lars Spuybroek	Son en Breugel	Netherlands	2000	2004
54. Soumaya Museum	Fernando Romero	Mexico City	Mexico	2005	2011
55. Stedelijk Museum	Benthem Crowel	Amsterdam	Netherlands	2007	2012
56. Swiss RE Headquarters	Foster & Partners	London	UK	2000	2004
57. The Admirant	Massimiliano Fuksas	Eindhoven	Netherlands	2003	2010
58. Walt Disney Concert Hall	Frank O. Gehry	Los Angeles	USA	1989	2003
59. Watercube National Acquatic Center	PTW	Beijng	China	2003	2007
60. Yas Hotel	Asymptote	Abu Dhabi	UAE	2007	2010

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KRIES, M., EISENBRAND, J., KAHN, L. I. & NEDERLANDS ARCHITECTUURINSTITUUT (ROTTERDAM) 2012. *Louis Kahn, the power of architecture,* Weil am Rhein, Vitra Design Museum.

Acoustic Barrier / Cockpit

ONL (Oosterhuis-Lénard)

Location	Utrecht	Software	Parametric Design
Country	Netherlands		
Date from	2006		
Date to	2009	Site Area	8.000
Type	Transportation structures	Total Area	2.970
		Cubature	60.750
Client	Projectbureau Leidsche Rijn Utrecht	Height	15
		Lenght	150
Context	Urban area	Depht	27

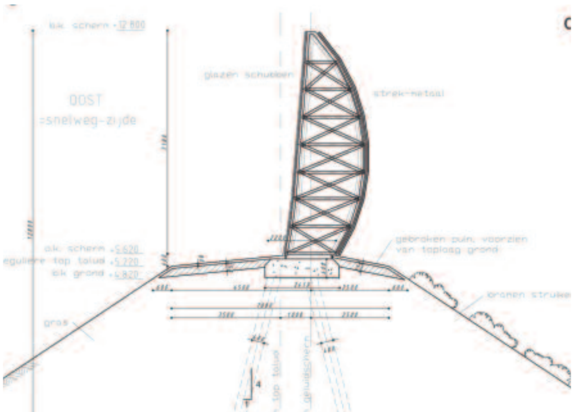
Description

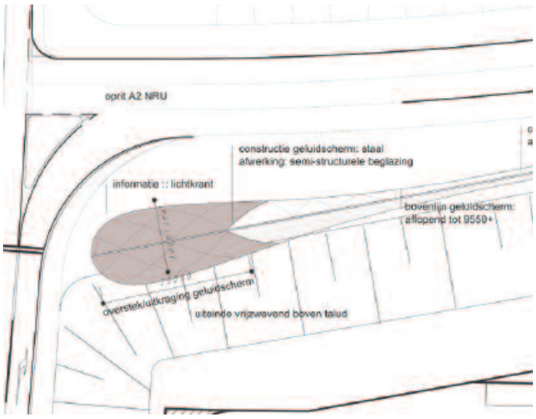
Along the A2 highway from Amsterdam to Maastricht, the Acoustic Barrier and the Cockpit have been designed from the perspective of a flow of cars passing by with the speed of 120 km/h. The dominant design principle in this building is the use of long continuous lines forming smoothly stretched shells on both sides of the barrier. The long elastic lines along the length of the barrier have no explicit beginning or end and make up a 1.5 km long stretched slender body. The integrated building volume is stretched in the direction of the flow of cars according to the formula: length: height = 10:1. In the preliminary design a surface is stretched between the elastic top and bottom lines and following the folding lines .

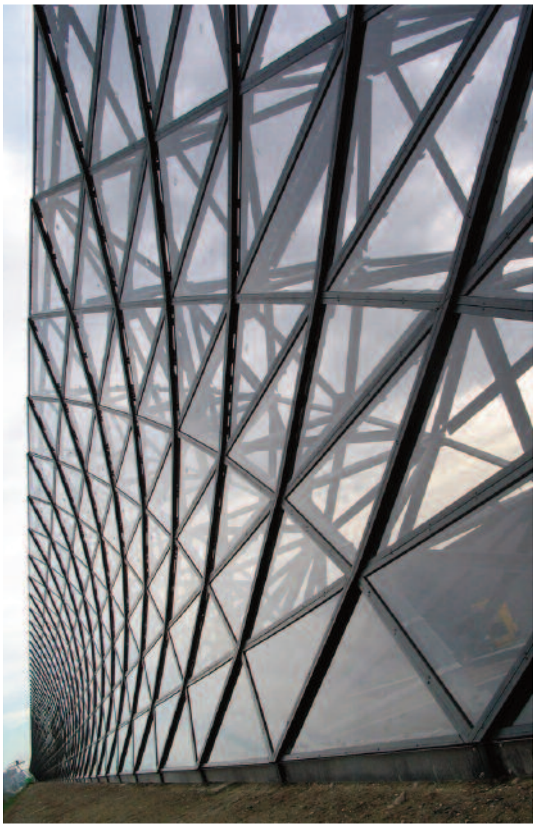
The design is a pure example of Non Standard Architecture realized on a big scale. Basic principle for the NSA is that all compiled components are in principle different. The exception is the rule. If there are two similar components, it is not on purpose and not relevant. But all exceptions take place in a rigidly defined parametric design system. The adagium "one building, one detail" applies here. NSA is based on the new industrial production method of mass customization. Repetition of similar elements is no longer an economic advantage and it is not a valid argument for the aesthetics of the repetition. Repetition of the same elements is not anymore identical to beauty. The beauty of the NSA principle is now in the shaping of the control of series of thousands of different elements. To acquire these new techniques ONL learned from the designing of industrial products which moves or are moved with a certain speed. One example of this are the folding lines which fade out into the curved surface. Non Standard Architecture is the architecture of smooth transitions.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Bulging; Loft; Sweep
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Mesh; Smooth
Additional primitive(s)	Cylinder	Main design strategy	Flows
Form and composition concepts	Alignment; Axiality; Complexity; Frontality; Linearity; Plasticity; Unity	Secondary design strategies	Fluidity

For more information, please see <www.oosterhuis.nl/quickstart/index.php>
<http://www.archdaily.com/15400/acoustic-barrier-onl/>







Allianz Arena

Herzog & De Meuron

Location	Munich	Software	AutoCAD; Rhinoceros
Country	Germany		
Date from	2001		
Date to	2005	Site Area	310.000
Type	Recreation structure	Total Area	171.000
		Cubature	2.190.000
Client	Munich City, Bayer München,	Height	50
	München 1860, Allianz Group	Lenght	227
Context	Urban fringe	Depht	258

Description

Three themes define the architectural and urban concept for the Allianz Arena football stadium in Munich: the presence of the stadium as an illuminated body that can change its appearance and is situated in an open landscape, the procession-like arrival of fans in a landscaped area and the crater-like interior of the stadium itself. Both the shell and the structural skeleton of the stadium are designed throughout to implement these three key concerns Hence, the main stairs along the outside of the shell follow the line of greatest slope, underscoring the procession-like approach of visitors to the stadium.

As a huge luminous body, the stadium marks a new location in the open landscape to the north between the airport and downtown Munich. The skin of the luminous body consists of large, shimmering white, diamond-shaped ETFE cushions, each of which can be illuminated separately in white, red or light blue, colours of the two local football clubs. The colour of the cushions can be controlled digitally and the changing appearance of the stadium will enhance its attraction as an urban monument even for people who are not interested in football.

The car parks are laid out between the underground station and the stadium so as to create an artificial landscape for the arrival and departure of the fans. Meandering asphalt paths determine and shape the rhythm and flow of the throngs of visitors, somewhat like a procession. Since only football will be played in the new Munich Stadium, the seating is directly adjacent to the pitch and each of the three tiers is as close as possible to the playing field.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding; Sweep
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Bulging; Mesh
Additional primitive(s)	Torus	Main design strategy	Blob
Form and composition concepts	Axiality; Balance; Harmony; Plasticity; Proportion; Simmetry; Unity	Secondary design strategies	Performance optimization

For more information, please see
<http://www.herzogdemeuron.com/index/projects/complete-works/201-225/205-allianz-arena.html>

ARCAM (Architecture Centre Amsterdam)

Renè van Zuuk

Location	Amsterdam	Software	AutoCAD; BIM
Country	Netherlands		
Date from	1999		
Date to	2003	Site Area	300
Type	Information handling facilities	Total Area	477
		Cubature	2.860
Client	Ontwikkelingbedrijf Geemente Amsterdam	Height	10
		Lenght	25
Context	City center	Depht	15

Description

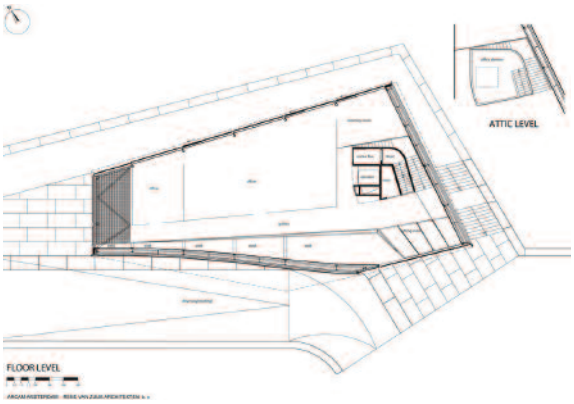
The ARchitecture Centre Amsterdam (ARCAM) needed a larger accommodation, found in a small pavilion also designed by Renzo Piano that was going to be demolished. Some structural elements needed to be integrated in the new design. Also three important requirements had to be taken into account. First, the view of the pavilion from the Maritime Museum needed to be utmost modest. Second, the street facade needed to represent a closed character and at the same time the building should open up on the waterfront. Last, it was demanded that the pavilion would be a compact monolith.

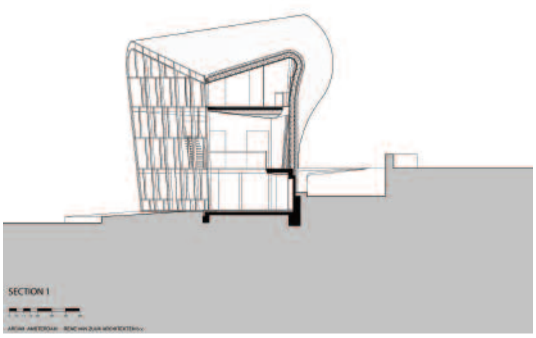
The new pavilion is a monolith, a humble and compact three-storey building. On the street level there is an exhibition space, while on the waterfront, at the quay level, a multipurpose space for meetings, discussions and reception of groups is located. All the different levels are linked by voids, in a way that all the spaces are a part of a perceptible larger entity.

The performance of the facades is mainly due to the ubiquitous application of a folded skin, ideal for creating singularly curved surfaces. The zinc-coated aluminium strips form a continuous plane curling itself all around the building mass, so as to create several distinctive perspectives. While the folded skin combined with the bevelling glass facade results in a spectacular entrance, the east side displays a most austere view. The waterfront view reveals the soul of the pavilion through the curtain glass. The peculiar sculptural shape of the pavilion, despite its unobtrusiveness and small dimensions, provides just enough attention in the monumental setting of the Oosterdok.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Extrusion; Folding
Principal primitive	Prism	Secondary composition operation(s)	Smooth; Sweep
Additional primitive(s)	NURBS Surfaces	Main design strategy	Folded surfaces
Form and composition concepts	Balance; Complexity; Harmony; Plasticity; Proportion; Simplicity; Unity	Secondary design strategies	Performance optimization

For more information, please see <http://www.renevanzuuk.nl/>
<http://www.archdaily.com/15091/arcam-rene-van-zuuk-architekten/>





Arnhem Station

UNStudio

Location	Arnhem	Software	AutoCAD; Grasshopper; Rhinoceros
Country	Netherlands		
Date from	1996		
Date to	2013	Site Area	7.500
Type	Transportation structures	Total Area	88.200
		Cubature	76.000
Client	Municipality of Arnhem, ProRail BV	Height	15
		Lenght	
Context	Inner city	Depht	

Description

Arnhem Central is a large urban plan development composed of diverse elements which amassed constitute a vibrant transport hub. The masterplan incorporates office space, shops, housing units, a new station hall, a railway platform and underpass, a car tunnel, bicycle storage and a large parking garage. A project with such an intricate set of requirements necessitates a methodological approach that can accommodate the hybrid nature of the development. The dynamic nature of the Deep Planning process allows the locus to fuse elements of time, occupant trajectories and program into an efficient and integral system. Housed under a continuous roof element these programs constitute one of the main thresholds into Arnhem, its architecture adding to the iconography of the city.
Arnhem Central represent the main terminal for high speed trains to Germany, and for this reason passenger numbers continued to grow, as to have the necessity to revitalize the railway infrastructure. While the main station building is under construction, the platforms and their connections have been already completed. The design concept for the new platform roofs provides a sense of light and space. Large roof lights, which together with the structural spans, add to a positive experience of the transfer platforms and surroundings. The elevated footbridge is fully integrated in the design, connecting the different platforms with each other and with the north entrance of the train station. The car park, integrated into the public transportation area interconnects and gives access to trains, taxis, buses, bikes, cars, office spaces and the town centre.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding; Sweep
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Extrusion; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Diagram
Form and composition concepts	Articulation; Complexity; Plasticity; Unity	Secondary design strategies	Flows; Fluidity

For more information, please see <http://www.unstudio.com/projects/arnhem-central-masterplan>
<http://www.unstudio.com/projects/arnhem-central-platform-roofs>

Auditorium Parco della Musica

Renzo Piano

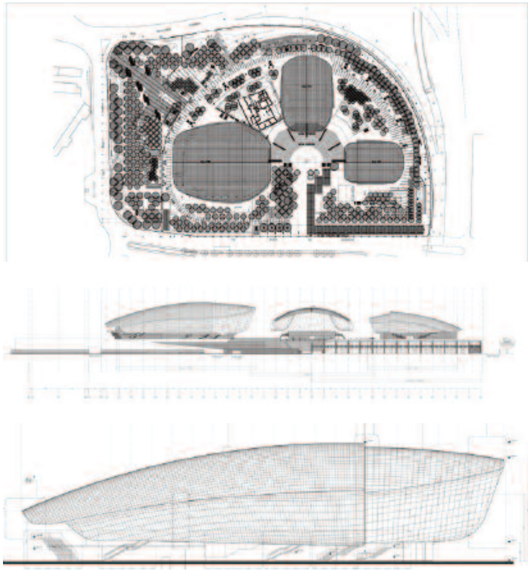
Location	Rome	Software	3D Modeling; AutoCAD
Country	Italy		
Date from	1994		
Date to	2004	Site Area	56.680
Type	Entertainment structure	Total Area	55.000
		Cubature	325.000
Client	City of Rome	Height	25
		Lenght	220
Context	City center	Depht	100

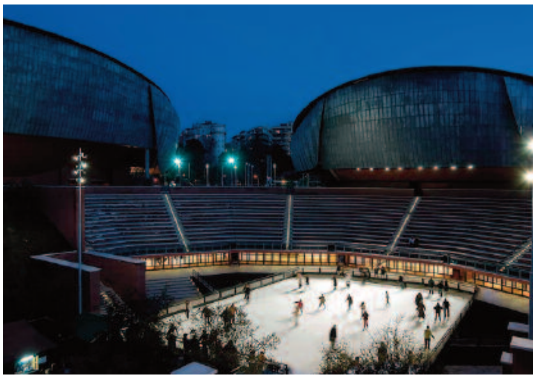
Description

The Parco della Musica, situated in the Flaminio area of Rome, was the result of a limited competition for the construction of a multipurpose complex to host musical and cultural events. The original competition did not stipulate three separate concert halls. However, in order to guarantee maximum flexibility of use and the best possible acoustics, RPBW introduced this new concept to the project. The halls are conceived as giant individual musical instruments, 'resonating chambers', sitting in a landscape.
The three halls are grouped in a semi-circle, their positions to some extent determined by the discovery, during early excavations, of a roman villa on the site. This layout results in a fourth space in the centre which became an outdoor amphitheatre known as 'la Cavea', with a capacity of almost 3,000, an element which gives particular public and urban dimensions to the site.
The three halls have different characteristics and capacities and are designed for specific types of performance and are structurally separated in order to improve sound insulation: The Petrassi hall with 750 seats, the Sinopoli hall with 1,200 seats and, finally the Santa Cecilia hall with 2,800 seats, reserved for symphonic concerts. The three halls are linked by the single-level foyer that runs discreetly around the perimeter of the 'Cavea'. Tucked under the upper levels of the outdoor amphitheatre seating, the foyer has the appearance of being physically separate from the halls above. A limited range of materials have been used for the building: travertine, Roman brick, pre-oxidised lead for the concert halls' distinctive roofs. Inside, wood dominates.

Geometry Morphology	Curvilinear Real-object Morphology	Primary composition operation(s)	Loft; Revolution
Principal primitive	Ellipsoid	Secondary composition operation(s)	Copy; Scale
Additional primitive(s)	Solid of revolution	Main design strategy	Artistic Fact
Form and composition concepts	Axiality; Plasticity; Scale; Simmetry	Secondary design strategies	Performance optimization

For more information, please see <http://www.rpbw.com/>
<http://www.fondazionerenzopiano.org/project/87/parco-della-musica-auditorium/>





Block 16

Renè van Zuuk

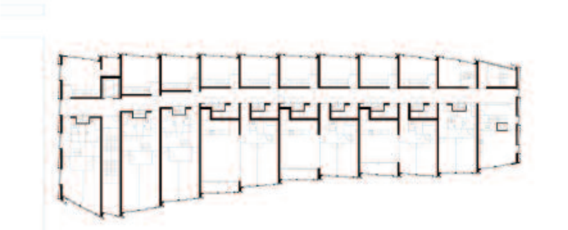
Location	Almere	Software	AutoCAD; BIM
Country	Netherlands		
Date from	2002		
Date to	2004	Site Area	1.650
Type	Residential building	Total Area	8.740
		Cubature	25.602
Client	Ontwikkelingscombinatie Almere Hart c.v.	Height	20
		Lenght	65
Context	Inner city	Depht	20

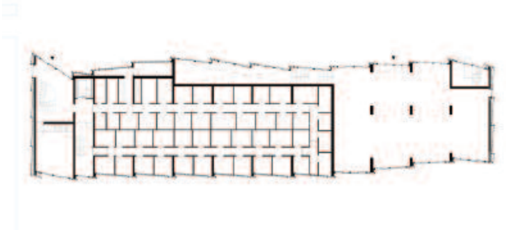
Description

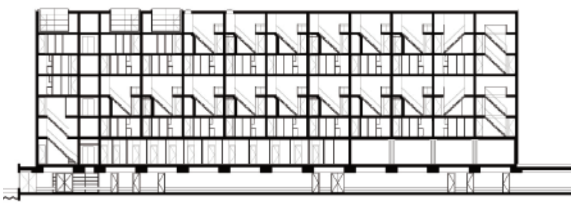
Block 16 is part of the master plan designed by OMA for a new prestigious city centre in Almere. The design of Block 16 is largely based on an analysis of tunnel formwork constructions. Implementation of this mode of construction is financially attractive in developing major housing projects. The basic principle of tunnel formwork is the simultaneous casting of floors and party walls. Similar to extrusion techniques, this requires a constant section. It is common practice that the tunnels are also of a constant length, resulting in a regular concrete skeleton. Variation in the length of adjacent tunnels breaks the monotonous structure. The result is a wavy façade surface providing the block with a dynamic quality. This unusual application of tunnel formwork implies a relatively small rise of the building costs, but yields a much more expressive image.
Block 16 is equipped with two central corridors, providing the occupants' access to the apartments. The living rooms of all the 49 apartments are south-facing and orientated to the waterfront. On the northern side of the block the private stairs are located interconnecting higher or lower floors. The main communal stairwell fills a seven-storey void located behind the biggest bulge. The deviant function is furthermore revealed in the exterior by the strip of half sized cladding panels.
The hollows and bulges in the façade all have a functional basis. The dimple on the north side marks the entrance and the protruding south façade arises from adding patios to some apartments.

Geometry Morphology	Both Geometrical	Primary composition operation(s)	Bulging
Principal primitive	Free-form solid	Secondary composition operation(s)	Boolean; Retract; Smooth
Additional primitive(s)	Parallelepiped	Main design strategy	Folded surfaces
Form and composition concepts	Articulation; Asymmetry; Complexity; Deconstruction; Gesture; Plasticity	Secondary design strategies	Fluidity; Grid

For more information, please see <http://www.renevanzuuk.nl/block-16/>
<http://www.archdaily.com/10116/block-16-rene-van-zuuk-architekten/>







BMW Welt

Coop Himmelb(l)au

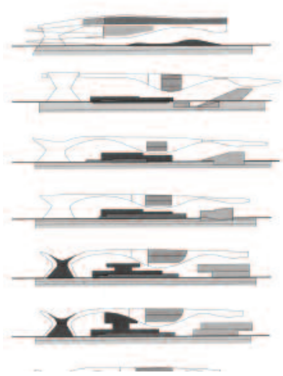
Location	Munich	Software	AutoCAD; Maya; Rhinoceros
Country	Germany		
Date from	2001		
Date to	2008	Site Area	25.000
Type	Multipurpose building	Total Area	16.000
		Cubature	531.000
Client	Client	Height	30
		Lenght	180
Context	BMW Group	Depht	130

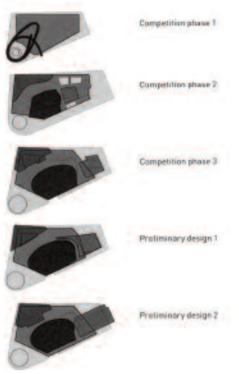
Description

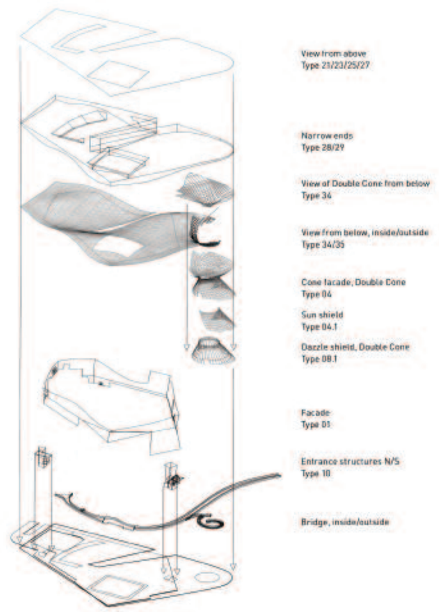
In 2000, the BMW Group decided to build a brand-experience and car-delivery center, close to the corporate headquarters, the BMW museum and the Olympiapark in Munich. In an open international, the design by COOP HIMMELB(L)AU came out winning in July 2001.
One of the central design ideas is to expand the existing configuration of the BMW Tower and the museum with an additional element so as to create a spatial, ideal, and identity-forming architectural ensemble. The design consists of a large transparent hall with a sculptural roof and a double cone informed by the relation with the existing company headquarter building. The various areas within BMW Welt are accommodated under a 'cloud-like' roof emerging from a double cone. This roof, clad entirely in stainless steel panels, rests on only a few columns and support points. As well as its protective function, the roof also both defines and encloses space. Its rising and falling underside articulates the hall below, marking out the different functional zones and giving the building its innovative and dynamic character.
Inside, all the public areas, such as the Forum, the restaurant tower and the double cone, are linked by a raised footbridge that winds through the space like a corridor, forming a second level and articulating the vertical space. Almost entirely encapsulated within the roof is the lounge where the customers gather for the hand-over event when they collect their new cars. The full-height glazed facades allow inside and outside space to merge, while within the single-volume hall large-format stainless steel panels achieve visual continuity between the different functional zones.

Geometry	Curvilinear	Primary composition operation(s)	Folding; Overturning; Revolution
Morphology	Biomorphic		
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Loft; Mesh; Smooth
Additional primitive(s)	Free-form solid; Helix	Main design strategy	Flows
Form and composition concepts	Complexity; Gesture; Monumentality; Plasticity; Scale; Unity	Secondary design strategies	Fluidity; Folded surfaces

For more information, please see <http://www.coop-himmelblau.at/architecture/projects/bmw-welt/>
<http://www.archdaily.com/29664/bmw-welt-coop-himmelblau/>







Bus Station

NIO Architecten

Location	Hoofdorp	Software	AutoCAD; Reverse Modeling; Rhinoceros
Country	Netherlands		
Date from	1999		
Date to	2003	Site Area	4.000
Type	Transportation structures	Total Area	200
		Cubature	0
Client	Schiphol Project Consult	Height	4
		Lenght	50
Context	Urban fringe	Depht	7

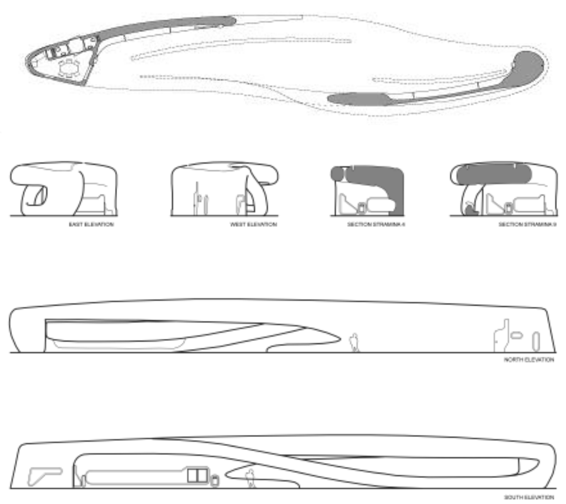
Description

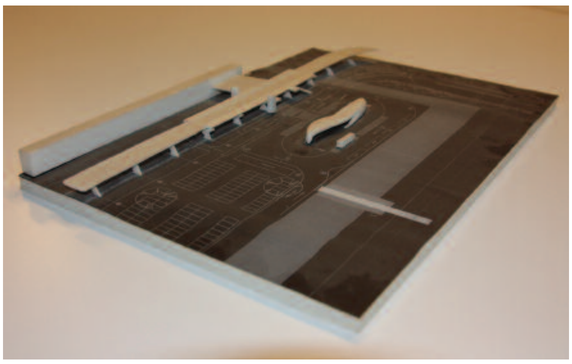
At the beginning of the year 2003 a bus station was built on the forecourt of Hoofddorp's Spaarne Hospital. This facilities block is located in the middle of a square and is a public area in the form of an island that serves as a junction for the local bus service. The design of this kind of building is generally neutral, but here the aim of designer was to create a strong, individual image that was less austere and generic. Hence, the building was digitally designed with an organic shape.

Due to this complex shape, the building is completely made of polystyrene foam and polyester and is, as such, the world's largest structure in synthetic materials. The available budget meant that it could never have been created using conventional construction methods. Indeed, the construction parts are manufactured directly out of a computer program by a computer-controlled grinder. The original colour was white, but in nowadays it is orange. In the interview, Maurice Nio explained the reasons of the colour changing: firstly after some years, the polystyrene foam was altering, with some green stains; secondly, due to the hospital presence, the client wanted to have a more fresh-looking colour, to revitalize the area.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding; Loft
Principal primitive	Free-form solid	Secondary composition operation(s)	Bulging; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Artistic Fact
Form and composition concepts	Articulation; Complexity; Gesture; Horizontality; Plasticity; Unity	Secondary design strategies	Blob

For more information, please see <http://www.nio.nl/wordpress/all-projects/the-amazing-whale-jaw/>





Casa da Musica

OMA Rem Koolhaas

Location	Porto	Software	3D Modeling; AutoCAD
Country	Portugal		
Date from	1999		
Date to	2005	Site Area	3.600
Type	Entertainment structure	Total Area	22.000
		Cubature	74.250
Client	Porto 2001 / Casa da Música	Height	18
		Lenght	75
Context	City center	Depht	55

Description

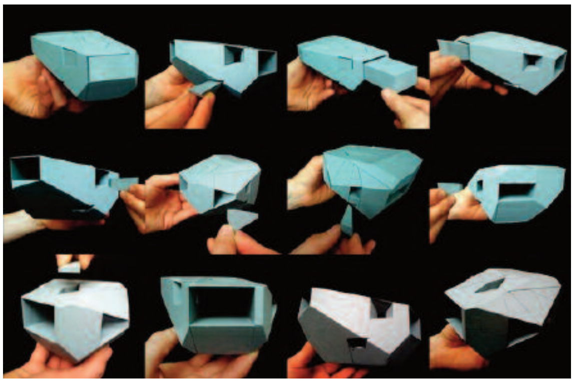
The Casa da Musica attempts to reinvigorate the traditional concert hall - the "shoe-box" - in another way: by redefining the relationship between the hallowed interior and the general public outside. The building, new home of the National Orchestra of Porto, stands on a new public square in the historic Rotunda da Boavista. It has a distinctive faceted form, made of white concrete, which remains solid and believable in an age of too many icons. Inside, the elevated 1,300-seats Grand Auditorium has corrugated glass facades at either end that open the hall to the city and offer Porto itself as a dramatic backdrop for performances. Casa da Musica reveals its contents without being didactic; at the same time, it casts the city in a new light.

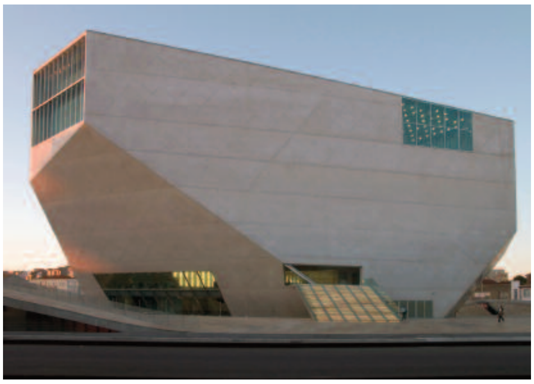
Locating the Casa da Musica was key in the development of OMA's thinking. they "chose not to build the new concert hall in the ring of old buildings defining the Rotunda but to create a solitary building standing on a travertine-paved plateau in front of the Rotunda's park, neighbouring a working class area. With this concept, issues of symbolism, visibility, and access were resolved in one gesture".

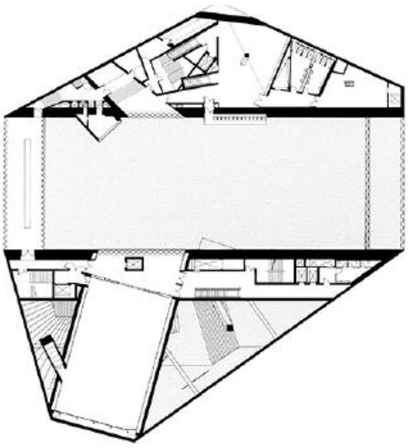
There is deliberately no large central foyer; instead, a continuous public route connects the spaces around the Grand Auditorium by means of stairs, platforms and escalators. The Casa da Musica also contains a smaller, more flexible performance space with no fixed seating, ten rehearsal rooms, recording studios, an educational area, a restaurant, terrace, bars, a VIP room, administration areas, and an underground car park.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Boolean; Slicing
Principal primitive	Prism	Secondary composition operation(s)	Stretch; Taper; Tilt
Additional primitive(s)	None	Main design strategy	Artistic Fact
Form and composition concepts	Asymmetry; Deconstruction; Monumentality; Obliquity	Secondary design strategies	Deconstruction

For more information, please see <http://oma.eu/projects/2005/casa-da-musica>
<http://europaconcorsi.com/projects/16869-Rem-Koolhaas-OMA-Casa-Da-M-sica>







City Hall

Foster & Partners

Location	London	Software	Generative Components; MicroStation
Country	UK		
Date from	2000		
Date to	2002	Site Area	12.000
Type	Institutional building	Total Area	18.000
		Cubature	39.000
Client	London Municipality	Height	45
		Lenght	45
Context	Central business district	Depht	45

Description

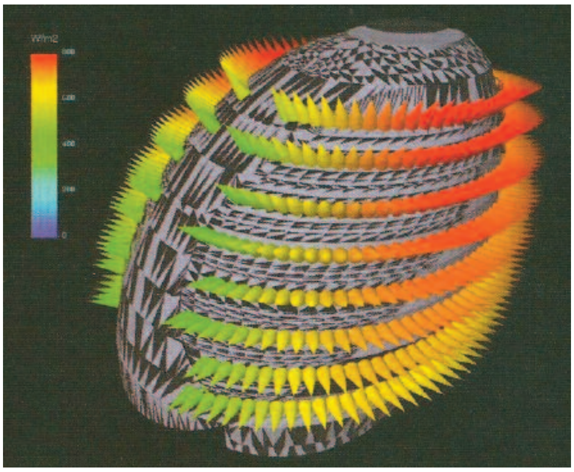
City Hall houses the chamber for the London Assembly and the offices of the mayor and staff of the Greater London Authority. It forms the focal point of the More London development – a new working community on the south bank of the Thames between London and Tower Bridges - and occupies a strategic position on the cultural route from Tate Modern, the Globe Theatre and Southwark Cathedral to HMS Belfast and the Design Museum. One of the capital's most symbolically important new projects, City Hall expressed the transparency and accessibility of the democratic process and demonstrating the potential for a sustainable, virtually non-polluting public building.

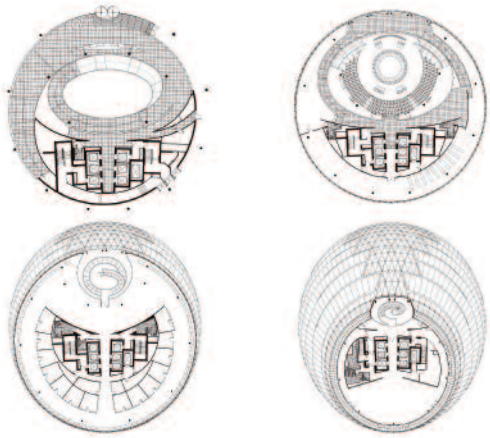
Designed using advanced computer-modelling techniques, the building represents a radical rethink of architectural form. Its shape achieves optimum energy performance by maximising shading and minimising the surface area exposed to direct sunlight. Offices are naturally ventilated, photovoltaics provide power and the building's cooling system utilises ground water pumped up via boreholes. Overall, City Hall uses only a quarter of the energy consumed by a typical air-conditioned London office building.

The landscaping in the streets and piazzas includes tree planting and water features and extends to the design of paving and street furniture. Alongside the offices, there are shops, restaurants and cafés, and the development includes the Unicorn Children's Theatre, a hotel, supermarket and fitness club. Together they help to create a lively and congenial social environment on the riverside.

Geometry Morphology	Geometry Geometrical	Primary composition operation(s)	Folding
Principal primitive	Sphere	Secondary composition operation(s)	Mesh; Taper
Additional primitive(s)	Ellipsoid	Main design strategy	Performance optimization
Form and composition concepts	Axiality; Obliquity; Plasticity; Simmetry; Unity	Secondary design strategies	None

For more information, please see <http://www.fosterandpartners.com/projects/city-hall/>





City of Culture

Peter Eisenman

Location	Santiago de Compostela	Software	3D Modeling; AutoCAD
Country	Spain		
Date from	2000		
Date to	2011	Site Area	700.106
Type	Exhibition building	Total Area	92.900
		Cubature	2.787.000
Client	Fundación cidade da cultura de Galicia	Height	42
		Lenght	515
Context	Urban area	Depht	285

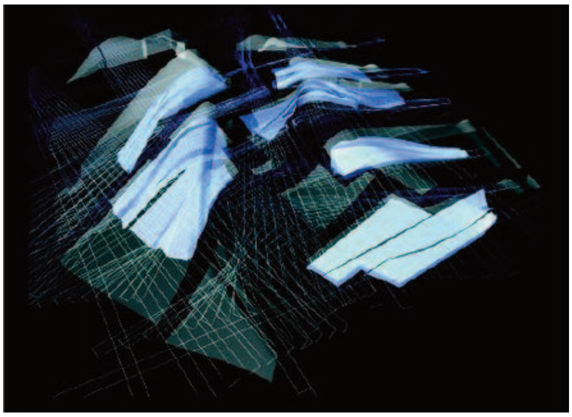
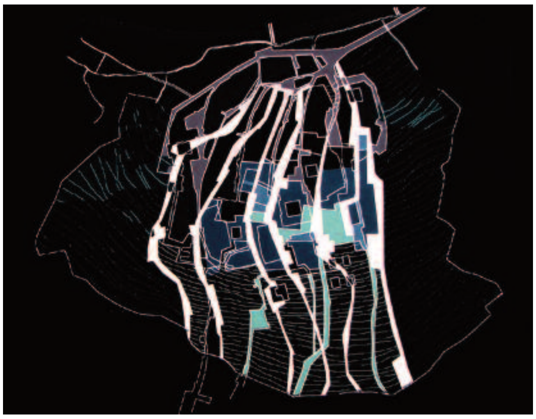
Description

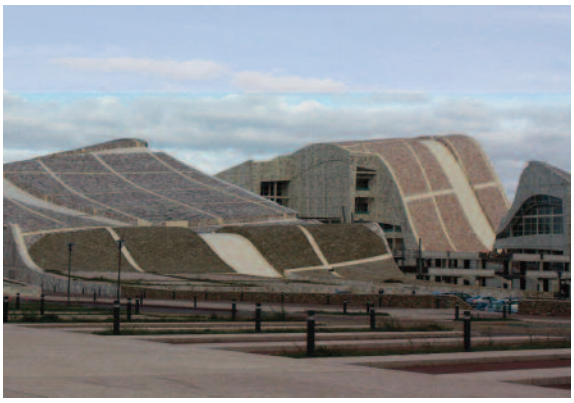
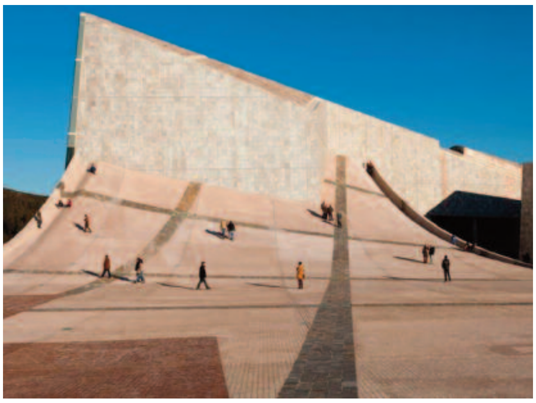
The City of Culture is a new cultural centre for the Province of Galicia in north-western Spain. Its design evolves from the superposition of three sets of information. First, the street plan of the medieval centre of Santiago is overlaid on a topographic map of the hillside site, which overlooks the city. Second, a modern Cartesian grid is laid over these medieval routes. Third, through computer modelling software, the topography of the hillside is allowed to distort the two flat geometries, thus generating a topological surface that repositions old and new in a simultaneous matrix never before seen. Through this mapping operation, the project emerges as a curving surface that is neither figure nor ground but both a figured ground and a figured figure that supersede the figure-ground urbanism of the old city. Santiago's medieval past appears not as a form of representational nostalgia but as a new yet somehow familiar presence found in a new form.

The six buildings of the project are conceived as three pairs: the Museum of Galicia and the International Art Centre; the Centre for Music and Performing Arts and the Central Services building; and the Library of Galicia and the Galician Archives. The 'caminos', or pedestrian streets, between the buildings, also open into a public plaza, which is bordered by the six buildings and features landscape and water elements. The heights of all of the buildings rise in gentle curves that seem to reconstruct the shape of the hilltop with their collective rooflines, which are all clad in stone and marked with the grids that inform the design of the site.

Geometry	Curvilinear	Primary composition operation(s)	Folding; Loft
Morphology	Biomorphic		
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Break; Slicing; Smooth
Additional primitive(s)	Free-form solid	Main design strategy	Diagram
Form and composition concepts	Gesture; Monumentality; Plasticity; Unity	Secondary design strategies	Artistic Fact; Deconstruction

For more information, please see <http://www.eisenmanarchitects.com/>
<http://www.archdaily.com/141238/the-city-of-culture-eisenman-architects/>

Cooper Union Building

Morphosis


Location	New York	Software	3D Modeling; AutoCAD
Country	USA		
Date from	2004		
Date to	2009	Site Area	2.000
Type	Institutional building	Total Area	16.258
		Cubature	51.300
Client	The Cooper Union for the Advancement of Science and Art	Height	38
		Lenght	45
Context	City center	Depht	30

Description

41 Cooper Square, the new academic building for The Cooper Union, aspires to manifest the character, culture and vibrancy of both the 150 year-old institution and of the city in which it was founded. The building aspires to reflect the institution's stated goal to create an iconic building – one that reflects its values and aspirations as a centre for advanced and innovative education in Art, Architecture and Engineering.

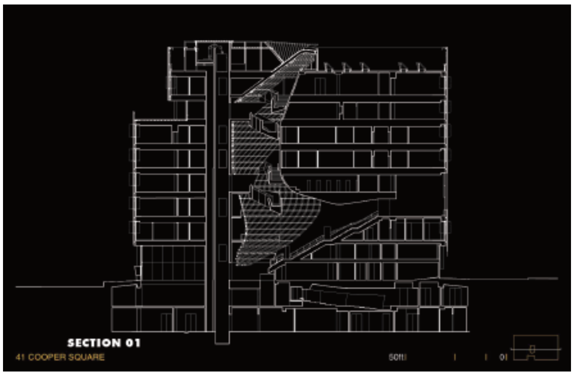
Responding to its urban context, the sculpted facade establishes a distinctive identity for Cooper Square through a high performance exterior double skin, with a semi-transparent layer of perforated stainless steel that wraps the building's glazed envelope. The façade registers the iconic, curving profile of the central atrium as a glazed figure that appears to be carved out of the Third Avenue façade, connecting the creative and social heart of the building to the street.

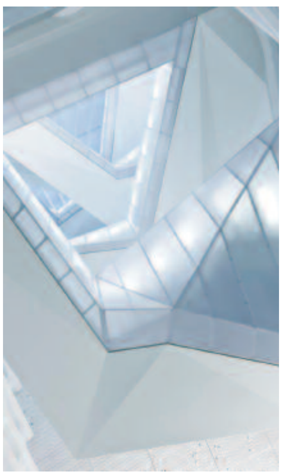
Internally, the building is conceived as a vehicle to foster collaboration and cross-disciplinary dialogue among the college's three schools. A vertical piazza forms the heart of the new academic building, providing a place for meetings, student gatherings, lectures, and for the intellectual debate that defines the academic environment.

In the spirit of the institution's dedication to free, open and accessible education, the building itself is symbolically open to the city. Visual transparencies and accessible public spaces connect the institution to the physical, social and cultural fabric of its urban context. At street level, the transparent facade invites the neighborhood to observe and to take part in the intensity of activity contained within.

Geometry	Both	Primary composition operation(s)	Boolean; Break; Slicing
Morphology	Geometrical		
Principal primitive	Cube	Secondary composition operation(s)	Folding; Smooth
Additional primitive(s)	None	Main design strategy	Deconstruction
Form and composition concepts	Alignment; Deconstruction; Frontality; Monumentality; Plasticity	Secondary design strategies	Folded surfaces

For more information, please see <http://morphopedia.com/projects/cooper-union>
<http://www.archdaily.com/40471/the-cooper-union-for-the-advancement-of-science-and-art-morphosis-architects/>





Dalian International Conference Center

Coop Himmelb(l)au

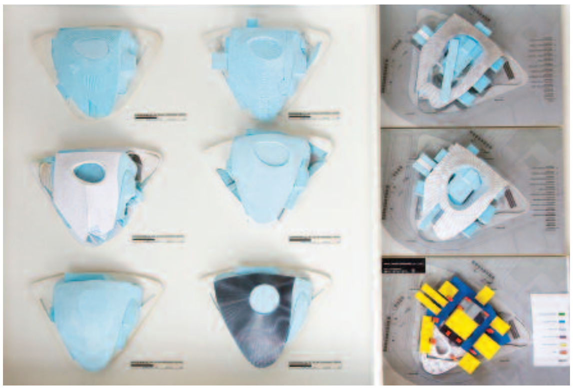
Location	Dalian	Software	AutoCAD; Maya; Rhinoceros
Country	China		
Date from	2008		
Date to	2012	Site Area	40.000
Type	Social and Civil building	Total Area	117.650
		Cubature	1.250.000
Client	Dalian Municipal People's Go-vernment, P.R. China	Height	60
		Lenght	220
Context	Industrial Area	Depht	200

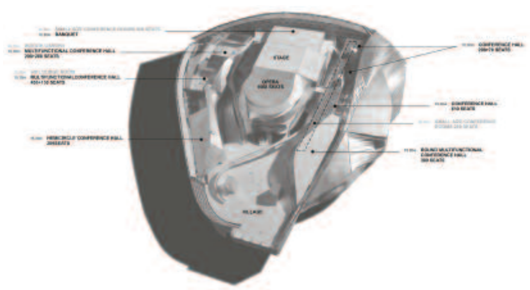
Description

The urban design task of the Dalian International Conference Center was to create an instantly recognizable landmark at the terminal point of the future extension of the main city axis. As its focal point the building will be anchored in the mental landscape of the population and the international community. The footprint of the building on the site is therefore arranged in accordance with the orientation of the two major urban axis which merge in front of the building. The cantilevering conference spaces that penetrate the facades create a spatially multifaceted building volume and differentiate the close surroundings. The various theatres and conference spaces are covered by a cone-shaped roof screen. Through controlled daylight input good spatial orientation for the visitors and atmospheric variety is assured.
A public zone at ground level allows for differentiating accessibility for the different groups of users. The actual performance and conference spaces are situated at +15,30 m above the entrance hall. The grand theater, with a capacity of 1.600 seats and a stage tower, and the directly adjacent flexible conference hall of 2.500 seats, are positioned at the core of the building. The smaller conference spaces are arranged around this core. Through this open and fluid arrangement the theatre and conference spaces on the main level establish a kind of urban structure with "squares" and "street spaces". These identifiable “addresses” facilitate user orientation within the building. The main entrance from the sea side corresponds to the future developments, including the connection to the future cruise terminal.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Boolean; Folding; Stretch
Principal primitive	Prism	Secondary composition operation(s)	Extrusion; Mesh; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Fluidity
Form and composition concepts	Axiality; Complexity; Gesture; Monumentality; Plasticity	Secondary design strategies	Artistic Fact; Flows

For more information, please see
<http://www.coop-himmelblau.at/architecture/projects/dalian-international-conference-center>





Design Museum

Ron Arad

Location	Holon	Software	Shape grammar
Country	Israel		
Date from	2006		
Date to	2010	Site Area	6.700
Type	Exhibition building	Total Area	3.200
		Cubature	44.400
Client	Holon Municipality	Height	12
		Lenght	60
Context	Inner city	Depht	50

Description

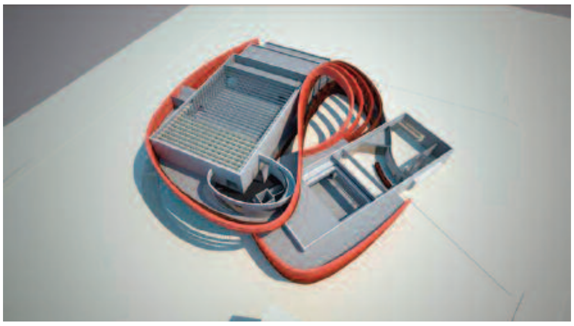
In March 2003, Ron Arad Architects were invited to design the first national Design Museum to be situated in a recently developed area of the city of Holon, a few miles south of Tel Aviv, designated to become a new cultural and educational hub for central Israel and to promote the appreciation of Israeli design both locally and abroad.

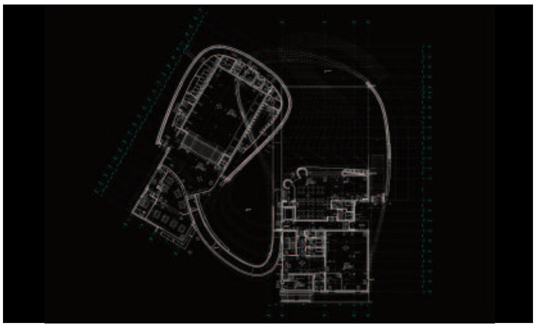
The Design Museum Holon (DMH) occupies a semi-rectangular 3,700m^2 site. The northern plaza acts as an introductory public space and entrance route to the Museum. The plateau-like topography of the site is articulated by the arrangement of the museum over two staggered levels, connected by an external sculptural ramp. In this way, the route through the museum becomes more experiential, as it leads the visitor through a series of dramatic internal views across the Museum's internal courtyard.

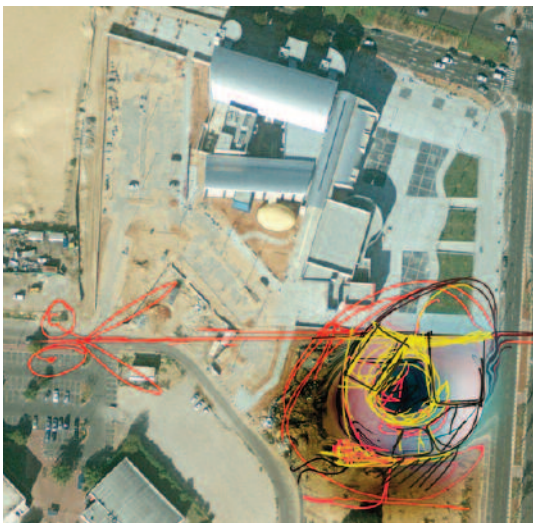
The notion of creating and exploiting the tension between an internal arrangement of efficient box-like spaces, and the dynamic and curvaceous external envelope, is the guiding design principle for the entire museum. The greater part of the museum is shrouded by five distinct bands of Cor-Ten structure which undulate and meander their way in, out and around the museum's internal volumes. The bands act as a spine for the building - both supporting large parts of it structurally and dictating its posture in relation to its surroundings. The topographic horizontality of the bands is emphasised further by a gradation of treated patinas, which echoes to the familiar geological striations of the Israeli desert. The bands are never entirely obscured from the visitor's sight, and act as a visual thread running through the museum.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Retract; Scale; Sweep
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Boolean; Sliding
Additional primitive(s)	Parallelepiped	Main design strategy	Mathematical derivation
Form and composition concepts	Balance; Complexity; Contrast; Frontality; Gesture; Horizontality; Plasticity; Scale	Secondary design strategies	Artistic Fact

For more information, please see <http://www.ronarad.co.uk/architecture/design-museum-holon/>
<http://www.archdaily.com/87173/design-museum-holon-ron-arad-architects/>







Docks en Seine

Jakob+MacFarlane

Location	Paris	Software	3D Modeling
Country	France		
Date from	2005		
Date to	2008	Site Area	6.400
Type	Exhibition building	Total Area	14.400
		Cubature	128.000
Client	Icade G3A, Caisse dès Dè-pots	Height	20
		Lenght	160
Context		Depht	40
	Inner city		

Description

The building was first designed in 2004 for a competition held by the city of Paris, won by Jakob + MacFarlane. The purpose of the competition was to revitalise the Docks, built on the Seine in 1907, and the architects were offered the option of either preserving or demolishing the long, narrow cement structure of the old warehouses. The designers decided to preserve the existing constructions, revealing and highlighting their cement structure. The new "light" skin covering them is a glass and steel tubular structure referred to as the "plug-over". The new skin is a result of deformation of the old building's structural grid. Inspired by the flow of water and the long river, it becomes a fluid pedestrian path permitting exploration of the construction, from the ground floor to the panoramic wooden terrace, coming back down again to return to the pedestrian paths in the neighbourhood.
The roof has also been developed using wooden decks and grassed areas. The front façade addition serves as the buildings circulation system allowing visitors to move between levels. Inside the new building will feature a variety of programming including galleries, retail shops, the french fashion institute, and cafes.

Geometry Morphology	Both Geometrical	Primary composition operation(s)	Align; Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Bulging; Mesh
Additional primitive(s)	Parallelepiped	Main design strategy	Fluidity
Form and composition concepts	Alignment; Complexity; Contrast; Frontality; Linearity	Secondary design strategies	Flows

For more information, please see <http://jakmak1.dotster.com/en/project/news-7/>
<http://www.citemodedesign.fr/>

Eden Project

Grimshaw Architects

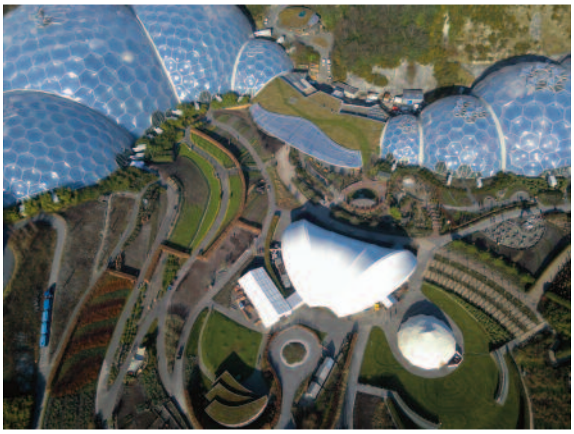
Location	Cornwall	Software	AutoCAD; MicroStation
Country	UK		
Date from	1998		
Date to	2001	Site Area	116.000
Type	Multipurpose building	Total Area	23.300
		Cubature	
Client	The Eden Project Ltd	Height	
		Lenght	
Context	Rural area	Depht	

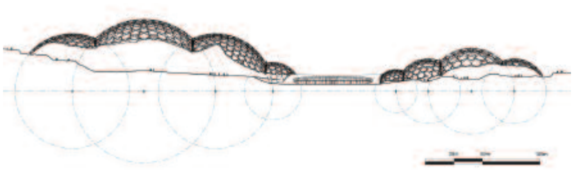
Description

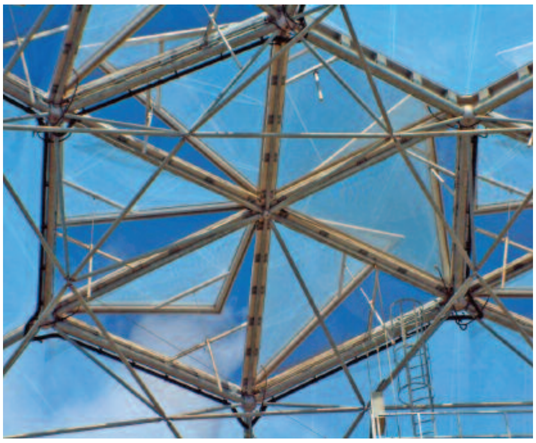
The Eden Project is a visitors attraction in Cornwall in the United Kingdom, a sort of botanic garden with artificial biomes, where are plants collected from all around the world.
The first phase of project was the development of the Visitors' Centre, known as the 'Gateway to Eden' and houses ticketing halls, shops, restrooms and educational galleries. The Visitors' Centre introduces the aims and objectives of The Eden Project, not only through its multimedia educational exhibits but also through its own sustainable credentials as a building.
The second phase refers to the 'biomes', a sequence of eight inter-linked geodesic transparent domes covering 2.2 hectares and encapsulating vast humid tropic and warm temperate regions. Grimshaw's design of the biomes is an exercise in efficiency, both of space and of material. Structurally, each dome is a hex-tri-hex space frame reliant on two layers. The efficiency of the frame relies on the components of the geometric shapes: steel tubes and joints that are light, relatively small and easily transportable. The cladding panels are triple-layered pillows of high performance ETFE foil and environmentally efficient, with maximum surface area and minimum perimeter detailing. The project is now one of the top three charging attractions in the UK and the second most visited destination outside London.

Geometry	Curvilinear	Primary composition operation(s)	Boolean; Scale
Morphology	Biomorphic		
Principal primitive	Sphere	Secondary composition operation(s)	Move; Sliding
Additional primitive(s)	None	Main design strategy	Blob
Form and composition concepts	Contrast; Disproportion; Monumentality; Rythm; Scale	Secondary design strategies	Natural Derivation

For more information, please see <http://grimshaw-architects.com/project/the-eden-project-the-biomes/>
<http://grimshaw-architects.com/project/the-eden-project/>







Elicium Amsterdam RAI

Benthem Crouwel

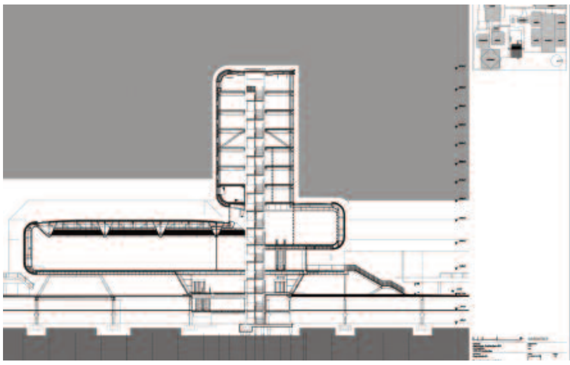
Location	Amsterdam	Software	AutoCAD; Revit
Country	Netherlands		
Date from	2004		
Date to	2009	Site Area	8.250
Type	Social and Civil building	Total Area	15.195
		Cubature	100.100
Client	Amsterdam RAI	Height	28
		Lenght	55
Context	Central business district	Depht	65

Description

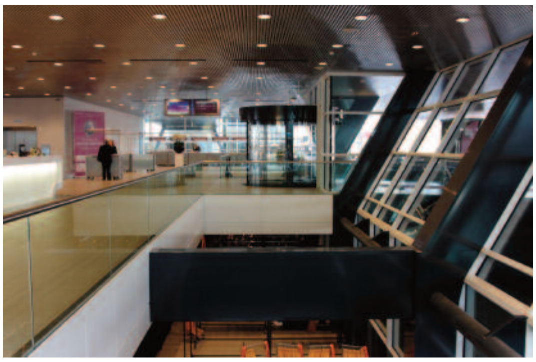
The RAI Exhibition and Congress Centre has been extended with a new building, Elicium (from Elysium, meaning a delightful place). Its lower component, the Expo Foyer or 'Ballroom', hovers 5 metres above street level and is attached to the existing complex on both sides by aerial walkways. This creates a circuit or perimeter walk, transforming the old forecourt into an 'enclosed garden'. Shifted up half a storey alongside the Expo Foyer are five congress halls; these are spatially linked but can be used separately. The Ballroom is a single large column-free space that may be divided up using sliding partitions. A seven-storey stack rises above the congress halls. Elicium puts the RAI in a better position to attract large multi-day international events and gives it a bold new front.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Boolean; Folding
Principal primitive	Parallelepiped	Secondary composition operation(s)	Overturning; Repeat
Additional primitive(s)	None	Main design strategy	Folded surfaces
Form and composition concepts	Balance; Harmony; Linearity; Proportion; Scale; Simplicity	Secondary design strategies	None

For more information, please see <http://www.benthemcrouwel.nl/portal_presentation/public-buildings/elicium-rai>
<http://www.archdaily.com/147339/elicium-rai-benthem-crouwel-architekten/>







EYE Film Museum

Delugan Meissl

Location	Amsterdam	Software	3D Modeling; AutoCAD
Country	Netherlands		
Date from	2009		
Date to	2012	Site Area	3.250
Type	Entertainment structure	Total Area	8.700
		Cubature	60.000
Client	ING – Real Estate	Height	18
		Lenght	130
Context	Urban area	Depht	95

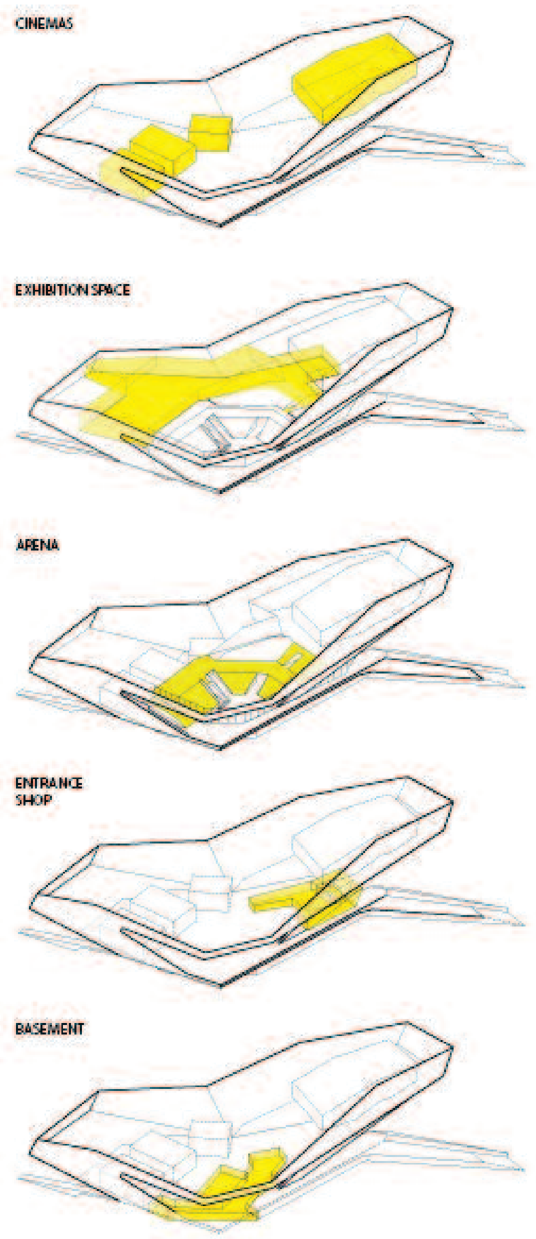
Description

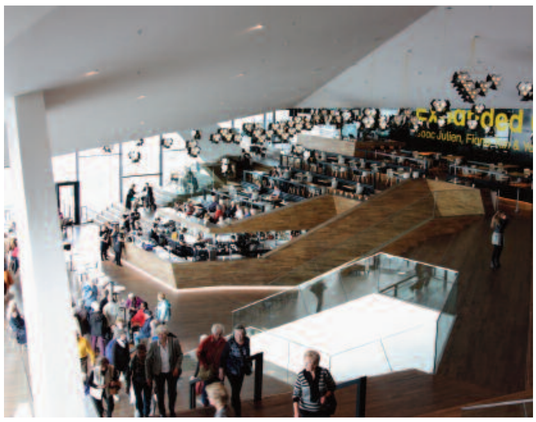
EYE Film Institute Netherlands is situated along the river Ij, opposite the historical part of the city and the Central Station. The building is conceived as a highly tense and dynamic geometric solid. The light is reflected in multiple ways by smooth, crystalline surfaces, thus subjecting the building's appearance to permanent optical changes during the course of the day. Movement and light manifest themselves clearly as essential parameters for the film as a medium in the architectural production. The entrance into the building is characterized by continuous spatial concentration and directed visual relations. Spatial development, light incidence, and materiality define the path that leads from the southern glass front and the museum shop into the heart of the building.

The interior's architectural formulation defines the foyer and arena as central divisors which integrate all path relations into the overall functional concept. Whereas on the south side the building's shell opens fully onto the adjacent river, partly alterable functional zones allow access to the exhibition level, to the projection rooms and restaurant. Flowing transitions between the single functional areas underline the distinctive continuity and the dynamic of the room flow, thus transforming the usage into a physiologically tangible sequence of constantly changing spatial impressions, through variegated atmospheric connections which oscillate between extrovert landscape reference and introverted spatial concentration. Accompanied by these variable perceptions, the perambulation of the building resembles a movie sequence with changeable visual effects.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Stretch; Tilt
Principal primitive	Prism	Secondary composition operation(s)	Boolean; Mesh
Additional primitive(s)	Mesh	Main design strategy	Diagram
Form and composition concepts	Articulation; Asymmetry; Complexity; Obliquity	Secondary design strategies	None

For more information, please see <http://www.dmaa.at/projekte/detail-page/eye-film-institute.html>





Ferrari Museum

Shiro Studio, FutureSystems

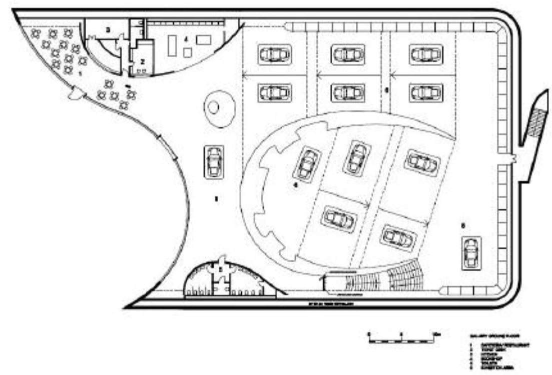
Location	Modena	Software	3D Modeling; AutoCAD
Country	Italy		
Date from	2004		
Date to	2012	Site Area	9.600
Type	Exhibition building	Total Area	5.000
		Cubature	56.250
Client	Enzo Ferrari Foundation	Height	15
		Lenght	75
Context	City center	Depht	50

Description

The Enzo Ferrari Museum in Modena is a building designed by Jan Kaplicky of Future Systems, won in competition in late 2004. Following the untimely passing of Jan Kaplicky in January 2009, Andrea Morgante, a former Associate Director of Future Systems who worked closely with Jan for almost eight years and directed the project from concept to detailed design, was appointed to complete the interiors and oversee the construction which began on site in April 2009. The Enzo Ferrari Museum aims to attract 200,000 visitors every year.
With a budget of €16 million and a total surface area of 5,000 square meters, the Museum comprises of two separate buildings open to visitors; The Enzo Ferrari birthplace, early nineteenth century house that will be meticulously restored to its original condition and a new Gallery, an innovative building that will house an ever-changing collection of racing cars built in Modena, displaying extraordinary makers such as Ferrari and Maserati.
The new Gallery features innovative construction technologies including a three-dimensional curved aluminium roof and an inclined, double-curved structural glass façade. This whilst adopting a wide array of energy-saving solutions such as free-cooling and geothermal energy, here applied to such a large public building in Italy for the first time. The Enzo Ferrari House permanent exhibition has been designed by Shiro Studio.

Geometry Morphology	Both Geometrical	Primary composition operation(s)	Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Bulging; Slicing; Taper
Additional primitive(s)	Parallelepiped	Main design strategy	Artistic Fact
Form and composition concepts	Alignment; Contrast; Gesture; Proportion	Secondary design strategies	Folded surfaces

For more information, please see <http://www.shiro-studio.com/ferrari.php>
<http://www.archdaily.com/253958/enzo-ferrari-museum-future-systems/>



Fiera Milano

Massimiliano Fuksas

Location	Milan	Software	AutoCAD; Rhinoceros
Country	Italy		
Date from	2002		
Date to	2005	Site Area	2.000.000
Type	Exhibition building	Total Area	530.000
		Cubature	
Client	Fondazione Fiera Milano	Height	35
		Lenght	1.500
Context	Urban fringe	Depht	32

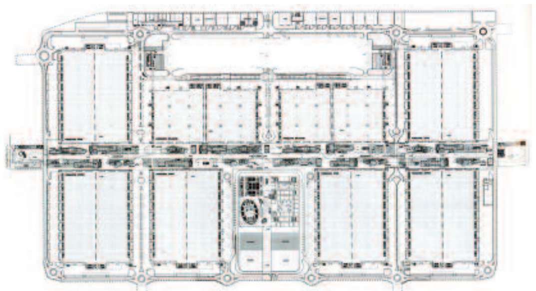
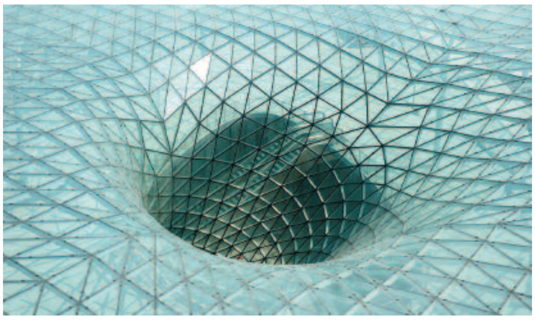
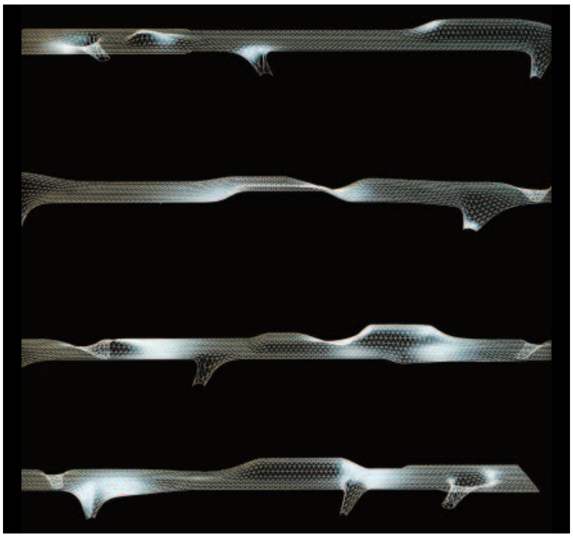
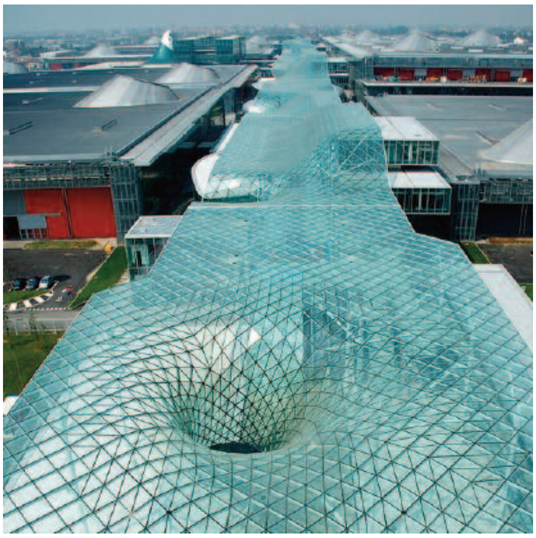
Description

The New Milan Trade Fair is an impressive construction, with a 5-kilometer perimeter and a 1.000.000 mq built surface that rises on a 2.000.000 mq land surface.
The New Trade Fair is made of eight big monoplanar and biplanar pavilions that, together, make a gross expositive surface of about 345.000 mq, plus 60.000 mq outdoors.
The whole route is on two areas, the one of the East entrance and the one of the West entrance. All the accesses and the exits to the Fair are organized through them. The buildings have got different functions (services, snack points, offices, hotel, commercial gallery, receptions of the pavilions, smaller expositive spaces). The placement of the buildings on the central axis is on different surfaces among water pools, green areas and epoxy resin floorings.
Above this spaces there is the big cover named “"Veil". The flow of this veil is made of constant arithmetic variations that refer to natural landscape: “craters”, "waves", "dunes", "hills". This spine (1,500 m in length and 32 m in width) is the symbol of the project: a "spinal column" that covers about 47.000 mq.
This is a construction thought for affairs, but not only. Indeed, the Fair finds its natural prolongation on a structure thought for communication and exchange of ideas: a Congress Centre subdivided into ten rooms (for a total of 2600 seats). Close to the Congress Centre, in the central point of the veil, there is the multifunctional service Centre. Lastly, a 9-hectar park and a green internal route surround the expositive pavilions on North West. Together, they represent a relax area of about 180.000 mq.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding; Mesh
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Align; Repeat; Sliding; Translation
Additional primitive(s)	Parallelepiped	Main design strategy	Folded surfaces
Form and composition concepts	Alignment; Articulation; Axiality; Complexity; Plasticity; Unity	Secondary design strategies	None

For more information, please see <http://www.fuksas.it/home.htm#/progetti/0703/>
<http://www.archdaily.com/248138/new-milan-trade-fair-studio-fuksas/>



Flowing Gardens

Plasmastudio

Location	Xi'an	Software	3D Modeling; Algorithmic Design
Country	China		
Date from	2009		
Date to	2011	Site Area	370.000
Type	Multipurpose building	Total Area	12.500
		Cubature	75.000
Client	Chan Ba Ecological District	Height	10
		Lenght	75
Context	Rural area	Depht	100

Description

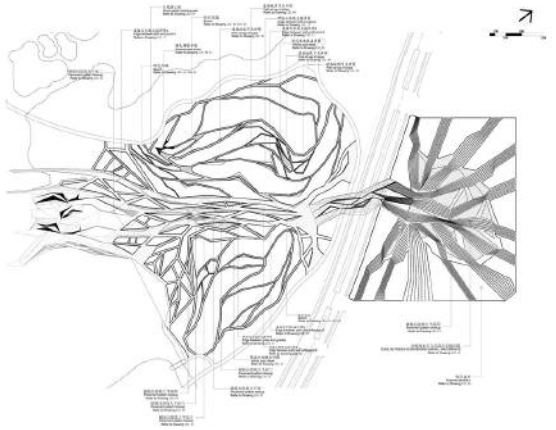
The International Horticultural Expo becomes instigator and core for the redevelopment of a large area between the airport and the ancient city center of Xi'an. Plasma Studio with collaborators GroundLab won this invited international competition with a radical self-sustainable vision for the future: Flowing Gardens creates a consonant functionality of water, planting, circulation and architecture into one seamless system.

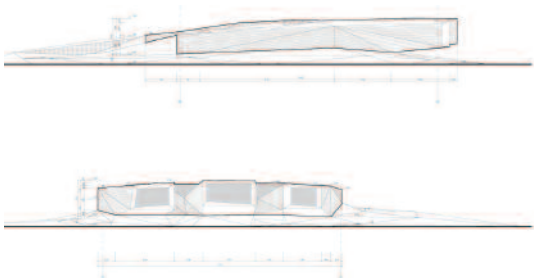
The proposal comprises of a 5000 sqm Exhibition Hall, a 4000 sqm Greenhouse and a 3500 sqm Gate Building sitting in a 37 ha landscape that houses the International Horticultural Expo and a park for Xi'an City as legacy. The Expo opened in 2011, receiving approximately 200,000 visitors a day.

Flowing Gardens unfolds many sinuous paths, creating a network of intermingling circulation, landscape and water. The given topography and its existing slopes were used to digitally draw out the paths in a way similar to how roads ribbon around a mountain, negotiating steepness with gradients. These paths vary in width ranging from main walkways and arteries to towpaths. The patches between these paths become the zones for various planting types and wetland areas, which retain a quality of ease of maintenance. The three projected buildings, located at the intersections of the major pathways are developed as the nodal articulation and intensification of the landscape. The gardens transform the two conditions of artificial and natural into a sustainable system that becomes more and more maintenance-free once the exhibition was over, allowing the park to become a new model, or paradigm, within the horticultural industry.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Mesh
Principal primitive	Mesh	Secondary composition operation(s)	Slicing; Stretch; Tilt
Additional primitive(s)	None	Main design strategy	Flows
Form and composition concepts	Articulation; Axiality; Complexity; Obliquity	Secondary design strategies	Grid

For more information, please see <http://www.plasmastudio.com/>
<http://europaconcorsi.com/projects/167080-Plasma-Studio-Flowing-Gardens>





Frog Queen

Splitterwerk

Location	Graz	Software	Shape grammar
Country	Austria		
Date from	2005		
Date to	2007	Site Area	17.500
Type	Office building	Total Area	1.250
		Cubature	5.500
Client	Prisma Engineering Maschinen	Height	17
	und Motorentechnik GMBH	Lenght	18
Context	Urban fringe	Depht	18

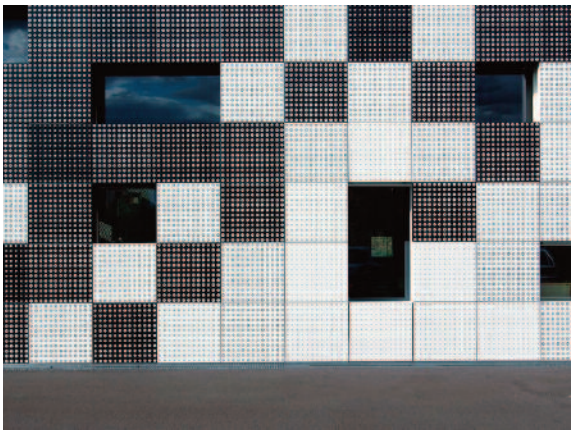
Description

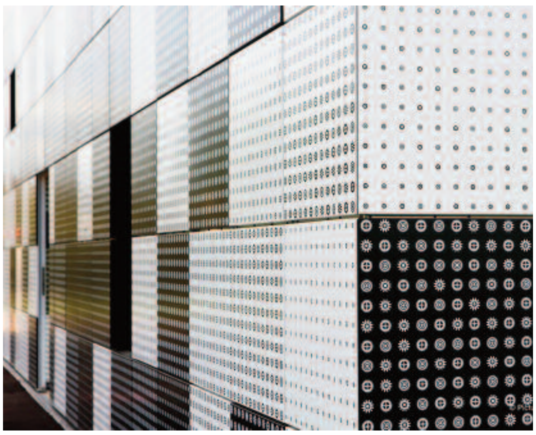
Frog Queen is the headquarters building of PRISMA Engineering, a machine and motor technology company also located in Graz. The goal was to design a structure which could house the company's various research and development programs, and selectively showcase the work to a varied range of often competing clientele.

The building form approximates a cube, measuring 18.125 x 18.125 x 17m, wrapped on all four elevations with a pixelated pattern of square panels. From a distance, these panels appear to be painted in a range of ten values of grey tone, together dematerializing the volume of the building against both the trees of the surrounding site and the clouds and sky. Thus the cubic building is at once monumental in its objecthood in the open landscape – scaleless and immaterial – and yet utterly non-iconographic in its overall form. As is characteristic of their work, SPLITTERWERK was interested in developing a play between pictorial image and spatial experience. Working with the effects of dimension, distance, and time, the building's skin was designed to generate shifting perceptions of the volume and texture. Each façade panel is itself nearly square and made of powder-coated aluminium, screen-printed with the various images. At the interior, individual office spaces are wallpapered with images of the surrounding Eastern Styrian landscape, creating a conceptual tension between the interior of the building envelope (narrative and pictorial) and the visual effects of its exterior panels (abstract and spatial).

Geometry	Rectilinear	Primary composition operation(s)	Repeat
Morphology	Geometrical		
Principal primitive	Cube	Secondary composition operation(s)	Boolean
Additional primitive(s)	None	Main design strategy	Pattern
Form and composition concepts	Articulation; Harmony; Rythm; Simplicity; Unity	Secondary design strategies	None

For more information, please see <http://www.splitterwerk.at/database/>
<http://www.archdaily.com/38910/frog-queen-splitterwerk/>





Guggenheim Museum

Frank O. Gehry

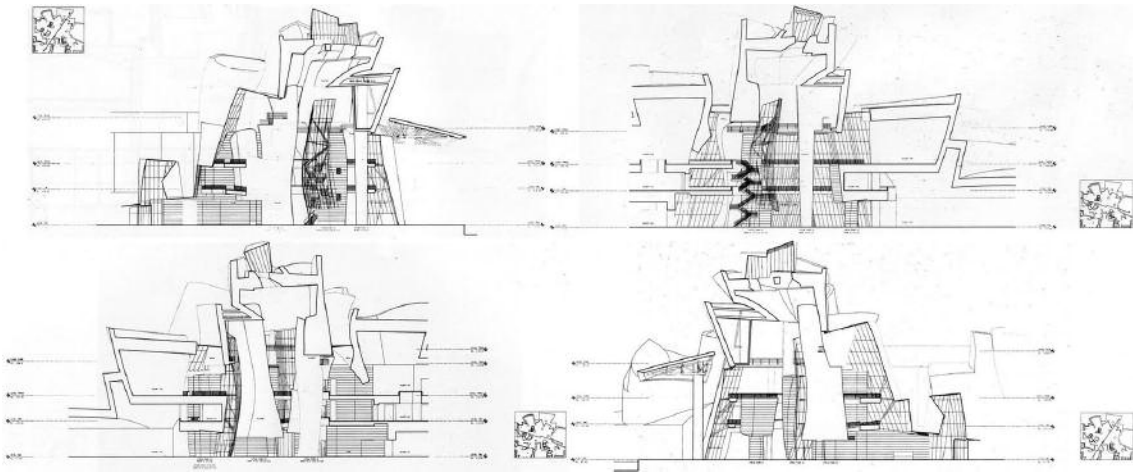
Location	Bilbao	Software	AutoCAD; Catia; Reverse Modeling
Country	Spain		
Date from	1990		
Date to	1997	Site Area	58.300
Type	Exhibition building	Total Area	24.000
		Cubature	640.000
Client	Solomon R. Guggenheim Foundation	Height	40
		Lenght	200
Context	Inner city	Depht	80

Description

Along the Nervión River in Bilbao, the Guggenheim Museum is a fusion of complex, swirling forms and captivating materiality that responds to an intricate program and an industrial urban context. Gehry’s museum not only changed the way of thinking about museums, but also boosted Bilbao’s economy with its astounding success. In fact, the phenomenon of a city's transformation following its construction is now referred to as the "Bilbao Effect". In 1991, the Basque government proposed to the Guggenheim Foundation to build a museum in a dilapidated port area, once the city's main source of income.
The building alludes to the landscape: although the metallic form of the exterior looks almost floral from above, from the ground the building more closely resembles a boat, evoking the past industrial life of the port of Bilbao. Constructed of titanium, limestone, and glass, the seemingly random curves of the exterior are designed to catch the light and react to the sun and the weather. Because of their mathematical intricacy, the twisting curves were designed using CATIA software. Essentially, the software digitizes points on the edges, surfaces, and intersections of Gehry's hand-built models (reverse modelling). The large, light-filled atrium serves as the organizing centre of the museum, distributing 11,000 sqm of exhibition space over nineteen galleries. Ten of these galleries follow a classic orthogonal plan that can be identified from the exterior by a limestone finish. The remaining nine galleries are identified from the outside by swirling organic forms clad in titanium.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding; Tilt
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Boolean; Break
Additional primitive(s)	Parallelepiped	Main design strategy	Artistic Fact
Form and composition concepts	Articulation; Contrast; Deconstruction; Monumentality; Plasticity	Secondary design strategies	Deconstruction

For more information, please see <http://www.foga.com/>
<http://www.archdaily.com/422470/ad-classics-the-guggenheim-museum-bilbao-frank-gehry/>



H2O Pavilion

NOX Lars Spuybroek

Location	Neltjie Jans Island	Software	3D Modeling; Algorithmic Design
Country	Netherlands		
Date from	1994		
Date to	1997	Site Area	2.100
Type	Exhibition building	Total Area	720
		Cubature	4.230
Client	Waterland bv Neeltje Jans	Height	6
		Lenght	60
Context	Rural area	Depht	12

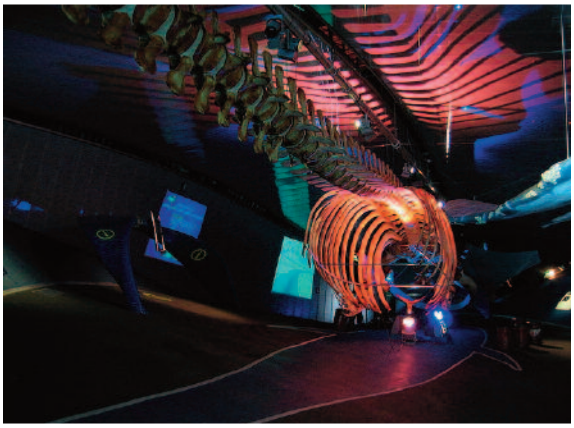
Description

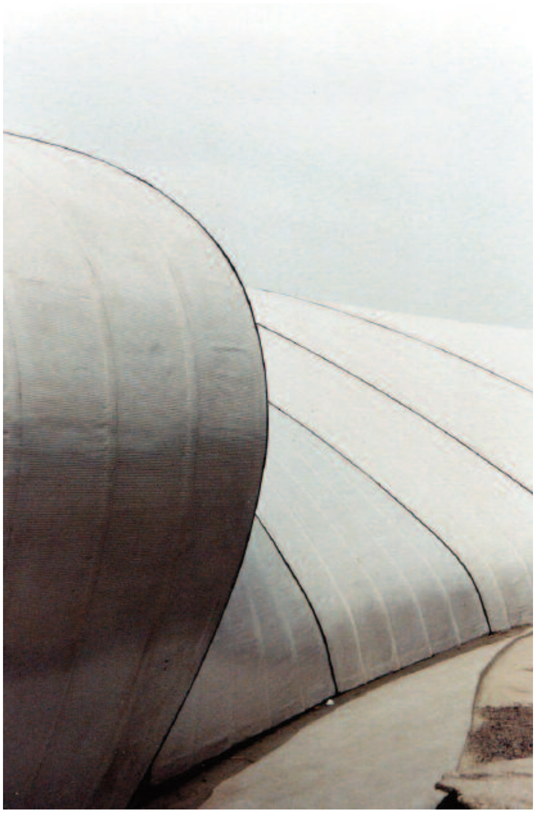
The water pavilion is the first of its kind to combine an innovative interactive interior involving all the senses with a continuous geometry. The design, which has received high international acclaim for introducing a completely new language of form, is one where floors transform into walls and walls into ceilings. The inbuilt exhibition is partly based on existing water technologies like the freezing of a wall, the spraying of mist, artificial rainfall, jumping jets of water and partly on very innovative real-time electronic interactions. The building contains a wide range of sensors through which visitors can change the sound, light and projections that completely alter the atmosphere of the interior.

The design was based on the metastable aggregation of architecture and information, it was intended to be a space in which visitors are allowed to flow freely, like water molecules.. The form itself is shaped by the fluid deformation of fourteen ellipses spaced out over a length of more than 65 meters. Inside the building, which has no horizontal floors and no external relation to the horizon, walking becomes akin to falling. The deformation of the object extends to the constant metamorphosis of the environment which responds interactively to the visitors to the water pavilion via a variety of sensors that register this constant reshaping of the human body called action.

Geometry	Curvilinear	Primary composition operation(s)	Bulging; Folding
Morphology	Biomorphic		
Principal primitive	Free-form solid	Secondary composition operation(s)	Boolean; Loft; Sweep
Additional primitive(s)	None	Main design strategy	Fluidity
Form and composition concepts	Complexity; Gesture; Plasticity; Unity	Secondary design strategies	Blob

For more information, please see <http://www.nox-art-architecture.com/>





Holocaust Memorial

Peter Eisenman

Location	Berlin	Software	3D Modeling; AutoCAD
Country	Germany		
Date from	1999		
Date to	2003	Site Area	19.000
Type	Monument	Total Area	19.000
		Cubature	1.220.760
Client	Germany Bundestag	Height	4
		Lenght	180
Context	Inner city	Depht	150

Description

The Holocaust Memorial is a memorial in Berlin to the Jewish victims of the Holocaust. It consists of a 19,000 sqm site covered with 2,711 concrete slabs or "stelae", arranged in a grid pattern on a sloping field. The stelae are 2.38 m long, 0.95 m wide and vary in height from 0.2 to 4.8 m. According to Eisenman's project text, the stelae are designed to produce an uneasy, confusing atmosphere, and the whole sculpture aims to represent a supposedly ordered system that has lost touch with human reason. The design represents a radical approach to the traditional concept of a memorial, partly because Eisenman did not use any symbolism, but with strong resemblance to a cemetery.

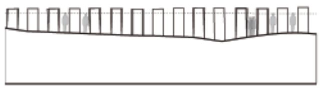
It is located one block south of the Brandenburg Gate, in the Friedrichstadt neighborhood. In April 1994 a competition for its design was announced in Germany's major newspapers. The winning proposal was to be selected by a jury consisting of representatives from the fields of art, architecture, urban design, history, politics and administration. Peter Eisenman and the artist Richard Serra collaborated on a plan that emerged as the winner of the next competition in November 1997. Richard Serra, however, quit the design team soon after, citing personal and professional reasons. On June 25, 1999, a large majority of the Bundestag decided in favor of Eisenman's plan, modified by attaching a museum, or "place of information," designed by Berlin-based exhibition designer Dagmar von Wilcken.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Extrusion; Repeat
Principal primitive	Parallelepiped	Secondary composition operation(s)	Folding
Additional primitive(s)	NURBS Surfaces	Main design strategy	Grid
Form and composition concepts	Alignment; Deconstruction; Proportion; Rythm	Secondary design strategies	Diagram

For more information, please see <http://www.eisenmanarchitects.com/>

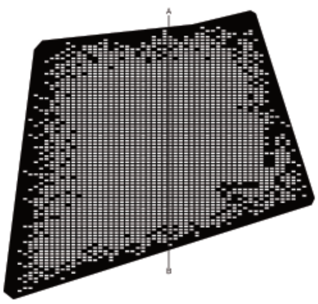
Site Plan with Grid

Section

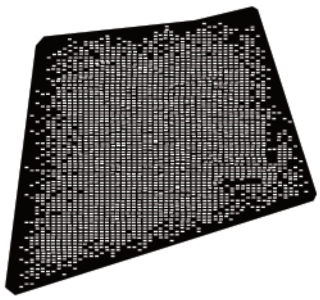


Section Detail

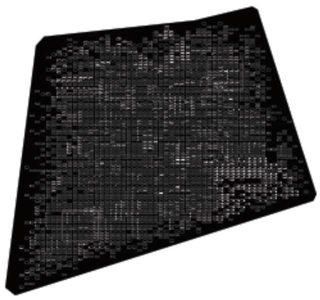
Plan Details



Base Plan of Modules



Top Plan of Modules



Merged Plans

Hydra Pier Pavilion

Asymptote

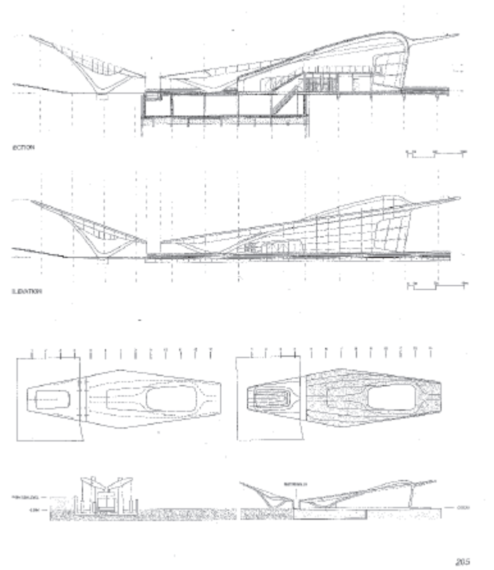
Location	Harlemeer	Software	3D Modeling
Country	Netherlands		
Date from	2001		
Date to	2002	Site Area	900
Type	Exhibition building	Total Area	1.250
		Cubature	11.040
Client	Municipality of Haarlemmer-meer	Height	6
		Lenght	80
Context	Industrial Area	Depht	23

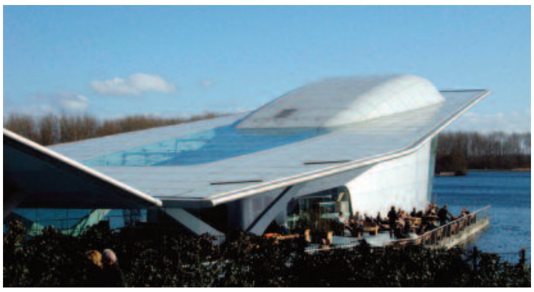
Description

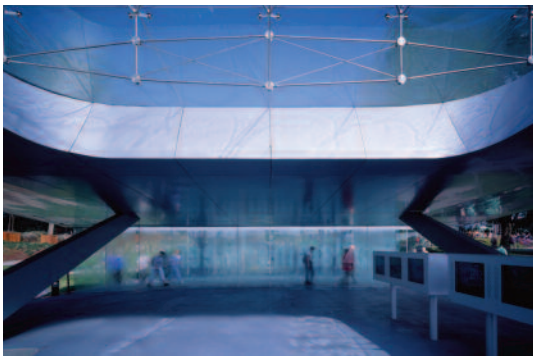
The HydraPier Pavilion was built in 2002 as the winning project in an international competition for the main municipal pavilion of the Floriade International Exposition. Asymptote's design for the HydraPier was inspired by an interest in the contradictory nature of its situation and site that was at once a pastoral landscaped setting while located directly beneath the flight path at nearby Schiphol Airport. The solution was an architecture that incorporated both strong material and formal aspects derived from aerospace technologies as well as inspiration drawn from the surrounding 'Dutch' manicured landscape. The HydraPier appears to be jutting out into the polder on which it is sited and has become an icon and symbol for the city of Haarlemmermeer Bos, where the predominate architectural presence throughout the area are pavilions that bridge the land and water.
The building is comprised of two wings like roof structures that are supported in the center by glass walls activated by cascading water that flows from the inclined roof planes onto the glass walls. In the interior a multimedia exhibition space looks out towards water and the landscape in the horizon. From the vantage point of the shore, the shimmering pavilion with its two converging roof planes forms a striking floating silhouette. The architecture of the HydraPier melds technological imagery with water and nature to achieve a unique and powerful architectural statement set within a picturesque Dutch landscape.

Geometry Morphology	Both Geometrical	Primary composition operation(s)	Bulging; Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Boolean; Extrusion
Additional primitive(s)	Prism	Main design strategy	Fluidity
Form and composition concepts	Balance; Horizontality; Obliquity; Plasticity; Simmetry	Secondary design strategies	Artistic Fact; Folded surfaces

For more information, please see <http://www.asymptote.net/#!hydr-slide-show/cvgi>







ING House

MVSA

Location	Amsterdam	Software	AutoCAD; Performance-based design
Country	Netherlands		
Date from	1997		
Date to	2002	Site Area	5.600
Type	Office building	Total Area	20.000
		Cubature	140.400
Client	ING Blauwhoed VOF	Height	52
		Lenght	136
Context	Central business district	Depht	28

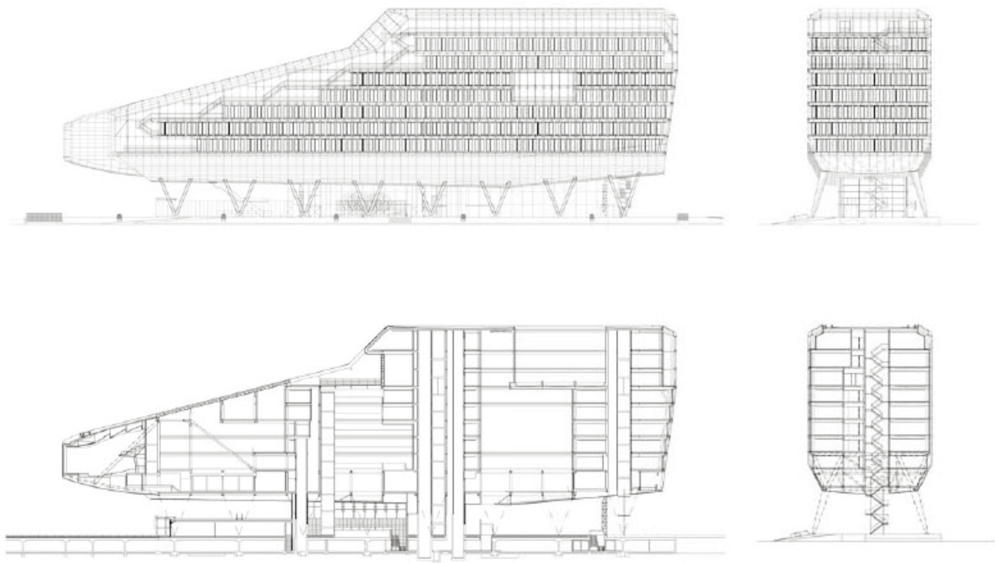
Description

The headquarter offices for the ING Group occupies a long, narrow site adjacent to the motorway ring around Amsterdam. The location is at the junction of two areas, the cosmopolitan high-rise of Zuidas and the green zone of De Nieuwe Meer. The building has been kept low on the green side, with the cantilevered auditorium as a projecting element, and rises towards the urban side. The building rests on stilts, so that travellers on the motorway still have a glimpse of the area behind the building. This arrangement also means that none of the offices in the building have their view blocked by the motorway embankment. The entrance zone is ensconced between the stilts.

The new headquarters symbolizes the banking and insurance conglomerate as a dynamic, fast-moving international network. Transparency, innovation, eco-friendliness and openness were the main starting points for the design. The building has an innovative interior environment control system. The double-skin facade, design through specific software, allows natural ventilation of the offices without admitting traffic noise. An advanced air treatment system and the use of an aquifer under the building and a mechanical pumping system to provide cold/warm thermal storage make this building energy-efficient. The atmosphere of the interior is richly varied and features an alternation of open and sheltered spaces. Areas with a panoramic view, such as the restaurant, the large conference room and the auditorium, exist alongside introverted spaces. Atriums, loggias, and gardens, both internal and external, are distributed through the building at various levels.

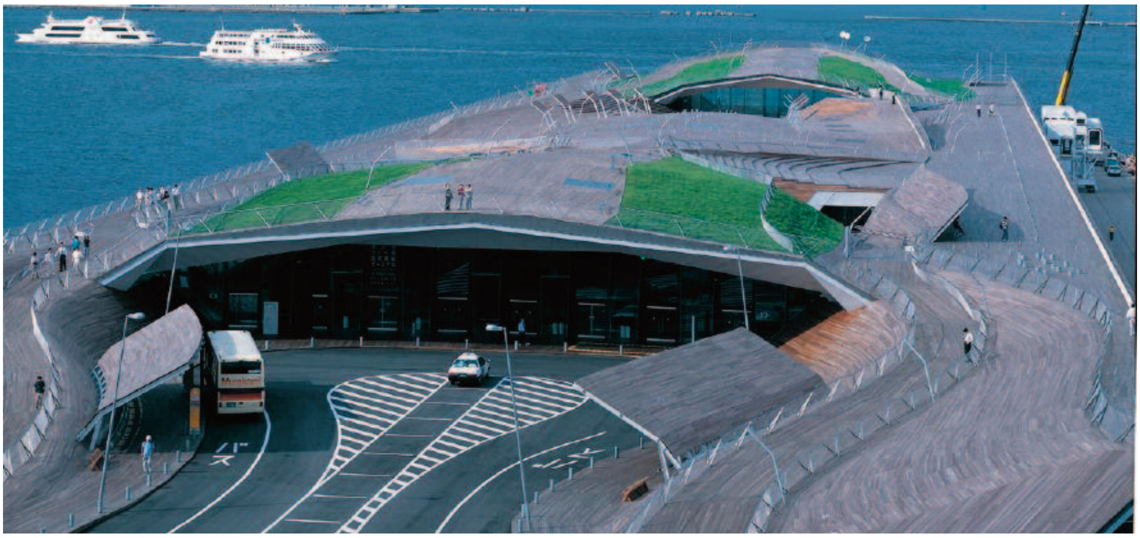
Geometry Morphology	Both Geometrical	Primary composition operation(s)	Extrusion; Folding; Tilt
Principal primitive	Geometrical	Secondary composition operation(s)	Boolean
Additional primitive(s)	None	Main design strategy	Performance optimization
Form and composition concepts	Alignment; Complexity; Horizontality; Monumentality; Obliquity; Simmetry	Secondary design strategies	None

For more information, please see <http://www.mvsa-architects.com/project/detail/4/ing-house>



International Port Terminal

Foreign Office Architects



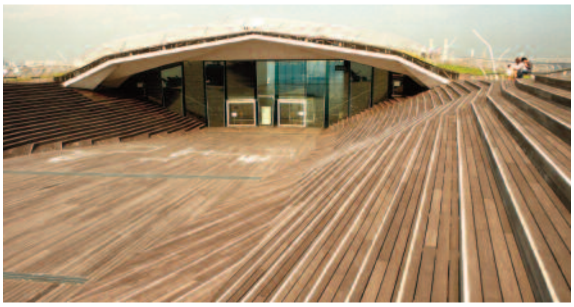
Location	Yokohama	Software	3D Modeling; AutoCAD
Country	Japan		
Date from	1995		
Date to	2002	Site Area	30.100
Type	Transportation structures	Total Area	438.243
		Cubature	1.314.729
Client	Port and Harbour Authority,	Height	15
	City of Yokohama	Lenght	430
Context	Inner city	Depht	70

Description

The Yokohama International Ferry Terminal is a new type of transportation space integrated with urban facilities. Rather than conceiving of the building as an object on the pier, detached from its context, it is designed as an extension of the pier ground, simultaneously hosting the terminal functions and creating a very large urban park on the roof of the terminal.
To ensure maximum urban life throughout the terminal, the building is organised around a circulation system which challenges both the linear structure characteristic of piers, and the directionality of the circulation, using a series of programmatically-specific interlocking circulation loops designed to produce an uninterrupted and multi-directional space, rather than a conventional gateway to flows of fixed orientation.
It is constructed as a systematic transformation of the lines of the circulation diagram into a folded and bifurcated surface which hosts the alternative program. In order to maximise flexibility, a unique structural system is designed as an integral part of the folded surface, avoiding interruptions due to vertical structure. A hybrid structural system of steel trussed folded plate and concrete girders allows the structural system to be coincident with the diagonal folded surface, especially adequate in coping with the lateral forces generated by the seismic movements which characterise Japanese geography. The tectonic system of the folded surface maximises the cruise terminal's flexibility - both hybridising the circulation, program and structural system and exploiting their differences to produce spatial variety.

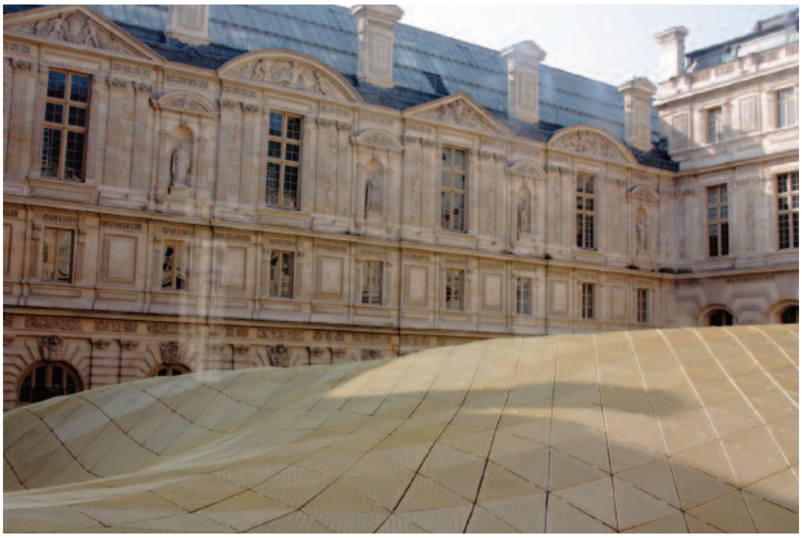
Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Boolean; Slicing; Smooth
Additional primitive(s)	Parallelepiped	Main design strategy	Folded surfaces
Form and composition concepts	Articulation; Balance; Complexity; Deconstruction; Plasticity	Secondary design strategies	Fluidity

For more information, please see <http://azpml.com/>, <http://www.farshidmoussavi.com/flash/index.html> <http://www.arcspace.com/features/foreign-office-architects/yokohama-international-port-terminal/>



Islamic Arts in Louvre Museum

Mario Bellini Architects & Rudy Ricciotti



Location	Paris	Software	3D Modeling; AutoCAD; Rhinoceros
Country	France		
Date from	2005		
Date to	2012	Site Area	3.400
Type	Exhibition building	Total Area	6.800
		Cubature	40.800
Client	Musée du Louvre	Height	12
		Lenght	52
Context	Inner city	Depht	40

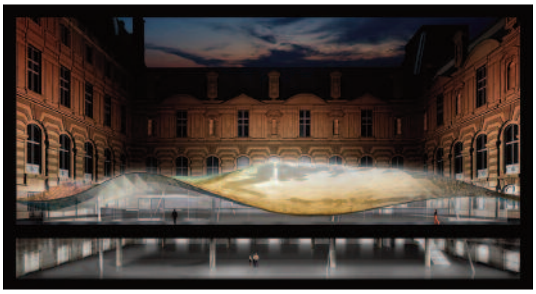
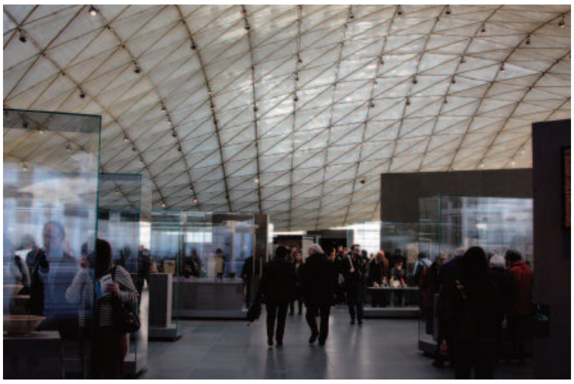
Description

"The Cour Visconti will not be covered but will, in fact, remain visible'': this is the architectural decision declared by the architects Mario Bellini and Rudy Ricciotti in order to achieve a "gentle and non-violent integration" of a decidedly contemporary architectural design within a historical place. The collections is displayed over an area of roughly 3,500 sqm, subdivided in two levels. The first, at courtyard level, houses works from the 7th to the 10th centuries while the second, in the basement, exhibits works from the 11th to the 19th centuries along with the prestigious collection of carpets. The new museum areas is covered by an "Iridescent Cloud" which, emanating a diffused glow, floats airily over the museum exhibition space. Thanks to this "luminescent covering" it is possible from inside the new museum area to see the facades of the courtyard outside. From inside the exhibition rooms, the visitor is able to admire the play of folds and undulations in the covering which add a poetic dimension to the overall effect.

Natural light is diffused by the covering "Veil", the iridescent skin of which is treated so as to graduate the intensity and avoid glare. In high summer, the level of light in the exhibition spaces don't exceed the lux level required for the proper conservation of the artifacts on display and the comfort of visitors. On the lower level, it is possible to catch a glimpse of the "Veil" from a number of points thanks to openings in the floor above along the perimeter of the courtyard, thus confirming the "Veil" in its role as unifying element between the collections.

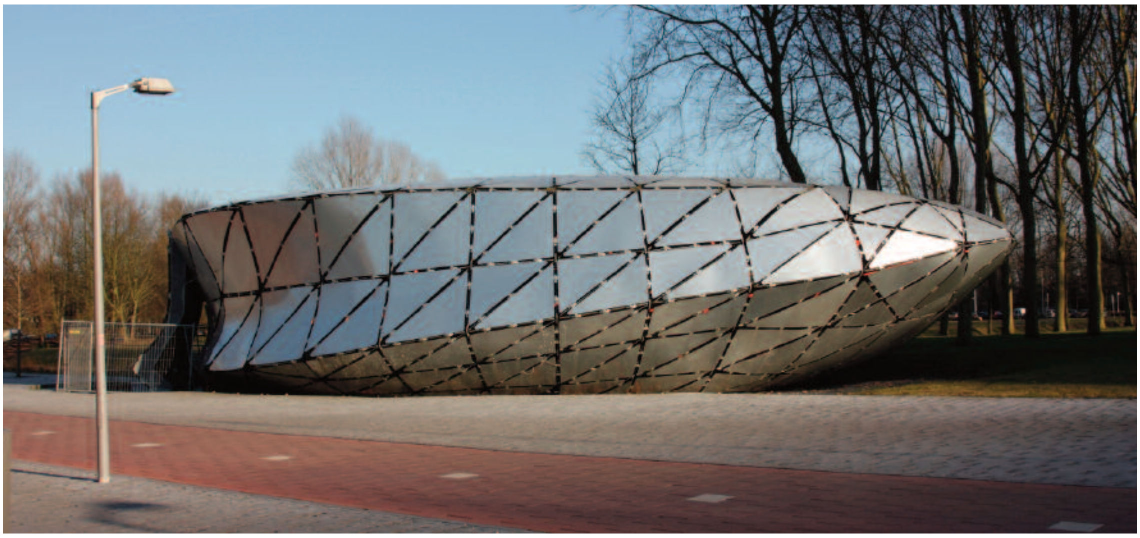
Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Mesh
Additional primitive(s)	None	Main design strategy	Folded surfaces
Form and composition concepts	Articulation; Contrast; Gesture; Plasticity; Simplicity; Unity	Secondary design strategies	Artistic Fact

For more information, please see <www.bellini.it/architecture/Louvre.html>
<http://www.louvre.fr/en/opening-new-department-islamic-art/architecture>


iWEB

ONL (Oosterhuis-Lénard)



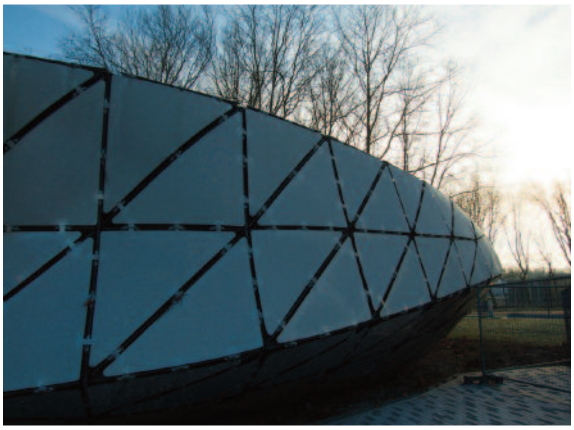
Location	Delft	Software	AutoCAD; Parametric Design
Country	Netherlands		
Date from	2002		
Date to	2002	Site Area	2.500
Type	Temporary Pavilion	Total Area	60
		Cubature	300
Client	Floriade World Exhibition / TU Delft	Height	5
		Lenght	6
Context	Urban fringe	Depht	10

Description

The spaceship the WEB of North-Holland, as designed by architect's studio ONL, entered the world stage at the Floriade World Exhibition in 2002. The WEB of North-Holland has been disassembled and renamed the iWEB and is scheduled to make a soft landing at the Mekelweg in front of the Faculty of Architecture of TU Delft by the end of the lustrum year 2005.
The iWEB is designed to become a transfacultary server to host Protospace, the augmented design studio for Collaborative Design and Engineering in Real Time. Its environment is based on the principles of Swarm Behavior, that is applied to all objects and players in the collaborative design game. Swarm Behavior forms the dynamic basis for all communication between people and objects in the interactive design worlds. Working in Protospace means working in an augmented reality environment, where changes in the design are calculated and evaluated in real time. It allows the players to explore alternatives in their own disciplinary field very quickly, and it immediate informs the other players on the validity of their alternatives.
The players are given the most natural ways to communicate with the design game: speech recognition, hand movements or simply moving around in the playing field. A step forward in the playing would trigger a pressure pad and bring the player forward in the design environment. The player can use speech to toggle on or off certain aspects of the design worlds like gravity active or inactive, surroundings hidden or revealed, graphic representation with or without icons, abstract or concrete representation of the proposed building volumes.

Geometry	Curvilinear	Primary composition operation(s)	Folding
Morphology	Geometrical		
Principal primitive	Free-form solid	Secondary composition operation(s)	Bulging; Mesh; Retract
Additional primitive(s)	None	Main design strategy	Blob
Form and composition concepts	Complexity; Gesture; Plasticity; Unity	Secondary design strategies	Flows; Mathematical derivation

For more information, please see <www.oosterhuis.nl/quickstart/index.php>



Kunsthaus

Peter Cook & Colin Fournier

Location	Graz	Software	Shape grammar
Country	Austria		
Date from	2000		
Date to	2003	Site Area	2.930
Type	Exhibition building	Total Area	13.100
		Cubature	55.650
Client	Graz Municipality	Height	25
		Lenght	53
Context	Old town	Depht	42

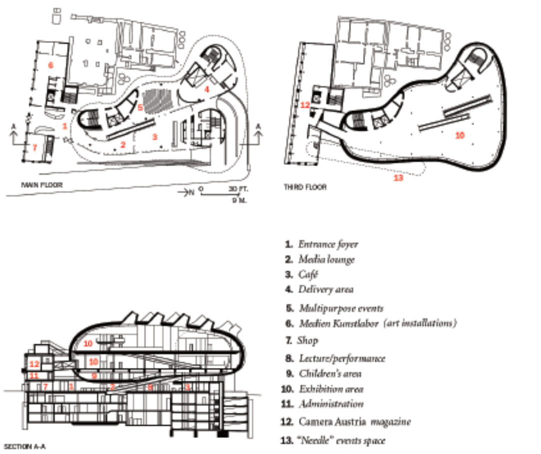
Description

Designed on the occasion of the European Cultural Capital 2003 and placed on the banks of the river Mur, on the corner of the Südtirolerplatz and the Lendkai, the building has been conceived to be a new architectural landmark. The designers created an impressive synthesis which unites their innovative design language with the historic setting of this urban district along the Mur. The aesthetic dialogue between the new biomorphic structure, the 'friendly alien', on the bank of the Mur and the old clock tower on Graz's famous Schloßberg (Castle Hill) is the trade-mark of a city aiming to create a productive tension between tradition and avant-garde. In content as well as from an urbanistic point of view, the museum acts as an interface between past and future.

Functionally and technically, its 11,100 sqm of usable space provide everything its managers need to participate in the global exhibition business on the highest level. An innovative and cost-effective air-conditioning system meets all the demands of the most important art owners. A big delivery area, depots and workshops, and modern lighting and security systems are available to ensure the professional handling of exhibition projects. The underground car park offers space for 146 vehicles. As a multi-disciplinary venue for exhibitions, events and other means of presenting contemporary art, new media, and photography, the Kunsthaus Graz has a complex palette of features and functions. While the building's interior is meant to inspire its curators as black box of hidden tricks, its outer skin is a media façade which can be changed electronically.

Geometry	Curvilinear	Primary composition operation(s)	Folding; Smooth
Morphology	Biomorphic		
Principal primitive	Free-form solid	Secondary composition operation(s)	Boolean; Mesh
Additional primitive(s)	Parallelepiped	Main design strategy	Blob
Form and composition concepts	Complexity; Gesture; Monumentality; Plasticity; Unity	Secondary design strategies	None

For more information, please see <http://www.museum-joanneum.at/de/kunsthaus>



Leonardo Glass Cube

3Deluxe Graphics

Location	Bad Driburg	Software	Shape grammar
Country	Germany		
Date from	2004		
Date to	2007	Site Area	6.400
Type	Commercial building	Total Area	2.800
		Cubature	9.600
Client	Leonardo Glass GMBH	Height	6
		Lenght	40
Context	Industrial Area	Depht	40

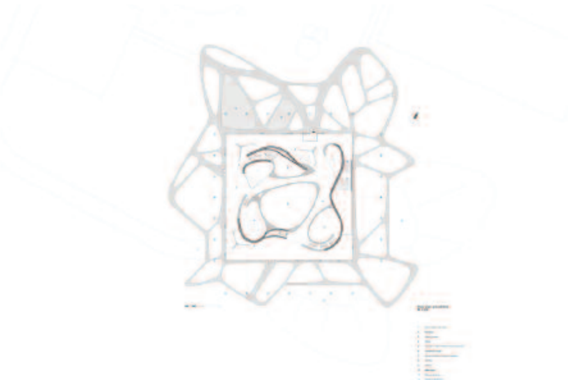
Description

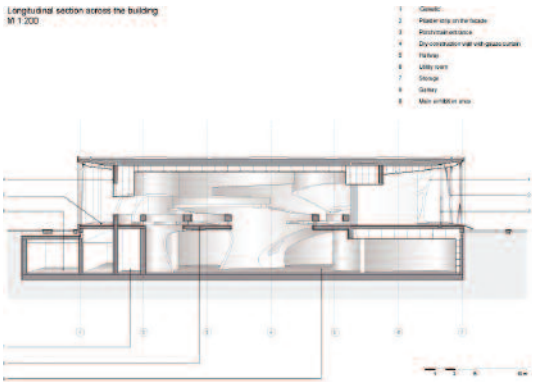
The Leonardo Glass Cube is the headquarte building for the Westfalian company who distributes glass 'Leonardo'. A significant corporate architecture was created that now forms a central element in the brand's overall communicative presence. The Leonardo Glass Cube conveys to guests and the staff alike the company's philosophy and visions in an inspiring manner.

The open floor plan layout of the clearly designed and multi-functional Leonardo building enables an integrative linkage of product presentation zones, seminar and meeting rooms, inspiring work areas and a lot more besides across a total area of 1,200 sqm. The edificial structure consists of two formally contrasting elements: A geometrically stringent, cube-like shell volume and a freeform positioned centrally in the interior. The undulating, curved white wall encases an introverted exhibition space and its other side circumscribes the extroverted hallway along the glass façade. Three white sculptural structures – so-called 'Genetics' – connect the separate zones of the building to each other again. On the glass façade 'Genetics' appear again in a two-dimensional version. The superimposed pilaster strips are continued in a network of white concrete pathways that surrounds the entire building and lets it grow together with its location. In the centre of the interior ground floor and basement are connected by a void crossed by bridges. Entering the Glass Cube through the ground-floor main entrance, visitors encounter a space that opens up not just horizontally, but also upwards and downwards.

Geometry	Rectilinear	Primary composition operation(s)	Boolean
Morphology	Geometrical		
Principal primitive	Parallelepiped	Secondary composition operation(s)	Extrusion; Sweep
Additional primitive(s)	Solid of extrusion	Main design strategy	Fluidity
Form and composition concepts	Balance; Contrast; Horizontality; Linearity	Secondary design strategies	Grid

For more information, please see <http://www.3deluxe.de/>
<http://www.archilovers.com/p5549/Leonardo-Glass-Cube>





Liwa Tower

ONL (Oosterhuis-Lénard)

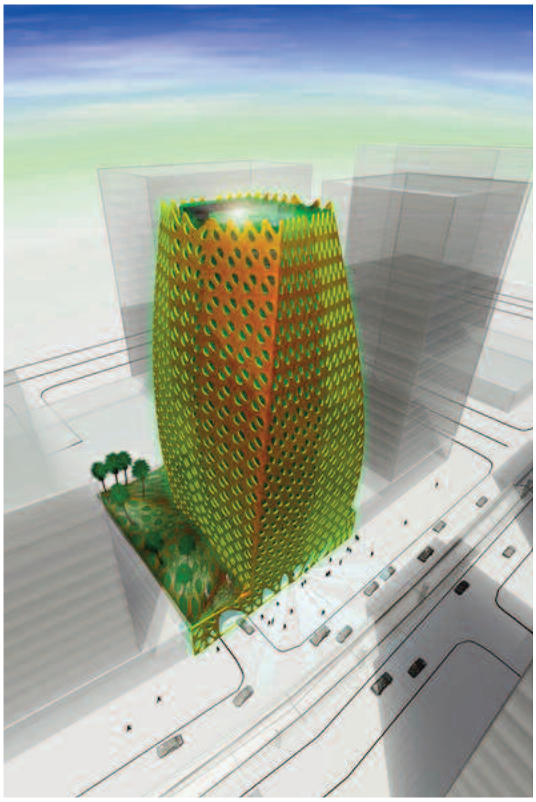
Location	Abu Dhabi	Software	Grasshopper; Parametric Design
Country	UAE		
Date from	2008		
Date to	2011	Site Area	2.500
Type	Office building	Total Area	21.700
		Cubature	70.000
Client	Al Nasser Investment LLC	Height	70
		Lenght	30
Context	Central business district	Depht	30

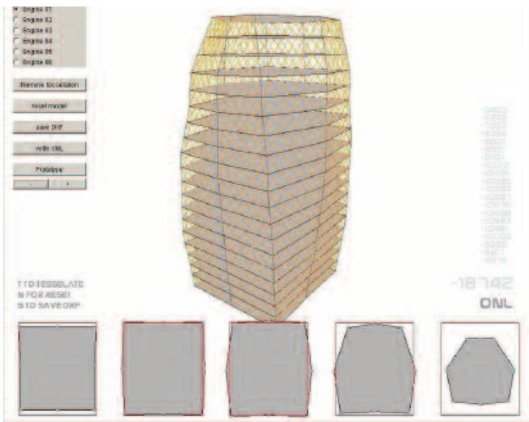
Description

The Liwa Tower or Al Nasser Headquarters forms our latest milestone in corporate office design in the United Arab Emirates. The brief was as simple as it was clear, to create the maximum allowed GFA within the pre-defined urban envelop and a fixed budget. These contextual constraints form a challenge in maximising the required office space and creating the characteristic architectural appearance within the strict limitations of the client's budget.
By using a state of the art design process designers were able to create an architectural freedom of expression that integrates architecture, structure and decoration into one coherent design attitude. The elegantly shaped curvature of the tower gives it a different expression from every angle you look at the building. The structural logic is expressed in the architecture and becomes a feature in the interior. The decorative patterns of the façade are the architectural translation of the base surfaces. This integrated approach forms the basis for the marriage of efficiency and architectural aesthetics.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Extrusion; Stretch
Principal primitive	Parallelepiped	Secondary composition operation(s)	Bulging; Divide; Mesh
Additional primitive(s)	None	Main design strategy	Grid
Form and composition concepts	Alignment; Gesture; Monumentality; Rythm; Verticality	Secondary design strategies	Pattern

For more information, please see <www.oosterhuis.nl/quickstart/index.php>





Maison Folie

NOX Lars Spuybroekv

Location	Lille	Software	Rhinoceros
Country	France		
Date from	2001		
Date to	2004	Site Area	756
Type	Recreation structure	Total Area	5.000
		Cubature	9.072
Client	Minicipality of Lille	Height	12
		Lenght	42
Context	Inner city	Depht	18

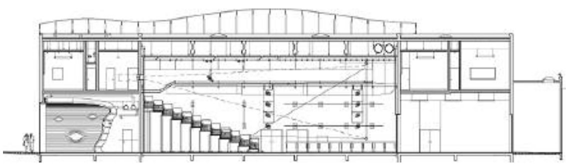
Description

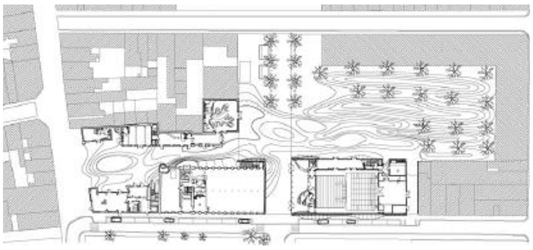
The project is half a renovation of an old textile factory into various art related functions (exhibition spaces, artist-in-residence homes) with clubs, Turkish baths and small restaurants, and half a newly constructed building which is a theater with foyer and sound studios, in a form that keeps to the historic urban fabric surrounding. To make the building communicate its activities, it is draped in an undulating stainless-steel skin that responds to artificial as well as natural light conditions. Both buildings are connected by a 'mineral landscape' that operates as a platform for smaller neighborhood activities.

The social exchanges, the interaction between programmatic elements is stimulated by an architecture of continuity, an uninterrupted connective surface, connecting the several areas and their related functions. Designer has incorporated all these functions within one undulating landscape, a mineral garden, that includes patches of smaller green gardens, either private or public. The landscape makes everything interact more easily, and feeds activity to activity. Since Wazemmes is a damaged area, NOX decided to finish the street with a façade: the black box glows externally with a luminous skin which transforms with movement in and around the Maison Folie. This glowing, almost holographic dress incorporates all the pulsations of art and life. The articulation of the façade is generated through a continuous variation and modulation of the vertical tectonics of the façade of the old factory: bending vertical lines in a complex pattern that produce a whole range of effects when walking or driving by.

Geometry	Curvilinear	Primary composition operation(s)	Bulging; Folding
Morphology	Real-object Morphology		
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Retract; Smooth
Additional primitive(s)	Parallelepiped	Main design strategy	Blob
Form and composition concepts	Alignment; Contrast; Gesture; Plasticity; Unity	Secondary design strategies	Artistic Fact; Fluidity

For more information, please see <http://www.nox-art-architecture.com/>
<http://architettura.it/architetture/20040330/>





Maxxi

Zaha Hadid

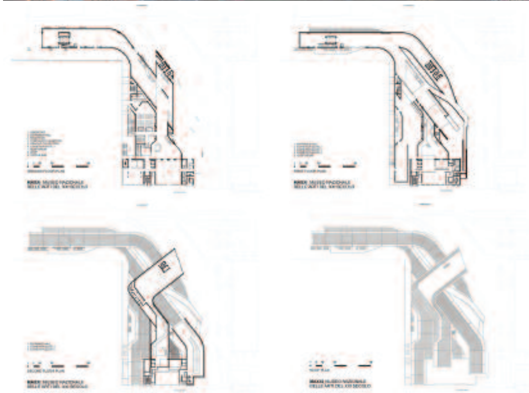
Location	Rome	Software	Maya; Rhinoceros
Country	Italy		
Date from	1998		
Date to	2010	Site Area	129.000
Type	Exhibition building	Total Area	19.640
		Cubature	113.000
Client	Italian Cultural Ministery	Height	23
		Lenght	63
Context	City center	Depht	130

Description

MAXXI, the first Italian public museum devoted to contemporary creativity, arts and architecture provides not only an arena in which to exhibit art, but a research 'hothouse' - a space where contemporary languages of design, fashion, cinema, art and architecture can meet in new dialogue. MAXXI supercedes the notion of museum as 'object' or fixed entity, presenting instead 'a field of buildings' accessible to all, with no firm boundary between what is 'within' and what 'without'. Central to this new reality - its primary force - is a confluence of lines - walls that constantly intersect and separate to create indoor and outdoor spaces.
The museum integrates itself with its surrounds, re-interpretation urban grids to generate its own geometric complexity. Through the flow of its walls it defines major streams - the galleries - and minor streams - interconnections and bridges, delighting in a peculiar L-shape footprint which in this context becomes 'liberation' - a freedom to bundle, twist and turn through existing buildings. In this very meandering MAXXI both draws on and feeds the cultural vitality of its mother city.
The building flanks a large high-reaching lobby, from which access to all galleries, auditoria, cafeteria, shops and services are provided. Movement from this point beyond MAXXI's containing walls are via a pedestrian walkway which shadows the building's contours, re-establishing an urban link obscured for over a century. The building expresses itself through glass, steel and cement - delighting in neutrality, achieving great curatorial flexibility and variety.

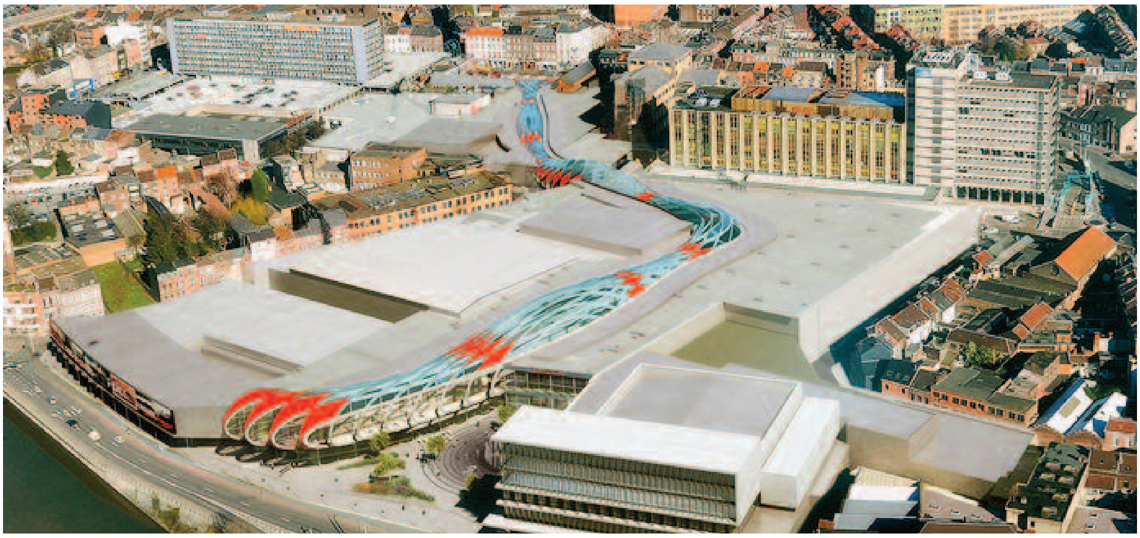
Geometry	Curvilinear	Primary composition operation(s)	Folding; Loft; Sweep
Morphology	Geometrical		
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Boolean; Taper
Additional primitive(s)	Parallelepiped	Main design strategy	Fluidity
Form and composition concepts	Articulation; Asymmetry; Complexity; Gesture; Horizontality; Plasticity; Unity	Secondary design strategies	Grid

For more information, please see <http://www.zaha-hadid.com/architecture/maxxi/>
<http://www.archdaily.com/43822/maxxi-museum-zaha-hadid-architects/>



Mediacite

Ron Arad



Location	Liegè	Software	AutoCAD; Rhinoceros
Country	Belgium		
Date from	2006		
Date to	2009	Site Area	10.000
Type	Commercial building	Total Area	9.750
		Cubature	77.000
Client	Wilhelm & Co	Height	8
		Lenght	385
Context	Inner city	Depht	25

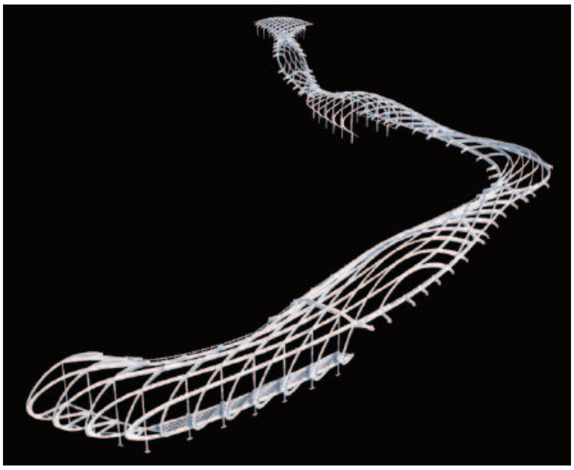
Description

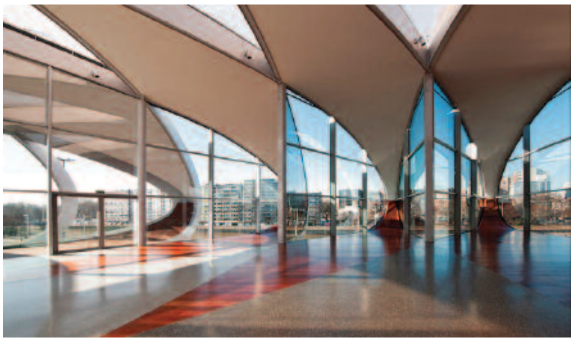
Ron Arad Architects were invited by Wilhelm & Co to design a new shopping mall within the 40,000 sqm 'Mediacite' development. Situated in Liege, once the world's foremost centre of steel production and since in economic decline, the building stands out as a symbol of the city's revitalisation and strives to spearhead the city's regeneration.The 350 m long mall weaves through the fabric of the refurbished old market centre at one end, through the new two storey building, connecting to the new Belgian national television centre at the other. The design of the roof unites these elements with a complex network of steel roof ribs that undulate through the mall. The lattice of steel sculpts the volume of the mall beneath, varying both in height and structural depth to form a variety of differing experiences.

The steel ribs overhead, mirrored in the floor pattern, draw a sinuous pathway pulling you towards and through each of the zones, revealing diverse vistas that surprise along the way. As the structure exits the volume of the main building (at the 2 Piazzas and at the link between the old market and new mall) the steel ribs wrap downwards, merging into facade to enclose the building's envelope. The structure is entirely free-spanning along its length and width, weaving through each other in a deformed grid-like network. To minimise loadings the complex 3 dimensional form is clad in transparent lightweight ETFE pillows. As the roof gradually transforms into facade the ETFE cladding merges into curved aluminium rain-screen panels and glass.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Bulging; Loft; Sweep
Principal primitive	Free-form solid	Secondary composition operation(s)	Mesh; Smooth
Additional primitive(s)	None	Main design strategy	Artistic Fact
Form and composition concepts	Articulation; Axiality; Complexity; Harmony; Plasticity; Simmetry	Secondary design strategies	Flows

For more information, please see <http://www.ronarad.co.uk/architecture/mediacitie/>
<http://www.archdaily.com/84872/mediacite-ron-arad-architects/>





Mercedes Benz Museum

UN Studio

Location	Stuttgart	Software	AutoCAD; Rhinoceros
Country	Germany		
Date from	2001		
Date to	2006	Site Area	18.000
Type	Exhibition building	Total Area	35.000
		Cubature	270.000
Client	Mercedes Benz Group	Height	40
		Lenght	80
Context	Industrial Area	Depht	80

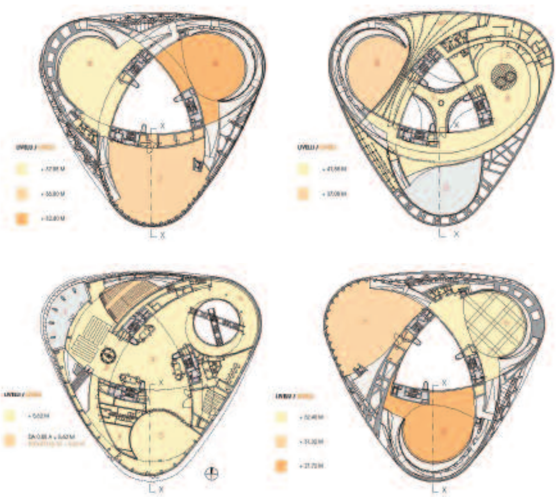
Description

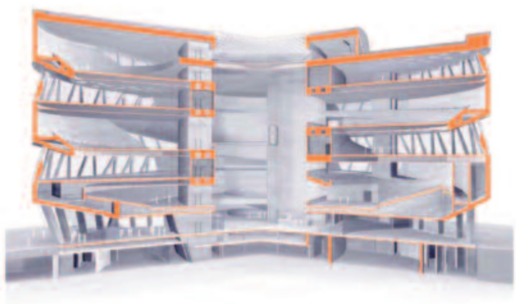
When approaching the city of Stuttgart from the eastern side, right next to highway B14 emerges the new Mercedes Benz Museum. Its sophisticated geometry synthesizes structural and programmatic organizations resulting in a new landmark building celebrating a legendary car. The structure is based on a trefoil; both in its internal organization and in its outward expression this geometry responds to the car-driven context of the museum. Inside, walking down the ramps of the Museum, surrounded by cars of different ages and types, the visitor is reminded of driving down the highway. Outside, the smooth curves of the building echo the rounded vernacular of nearby industrial and event spaces. In its materialization the museum reproduces the values that we associate with Mercedes Benz: technological advancement, intelligence, and stylishness.

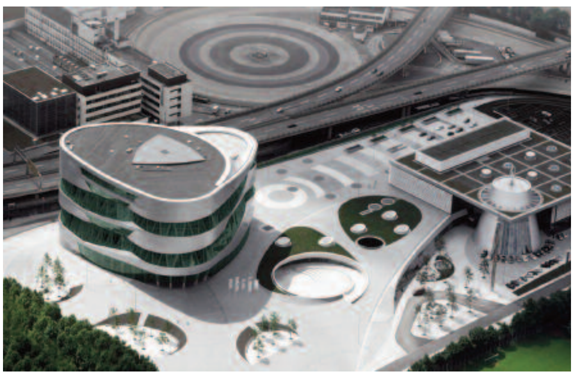
Visitors enter the building from the northwest corner, through an entrance lobby that introduces to the organizational system of the Museum, which entails the distribution of the two types of exhibitions over three 'leaves', which are connected to a central 'stem' in the form of an atrium. One exhibition flow contains the Collection rooms, which are exposed and day-lit, surrounded by panoramic windows. The other consists of historical displays, Legend rooms, theatrical spaces, sheltered and artificial lit. The Museum experience begins with visitors travelling up through the atrium in one of the three, capsule like, elevators. At the top floor the visitor may take one of the two spiralling main paths down, intersecting with each other at several points, like strands of a DNA helix.

Geometry	Curvilinear	Primary composition operation(s)	Folding; Revolution; Sweep
Morphology	Geometrical		
Principal primitive	Helix	Secondary composition operation(s)	Boolean; Repeat; Slicing; Smooth
Additional primitive(s)	Prism	Main design strategy	Diagram
Form and composition concepts	Articulation; Complexity; Monumentality; Simmetry; Unity; Verticality	Secondary design strategies	Fluidity

For more information, please see <http://www.unstudio.com/projects/mercedes-benz-museum> <http://www.archdaily.com/72802/mercedes-benz-museum-un-studio-photos-by-michael-schnell/>







Metropol Parasol

J. Mayer H.

Location	Seville	Software	ArchiCAD; Maya; Rhinoceros
Country	Spain		
Date from	2004		
Date to	2011	Site Area	18.000
Type	Multipurpose building	Total Area	12.670
		Cubature	0
Client	Ayuntamiento de Sevilla	Height	28
		Lenght	150
Context	Old town	Depht	75

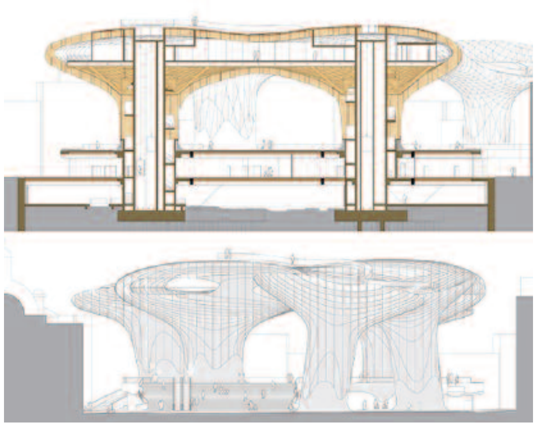
Description

The Metropol Parasol was a redevelopment project of the Plaza de la Encarnacíon in Seville, designed by J. MAYER H. architects, that becomes the new icon for Seville, – a place of identification and to articulate Seville's role as one of the world's most fascinating cultural destinations. The structure, which is at the same time roofing and building, explores the potential of the Plaza de la Encarnacion to become the new contemporary urban centre. Its role as a unique urban space within the dense fabric of the medieval inner city of Seville allows for a great variety of activities such as memory, leisure and commerce. A highly developed infrastructure helps to activate the square, making it an attractive destination for tourists and locals alike.

The Metropol Parasol scheme with its impressive timber structures offers an archaeological museum, a farmers market, an elevated plaza, multiple bars and restaurants underneath and inside the parasols, as well as a panorama terrace on the very top of the parasols. Realized as one of the largest and most innovative bonded timber-constructions with a polyurethane coating, the parasols grow out of the archaeological excavation site into a contemporary landmark, defining a unique relationship between the historical and the contemporary city. The mix-used character of building initiated a dynamic development for culture and commerce in the heart of Seville and beyond.

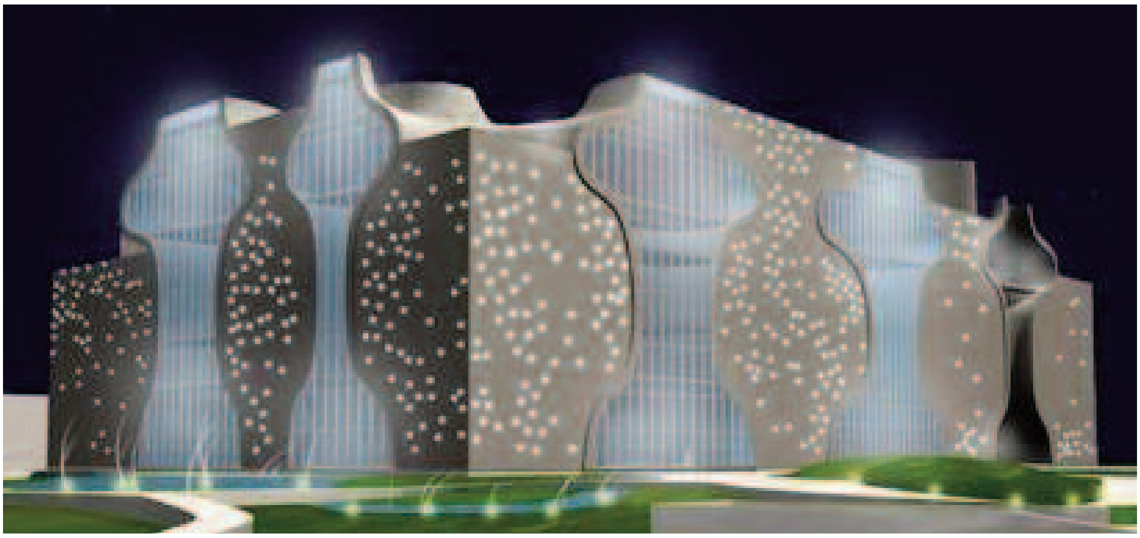
Geometry Morphology	Curvilinear Biomorphic	Primary composition operation(s)	Folding
Principal primitive	Free-form solid	Secondary composition operation(s)	Mesh; Smooth; Sweep
Additional primitive(s)	NURBS Surfaces	Main design strategy	Natural Derivation
Form and composition concepts	Articulation; Balance; Complexity; Contrast; Disproportion; Gesture; Monumentality; Plasticity; Unity	Secondary design strategies	Artistic Fact

For more information, please see <http://www.jmayerh.de/19-0-Metropol-Parasol.html>



Metropolitan Opera House

Toyo Ito



Location	Taichtung	Software	Rhinoceros
Country	Taiwan		
Date from	2009		
Date to	2014	Site Area	57.000
Type	Entertainment structure	Total Area	51.250
		Cubature	295.596
Client	Government of Taiwan	Height	34
		Lenght	126
Context	City center	Depht	69

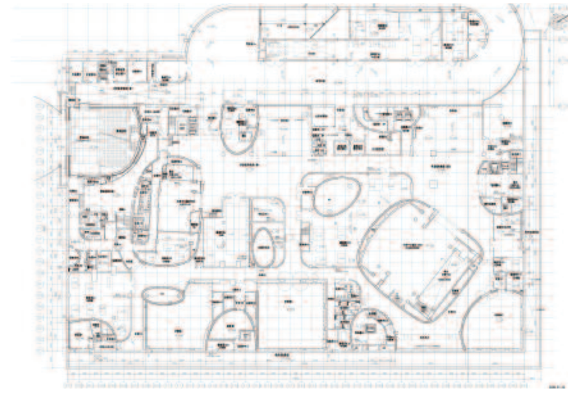
Description

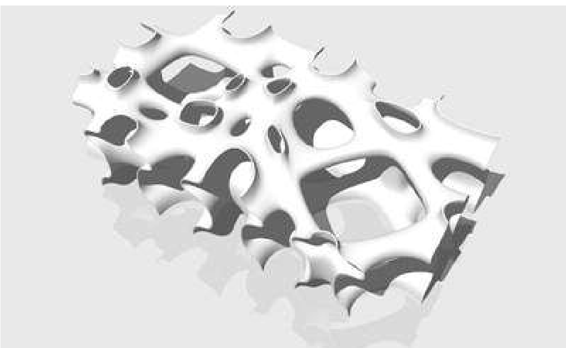
Taichung National Opera House is under construction in the 7th Metropolitan area of Taichung city, Taiwan. The design was a result of a design competition won by Toyo Ito. While providing optimum settings for traditional Eastern and Western types of performances, the design by Ito moves beyond the constraints of a traditional Opera House. The design is an open structure which actively engages its surroundings in all directions and creates opportunities for meetings. Ito calls this space the Sound Cave. Located in a park within a dense urban high-rise development, the building is not only interior, but connects seamlessly with the outside, merging with the surrounding park and creating a place of communication between people. The fluid continuity of the structure reflects the idea that the theatrical arts are spatial arts which combine the body, art, music, and performance.

As Toyo Ito declared "Architecture has to follow the diversity of society, and has to reflect that a simple square or cube can't contain that diversity". Then he articulated a regular box, where inside the space is freely organized. The Sound Cave is both a horizontally and vertically continuous network. Even before entering one of the three theatres, the Sound Cave is perceived as a fascinating and flexible "acoustic space," which, in three dimensions, connects Arts Plaza, workshops, foyers, restaurants etc. The spatial complexity is based on a few simple geometric rules. A membrane between two surfaces is divided into alternating zones A and B. As the surfaces are pulled apart, two continuous spaces A and B evolve, separated by the curvilinear membrane.

Geometry	Both	Primary composition operation(s)	Boolean; Folding
Morphology	Biomorphic		
Principal primitive	Parallelepiped	Secondary composition operation(s)	Bulging; Extrusion; Sweep
Additional primitive(s)	Free-form solid	Main design strategy	Natural Derivation
Form and composition concepts	Articulation; Complexity; Contrast; Deconstruction; Plasticity	Secondary design strategies	Diagram

For more information, please see <http://www.toyo-ito.co.jp/WWW/index/index_en.html>





MiCo Milano Convention Center

Mario Bellini

Location	Milan	Software	3D Modeling; AutoCAD; Rhinoceros
Country	Italy		
Date from	2008		
Date to	2012	Site Area	12.000
Type	Social and Civil building	Total Area	37.000
		Cubature	216.000
Client	Fondazione Fiera Milano	Height	18
		Lenght	200
Context	City center	Depht	120

Description

The project, a direct commission, includes the restoration and renewal of the existing complex, followed by its extension and integration with the new part, thus creating a door open onto the Expo. In the words of Bellini: "it is extremely rare that an architect gets the chance to bring a creation of his to life a second time". After only 11 years, the Portello exhibition complex needed to be visually restored to have a leading role for the Milano Expo 2015.
The first was the construction of a large Congress Centre in the southernmost building. This structure – overlooking the site where City Life with its already renowned skyscrapers is going to be built, is first off the blocks and issues a renewed challenge. A graft of metal and glass bodies – three tapering foyers on different levels – with spectacular 180 degree views over City Life – will give a radical twist and conclude the old building head which has remained incomplete until now. A great square volume bulges outward and violates the existing roof, while an unexpected asteroid-auditorium floats beside it on a crown of preexisting columns.
A real earthquake in volumetric terms which required and generated the synthesis which resolves all: the invention of a silvery airy comet which surmounts and embraces the new building head together with part of the flanks and roof of the building. Transforming it into a rare new creature yet remaining coherent with the overall complex, an unmistakable landmark, conceived as a swarm of luminescent rays rippling from the denser nucleus of the bulkhead and forming a 200 m long tail.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Mesh
Additional primitive(s)	None	Main design strategy	Folded surfaces
Form and composition concepts	Articulation; Complexity; Contrast; Gesture; Monumentality; Plasticity; Unity	Secondary design strategies	Artistic Fact

For more information, please see <http://www.bellini.it/architecture/fiera_milano_congressi.html>
<http://europaconcorsi.com/projects/218100-MiCo>

MINI Opera 21Space

Coop Himmelb(l)au

Location	Munich	Software	Generative Components; Performance-based design
Country	Germany		
Date from	2008		
Date to	2010	Site Area	1.790
Type	Temporary Pavilion	Total Area	560
		Cubature	4.350
Client	Bayerische Staatsoper, MINI	Height	12
		Lenght	38
Context	Old town	Depht	26

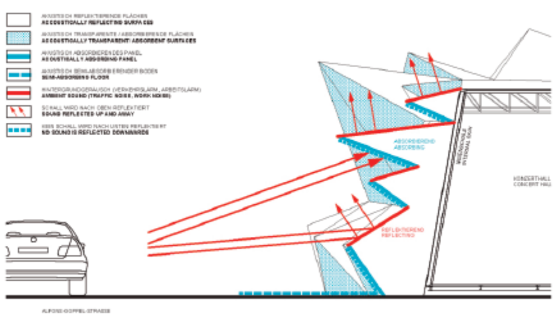
Description

The task which we had to solve with our design was to create a space with 300 seats (or 700 standing spectators) for experimental performances of the Bavarian State Opera. The Pavilion should be dismountable, transportable and re-mountable and make the respective urban space distinctive through its shape. Mass and therefore weight are the decisive criteria for good acoustics. The conception of the Pavilion 21 MINI Opera Space therefore had to overcome a contradiction: to design a lightweight construction which must allow to be dis- and re-assembled quickly, but which at the same time meets the acoustical requirements of a concert hall.

Already the first idea was to introduce elements which are on the one hand the spatial transformation of sound sequences, and which on the other hand develop sound reflecting and absorbing properties through their pyramid-like shape: "Soundscaping". As a starting point towards the abstraction of music into spatial form, a sequence from the song "Purple Haze" by Jimi Hendrix and a passage from "Don Giovanni" by Mozart were transcribed. Through the analysis of frequency sections from these pieces of music and through the combination with the computer generated 3D model, the sequences are translated into pyramidal "spike constructions" by means of parametric "scripting". In order to implement the objectives of the interior spatial acoustics, the interior wall and ceiling surfaces were fitted with a combination of perforated absorbing and smooth reflecting sandwich panels, while the external texture was designed to reflect and absorbs sound.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Extrusion; Stretch; Taper
Principal primitive	Pyramid	Secondary composition operation(s)	Boolean; Mesh; Scale
Additional primitive(s)	Tetrahedra	Main design strategy	Mathematical derivation
Form and composition concepts	Articulation; Asymmetry; Complexity; Obliquity; Rythm	Secondary design strategies	Performance optimization

For more information, please see <http://www.coop-himmelblau.at/architecture/projects/pavilion-21-mini-opera-space>



Moebius House

UNStudio

Location	Het Gooi	Software	3D Modeling; AutoCAD
Country	Netherlands		
Date from	1993		
Date to	1997	Site Area	5.000
Type	Residential building	Total Area	550
		Cubature	3.300
Client	Anonymous	Height	6
		Lenght	40
Context	Rural area	Depht	15

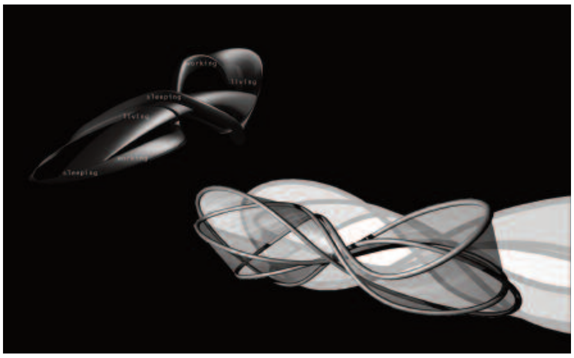
Description

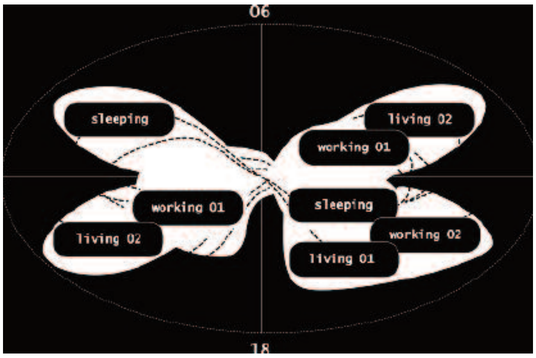
With its low-slung, elongated outlines the private house forms a link between the different features of the surroundings; the spatial loop enables the house to take in the extreme aspects of the landscape. By being stretched to the maximum, rather than displaying a compact or tall shape, the house conveys from the interior the idea of a walk in the countryside.

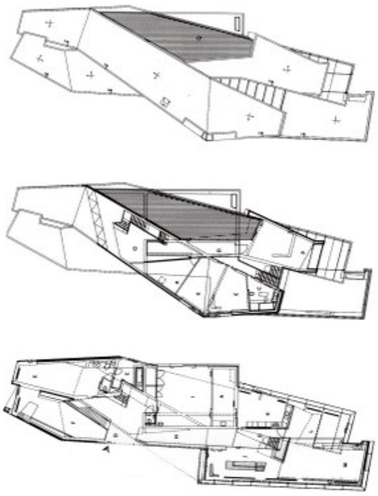
The Möbius loop, the spatial quality of which means that it is present in both plan and section, translates into the interior into a 24-hour cycle of sleeping, working and living. As the loop turns inside out the materialization follows these change-overs; glazed details and concrete structural elements swap roles as glazed facades are put in front of the concrete construction, dividing walls are made of glass and furniture such as tables and stairs are made of concrete. The diagram of the double-locked torus conveys the organization of two intertwining paths, which trace how two people can live together, yet apart, meeting at certain points, which become shared spaces. The mathematical model of the Möbius is not literally transferred to the building, but was digitally conceptualized or thematized and can be found in architectural ingredients, such as the light, the staircases, and the way in which people move through the house. So, while the Möbius diagram introduces aspects of duration and trajectory, the diagram is worked into the building in a mutated way.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Extrusion; Sweep
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Boolean; Sweep
Additional primitive(s)	Prism	Main design strategy	Diagram
Form and composition concepts	Articulation; Complexity; Horizontality; Unity	Secondary design strategies	Flows; Fluidity

For more information, please see <http://www.unstudio.com/projects/mobius-house>
<http://europaconcorsi.com/projects/143152-UNStudio-M-bius-House>







Mur Island

Vito Acconci

Location	Graz	Software	3D Modeling; AutoCAD
Country	Austria		
Date from	2003		
Date to	2003	Site Area	2.000
Type	Recreation structure	Total Area	1.052
		Cubature	4.128
Client	Graz European Capital	Height	6
		Lenght	43
Context	Inner city	Depht	16

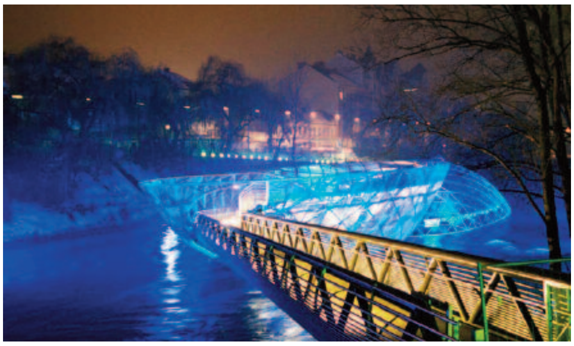
Description

The idea of integrating the river Mur into the life of the city came up right at the beginning of the planning phase for the Cultural Capital, as the river not only divides the city, but also connects it. The artist Vito Acconci undertook a quest for a new, exceptional building site, by implanting an "artificial joint" linking nature and city, which forces visitors to adopt new perspectives and guides them along grounds which have hitherto been inaccessible.

The island was an organically twisted construction composed of various merging shells. Each part, no matter whether closed or open, has been assigned certain functions depending on its specific spatial character. The designer called it "a bowl that morphs into a dome that morphs into a bowl". This bowl functions as a theatre, but when it is not used as a theatre, it is a plaza, you sit face-to-face in everyday conversation. The dome functions as a café/restaurant: the entrance canopy twists down to make lounge-seating around the dome — curved triangular tables are joined together for different-sized groups of people – the rubber-edge of the terrace above twists down to make multiple bar-counters (wherever you put down your drink, it meets a counter). The warping of bowl into dome, & vice versa, forms a playground for children.

Geometry	Curvilinear	Primary composition operation(s)	Divide; Folding; Slicing
Morphology	Biomorphic		
Principal primitive	Sphere	Secondary composition operation(s)	Boolean; Overturning; Translation
Additional primitive(s)	NURBS Surfaces	Main design strategy	Blob
Form and composition concepts	Balance; Deconstruction; Gesture; Plasticity	Secondary design strategies	Artistic Fact; Deconstruction

For more information, please see <http://acconci.com/>
<http://www.graz03.at/servlet/sls/Tornado/web/2003/content_e/8FCE673302F9BE61C1256B81005CED38>



Nardini Research Centre

Massimiliano Fuksas

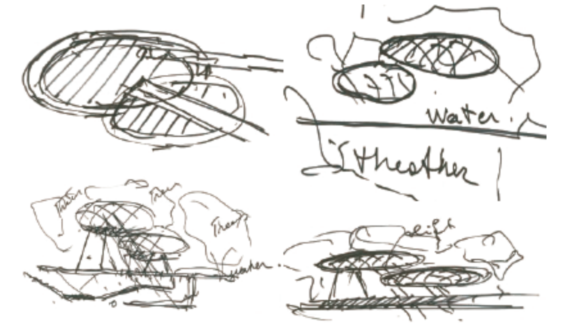
Location	Bassano del Grappa	Software	AutoCAD; Rhinoceros
Country	Italy		
Date from	2002		
Date to	2004	Site Area	2.600
Type	Research structure	Total Area	1.200
		Cubature	2.400
Client	Bortolo Nardini s.p.a.	Height	10
		Lenght	30
Context	Urban fringe	Depht	15

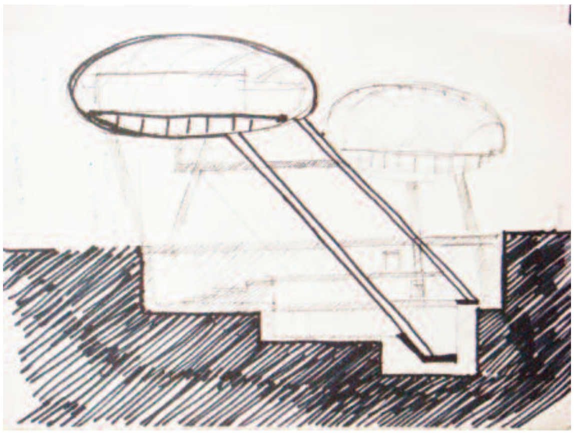
Description

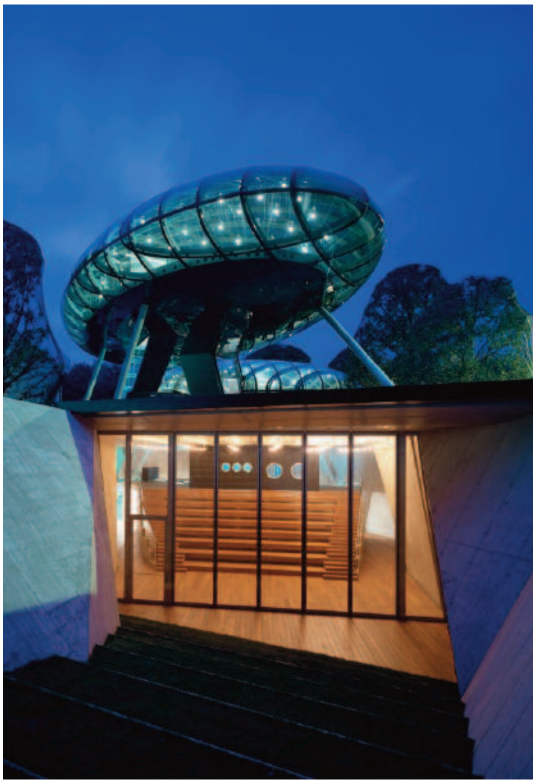
Two "worlds": the first "suspended", composed of two transparent ellipsoidal bubbles holding the research centre laboratories, and the other "submerged", a space cut into the ground like a natural canyon holding a 100-seat auditorium. A descending ramp shapes the canyon space leading through the auditorium and may also be used as an outdoor stage. The contrast between the two sloping platforms creates one single seamless arena for hosting events. Seated spectators are surrounded by a landscape generated from the arrhythmic pattern of the sloping walls.
The reflective surface of the water at ground level creates a reverberating and shimmering space in the entrance area set between the two bubbles, which appears to float "suspended" in the air. The underwater skylights let the light filter and spread through the underground space during the day; during the night, they become a luminous source. Visitors are faced with a sequence of constantly changing views generated by the carefully gauged symmetry of the various architectural features: the two staggered and overlapping ellipsoids, the sloping lift contrasting with the airy stairway and the rotating form of the entrance ramp.
The surface of the bubbles is composed of a totally transparent double skin allowing us to focus for 360° on the splendid mountain landscape of Montegrappa. Two signs: one of which is refined, elegant, technological and immaterial. The other is quite brutal as the material, the reinforced concrete, turns into an epiphany of form.

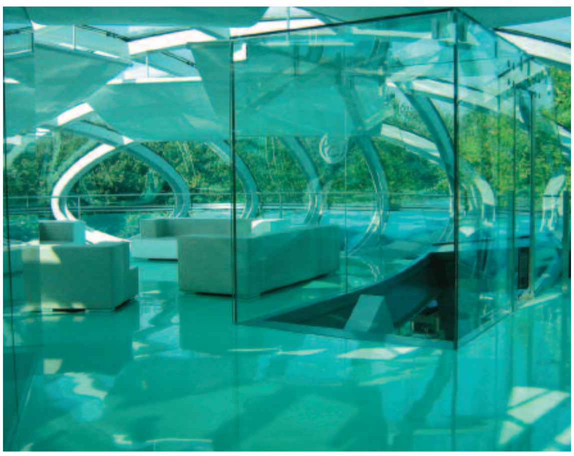
Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Copy; Scale
Principal primitive	Ellipsoid	Secondary composition operation(s)	Repeat; Rotation; Translation
Additional primitive(s)	None	Main design strategy	Blob
Form and composition concepts	Balance; Monumentality; Plasticity; Proportion; Scale	Secondary design strategies	None

For more information, please see <http://www.fuksas.it/home.htm#/progetti/0800/>
<http://www.archdaily.com/233532/nardini-grappa-distillery-bolle-massimiliano-and-doriana-fuksas/>









Olympic Stadium

Herzog & De Meuron

Location	Beijng	Software	AutoCAD
Country	China		
Date from	2002		
Date to	2008	Site Area	202.900
Type	Recreation structure	Total Area	120.000
		Cubature	3.600.000
Client	International Olympic Commit-	Height	63
	tee, Chinese National Republic	Lenght	330
Context	Urban fringe	Depht	220

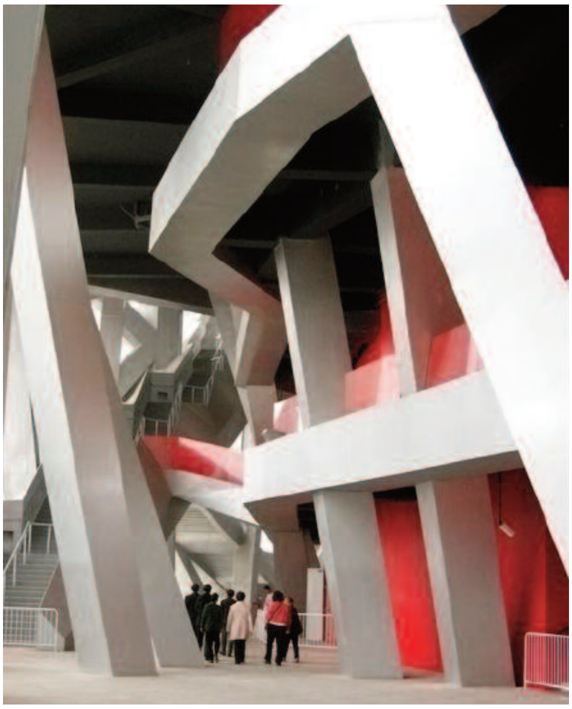
Description

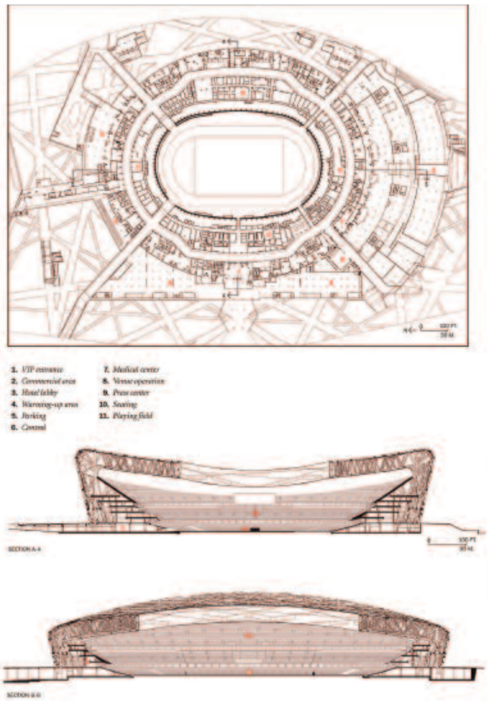
The National Stadium is situated on a gentle rise in the centre of the Olympic complex to the north of Beijing. Its location was predefined by the master plan. The most important principle throughout has been to develop an architecture that will continue to be functional following the Games in 2008, in other words, to create a new kind of urban site that will attract and generate public life in this part of Beijing. The Chinese themselves nicknamed the stadium "Bird's Nest" in the very early stages of the project.From the distance, the stadium looks like a gigantic collective shape, like a vessel whose undulating rim echoes the rising and falling ramps for spectators inside the stadium, one can clearly distinguish not only the rounded shape of the building but also the grid of the load-bearing structure, which encases the building, but also appears to penetrate it.

The spatial effect of the stadium is novel and radical, and yet simple and of an almost archaic immediacy. Its appearance is pure structure. Façade and structure are identical. The structural elements mutually support each other and converge into a spatial grid-like formation, in which façades, stairs, bowl structure and roof are integrated. To make the roof weatherproof, the spaces in the structure of the stadium are filled with a translucent membrane. In this space, that is façade, structure, decoration and public space all in one, people get together in restaurants, bars, hotels and shops, or on the platforms and the crisscrossing horizontal, diagonal and vertical paths of access.

Geometry	Curvilinear	Primary composition operation(s)	Folding; Sweep
Morphology	Biomorphic		
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Boolean; Bulging
Additional primitive(s)	Torus	Main design strategy	Natural Derivation
Form and composition concepts	Axiality; Complexity; Gesture; Harmony; Monumentality; Simmetry; Unity	Secondary design strategies	None

For more information, please see
<http://www.herzogdemeuron.com/index/projects/complete-works/226-250/226-national-stadium.html>





Opera House

Zaha Hadid

Location	Guaghzhou	Software	AutoCAD; Rhinoceros
Country	China		
Date from	2003		
Date to	2010	Site Area	45.325
Type	Entertainment structure	Total Area	70.000
		Cubature	684.000
Client	Guangzhou Municipal Gover-nment	Height	40
		Lenght	190
Context	Inner city	Depht	90

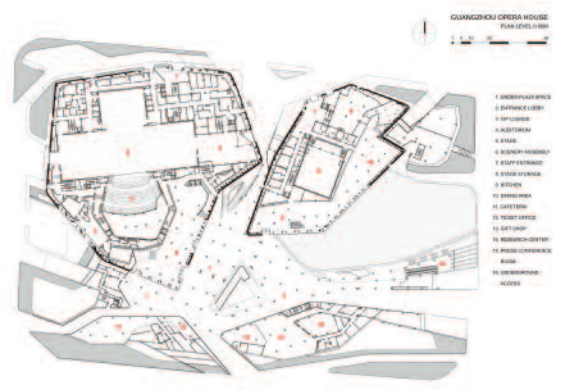
Description

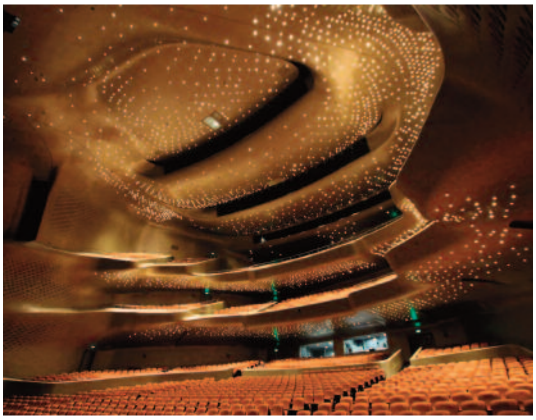
The Opera House is at the heart of Guangzhou's cultural development. Its unique twin-boulder design enhances the city by opening it to the Pearl River, unifying the adjacent cultural buildings with the towers of international finance in Guangzhou's Zhujiang new town. The 1,800-seat auditorium of the Opera House houses the very latest acoustic technology, and the smaller 400-seat multifunction hall is designed for performance art, opera and concerts in the round.

The design evolved from the concepts of a natural landscape and the fascinating interplay between architecture and nature; engaging with the principles of erosion, geology and topography. The Guangzhou Opera House design has been particularly influenced by river valleys – and the way in which they are transformed by erosion. Fold lines in this landscape define territories and zones within the Opera House, cutting dramatic interior and exterior canyons for circulation, lobbies and cafes, and allowing natural light to penetrate deep into the building. Custom moulded glass-fibre reinforced gypsum (GFRC) units have been used for the interior of the auditorium to continue the architectural language of fluidity and seamlessness. The Guangzhou Opera House has been the catalyst for the development of cultural facilities in the city including new museums, library and archive, through an exploration of contextual urban relationships, combining the cultural traditions that have shaped Guangzhou's history, with the ambition and optimism that will create its future.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	Free-form solid	Secondary composition operation(s)	Boolean; Extrusion; Mesh; Smooth
Additional primitive(s)	Prism	Main design strategy	Artistic Fact
Form and composition concepts	Complexity; Gesture; Monumentality; Obliquity; Plasticity; Unity	Secondary design strategies	Fluidity

For more information, please see <http://www.zaha-hadid.com/architecture/guangzhou-opera-house/>
<http://www.archdaily.com/115949/guangzhou-opera-house-zaha-hadid-architects/>





Orange Cube

Jakob+MacFarlane

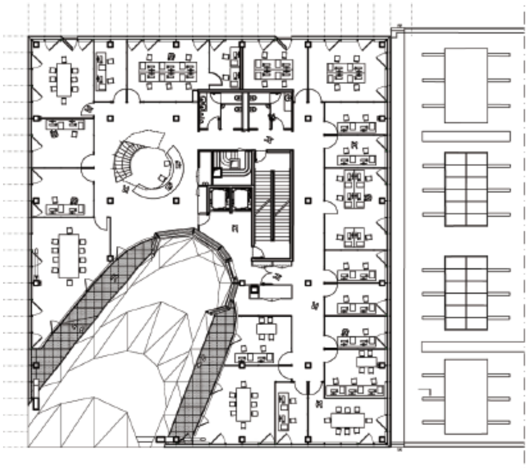
Location	Lyon	Software	3D Modeling
Country	France		
Date from	2005		
Date to	2010	Site Area	1.000
Type	Office building	Total Area	6.300
		Cubature	21.100
Client	Rhône Saône Développement	Height	22
		Lenght	33
Context	City center	Depht	29

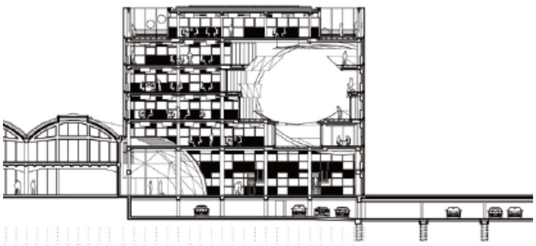
Description

The ambition of the urban planning project for the old harbor zone was to reinvest the docks of Lyon on the river side and its industrial patrimony, bringing together architecture and a cultural and commercial program. The project, placed on these docks, is designed as a simple orthogonal « cube » into which a giant hole is carved, responding to necessities of light, air movement and views. This hole creates a void, piercing the building horizontally from the river side inwards and upwards through the roof terrace.
The cube, next to the existing hall highlights its autonomy. It is designed on a regular framework made of concrete pillars on 5 levels. A light façade, with seemingly random openings is completed by another façade, pierced with pixilated patterns that accompany the movement of the river. The orange color refers to lead paint, an industrial color often used for harbor zones. In order to create the void, Jakob + MacFarlane worked with a series of volumetric perturbations, linked to the subtraction of three conic volumes disposed on three levels: the angle of the façade, the roof and the level of the entry. These perturbations generate spaces and relations between the building, its users, the site and the light supply, inside a common office program. Each platform enjoys a new sort of conviviality through the access on the balconies and its views, creating spaces for encounter and informal exchanges. The research for transparency and optimal light transmission on the platforms contributes to make the working spaces more elegant and light. The last floor has a big terrace to admire the whole panoramic view on Lyon.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Boolean
Principal primitive	Parallelepiped	Secondary composition operation(s)	Align; Repeat
Additional primitive(s)	Cone	Main design strategy	Deconstruction
Form and composition concepts	Asymmetry; Deconstruction; Disproportion; Monumentality	Secondary design strategies	Pattern

For more information, please see <http://jakmak1.dotster.com/en/project/news-3/>
<http://www.archdaily.com/111341/the-orange-cube-jakob-macfarlane-architects/>





Paul Klee Museum

Renzo Piano

Location	Bern	Software	3D Modeling; AutoCAD
Country	Swizerland		
Date from	1999		
Date to	2005	Site Area	18.450
Type	Exhibition building	Total Area	15.000
		Cubature	184.000
Client	Maurice E. and Martha Müller Foundation	Height	21
		Lenght	145
Context	Urban fringe	Depht	80

Description

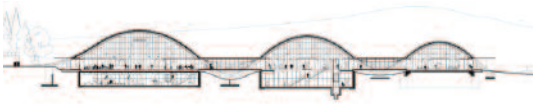
The Zentrum Paul Klee, located near the city of Bern, is home to nearly 40% of the artist's entire collection, for a total of more than 4,000 works; it's one of the world's largest monographic collections. It is also a multifunctional space: in addition to being the home of a permanent collection of Klee's artworks, it also has temporary exhibition space, a concert hall, and an education centre.

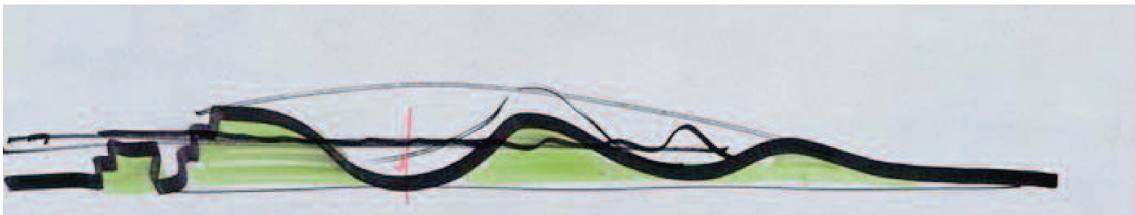
It was a hilly site of about 2.5 hectares, located in the city's eastern Schöngrün quarter and the shape of the building recalls the curves of the surrounding landscape, thus becoming an integral part of it. The Centre is composed of three 'hills' made of glass and steel. Each hill corresponds to a different function of the centre, and runs through the life of the artist – a painter, a musician, a poet. The exhibition rooms are situated below ground level. The individual sections were obtained from enormous steel plates, which were cut using high-precision computerized instrumentation and then welded together by hand.

The light intensity had to be particularly controlled due to the types of artworks that would be present (watercolours, drawings, etc.), which are fragile and cannot withstand greater light intensities. The artworks would also be extremely sensitive to changes in temperature and humidity, and therefore the climatic data also had to be constantly monitored. These values became the basis for another extremely important aspect of the design, to guarantee the lowest possible levels of energy consumption.

Geometry	Curvilinear	Primary composition operation(s)	Extrusion; Folding
Morphology	Biomorphic		
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Repeat; Scale; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Mathematical derivation
Form and composition concepts	Axiality; Harmony; Proportion; Rythm; Scale; Simmetry; Unity	Secondary design strategies	Performance optimization

For more information, please see <http://www.rpbw.com/>
<http://www.fondazionerenzopiano.org/project/64/zentrum-paul-klee/>





Porsche Museum

Delugan Meissl

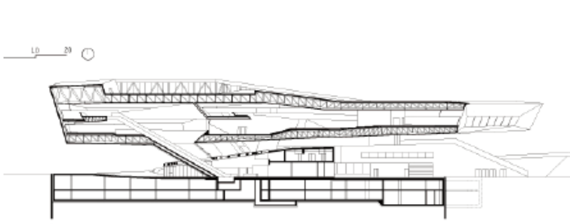
Location	Stuttgart	Software	3D Modeling; AutoCAD
Country	Germany		
Date from	2003		
Date to	2009	Site Area	8.200
Type	Exhibition building	Total Area	27.690
		Cubature	225.645
Client	Porsche Group	Height	30
		Lenght	155
Context	Industrial Area	Depht	65

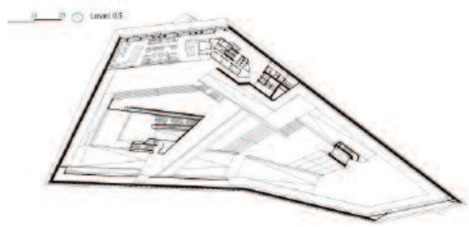
Description

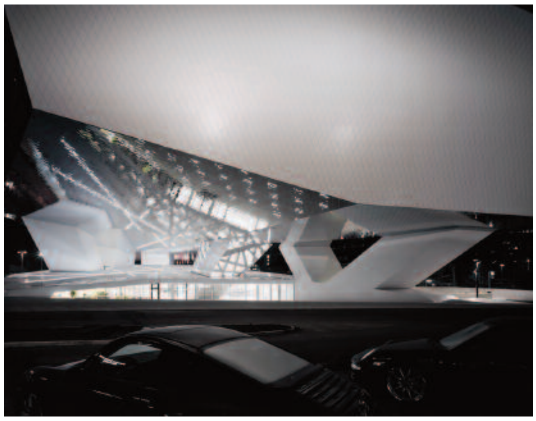
The central draft concept was the translation of the versatile and vivid brand into the language of architecture. The museum features those specific conditions which the Porsche brand conveys both spatially and sensually to visitors. Drive and speed, statics and logjams can be experienced both in the building's configuration as well as through the spatial medium.
The museum is an open, clearly defined place which incorporates all brand specific qualities. Experience and the opportunity to experience were the primary design parameters through respective spatial allocations in the basic architectural concept. The seeming dichotomy of the architectural shape is the appropriate answer to the building's function and the exceptional position of its exhibits. The museum's conceptual design demonstrates designers' perception of buildings as interactive organisms, as communicating part of a whole. The consistent interaction between the building and its environment is conceived as a quality, as is a functional and practical utilisable space. The specific characteristics of the spatially definable environment are conceived as a landscape or urban landscape, its interpretation as the corporate approach.
The Porsche museum is designed as a dynamically formed, monolithic structure, seemingly detached from the entry level's folded topography. Its reflective soffit absorbs the architectural landscape below and atmospherically increases the space between base and exhibition area. Thus this architectural gesture underlines the duality of experience and opportunity to experience on which the structural design is based.

Geometry Morphology	Rectilinear Geometrical	Primary composition operation(s)	Stretch; Tilt
Principal primitive	Prism	Secondary composition operation(s)	Boolean; Mesh; Slicing
Additional primitive(s)	Mesh	Main design strategy	Diagram
Form and composition concepts	Articulation; Complexity; Monumentality; Obliquity	Secondary design strategies	None

For more information, please see <http://www.dmaa.at/projekte/detail-page/porsche-museum.html>







Sarpi Border Checkpoint

J. Mayer H.

Location	Sarpi	Software	ArchiCAD; Maya; Rhinoceros
Country	Georgia		
Date from	2010		
Date to	2011	Site Area	4.500
Type	Public building	Total Area	1.800
		Cubature	6.700
Client	Ministry of Finance of Georgia	Height	32
		Lenght	45
Context	Rural area	Depht	10

Description

Drivers crossing the coastal border between Turkey and Georgia have to pass below a knobbly observation tower by Berlin architect J. Mayer H. The customs checkpoint is situated at the Georgian border to Turkey, at the shore of the Black Sea. The bumpy tower, which sits atop the Sarpi Border Checkpoint building, houses a series of elevated terraces within its folds.

Geometry	Both	Primary composition operation(s)	Extrusion; Sweep
Morphology	Biomorphic		
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Loft; Sliding
Additional primitive(s)	Parallelepiped	Main design strategy	Natural Derivation
Form and composition concepts	Articulation; Asymmetry; Complexity; Gesture; Linearity; Plasticity	Secondary design strategies	Artistic Fact

For more information, please see <http://www.jmayerh.de/index.php?article_id=6>
<http://www.archdaily.com/184315/sarpi-border-checkpoint-in-georgia-j-mayer-h-architects/>

Selfridges Store

Future Systems

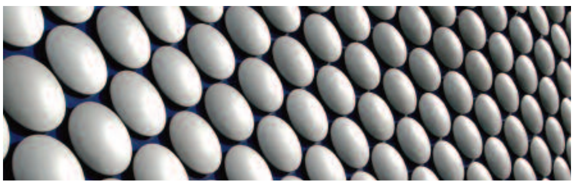
Location	Birmingham	Software	AutoCAD; Rhinoceros
Country	UK		
Date from	1999		
Date to	2003	Site Area	6.000
Type	Commercial building	Total Area	25.000
		Cubature	240.500
Client	Selfridges & Co.	Height	37
		Lenght	100
Context	Old town	Depht	65

Description

This Birmingham-based department store is a truly remarkable example of a notion called blobitecture. Its form escapes the usual structure of edges and walls into a curved and rounded sculpture, one could even call organic. Not only its unique shape and aluminium facade discs, but also the location right on the edge of city centre between the rail and bus stations, make it instantly noticeable in Birmingham's skyline. The building is situated just by St Martin's church in Bullring shopping area, which creates this kind of awkward relationship between the historic sight of faith and more current but also glorious temple to consumption.
Inside you can find an impressive criss-cross of white escalators around the main atrium, surrounded by approx 25,000 m2 of retail store area. What is more, on the top floor, the building is joined with a parking lot on the opposite side of the street through a walking tunnel, which makes it look as if it has a tongue sticking out of it. The interior architecture shifts from the scaled appearance of the exterior to sleek and white surfaces. The four levels wrap around a main atrium which features criss-crossing escalators running up through the space.

Geometry	Curvilinear	Primary composition operation(s)	Folding
Morphology	Biomorphic		
Principal primitive	Free-form solid	Secondary composition operation(s)	Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Blob
Form and composition concepts	Balance; Contrast; Gesture; Monumentality; Plasticity; Unity	Secondary design strategies	None

For more information, please see <http://www.ala.uk.com/portfolio/selfridges/>
<http://www.galinsky.com/buildings/selfridges/>



Singapore gardens

Wilkinson Eyre Architects

Location	Singapore	Software	MicroStation; Revit; Rhinoceros
Country	Singapore		
Date from	2006		
Date to	2012	Site Area	68.000
Type	Recreation structure	Total Area	40.000
		Cubature	1.400.000
Client	National Parks Board Singapore	Height	42
		Lenght	350
Context	Industrial Area	Depht	100

Description

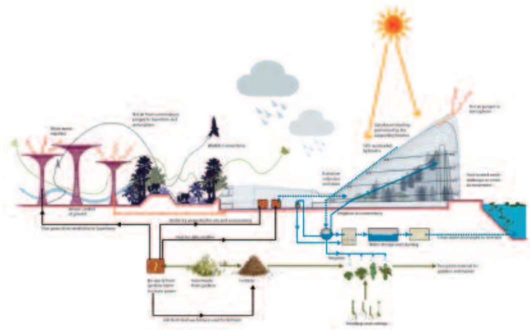
This project was won in an international design competition as part of a team led by landscape architects Grant Associates. The masterplan for Marina South forms part of Singapore's new Gardens by the Bay development and draws from the distinctive flora of the region to create a new destination in the city. It has been designed as a series of distinct ecosystems which will enable the gardens to function with maximum environmental efficiency, and to showcase those world habitats most at risk from climate change.

The garden at Marina South is home to some of the site's most spectacular structures, including two cooled conservatories which are among the largest climate-controlled glasshouses in the world. The cool-dry conservatory explores issues related to plants and people, whilst the cool-moist conservatory focuses on plants and the planet.

The curvilinear conservatory structures have been designed with sustainability as a starting point, with every consideration given to passive climate control techniques. A computer-controlled shading system and carbon neutral cooling technologies have been integrated into the fabric of the building to efficiently maintain the climate within. The cooled conservatories jointly enclose an area of over 20,000 sqm and reach a height of 58 metres above the shore of the bay. Bay South Garden is built on reclaimed land and, in the absence of a natural landscape, the conservatories are landmarks that prominently address both the bay and the skyscrapers of densely urban districts that will surround the garden.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Bulging; Loft
Principal primitive	Solid of revolution	Secondary composition operation(s)	Smooth; Sweep
Additional primitive(s)	None	Main design strategy	Performance optimization
Form and composition concepts	Balance; Complexity; Plasticity; Unity	Secondary design strategies	Mathematical derivation

For more information, please see <www.gardensbythebay.org.sg>
<http://www.wilkinsoneyre.com/projects/singapore-gardens-by-the-bay.aspx?category=sport-and-leisure>



Son-O-House

NOX Lars Spuybroek

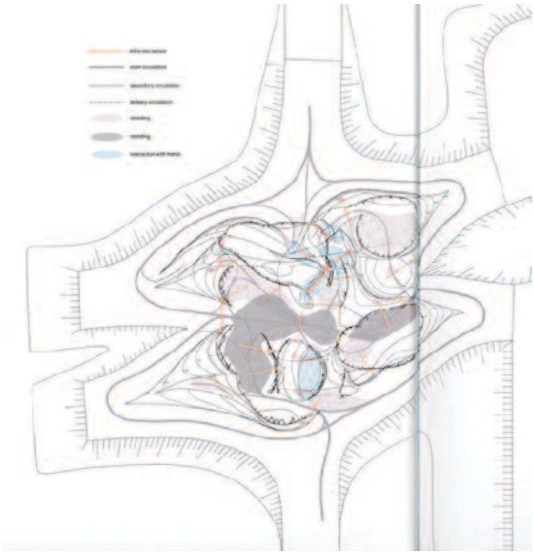
Location	Son en Breugel	Software	Performance-based design; Rhinoceros; Shape grammar
Country	Netherlands		
Date from	2000		
Date to	2004	Site Area	1.600
Type	Temporary Pavilion	Total Area	280
		Cubature	5.000
Client	Ekkersrijt Industries	Height	8
		Lenght	25
Context	Industrial Area	Depht	25

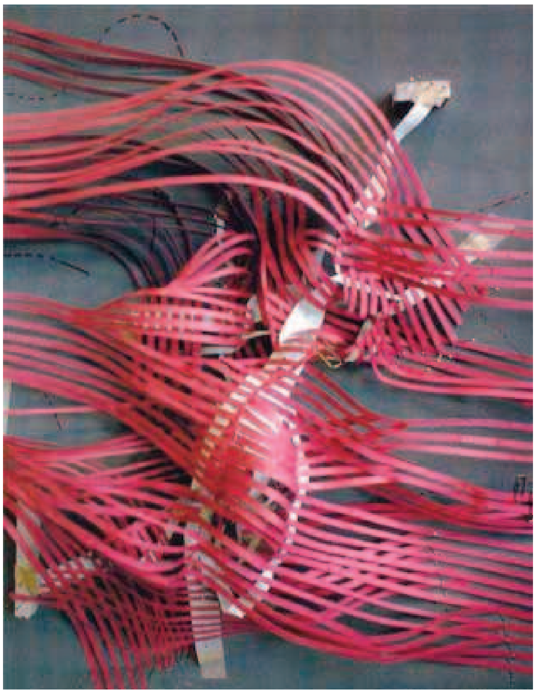
Description

Son-O-house is "a house where sounds live", not being a real house. but an artwork that refers to living and the bodily movements that accompany habit and habitation. Located in a large industrial park in Eindhoven's periphery, it is a public pavilion where visitors can sit around, eat their lunch and have meetings, surrounded by IT related companies. The structure is both an architectural and a sound installation that allows people to not just hear sound in a musical structure, but also to participate in the composition of the sound. It is an instrument, score and studio at the same time.
The structure is derived from typical action-landscapes that develop in a house: a fabric of larger scale bodily movements in a corridor or room, together with smaller scale movements around a sink or a drawer. This carefully choreographed set of movements of bodies, limbs and hands are inscribed on paper bands as cuts. The design was carried-out manually, by working on a paper maquette. Then, with a reverse modelling, they digitized this paper analog-computing model and remodel it into the final structure.
In the Son-O-house a sound work composed/designed by Edwin van der Heide generates new sound patterns activated by sensors picking up actual movements of the visitors. The convoluting surfaces act as domes that overlap in three different scales, all of which are tracked by the sensors that fill the space with music, a music that saturates the house with the presence of previous visitors.

Geometry	Curvilinear	Primary composition operation(s)	Folding
Morphology	Biomorphic		
Principal primitive	Free-form solid	Secondary composition operation(s)	Bulging; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Blob
Form and composition concepts	Complexity; Gesture; Plasticity	Secondary design strategies	Mathematical derivation; Performance optimization

For more information, please see <http://www.nox-art-architecture.com/>
<http://www.evdh.net/sonohouse/>





Soumaya Museum

Fernando Romero

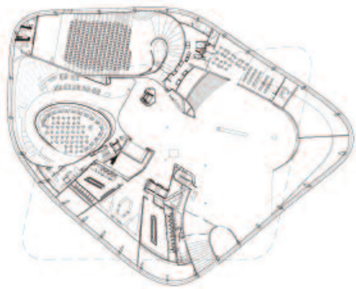
Location	Mexico City	Software	3D Modeling; Revit; Rhinoceros
Country	Mexico		
Date from	2005		
Date to	2011	Site Area	7.250
Type	Exhibition building	Total Area	16.000
		Cubature	80.000
Client	Fundación Carlos Slim	Height	30
		Lenght	70
Context	City center	Depht	55

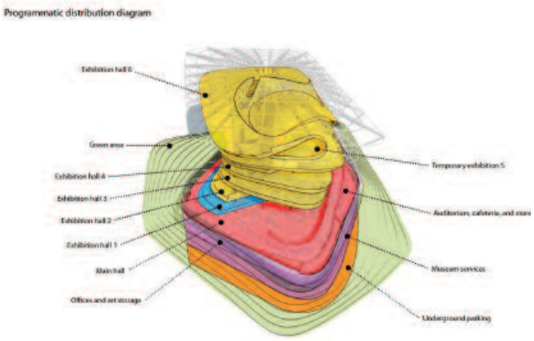
Description

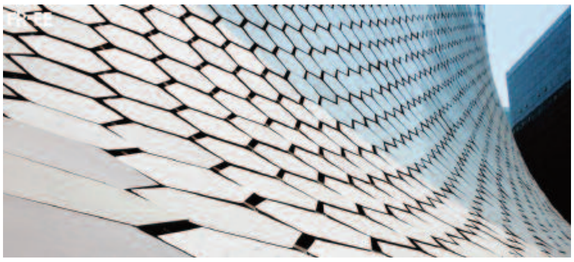
The Soumaya Museum is a private museum in the Nuevo Polanco area of Mexico City and holds over 66,000 pieces of art, most of them are by many of the best known European artists from the 15th to the 20th century. Museum building tends to be conceived either for maximum functionality – acting as neutral containers for art – or as iconic structures that represent a city at a particular historic moment. The museum was designed as both: a sculptural building that is unique and contemporary, yet one able to house a collection of international paintings, sculptures, and decorative objects dating from the fourteenth century to the present. The exterior of the building is an amorphous shape perceived differently from every angle, reflecting the diversity of the collection inside.
The building's distinctive façade is made of hexagonal aluminum modules facilitating its preservation and durability. The shell is constructed with steel columns of different diameters, each with its own geometry and shape, creating non-linear circulation paths for the visitor. The building encompasses 20,000 sqm of exhibition space divided among five floors, as well as an auditorium, café, offices, gift shop, and multipurpose lobby. The top floor is the largest space in the museum, with its roof suspended from a cantilever that allows in natural daylight.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Loft
Principal primitive	Solid of extrusion	Secondary composition operation(s)	Extrusion; Mesh; Smooth
Additional primitive(s)	Solid of revolution	Main design strategy	Artistic Fact
Form and composition concepts	Complexity; Gesture; Monumentality; Plasticity; Unity; Verticality	Secondary design strategies	Flows; Fluidity; Mathematical derivation

For more information, please see <http://fr-ee.org/projects/soumaya-museum-mexico-city-mexico/>
<http://www.archdaily.com/33925/soumaya-museum-lar-fernando-romero/>







Stedelijk Museum

Benthem Crouwel

Location	Amsterdam	Software	AutoCAD; Revit
Country	Netherlands		
Date from	2007		
Date to	2012	Site Area	4.000
Type	Exhibition building	Total Area	26.500
		Cubature	35.000
Client	City of Amsterdam	Height	14
		Lenght	100
Context	Inner city	Depht	40

Description

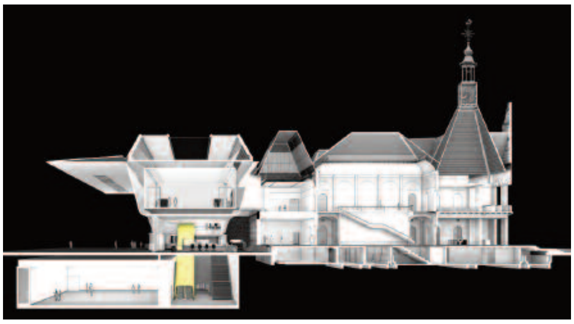
Amsterdam's Stedelijk Museum, designed by A.W. Weissman and celebrated for its majestic staircase, grand rooms and natural lighting, needed to be renovated and enlarged. The existing building is left almost entirely intact and in full view by lifting part of the new volume into space and sinking the rest underground.

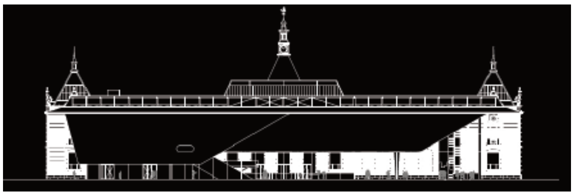
Its entrance has been moved to the open expanse of Museumplein where it occupies a spacious transparent extension. The smooth white volume above the entrance, also known as ‘the Bathtub’, has a seamless construction of reinforced fibre and a roof jutting far into space. Against the backdrop of the old building, the white synthetic volume is the new powerful image of the Stedelijk Museum.

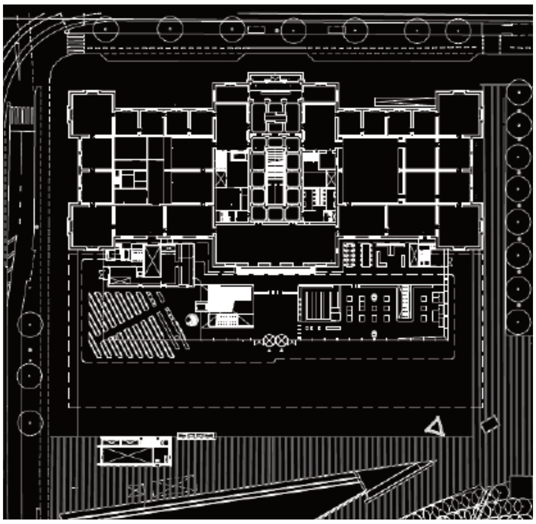
Besides the entrance, a museum shop and the restaurant with terrace are situated in the transparent addition on ground level. Below the square are among others, a knowledge centre, a library and a large exhibition hall of 1100 m2. From this lowest level in the building it is possible to move to a new exhibition hall in the floating volume level. Via two escalators in an enclosed "tube", straight through the new entrance hall, the two exhibition areas are connected. This way the visitor crosses the entrance area without leaving the exhibition route and without being distracted by the public functions; visitors remain in the museum atmosphere. The detailing and color on the inside of the old and new buildings is in alignment, making the explicit contrast between the old building and the new building barely noticeable when walking through the museum.

Geometry Morphology	Rectilinear Real-object Morphology	Primary composition operation(s)	Align; Boolean
Principal primitive	Parallelepiped	Secondary composition operation(s)	Smooth; Taper
Additional primitive(s)	Plane	Main design strategy	Artistic Fact
Form and composition concepts	Alignment; Contrast; Frontality; Horizontality; Obliquity; Unity	Secondary design strategies	None

For more information, please see <http://www.benthemcrouwel.nl/portal_presentation/museums/stedelijk-museum> <http://www.archdaily.com/350843/stedelijk-museum-amsterdam-benthem-crouwel-architects/>







Swiss RE Headquarters

Foster & Partners

Location	London	Software	Generative Components; MicroStation
Country	UK		
Date from	2000		
Date to	2004	Site Area	4.500
Type	Institutional building	Total Area	47.950
		Cubature	1.100.000
Client	Swiss RE Group	Height	180
		Lenght	45
Context	Central business district	Depht	45

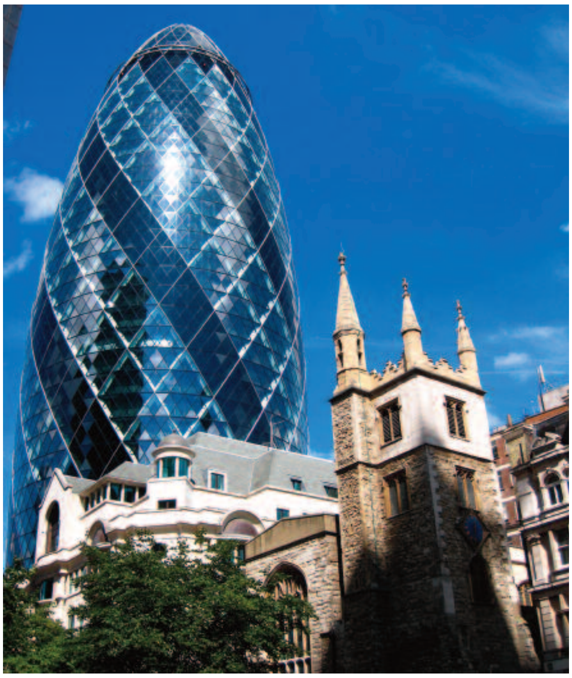
Description

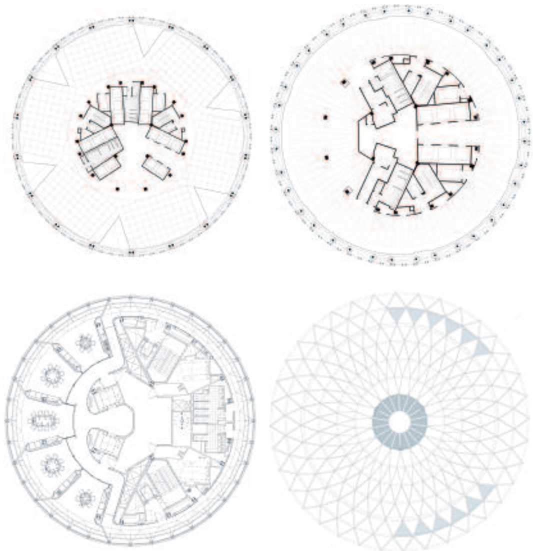
London's first ecological tall building and an instantly recognisable addition to the city's skyline, this headquarters for Swiss Re is rooted in a radical approach – technically, architecturally, socially and spatially. Forty-one storeys high, it provides 46,400 sqm net of office space together with an arcade of shops and cafés accessed from a newly created piazza. At the summit is a club room that offers a spectacular 360-degree panorama across the capital.

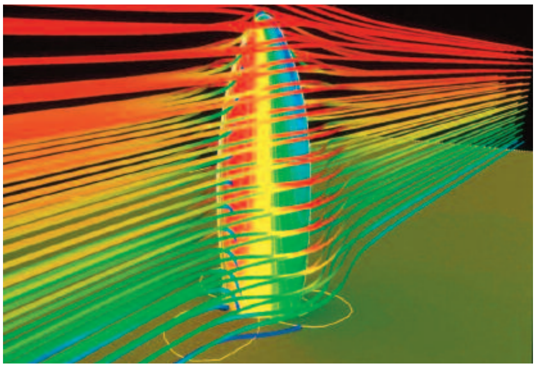
Generated by a circular plan, with a radial geometry, the building widens in profile as it rises and tapers towards its apex. This distinctive form responds to the constraints of the site: the building appears more slender than a rectangular block of equivalent size and the slimming of its profile towards the base maximises the public realm at street level. Environmentally, it was digitally designed to reduce wind deflections compared with a rectilinear tower of similar size, helping to maintain a comfortable environment at ground level, and creates external pressure differentials that are exploited to drive a unique system of natural ventilation. The tower's diagonally braced structure allows column-free floor space and a fully glazed facade, which opens up the building to light and views. Atria between the radiating fingers of each floor link vertically to form a series of informal break-out spaces that spiral up the building. These spaces are a natural social focus and function as the building's 'lungs', distributing fresh air drawn in through opening panels in the facade, reducing the reliance on air conditioning.

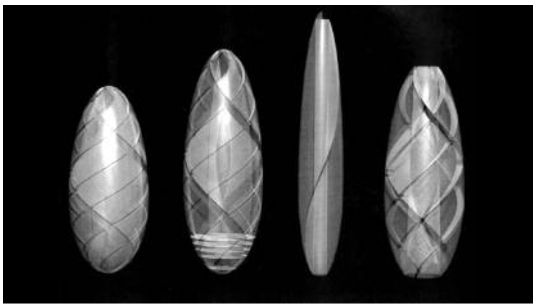
Geometry	Curvilinear	Primary composition operation(s)	Extrusion; Folding
Morphology	Biomorphic		
Principal primitive	Cylinder	Secondary composition operation(s)	Bulging; Mesh; Smooth
Additional primitive(s)	Cone	Main design strategy	Performance optimization
Form and composition concepts	Axiality; Disproportion; Monumentality; Scale; Verticality	Secondary design strategies	None

For more information, please see <http://www.fosterandpartners.com/projects/swiss-re-headquarters-30-st-mary-axe/>



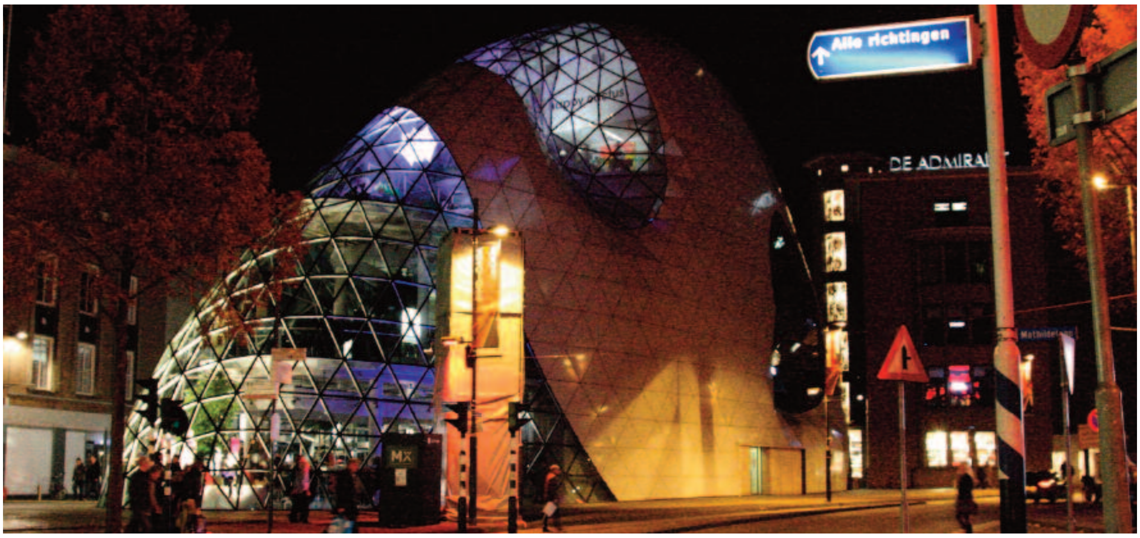






The Admirant

Massimiliano Fuksas



Location	Eindhoven	Software	AutoCAD; Rhinoceros
Country	Netherlands		
Date from	2003		
Date to	2010	Site Area	1.200
Type	Commercial building	Total Area	6.000
		Cubature	30.000
Client	Rond de Admirant Cv	Height	20
		Lenght	60
Context	Inner city	Depht	40

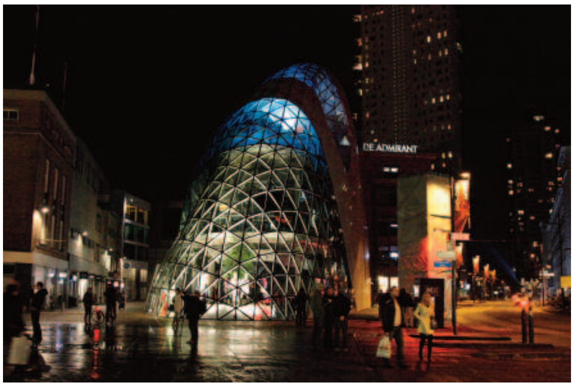
Description

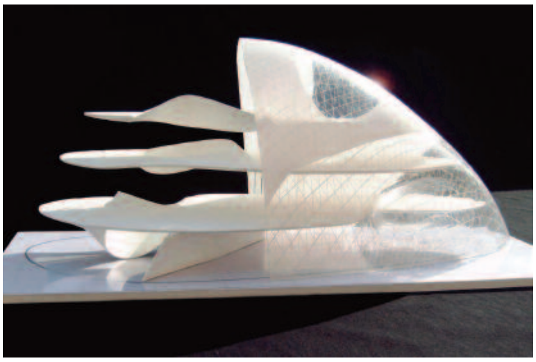
Following the outline of the Masterplan in 1998 for the center of Eindhoven in the Netherlands, studio Fuksas developed the four projects associated with it: a square of 7.000 mq with an underground parking, a shopping center, a store for the sale of electrical appliances and electronic equipment and the Admirant Entrance Building. The Admirant is located just at the border between the new quarter and the square, forming the main gateway to a new shopping axis. This prominent position called for an iconic building: a request that the Admirant Entrance Building fulfilled entirely.

The project of the Admirant Entrance Building is based on an intensive form finding process whose result has prescribed for an unpredictable design: conventional design rules lose their meaning. Compared with the immediate surroundings, the new architecture seems to be at a first glance like an amorphous or organic object. The architecture is full of movement: dynamics go in different directions and with varying intensity. This further flow of speed has its origin in the contrast of the two facade materials: crystalline, the maritime blue of the glass is in contrast to the dense and clear white panels. Open and closed surfaces alternate smoothly and flow over softly. The building consists of two elements: the 5-storey high primary concrete structure and the glass and steel envelope. Commercial spaces are located on the ground and first level and office spaces on level three and four (plus an additional technical level). The geometry of the façade varies from vertical surfaces to amorphous shapes, which create a dynamic inside of the building.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	NURBS Surfaces	Secondary composition operation(s)	Bulging; Mesh; Retract
Additional primitive(s)	Free-form solid	Main design strategy	Blob
Form and composition concepts	Alignment; Complexity; Gesture; Plasticity; Unity	Secondary design strategies	None

For more information, please see <http://www.fuksas.it/home.htm#/progetti/0506/>
<http://www.archdaily.com/69386/admirant-e-18-september-plein-massimiliano-doriana-fuksas/>





Walt Disney Concert Hall

Frank O. Gehry

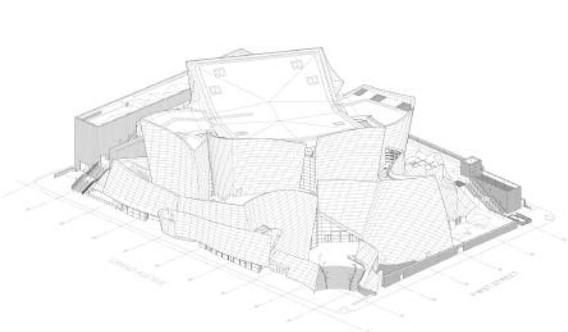
Location	Los Angeles	Software	AutoCAD; Catia; Reverse Modeling
Country	USA		
Date from	1989		
Date to	2003	Site Area	13.500
Type	Entertainment structure	Total Area	14.560
		Cubature	435.500
Client	Lilian Disney, Walt Disney Company	Height	30
		Lenght	115
Context	Central business district	Depht	80

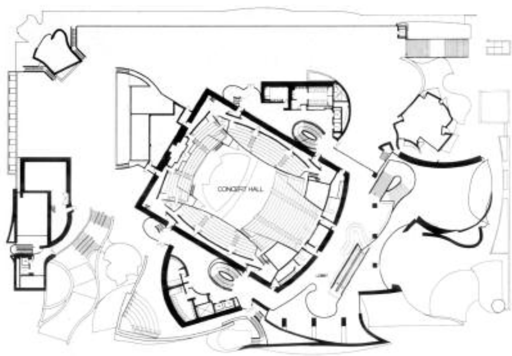
Description

In 1987, Lilian Disney donated $50 million to establish a concert hall in honour of her husband, Walt. Frank Gehry was selected during a design competition the following year. His proposal was largely oriented toward the public, with much of the site allocated to open gardens.
The exterior is a composition of undulating and angled forms, symbolizing musical movement and the motion of Los Angles. The design developed through paper models and sketches, characteristic of Gehry's process. The reflective, stainless steel surface engages light as an architectural medium. The facade's individual panels and curves are articulated in daylight and coloured by city lights after dark. Thin metal panels allowed for more adventurous curvature and could be structurally disassociated from the ground. Glass fissures in the facade bring light into the lobby and pre-concert room, reading as a grand entryway through the otherwise opaque facade.
Inside, the concert hall was designed as a single volume, with orchestra and audience occupying the same space. Seats are located on each side of the stage, providing some audience members with distant views of the performers' sheet music. Curvilinear planes of Douglas fir provide the only partitions, delineating portions of the 2,265 member audience without creating visual obstructions. The steel roof structure spans the entire space, eliminating the need for interior columns. The organ stands at the front of the hall, a bouquet of 6,134 curved pipes extending nearly to the ceiling. Gehry worked with acoustical consultants to hone the hall's sound through spatial and material means.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	Free-form solid	Secondary composition operation(s)	Boolean; Break; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Artistic Fact
Form and composition concepts	Articulation; Complexity; Contrast; Deconstruction; Gesture; Monumentality; Plasticity	Secondary design strategies	Deconstruction

For more information, please see <http://www.foga.com/>
<http://www.archdaily.com/441358/>





Watercube National Acquatic Center

PTW

Location	Beijing	Software	AutoCAD; Performance-based design
Country	China		
Date from	2003		
Date to	2007	Site Area	110.000
Type	Recreation structure	Total Area	65.000
		Cubature	982.200
Client	International Olympic Committee, Chinese	Height	31
		Lenght	178
Context	Urban fringe	Depht	178

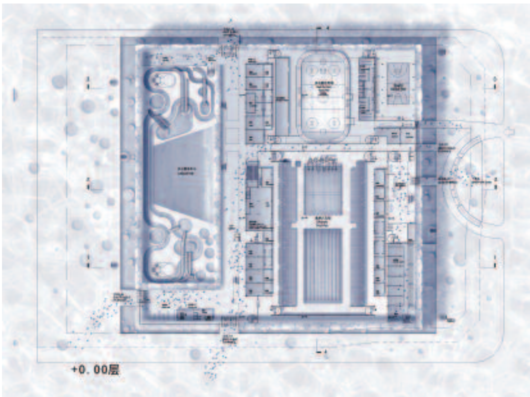
Description

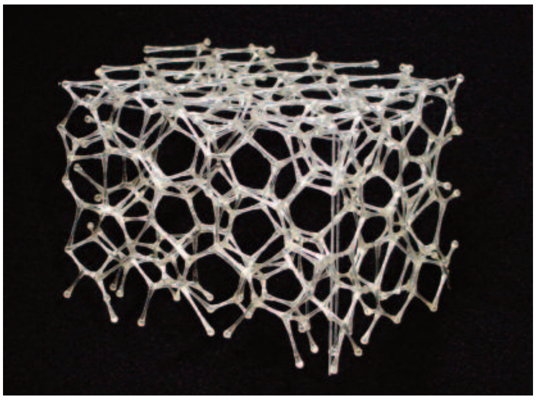
CSCEC + PTW + CCDI and ARUP won the International Design Competition for the Beijing 2008 Games aquatic centre. The scheme met international standards for competition, while maximising social and economic benefits. In addition to being an aquatic competition venue for the games, the centre provides public multi-function leisure and fitness facilities before and after the games. The concept combines the symbolism of the square in Chinese culture and the natural structure of soap bubbles translated into architectural form. Located close to Herzog & DeMeuron's stadium, contextually the cube symbolises earth whilst the circle (represented by the stadium) represents heaven.

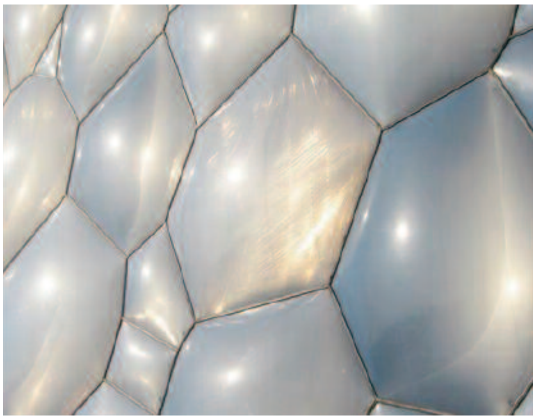
The design uses state-of-the-art technology and materials to create a building that is visually striking, energy efficient, and ecologically friendly. The outer wall is based on the Weaire–Phelan structure, which devised from the natural pattern of bubbles in soap lather. The complex Weaire–Phelan pattern of the façade was developed by slicing through bubbles in soap foam, managing it digitally to become a steel space frame, which is filled by the largest ETFE clad structure, that visually forms the bubbles. The striking Watercube structure is energy efficient by maximising natural light and capturing solar energy to heat the interior spaces as well as the pools. Water efficiency is achieved by rainwater harvesting, recycling, efficient filtration and backwash systems.

Geometry	Rectilinear	Primary composition operation(s)	Extrusion
Morphology	Biomorphic		
Principal primitive	Parallelepiped	Secondary composition operation(s)	Bulging; Repeat
Additional primitive(s)	None	Main design strategy	Natural Derivation
Form and composition concepts	Articulation; Complexity; Horizontality	Secondary design strategies	None

For more information, please see <http://www.ptw.com.au/ptw_project/watercube-national-swimming-centre/>
<http://www.water-cube.com/cn/>







Yas Hotel

Asymptote

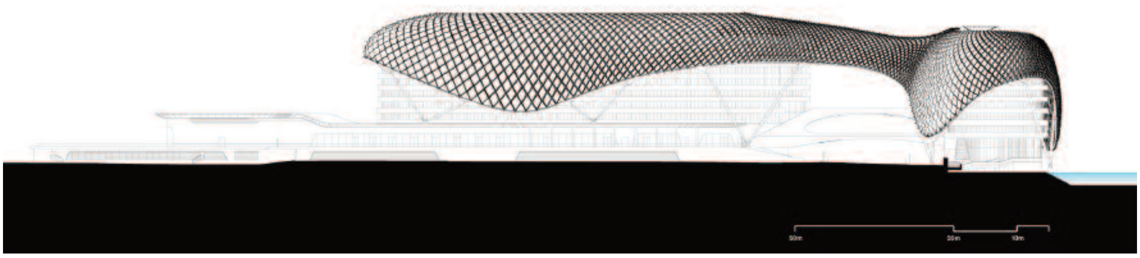
Location	Abu Dhabi	Software	3D Modeling; BIM
Country	UAE		
Date from	2007		
Date to	2010	Site Area	35.000
Type	Public accommodation	Total Area	85.000
		Cubature	371.875
Client	Aldar properties, PJSC Abu Dhabi	Height	35
		Lenght	210
Context	Urban fringe	Depht	160

Description

Asymptote's design of the Yas Island Marina Hotel architecture reconciles the dramatic site conditions with the ambitious program to contain a luxury 500-room hotel with extensive amenities situated above a Formula 1 Racetrack and within a Yacht Marina.
The architecture is comprised of two 300m long elliptical blocks each ten story high, one being a land based structure while the other is located in the Marina inlet waters. A large free-span, fuselage like steel bridge spanning the F-1 racetrack below connects both hotel towers, affording unprecedented views onto the race and environs. The entire complex is covered in a monumental steel and glass lattice grid shell structure that produces the Hotels now famous iconic image. While the gridshell structure gives the building its image and form it also serves an environmental purpose for the building by assisting in the stack effect of exiting heated air up and over the facades of the building, something especially important in the hot arid Abu Dhabi climate. This complex geometric skin, digitally conceived, reflects the sky and surroundings by day, and by night is fully lit by way of a state of the art programmable LED lighting system. Asymptote's design enables the merging of an active marina environment with the spectacle and energy of the annual Formula One Grand Prix while also projecting a modern image of Abu Dhabi onto the international stage.

Geometry Morphology	Curvilinear Geometrical	Primary composition operation(s)	Folding
Principal primitive	Free-form solid	Secondary composition operation(s)	Boolean; Mesh; Smooth
Additional primitive(s)	NURBS Surfaces	Main design strategy	Folded surfaces
Form and composition concepts	Articulation; Axiality; Complexity; Gesture; Unity	Secondary design strategies	Artistic Fact; Blob

For more information, please see <http://www.asymptote.net/#!yas-slide-show/cau8>
<http://www.archdaily.com/43336/the-yas-hotel-asymptote/>



CHAPTER 5
Queries

After collecting all data and settled up all parameters for each case-study, we used the database to obtain results through its combinatorial possibilities. Hence, the main operation was the setting out of several *queries*, through which questioning the software in order to quickly visualize the results and combinations in form of graphs, tables, reports, etc.

5.1. Definition and goals of queries

Query is a general term that is synonymous with question, inquiry, or quiz. In Access®, to query a database is to ask a question about the information stored within it. A query can regard the data in a single table or in multiple related tables. Access® provides several types of queries, ranging from the popular *select query*, that extracts specific data, to the more exotic *action query*, that can insert, update, and delete records (Andersen, 2007).

You can use queries to do the following:

- look at data from related tables;
- look at subsets of your data — a selective slice that meets certain criteria that you specify;
- sort and alphabetize data;
- create new calculated fields.

To create a query, you need to know what data — more specifically, which fields — you want to see and in which tables those fields are contained. As you define the query, you may have criteria that limit the data and after its definition, you can view the data in a datasheet. The datasheet created by a query is dynamic - that is, you see the data that meets the query definition each time you view the datasheet. If data has been added, edited, or deleted, the query datasheet may display different data. For the query creation, you use either a wizard or Design view (or both) to tell Access® which data you want to visualize and information to extract.

The many different types of queries provided by the software give you many different ways to select and view specific data in your database. You choose the type of query, the fields you want to see, and you define criteria to limit the data shown as necessary. The following list includes the types of queries available in Access®:

- *Advanced Filter/Sort*: The simplest kind of query, it allows you to find and sort information from a single table in the database.
- *Select Query*: it selects the data you want from one or more tables and displays the data in the desiderate order to be displayed. A select query can include criteria

that tell Access® to filter records and display only some of them. Select queries that display individual records are called *detail queries*; those that summarize records are called Summary or Totals queries.

- *Totals or Summary Query*: These queries are a subset of select queries, but they allow you to calculate a sum or some other aggregate (such as an average) rather than displaying each individual record.
- *Parameter Query*: it asks you for one or more pieces of information before displaying the datasheet.
- *AutoLookup Query*: A query that fills in information for you. It is used when you want to enter one value and see other data from the same table
- *Action Query*: Action queries change your data based on some set of criteria. Action queries can delete records, update data, append data from one or more tables to another table, and make a new table.
- *Crosstab Query*: Most tables in Access®, including ones generated by queries, have records down the side and field names across the top. Crosstab queries produce tables with the values from one field down the side and values from another field across the top of the table. A crosstab query performs a calculation — it sums, averages, or counts data that is categorized in two ways, as defined by the row and column labels.

Select queries are the most common type of queries used in Access. In fact, select queries are the most general type of query, and all the other query types add features to select queries. When you define a select query, you use the design grid to select which fields and records to display in the new datasheet. The skills you use to define select queries are also used to define the other types of queries (Simpson et al., 2007).

After creation of a query, you can open it in different ways:

- *Design view*: it is useful because you can select tables, fields, create criteria, expressions, define sort order, and all the other things you need to do to define a query.
- *Datasheet view* displays the fields from the query in a datasheet, just as if you were looking at a table datasheet.
- *SQL view* displays the query definition as a statement in SQL (Structured Query Language).
- *PivotTable* and *PivotChart* views summarize and chart the data from the query. This view is particularly useful when you need to create graphs or quickly visualize averages and prevalence.

5.2. Cases database: simple queries and predominance

The first operation we need, in order to obtaining the first result, is understanding the prevalence of data in each category we defined. As it was explained before, while you create a query, Microsoft Access® ask you which data you want to use and, in this way, you can connect data from different tables. The software maintains relationships between the tables in your database, that were created when the database was initially designed (please refer to Chapter 3, section 3.3.2.). In fact, when you build the tables and organize them with special key fields, setting the dependence among tables, you actually prepare the tables to work with a query (Ulrich-Fuller and Cook, 2010).

In the case of simple queries, when aim is obtaining the percentage of each parameter in a specific field, the best operation do is to create a query which *counts* data and to show data in a *Pivot table*, so that we can easily create graphs though *pivot charts*. By creating a query through the lookup wizard, firstly we have to choose a table where data resides, that is the main table - we called *Cases* - and, after that, the table where we want to make the calculation. Then we have to choose the right parameters in both the tables. E. g. in the main table *Cases*, you need to understand the prevalence in the field *Context*; then you have to choose the field where you want to do the count in the main table *Cases*, that is *context*, while in second table, named indeed *Master_context*, you have to choose the field *Type*, where all the values of the category are inserted (Fig. 1).

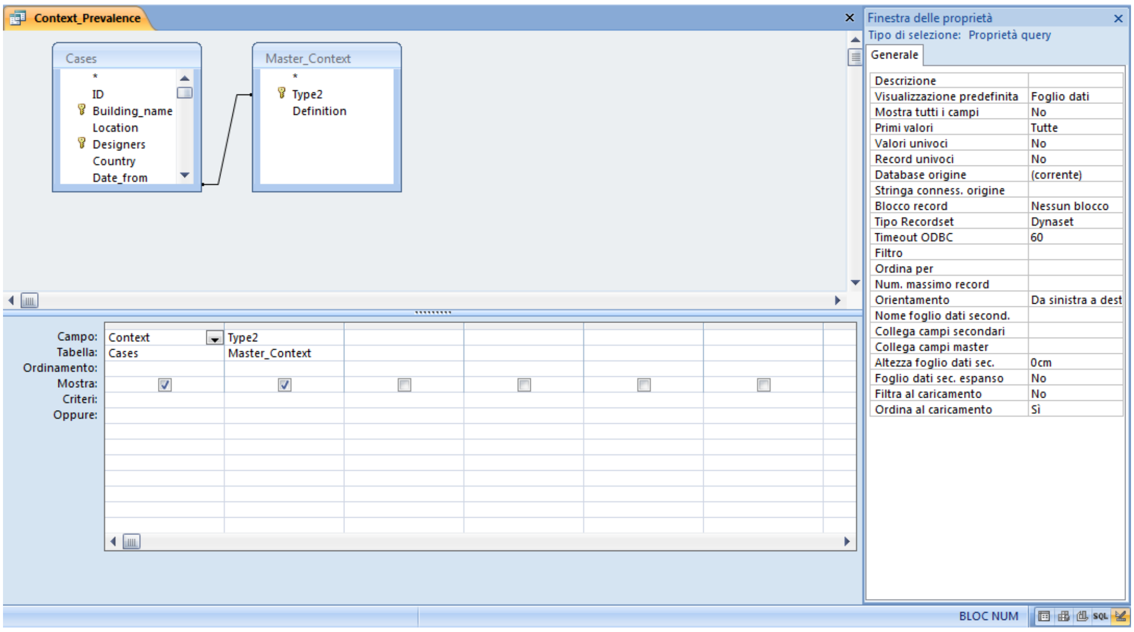


Fig. 1 Screenshot of the main nterface of a simple query in design view.

Then the query is virtually ready, but we need to obtain a tangible result, that could be expressed in terms of graphs, as an histogram, by using pivot tables. Then, by clicking the button to pivot table view, so that we have a blank PivotTable. In order to see data, you need to drag and drop fields into the drop areas. Each field name in the PivotTable Field List has a plus sign (expand indicator) or a minus sign (collapse indicator) next to it and, by clicking an expanding indicators in the PivotTable Field List, we can see more options for fields to drag and drop. The four possible drop areas are as follows:

- *Totals* or *Detail Fields*: Drag the name of the field that contains the values you want displayed in the body of the PivotTable to this drop area. The values in this field are organized by the values in the column and row fields. After you drag a field to the Totals or Detail Fields drop area, you see data in your PivotTable.
- *Column Field*: Drag the name(s) of the field(s) you want to show as column headings to this area.
- *Row Field*: Drag the name(s) of the field(s) you want to show as row headings to this area.
- *Filter Fields*: Drag the names of any fields you want to use for filtering purposes to this area.

Then we have to put the field *type* of the table *Master_Context* in the *chart view* columns, in order to show each parameter (old center, inner city, etc.) Practically we define a histogram graph in the where the parameters are shown in the x-axis and the relative quantities in the y-axis (Fig. 2).

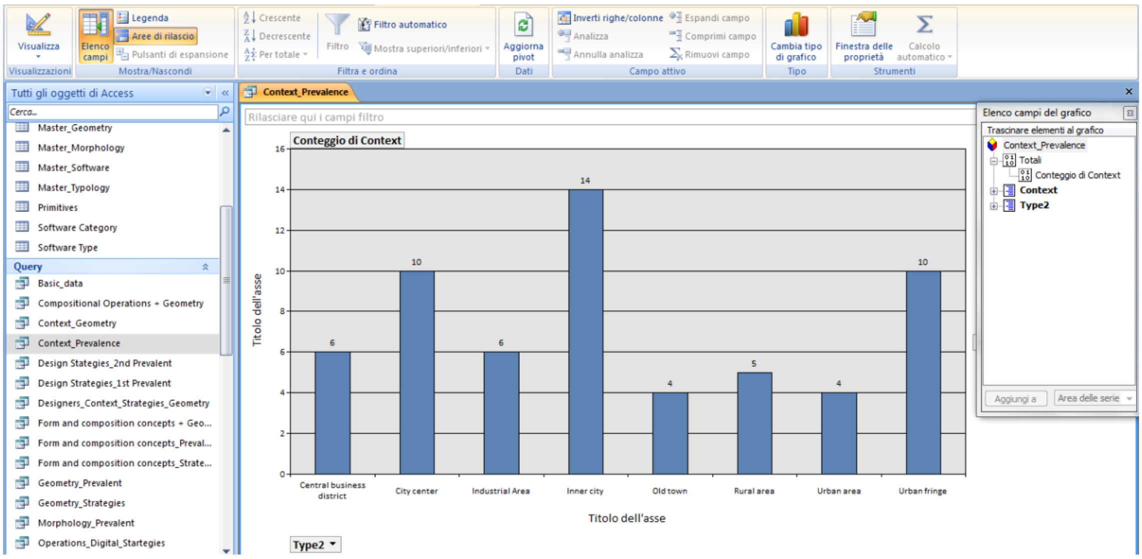
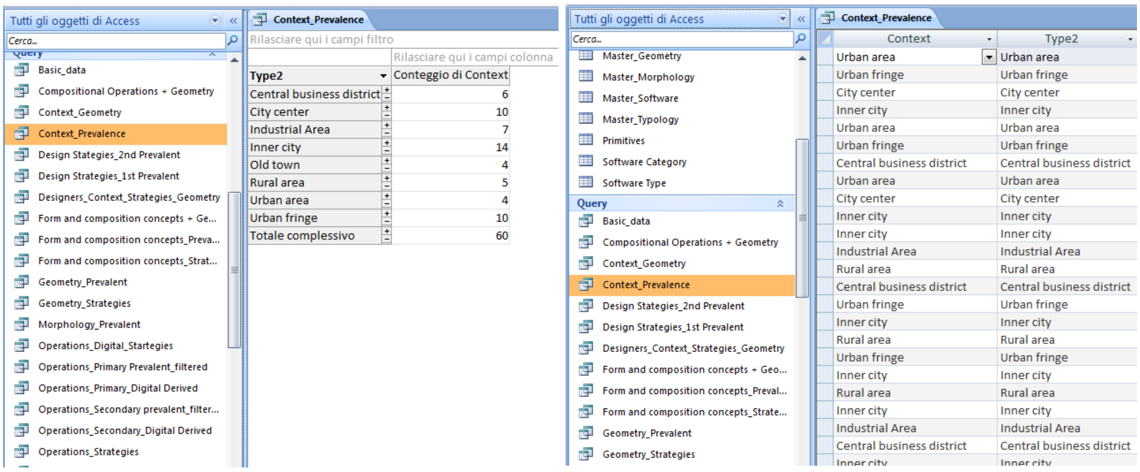


Fig. 2 *Pivot chart* with an histogram showing the prevalence in the category *Context*, taken as example.

The results can also be showed as pivot table (Fig. 4), which essentially contains the data (numbers), as a data sheet (Fig. 5) and as SQL (Structured Query Language), a special-purpose programming language designed for managing data held in a relational database management systems, that could be useful to immediately show the relationships among elements and, then, to recognize if the process is correct (Fig. 3).

```
SELECT Cases.Context, Master_Context.Type2
FROM Master_Context INNER JOIN Cases ON Master_Context.Type2 = Cases.Context;
```

Fig. 3 Example of SQL visualization.



Figg. 4 and 5. On the left, an example of pivot table. On the right, the data sheet view of the query created.

Understand the absolute prevalence per each category it is fundamental to have an overall overview about our research. In fact, in this case we were able to map which are the most recurrent:

- context where the building are placed;
- typology;
- overall geometry;
- morphology;
- primitives, both in first and second order;
- operations, both in first and second order;
- concepts;
- design strategies.

The simple queries give us the possibility to understand the general overview about the digital influence on current architecture, through the discover, for example, of which is the most recurrent geometrical configuration - curvilinear or rectilinear? - or which are most used primitives and operations. But to limit our investigation only at this level is limiting, because the most interesting part and the biggest advantage of the database resides in the great possibility of combinations and interrelation. For this reason, we have to resort to the complex queries.

5.3. Complex queries: filtering and data crossing

Hence, we use more complex queries in order to obtain results which can relate different categories to each other and, then, we can have a more comprehensible scenario about the existing relationships among different aspects.

One of the most useful operation for our work done on the database was the *filtering*, that means we filtered our result through other criteria. E.g. by working on the category *Primitives*, we want to understand the prevalence of digital-derived primitives, which can be done with a normal query including the field of digital-derived primitives and making a calculation in the category primitive of the main table *Cases*. We obtained an histogram showing that the primitives born in the computational domains are the most prevalent (Fig. 6).

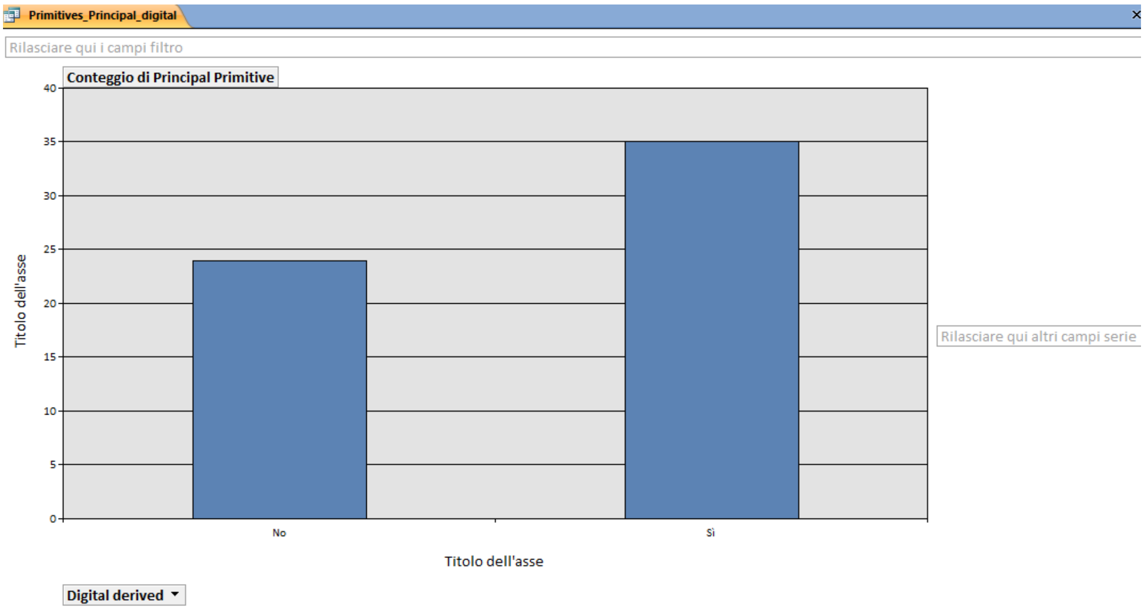


Fig. 6. Screenshot of Access®, where it was set a simple query showing the prevalence in digital primitives.

But, now, we want to know more, for example the existing relationship with our design strategy casuistry. To do this, we add the category *Design Strategies* as filter, then we can understand which primitives were used per each trend and in which trend we recognize the prevalence of digital derived primitives and in which not (Fig. 7-8).

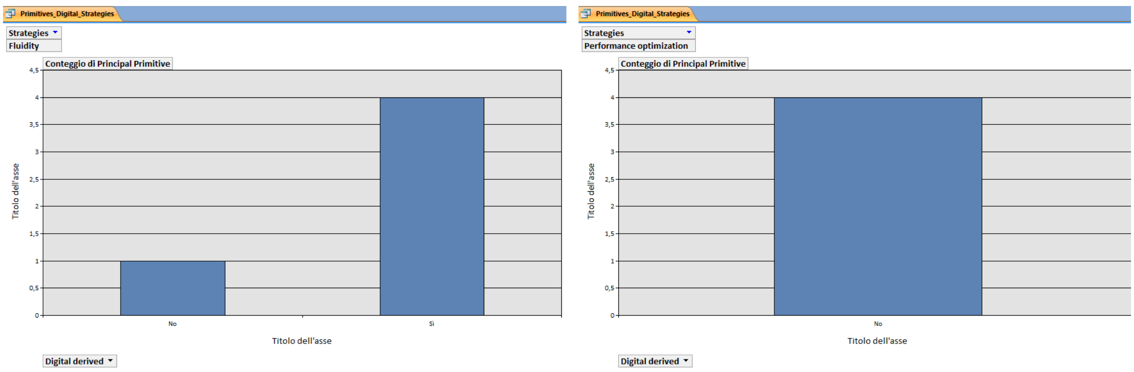


Fig. 7 and 8. In the first part, the precedent query showing the prevalence in digital primitives was filtered through the variable of *Design Strategies* and it is showing only the values for the parameter *Fluidity*. In the right part, the filter was the parameter *Performance*.

Definitely, filtering by excluding selected values enables us to hide record we do not want to see (Ababio, 2005) and, through the visualization of selected records, we can obtain information more focused and precise.

The process of setting complex queries and understanding which results we want to see is an operation that requires a logical approach and obviously a greatest understanding of our research and of the results we want to achieve. In fact the database is a tool allowing almost endless combining possibilities and, for this reason, we have to understand before setting the queries what we want to show for obtaining significant data and, then, to discuss and comment it. Hence, after having set all the data, the work continues through the analysis of the results and the discussion about them, which we will deepen in the third part of the thesis.

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PART III

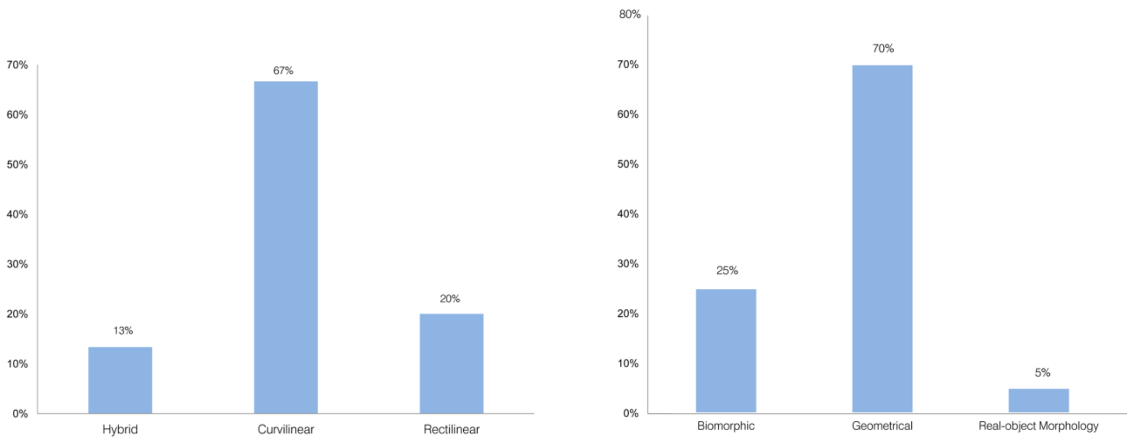
interpretation

CHAPTER 6
Results and discussion

After setting out the several queries, it seems more interesting to report our results from them and to discuss by starting to analyze morphological, compositional and conceptual issues and by concluding with more generic features, which are about *type*, *context* and *construction*. Indeed, the analysis of the first matters mentioned it is undoubtedly related to what has been the main subject of this research, that is the evolution of architectural expressivity and design methodology in the digital age. Hence, questions about relationship between form and type, or context and language, are influenced by what precedes and instead concerns designer's approach to design.

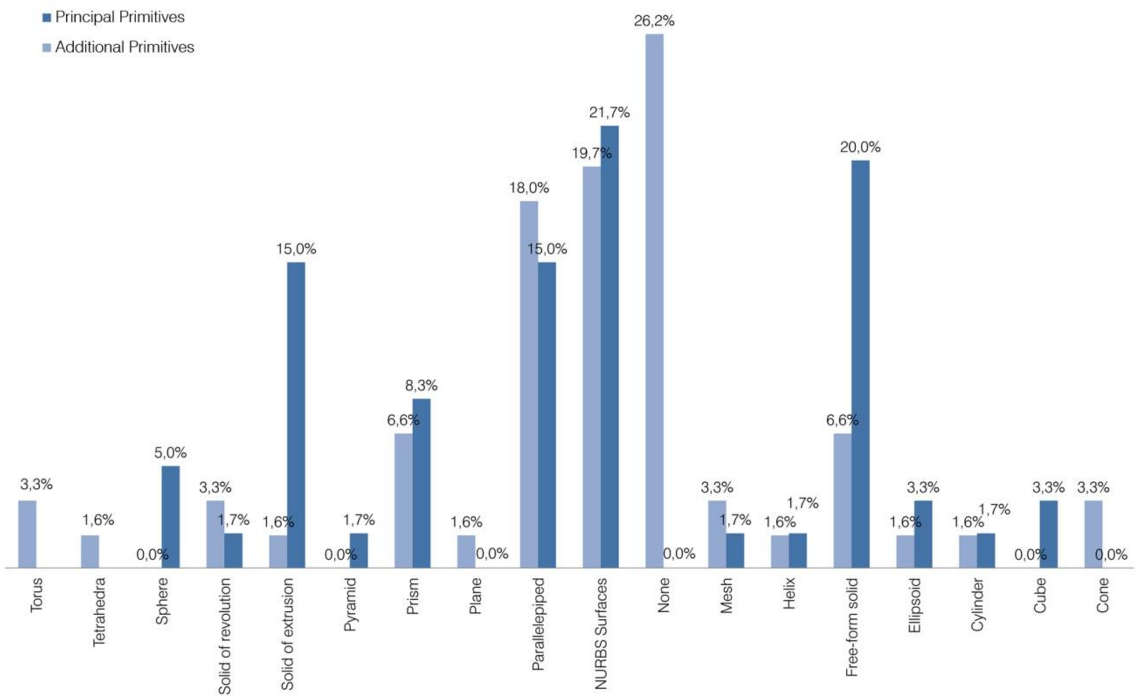
6.1. Morphological features: does digital take control?

By focusing on morphological features, we deal with three main investigation fields, which are the discover of the prevalent overall *geometry*, the *morphology* - intended as the literal *study of the shape*, with the goal to understand if formal configuration of buildings is somehow *similar* to something (*zoomorphic, anthropomorphic*, etc.) or if it is geometrically conceived - and finally which primitives were used to compose each design.



Graphs 1-2. Cases prevalence, respect with *Geometry* and *Morphology.*

Then, we queried the database as to show the related prevalence per each category, by setting up some simple queries. Referring to *Geometry* (graph 1), we note the high prevalence of the *curvilinear* one (66%); moreover, in the category *Morphology* there is an high percentage of *geometrical* one (69,5%) (graph 2). This shows a strongly tendency towards designs with curvilinear configurations, but with a rigid geometrical control allowed by the almost endless possibilities of manipulation and deformation of the shape allowed in digital representation.

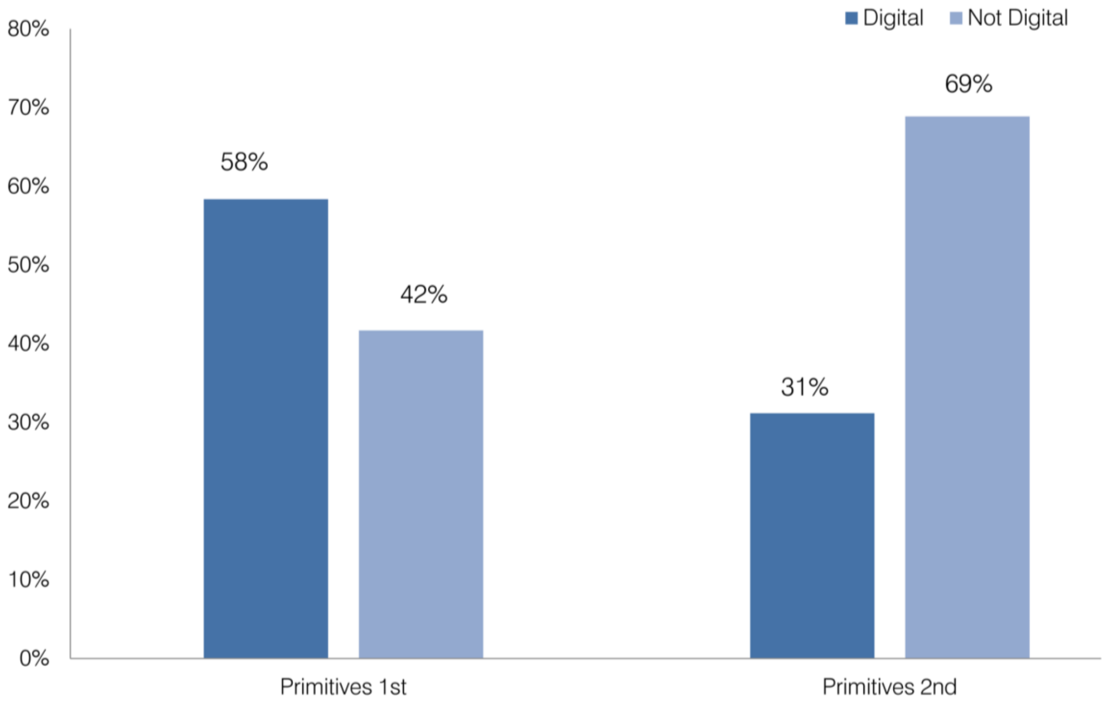


Graph 3. Confrontation of absolute prevalence in pricipal and additional primitives.

On the other hand, concerning *Primitives*, which are distinguished in *prevalent* and *additional*, we can observe the prevalence of NURBS Surfaces in the first order (22%) and of *no other primitives* in the additional level (graph 3). Furthermore, we have filtered the *Primitives* data through the variable *Digital - Not Digital* (graph 4): in the first order we found an high prevalence of digital primitives (59%) but not in the second order (only 30%). This is an important result because it suggests that, by developing design concept, the starting point, expressed in terms of primitive, is in prevalence digital, while primitives used in refining conceptual idea - expressed then in the second order - are conventional and not digital-derived.

We therefore conclude that the conceptual phase begins in the computational space with a primitive, rather than e. g. with a sketch. It also shows that with the introduction of architectural computing, during conceptual phase, designers have substituted the value of the sketch, which for centuries was the first sign to express an idea almost always unclear in the same designer's mind with the primitives currently available in each architectural software (Dorta et al., 2008). Now practitioners start with a parallelepiped or a sphere and then work on it by refining, deforming, cutting, etc. The main difference with respect to traditional sketches is the level of definition: in general, sketches are perceived as less descriptive and more chaotic than computer generated forms, which, in turn, have a strong quality of precision and realism (Bates-Brkljac, 2009).

Furthermore, we filtered Primitives data also through the variable of the Geometry, which revealed that the configuration remains curvilinear both in the first and second level, even if we have to report the high level of unused secondary primitives (29%) and, in general, percentages more balanced.

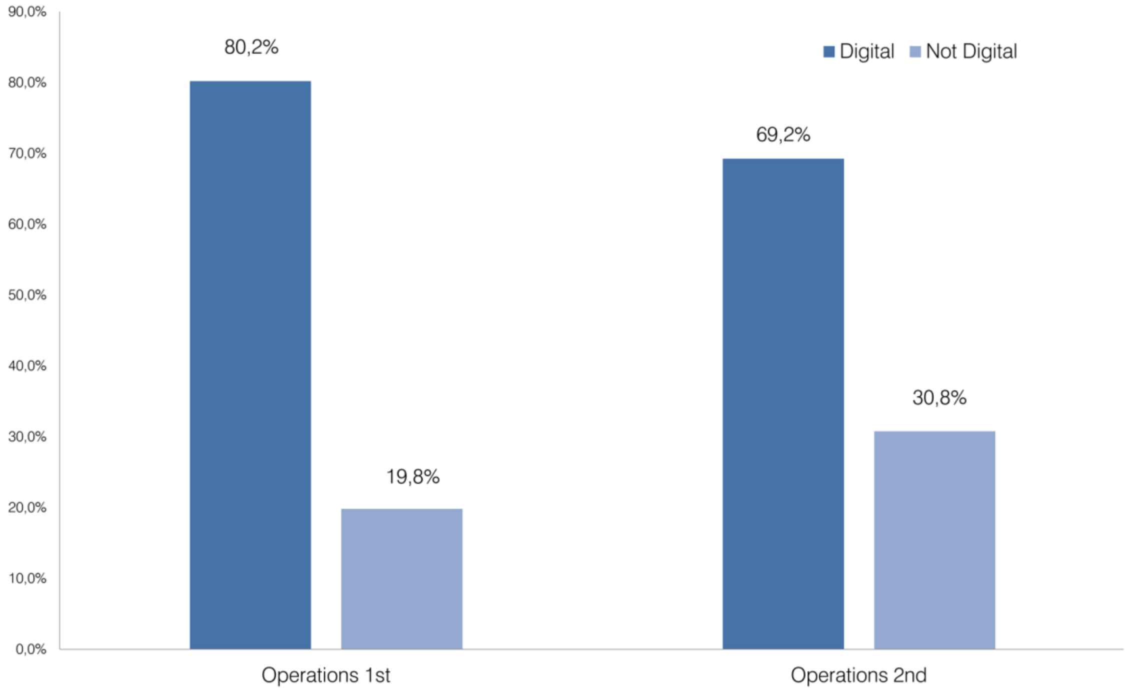


Graph 4. Digital primitives in the first and second level.

6.2. Composition issues: digital absolutely takes control.

Firstly we analysed those operations we can easily recognize in the overall design configuration. Even in this case, we have split up the category in first order, according to those operations that unequivocally are prevalent, both in dimensional and figurative terms, and second order, where we have recognized all instrumental actions that generally were used to refine the shape, in order to reach the right consistency with design idea. Also here it is evident that a high percentage of designs using operations totally digital. Digital operations are prevalent in both levels, primary and secondary, as we can observe in the graph 5.

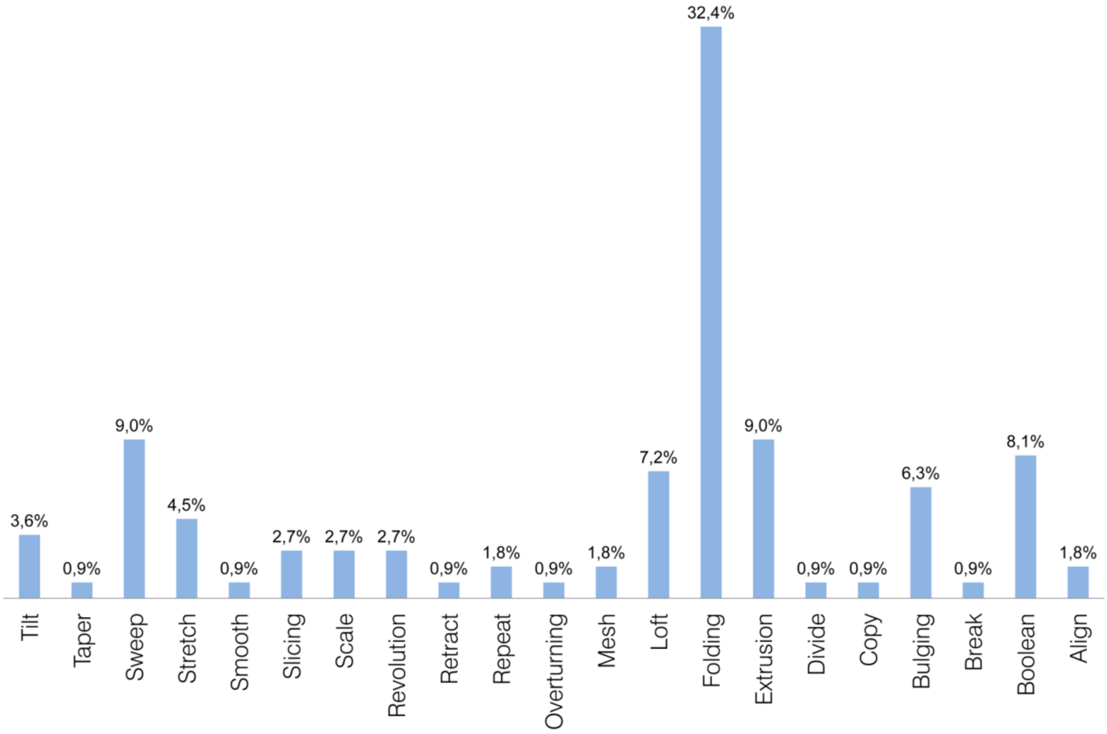
If we look at the prevalent operations in the first level, *folding* (32,4%) dominates both as an expression of the ability to reliably control complex surfaces in the computer and of certain tendency to abandon straight and regular geometries, preferring curved lines, sloping planes and organic spatial configurations. This attitude is arguably also confirmed by the relevant presence of operations like *loft* and *bulging*, both in the first and second order, and of *smooth*, *mesh* and *sweep*, operation usually used to refine a curvilinear surface, only at the second level (graph 6). In parallel, it is interesting to note almost the same prevalence in both levels of those operations we could call instrumental, with respect to the interaction with primitives and 3D solids, like *extrusion* and *Boolean* (union, subtraction, interaction).



Graph. 5. Digital operations in first and second level.

We can therefore conclude that *digital absolutely take control*, in both morphology and composition. Design thinking and conception are becoming more and more identified by a pervasive use of digital technology and by the geometrical and mathematical operations offered by commercial software. This is obviously correlated to the improved skills of designers to visually manage architectural shape but also to the undeniably increased speed through which we can nowadays model and represent an abstract idea, to improve and refine it until we reach a result that best fits the desired design concept.

As regards formal concepts, most cannot be called strictly digital. However, the popularity of concepts like *plasticity* (11,7%), *complexity* (11,4%) and *unity* (9,1%) suggests an emergent trend towards the visual in architecture (graph 7). In fact, among the cases we find many examples of buildings with a unique envelope, which very often is treated as a complex surface with a curvilinear configuration that may refer to a sort of artistic plasticity. This seems a dominant motif in current architectural scenarios, an evolution of organic and expressionist trends from the first half of the twentieth century – what could be termed *Digital Expressionism* (Riccobono et al., 2013), which we will discuss in greater detail in the Chapter 7, also with other trends that we have recognized.



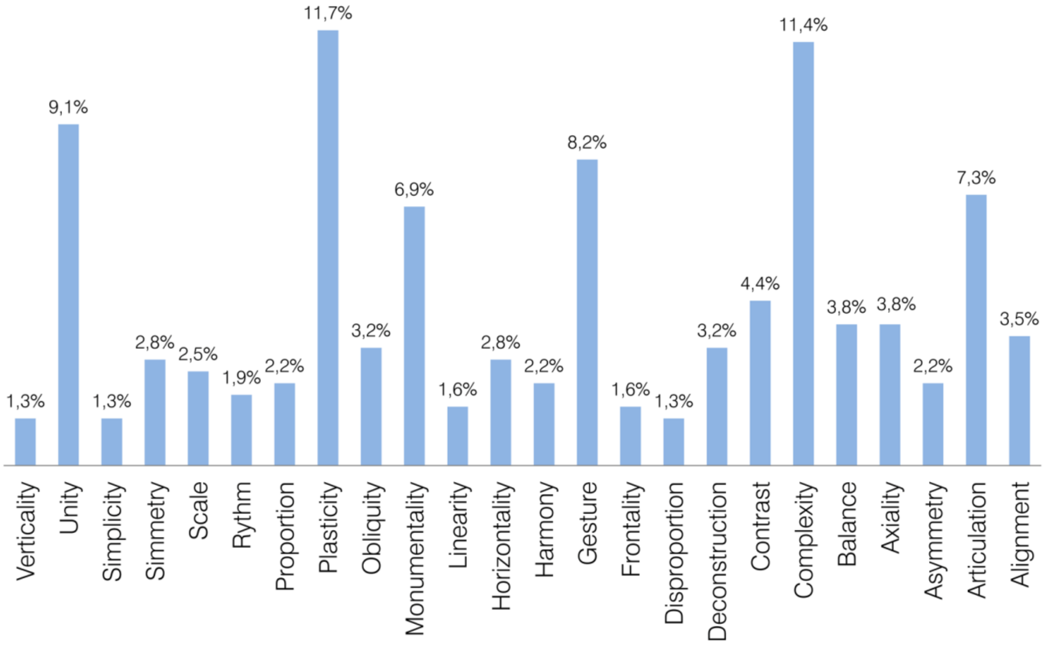
Graph 6. Prevalent operations in the first level on analysis.

This feeling is reinforced by the conspicuous presence of concepts like *articulation*, *monumentality* and *gesture*, which suggest a strong tendency to deal with architectural design in a figurative way. Moreover, we note present the concept of *balance*, which often indicates that the project is proportionate and poised, in the same way as the concept of *contrast*. It is noteworthy that contrast is expressed not regarding the composition but rather than its urban context; this appears to confirm that attitudes underlying digital tendencies sometimes are rather distant from traditional design approaches in terms of type, form and morphology (Arís, 1993).

6.3. Combinatorial approach. When morphology meets composition.

Since the database has given us the possibility to combine different categories and compare the results, we also had the opportunity to correlate morphological and compositional issues, as we can observe summarized in Table 1. Looking at the prevalence of compositional operations and formal concepts, filtered through the variable of *Geometry*, we can observe that, in the case of *curvilinear* configurations, the most recurrent operation is *folding* (41,3%) and the associate concept is *plasticity* (14,3%), with a lesser presence - but not less important - of *unity* (11,6%) and *complexity* (11,2%).

This leads to the suggestion that the most recurrent figurative trend is to design buildings that are configured as unique envelopes, with plastic geometrical configurations. In the case of rectilinear configurations the most common operations are *extrusion* and *Boolean* (20%), immediately followed by *Stretch* (15%), with which the formal concept of *articulation* (13,7%) is most often associated, followed by *Obliquity* and *Complexity* (both 11,8%). We can interpret this result as taking advantage of digital representations without substantial change to what has happened in architectural design thinking and style in the last fifty years: the architects work on the combination of different solids, on the recurring elements, or on the complex configurations obtained by sum of several elements (*articulation*).



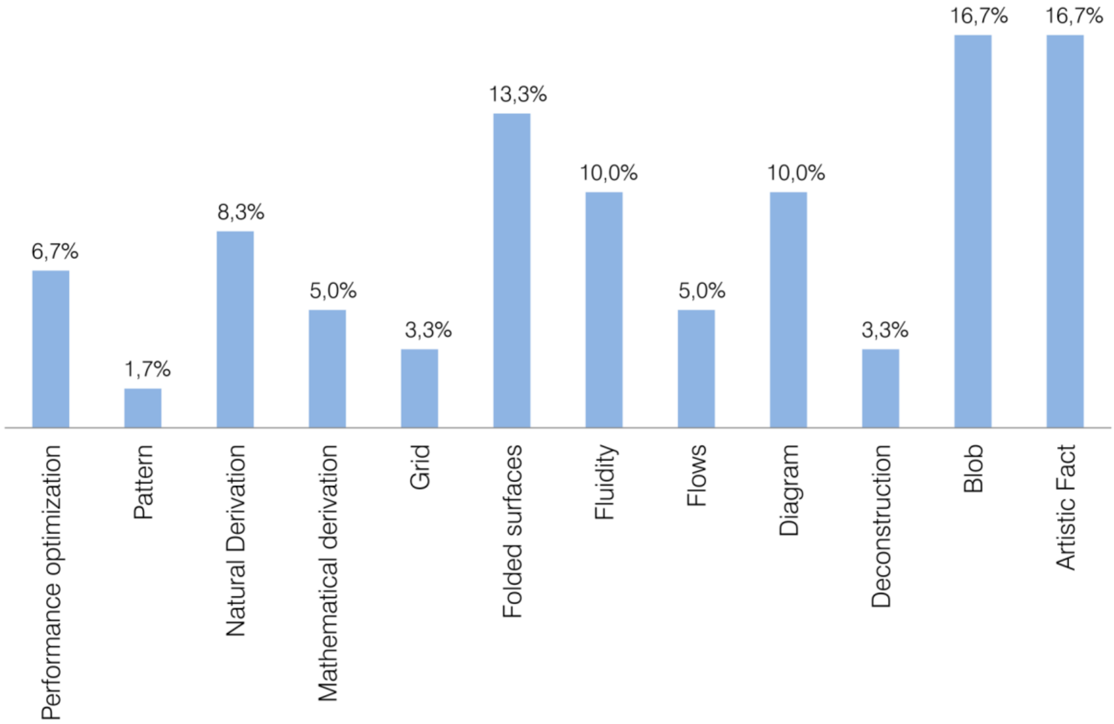
Graph 7. Prevalence in *Form and composition concepts.*

Geometry	Curvilinear	Rectilinear
Operations	Folding (41,3%)	Extrusion, Boolean (20%)
Concepts	Plasticity (14,3%)	Articulation (13,7 %)
	Unity (11,6 %)	Obliquity (11,8%)
	Complexity (11,2 %)	Complexity (11,8%)

Table 1. Comparison of main features in designs with *curvilinear* and *rectilinear* configurations.

6.4. Design Strategies: operative digitality, less conceptual

On the basis of our classification of cases with respect to the strategies easily recognizable in a design, both because the architects explicitly explained their concepts or because some characteristics in form, morphology or in the treatment of the interior space suggest one classification rather than another one, we have observed the prevalence of *Blob* accompanied by the important recurrence of *Artistic Fact*, *Diagram*, *Fluidity*, that make us able to assert that there is a substantial balance among the several trends (graph 8).



Graph 8. Absolute prevalence with respect to *Design Strategies.*

The analysis give us more interesting results if we try to filter digital operations and primitives in relation with each strategy of our selection. Well, as we previously saw at general level, the digital influence is more pervasive at level of operations rather than primitives. The only trend where there are no digital operations is *Pattern*, while in *Grid* and *Deconstruction* we have 50-50% of digital and not, in *Folded surfaces* and *Natural derivation* the used operations are only digital.

It was interesting to understand which are the most common concepts per strategy, beyond purely comprehending if the operations are digital or not. For instance, we have to note that the common operations related to *Pattern* are *repeat* and *copy*, which do not belong formerly to the computational domain, but that assume completely different meaning within the virtual space: *copying* and *repetition* are static operations on paper, while they are dynamic within software, e.g. many architects use specific algorithms to automatically generate a facade pattern, often repeating a graphic motif with an imposed or random scheme.

This suggest us that the architect's cognition, during the creative process, is completely changed under the influence of digital media and it seems further confirmed if we look at level of digital primitives filtered with respect to our trends selection. In this case we saw almost a balance between trends where the starting primitive belongs to computational domain or not. While in *Natural Derivation* and *Folded Surfaces* we recognized only digital operations, at level of primitives we have a total balance (50-50%) between digital primitives or not. Furthermore in the *Diagram* and *Performance optimization* the starting primitive is not digital (100 %). This is also evident in the trends *Deconstruction*, *Grid*, *Pattern*. Hence we could conclude that some *old* concepts, formally expressed obviously through the primitives, were made *new* with digital manipulation of form (folding, bulging, etc.). The designers could start from an old point of view and adapt themselves to the new age, that actually seems to require a precise figurative dimension, often digital-derived and curvilinear. Particularly clear is the case of *Performance Optimization*, where the structural and climatic parameters become the reason to create new forms starting from known shapes (Norman Foster, Grimshaw, Hi-Tech evolution).

6.5. Type: the Museums as new Icons

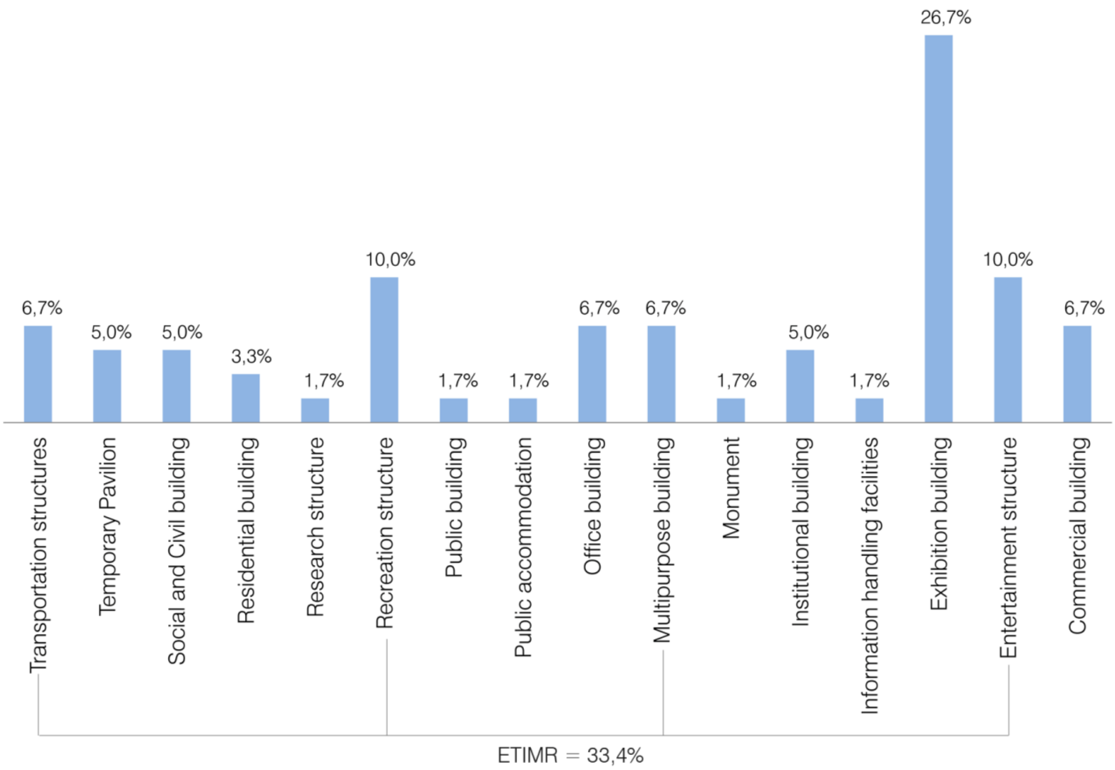
Now we are looking at the prevalent type of analysed buildings. It is surprising to see the great quantity of Exhibition buildings (26,7%), that comprise both museums and centres where the main scope is the dissemination of information through the exhibition, such as trade fairs, temporary pavilion, etc. Furthermore the other prevalent categories are entertainment, transportation, multipurpose and recreation, which we can group with the initials ETMR for reasons of brevity, in total 33,4% (graph 9).

At this point it was very useful to filter the several types recognized through the variable of geometry, even if we know, by precedent analysis, that in general the curvilinear one is absolutely the most represented. Hence we can observe that exhibition buildings have 69% of curvilinear configurations, while the group ETMR the 75%. Moreover if we look at categories as Office Buildings or Commercial Buildings, we see a substantial balance, but with a predominance of rectilinear configurations.

This datum appears very significant in order to understand our contemporary culture and society. In fact, while in architectures such as offices the formal experimentation remains more limited by the function - and we should also report the absence of digital influenced buildings in the categories *commercial buildings, industrial, public accommodation,* etc. - the digital expressiveness gains the upper hand: de facto architects have the freedom to fully play with morphology in relation to museums, stations, multipurpose buildings, etc. Indeed, in those cases the architecture is characterized by more flexible spaces, where functions are sometimes not well distinguished, by, very often, impressive dimensions and, above all, they all are buildings with a great cultural value for the community and the cities, where there are often required elements of novelty, iconoclasm, non-conformism, majesty.

What is surprising about digital influenced architectures is that the majority of them are referred to functions connected to sharing information and communicating culture and belonging. Buildings where people can identify and admire the *mise-en-scene* of own passions, i.e. in the cases of automotive museums (BMW, Porsche, Mercedes, Ferrari), in an atmosphere of grandiosity and celebration.

Without fear of making mistake, we can assert that museums are the new churches: as in the Past, at least until the Industrial Revolution, the major role to propose new iconic and representative buildings, avant-gardes in the upcoming architectural language and style, was covered by the Catholic Church, in the current times it seems this role belongs to who wants to share culture, both in public and private sector.

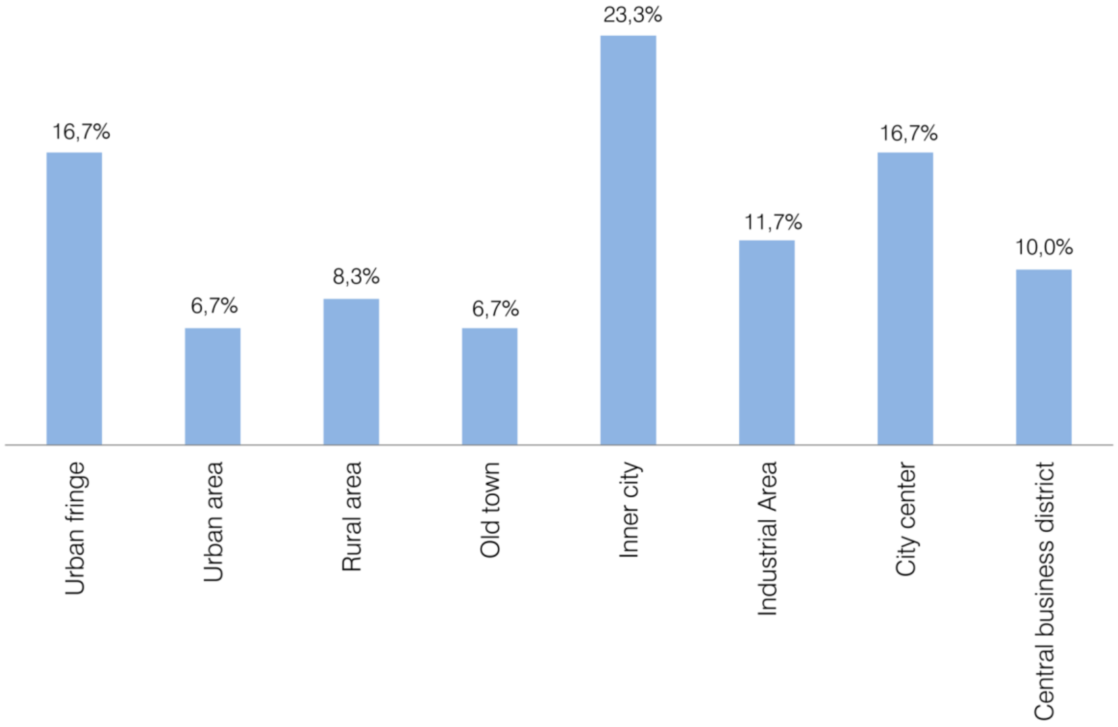


Graph 9. Absolute prevalence in the category *Type.*

6.6. Same expressivity, different contexts

Our analysis reveals that architects maintain the same approach with respect to diverse physical context - it seems that is indifferent if we are in an old city, inner city or rural area, etc. - with percentages more or less balanced (graph 10). Also the geographical area seems to be indifferent and this is the evidence that we are dealing with a global tendency.

Then, architectures are often treated as *objects* rather than *buildings*, positioning these *friendly aliens*, as Peter Cook (2004) defined his Kunsthaus design in Graz, with the scope to attract people who want to admire - or criticize - their art work. As we have already discussed about museums and type, everyone competes to acquire an architecture that express the latest innovations in terms of style, materials and overall image. For this reason we can explain and justify the tendency to acquire new fashion architectures, particularly evident in those countries where the economy is in growing - Middle East, China and Orient in general. The buildings are statements to have become part of the capitalist system and, then, have to express a certain sense of belonging. Moreover in these countries there is still less attention to the urban context with respect to what happens in Europe, where, as far as possible, it was tried to preserve the historical and cultural roots.



Graph 10. General prevalence in *Context*.

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CHAPTER 7
Conclusions. A rational overview on digitization of Architecture in the last 15 years

7.1. Emerging Patterns

Drawing conclusions is like rendering an overview from a rich palette of insights. The actual results, coming directly from the analysis made through the database, were discussed in all aspects in the last Chapter 6.

Now, we want to look at morphological and compositional issues detected among the cases, filtering them through the variable of Design Strategies. This has two main aims: firstly it contributes to confirm the accuracy of our analysis, i.e. in the category *Blob*, the most represented concept is *plasticity*, followed by *unity* and *monumentality*; secondly it make us able to understand the existing relationship among designer's thinking, use of digital media, composition and morphological tendencies, which all are expression of current times and are related with the digital era at level of form, cultural soul and connection to information technology.

By observing these results, we propose a classification of digital-influenced architecture in some emerging patterns, which are deepened in the next sections.

7.2. Digital Expressionism

This architectural trend comprises *strategies* from our selection, like *Artistic Fact*, *Blob*, *Flows*, *Fluidity*, *Folded Surfaces*, *Mathematical derivation* and *Natural derivation*. Then, do not surprise that the most present concept is *plasticity*. Moreover this fashion, that finally includes the majority of cases, is the one where the digital influence is absolute, both in operations and primitives. This shows that each design was born in the digital domain, while the prevalent geometrical configuration is *curvilinear*, as summarised in Table 1. This appears the main revolution of the triumphal entry of digital media in architecture. Now we will linger to discuss in detail the individual aspects, analyzing causes and motivations and testing the real effects on current digital influenced architecture.

Geometry	*Operations*	*Concepts*	*Design Strategies*
Curvilinear	Digital Domain	Plasticity, Complexity, Unity	Artistic Fact, Blob, Flows, Fluidity, Folded Surfaces

Table 1. The main features of *Digital Expressionism*.

Changing in Representation field and morphological approach to the design

Since first Sutherland's digital drawing system, passing through software initially born for other fields of industry and later borrowed by architectural practice, until the huge diffusion of CAAD programs due to their cost reduction, as a result of mass-production of both hardware and software and then to the augmented accessibility for everyone, it is undeniable that the main change of digitization of architecture is related to Representation.

This is probably the main aspect of the digital revolution, because a significant change in methods of representation means a change in the ways of exploration and conception of architectural space, which is the main subject of design practice. In fact, one of the main prerogative of the architectural design is the extensive use of visual methods and techniques in the development of a composition (Koutamanis, 2000) and each radical discovery in representation field had always constituted a revolution in the architectural design thinking. If we look at the discovery of Perspective by Filippo Brunelleschi in XV Century, there is no question that it was important not only for representation, but for the different spatial exploration allowed by perspective, which contributed to create a new idea about architectural space (Evans, 1995). At this point, it seems interesting to briefly understand what aspects have changed and how they have influenced the emergence of a new architectural conception in the digital era.

Firstly, the new software, as we report in Chap. 2, were initially born not for Architecture, but for Aerospace, Automotive and Military Industries. The kind of representation requested in those fields pushed on the possibilities of formal control, especially of complex geometries. Then what happened when this potentiality is made available to Architecture? Our cases reveal that the morphological approach to architectural design takes over and the architectural design starts often from the curvilinear manipulation of shape, pushing to the limit the potential of software to search for often unusual spatial configurations. It does not mean that curvilinear geometries and complex surfaces were not used and not experimented in the past, especially if we think at the work of i.e. Eero Saarinen, Hans Scharoun, Erich Mendelsohn (Fig. 1-2).

Fig. 1-2. Frei Otto structures for Munich Olympic Games (1972) compared with the Mario Bellini's Islamic Art department at Louvre (2012).

The main difference with respect to the '60s is the extreme facility to conceive free forms. Indeed, having a tool, that give us an extraordinary geometrical control, make us able to think free forms without caring about their geometry in the first stage, and to progressively refine the configuration according to aesthetical, structural, functional needs. Furthermore the communication among different kind of software, e.g. for the structural or climatic analysis, makes the design process and realization even easier.

The actual interest of designers seems to be focused on the morphological curvilinear deformation of complex shapes, rather than the creations of *new* forms. In fact, despite a declared refuse of traditional Cartesian geometry, insomuch that some tends to identify several projects under the category of *non-Euclidean* shapes, architects prefer often to start from the known and to proceed towards the unknown, through the endless possibilities of geometrical deformation. This is translated in a presumed idea that *everything is possible* and *producible*, which denotes the risk to deal with architectural design as *product design*, therefore considering other parameters, like performance, material, human-interaction, rather than other aspects that normally belong to architectural design, *in primis* the physical context of a building. Furthermore we have to report that, even if there are a lot of new software, algorithms, applications, add-on, specifically devoted to architectural practice, the potential of visual control appears in any case the most advantage given by digital instruments (fig. 3-4) . Patrik Schumacher, director at Zaha Hadid Architects and theorist of architecture, has understood that this new approach has lead us towards a new style:

> «We are confronted with a new style rather than just with a new set of techniques. [...] Avant-garde styles might be interpreted and evaluated in analogy to new scientific paradigms, affording a new conceptual framework, and formulating new aims, methods and values». (Schumacher, 2009)


Fig. 3-4. Riverside Museum in Glasgow by Zaha Hadid Architects.

Other undeniable advantages of CAAD software are the augmented possibilities to virtually explore their conceptual idea; in fact in the ideation stage designers tend to exteriorize their internal mental images, engaging in a conversation of sort with themselves (Dorta et al., 2008). About this issue, two main things appear relevant: firstly those questions related to the cognitive aspects of designer who takes advantage of real-time visualization, where each action made on the model or on the e.g. the plan produces effects suddenly valuable; secondly the augmented speed in practicing those operations which previously required a longer time, which instead can lead to a little reflecting during the design stage.

The first issue was analyzed by several authors, since CAAD software have appeared within architectural practice, with two different approaches: on one hand Schön (1983) intended design as reflective conversation with the situation and digital technologies open the issue relative to this *reflection-in-action*, which remands to our second issue; on the other hand the treatment of design as a reflective conversation lacks the clarity and rigor achieved by the rational problem solving paradigm (Dorst and Dijkhuis, 1995). Practically, according to some interviews done with designers, as you can see in the Appendix I, their approach is totally figurative. Indeed, firstly they approach the problem as a traditional problem solving - I have to satisfy these needs, so I will do this, this and that - but, regarding instead to aesthetical issues, designers actually work on the shape, modifying and perfecting it, always not forgetting the problem-to-solve, and they stop when they think the final shape suits their creativity. To my question «When do you stop working on a shape?», often they answered with a laconic «When I like it», or something like this. Usually it is a team decision. Moreover, regarding instead to the second issue, that is the operative speed guaranteed by software, the main advantage consist in the possibility of continuously shaping and forming, of making several versions of the same project at the same time, definitely the operative speed it is an undeniable advantage because it allows a full possibility of spatial exploration.

The new conception of architecture and its cultural references

Despite at first impression the morphological approach could consist only in an obsessive search for the figural goodness (Koutamanis, 1997), we have to report that this new architectural trend has its root in those artistic and architectural tendencies born in the second half of the XX Century, essentially known as early Post Modernism and *utopian* and *visionary architecture*, as we have already seen in Chapter 1. If we make a comparison between some analysed cases and some utopias' project, we could note several strongly assonances, especially in terms of figurativeness.

Starting from a stimulating interview done with Maurice Nio, founder of NIO Architecten in Rotterdam, reported in Appendix I, at the direct question about his cultural and architectural references at the beginning of his profession, he answered that he has certainly Neil Denari and Lebbeus Wood among his *heroes.* This was an interesting research front to further deepen. In fact, by studying the some utopias' project dated to the second half of XX Century, it was surprising to note that the figurativeness they represented is not so far from some project of the Digital Era. The works of Lebbeus Wood, especially those contained in the book *Radical Reconstruction* and dated to the first 90's (Woods, 1997), seem have had a great influence in some *digital* project of F. O. Gehry and of the Viennese studio Coop Himmelb(l)au. If we look at the same time at projects like i.e. the Akron Art Museum in Ohio by Coop Himmelb(l)au (Fig. 6) and the Guggenheim Museum in Bilbao by Gehry (Fig. 8) and some drawings by Wood (Fig. 5 and 7), the figurative assonance among them is particularly evident.

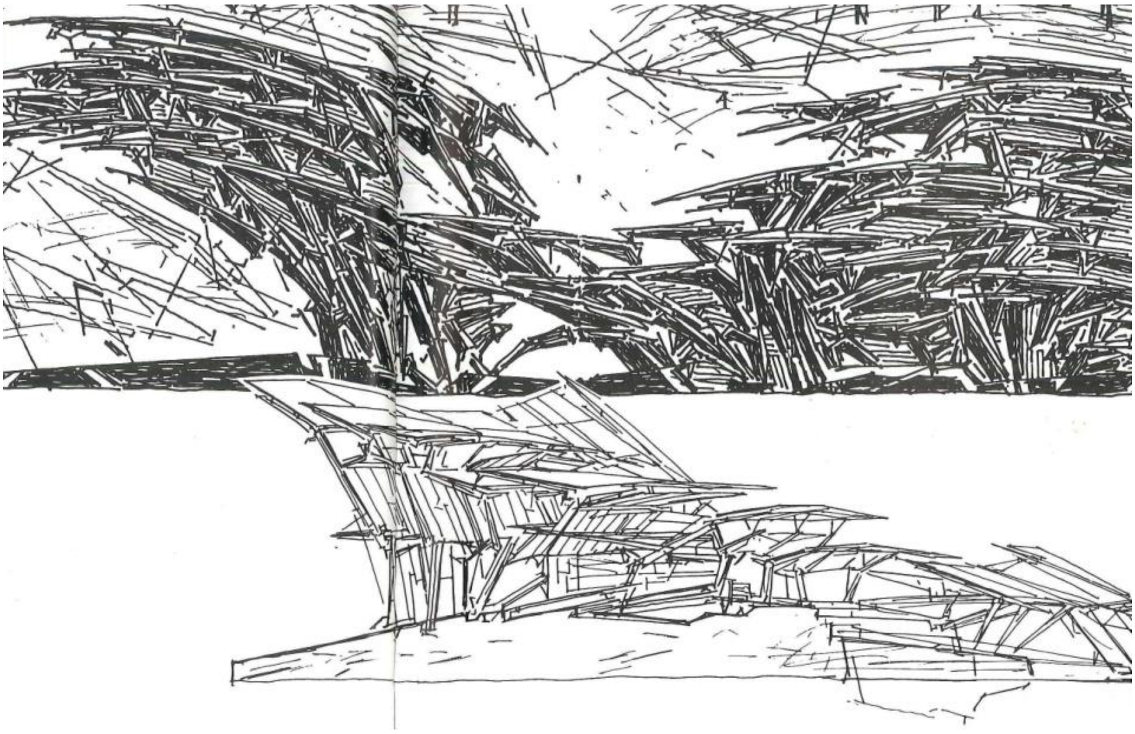


Fig. 5-6. Above, Lebbeus Wood, San Francisco Quake City, 1995. Under, Coop Himmelb(l)au, the Akron Art Museum, Ohio, 2007.

Even in the works of Bruce Goff (Fig. 9 and 13), American architect and professor inserted by architectural historians among exponents of Organic Architecture, seems linked to some current designs. Especially in some of his *on-paper* projects, we could trace figurative correspondence in the work of Zaha Hadid (Fig. 10-11) and UN Studio (Fig. 12).

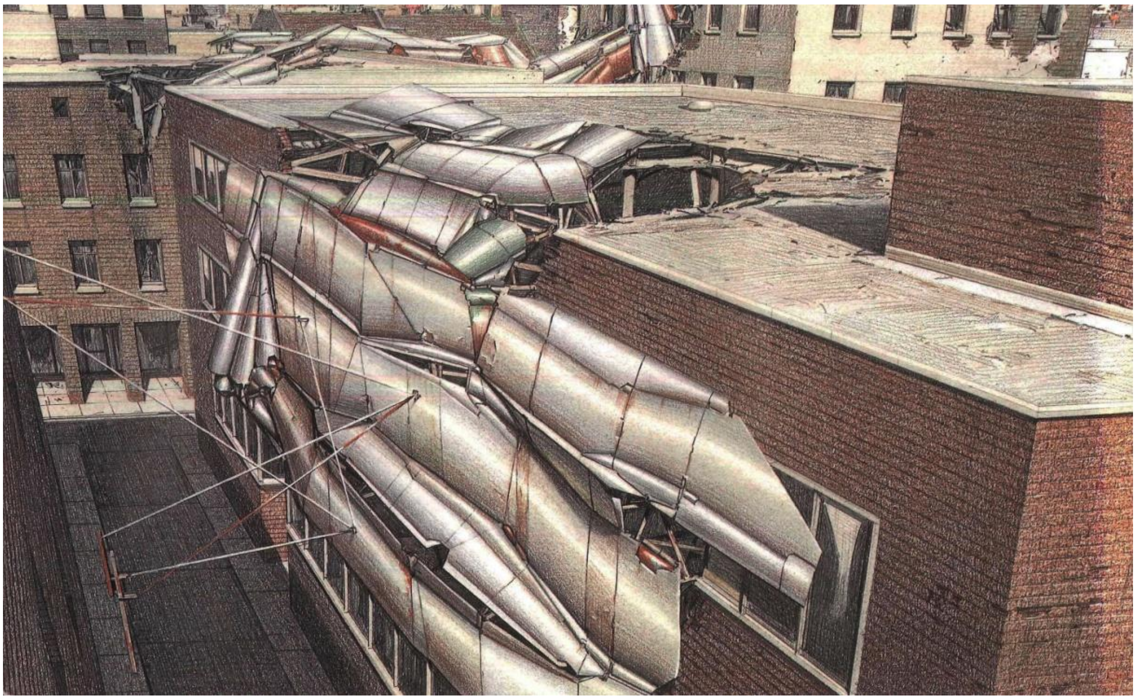


Fig. 7. Lebbeus Wood, Sarajevo Scab Project, 1993.

Fig. 8. Frank O. Gehry, Guggenheim Museum in Bilbao, 1997.

Furthermore, beyond the purely figurative factor, some protagonists of that cultural movements has designed buildings that now are become manifestos of the digital-influenced architecture. The most evident case is the Kunsthaus in Graz, designed by Colin Fournier and Peter Cook, one of the founders of Archigram. Some sketches produced by them in 1964 (Archigram, 1999) may well be seen as the representation of the realized building, completed in 2003 in occasion of Graz Capital of Culture in Europe. The Graz's Kunsthaus, that is very often recognized as manifesto of the *Blob Architecture* (Lynn, 1998) due to its free-form geometry and to the explicit intention of the designers, who called it the *friendly alien* (Cook et al., 2004), in reality puts on a 30 years old concept (Fig. 14-15).

Fig. 9-11. Bruce Goff, the project of Telemotive Building in Bartlesville (1957) and Zaha Hadid's maXXI in Rome, 2010.

The strong connection between digital expressionism architectures and visionary projects could be easily explicable if we look at the overall cultural and social scenario of that years. Indeed, the '70s were years dominated by a new sense of freedom of expression, that saw the birth of the hippy movement, of new musical styles, such as classic rock and dance, of new experiments in cinema industry. In architecture, one of the main discussed idea was about how to think of the future, what should have had to be the new style, in a futuristic way. Then, there was a lot of experiments in that sense, mainly regarding the *house of the future*, as we have previously in Chapter 1. In general the space missions, in conjunction with movie like Star Wars, were transferred into architecture in some way (Fig. 16-17). Most of the protagonist of our digital expressionist architecture grew personally and professionally in such environment and it seems that nowadays they are experimenting that figurativeness, because the future is here.

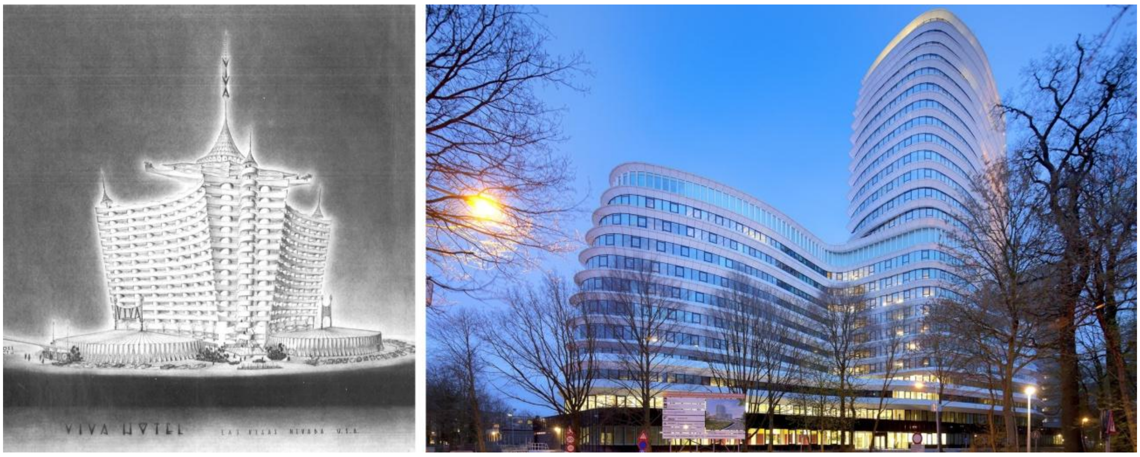


Fig. 12-13. Bruce Goff, the Viva Hotel project in Las Vegas (1961) and the UN Studio's Education executive Agency & Tax Office in Groningen, 2011.

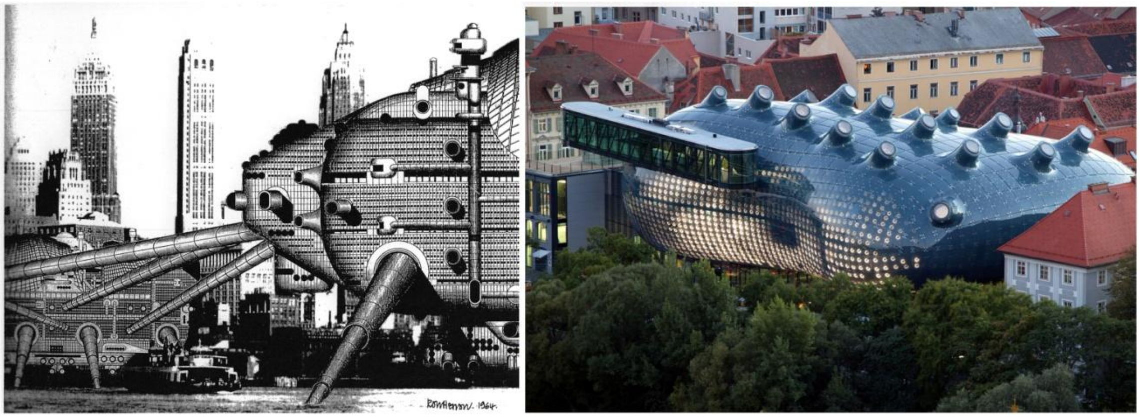


Fig. 14-15 The Archigram's Walking City project in 1964 and Peter Cook and Colin Fournier, Kunstahus in Graz, 2003.

Fig. 16-17. The Casa da Musica in Oporto by Rem Koolhaas and an architecture from the movie Star Wars.

Clients and public favour. Iconic buildings in a global scenario

The apparently declared *absence of rules* in favour of morphological approaches and of new aesthetical belief, made of not only curved lines, but also new *modern* materials and technologies, is creating *de facto* a new figurative trend. We explained the causes on the basis of the triumphal comparison of *Digital Expressionism*. But it is interesting understanding what is happening, in terms of reactions, critics, appreciations, in the architectural public.

It seems particularly significant the data that the most important and representative companies from all over the world (BMW, Mercedes Benz, Cooper Union, etc.), but also cities that want to promote and/or reinforce their appeal and countries that are in rapid growth make often competitions to provide themselves with a vanguard architecture, designed by an international firm, that often become the new symbol of the brand or city. This testifies us that, despite the favour this new buildings could have or not in academia or among experts, the world wants them, above all for their undeniable attitude to attract people and to be a driving force of cultural rebirth, as in the lucky case of Guggenheim Museum. Everyone competes to acquire an architecture that express the latest innovations in terms of style, materials and overall image, as we have seen in the graphs about *Type* and *Context* shown in the Chapter 6.

7.3. Hi-Tech evolution

Comparing main features of this trend, as reported in Table 2, we can note a strong similarity with the previous *Digital Expressionsm*. What is undeniably different, is the concept on the basis of each design: while in Digital Expressionism the designer could start with the purpose to build a *Blob* or a *fluid* architecture, here designers start from the optimization of one or several parameters, to increase building *performance*.

Geometry	*Operations*	*Concepts*	*Design Strategies*
Curvilinear	Digital Domain	Complexity, Articulation, Plasticity	Performance optimization, Mathematical Derivation

Table 2: The main features of *Hi-Tech Evolution*.

As we have already seen in Chapter 2, when digital media appeared in professional practice, some architects with a strong technological approach have adapted their design methodology to new software for architecture, that allows the creation of autonomous forms, arising from the optimization of different parameters. You can choose to focus on the structural, the climate - environmental, but also the social and procedural aspects, and many others. On the contrary, the final shape can be achieved also due to the modification of a primitive by starting e.g. from a sphere, a cube, a parallelepiped and progressively modifying it, deforming it by following approximations, until it reaches the best possible configuration.

This trend was called by some critics *Performative Architecture* (Kolarevic, 2005), even if it not properly a *new* attitude. In fact, looking at the protagonists of this kind of methodology, we find Norman Foster, Nicholas Grimshaw, Renzo Piano, who were the same protagonist of the so-called *Hi-tech* trend in the '80s. Hence, it seems we are looking at a natural evolution of a trend, that through the possibilities of digital design has pushed until the limit the building technology, creating an old expressivity in terms of material - almost always steel structure with glass walls - but new regarding to the envelope's shapes (Fig. 18-23).

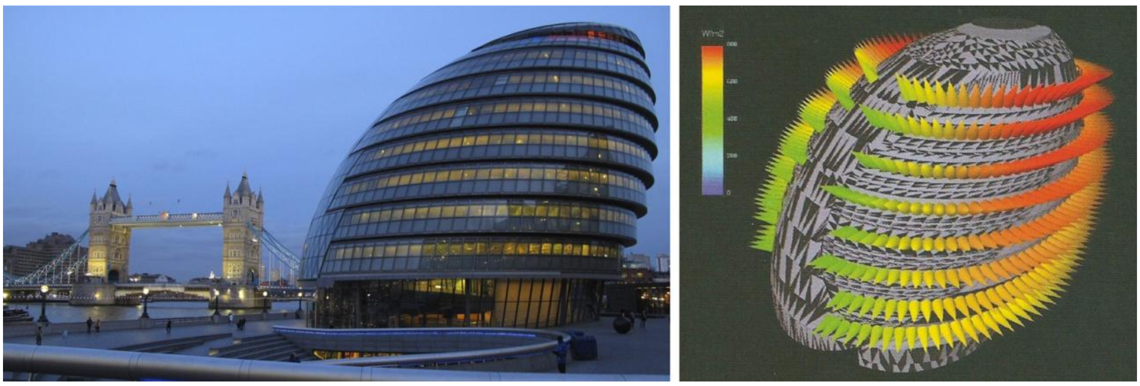


Fig. 18-19. London City Hall (2002) by Foster and Partners, building and performative models.

Norman Foster, one of the main protagonists of this approach, in an interesting intervention on DLD Conference[1] in 2007, spoke about the possibilities of digital technology and on the necessity to solve building problems through it.

«As an architect you design for the present, with an awareness of the past, for a future which is essentially unknown. [...] I think that digital revolution now is coming to the point where, as the virtual world, which brings so many people together here, finally connects with the physical world, there is the reality that has become humanized, so that digital world has all the friendliness, all the immediacy, the orientation of the analogical world. Probably summed up in a way by the stylish or alternative available here and again, inspired by the incredible sort of sensual feel. A very, very beautiful object. So, something which in the '50s, '60s was very exclusive has now become, interestingly, quite inclusive. [...] And I think it's very tempting to, in a way, seduce ourselves -- as architects, or anybody involved with the design process -- that the answer to our problems lies with buildings». Norman Foster (2007)

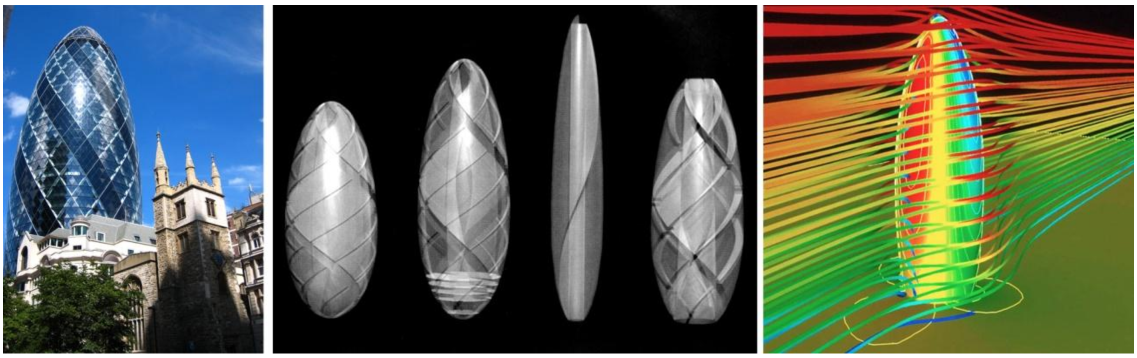


Fig. 20-23. Swiss RE Headquarters (2004) in London by Norman Foster.

Regarding the aesthetical values, it holds good what it was said about *Digital Expressionism*. What differs significantly, it is related to the designers' thinking, where their conception about architecture is not only devoted to the figurative aspects, which is obviously part of their investigations, but rather to a sort of ethical program. The dualism Ethic vs. Aesthetics of architectural design is a well-known matter, subject of many studies in the past years (Lagueux, 2004, Zinsmeister, 2012), starting from Banham (1966), who analysed the ethical and aesthetical values of Brutalism.

For the protagonists of this trend, the architect has an intrinsic responsibility for the world (Piano and Cassigoli, 2000): designers must consider the effects of their work on the cities, the lands and, above all, on the environment. This ethics have its bases on the Sustainability paradigm, firstly theorized by Buckminster Fuller (Fuller and Marks, 1963), and indeed in his lecture Norman Foster have spoken about a *green agenda*. With the advent of computer revolution, digital tools are used with an ethical purpose, in order to optimize all parameters needed to an overall saving of energy or to reduce building's emission in the atmosphere, in general to guarantee a less possible impact of buildings on the Earth.

7.4. Digital diagrammatic architecture

This trend is not born with digital technologies, but with their huge diffusion the sense and use of architectural diagrams was modified. By analyzing main features of digital diagrammatic architecture (Tab. 3), we find a balance in geometrical matters, that indicates that there is no predefined *idea* or *preference* about the formal result, the operations are digital - this is the reason to add the adjective *digital* to the trend's name - formal concepts are related to what means *complexity* nowadays. Now it seems necessary firstly to explain what is a diagram in architecture, then to understand which possibilities were opened by digital diagrams and with which formal results.

Geometry	*Operations*	*Concepts*	*Design Strategies*
Curvilinear (50%) Rectilinear (50%)	Digital Domain	Complexity, Articulation	Diagram, Grid

Table 3. The main features of *Digital diagrammatic architecture.*

Let's start from the term: *diagram* in architecture it is usually thought of as *graphic tool* (Bijlsma, 1998), that is the translation of a series of possible relationships between the parties in a drawing, but it can't be attributed either to the type, nor even to a sketch. The term derives from Greek *dià* (through) and *grámma* (something written).

Although it is usually made up of points, lines and surfaces organized in two-dimensional or three-dimensional patterns, it may include data, legends, text, and then relate different aspects at the same time, crossing data, connecting functions and needs. *Digital diagrams*, sometimes integrated in some software or add-on, have become an operational concept tools. Design tools as well as a means of reading. At this proposal it is particularly interesting Peter Eisenman's work, because his use of diagrams has begun before the digital era and it evolved due to the computer use.

Eisenman's techniques for drawing diagrams have become his unique way of writing architecture: diagrams not only generate his projects but can serve as a tool for worldwide architects to design their own future projects. Eisenman's conceptual work does not begin in digital domain, but on paper; then it is transferred to computer and the work continues on it, in a constant going on and back between paper and digital tool. E.g. one of his most used techniques is morphing (Galofaro and Eisenman, 1999), because it allows an observation of transitions between two different configurations, introducing then the concept of dynamism and time. Architecture is an ongoing event, where time acquires the features of accumulation and extension and form becomes an aggregation of movements. Recently Peter Eisenman has spoken about diagram, which for him is also synonymous of drawing:

«To me, drawing and reading are the same thing. I can't read on the computer. So when someone draws something on it, I print it so I can draw over it either with tracing paper on it or without it. You cannot make a plan in the computer by connecting dots. You have to think about a *diagram* or what it is you are doing. You have to think in drawing. So to me, all of my work is drawn by hand first, then we give it to computer guys and they model it and then we get it back, etc.
Drawing is a way of thinking. I can't think or write ideas on a computer. [...] So to me drawing is a form of writing, and a form of reading what I write. [...]. To me drawing is not making pretty things or making representations. It's not representing anything; it is the incarnation of the thing» Peter Eisenman[2], 2013.

In this way, Eisenman's diagrams, independently if digital or not, are more projective than representational (Fig. 24-25). Then, the formal result is unpredictable because the focus is on the concept rather than on the shape, form is just a final result of a conceptual work. For this reason we can explain our balance in Geometry field: 50% rectilinear, 50% curvilinear. Indeed, the use of diagrams implicates that there is no predefined formal idea about the project, but it arises from a diagram that could be either made of rectilinear lines or curvilinear splines. Furthermore, it is not surprising that the concepts related to this trend are complexity and articulation: indeed diagrams serve to manage complexity through formal and compositional articulation.

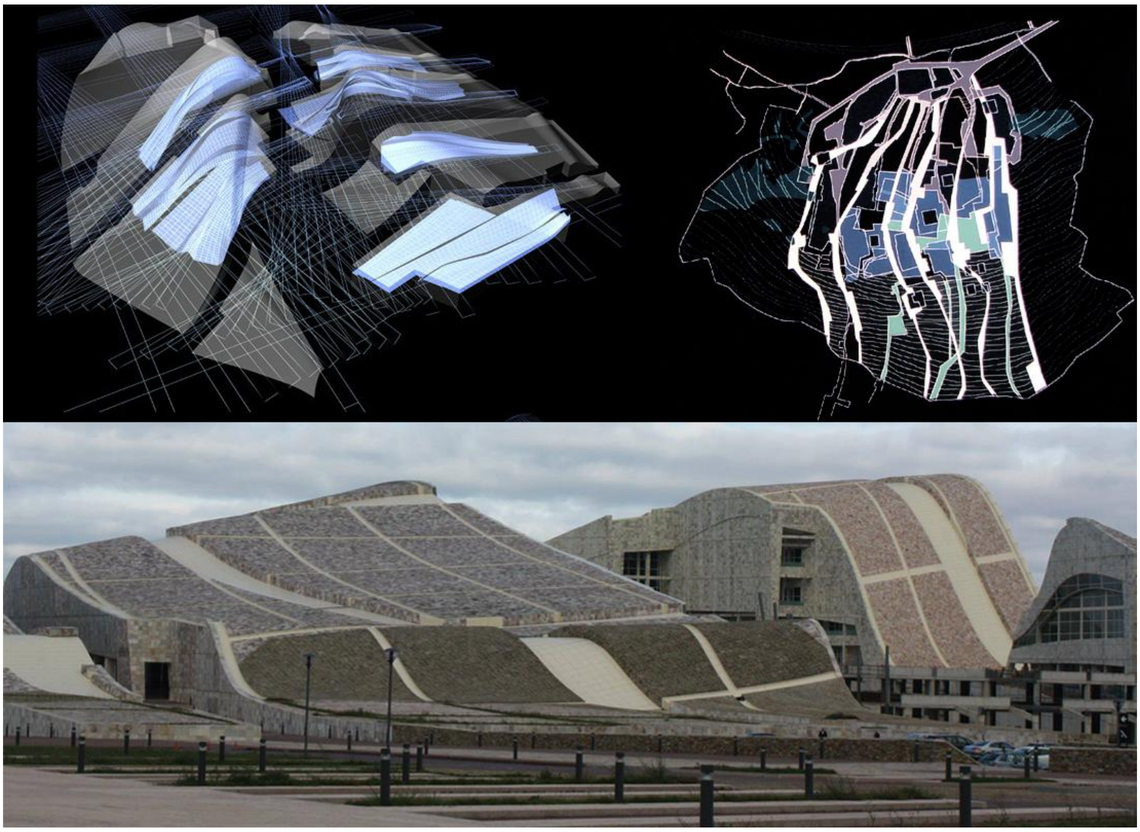


Fig. 24-25. City of Culture in Santiago de Compostela by Eisenman.

Other architects make intensive use of diagrams, like UN Studio or Rem Koolhaas (Fig. 26-27), even if their diagrams is more focused on functions and needs. In their practice, it is often happened that what was initially mapped as diagram, e.g. for function or users movement, in the final phase of project become the base of formal configuration. Even in this case the final solution it could be either rectilinear or curvilinear, depending on several factors, such as e.g. on which tool was used to create the diagram

We reported a definition of what a diagram is, made by Ben van Berkel and Caroline Bos, founders of UNStudio, pioneers in the use of IT in architecture and digital diagrams.

> «The diagram is not a metaphor or paradigm, but an 'abstract machine' that Is both content and expression. This distinguishes diagrams from indexes, Icons and symbols. [...] Diagrammatic practice delays the relentless intrusion of signs. thereby allowing architecture to articulate an alternative to a representational design technique. A representational technique implies that we converge on reality from a conceptual position and in that way fix the relationship between idea and form, between content and structure. When form and content are superimposed in this way, a type emerges». (Van Berkel et al., 1999)

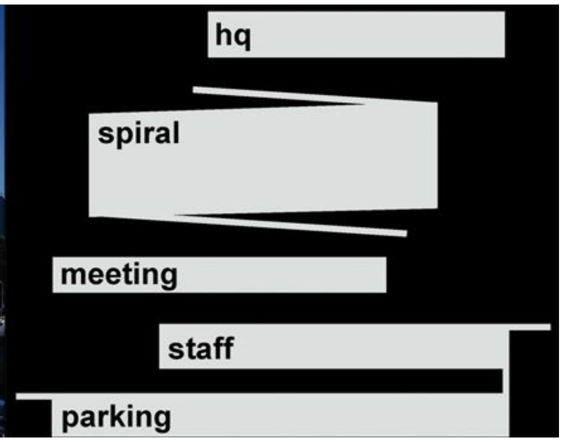


Fig. 26-27. Above, the Seattle Public Library (2004) by Rem Koolhaas.

7.5. Digital Post-Modernism

By giving a superficial look at this category, it could be spontaneous wondering why it is part of this dissertation which wants to understand the effects of digital technologies in architecture. Indeed, concepts such as Pattern, Deconstruction and Natural Derivations are transversal and present in the whole history of architecture (Tab. 4). However, digital technologies have changed the value of this concepts and have posed it on the basis of architectural design, most of the times in order to implement and bring on the idea of *Ornament*. For this reason it was chosen to name this trend *Digital Post-Modernism*, referring then to the great attention deserved by the protagonists of that movement to the return of ornament as opposition to Brutalism, as we have already explained in Chapter 1.

Geometry	*Operations*	*Concepts*	*Design Strategies*
Rectilinear (37%) Hybrid (37 %)	Digital Domain	Deconstruction, Monumentality	Pattern, Deconstruction, Natural Derivation

Table 4. The main features of *Digital Post-Modernism.*

One of the main interest of digital influenced architecture is related to the concept of *Pattern*, which traditionally indicates the repetition of a geometric graphic motif on a plane. The new software allows the creation of digital patterns, often through generative algorithms or shape grammars, that we have previously defined in the Chapter 2, and several experiments were done in recent years, well reported in some recent essays (Leach, 2004, Iwamoto, 2009, Spuybroek, 2009, Pell and Hild, 2010). Indeed, digital tools allow a particularly easy control of patterns, as well as the adaptation of that pattern to a complex surface. Software permits the consistency between façades and graphic motifs and makes easier their construction.

Fig. 28-29. The watercube by PTW Architects in Beijing.

In this sense, we have to report that the main operations used for refining a pattern are generally *copy* and *repetition*. The use of the computer have altered the character and often also the content of these operations: repetition and copying in the computer are dynamic as opposed to static on paper and also they can be implemented in an algorithm, in order to *form* a recurrent scheme and make it consistent with a surface. The graphic motif of new digital patterns can include the repetition of simple figures and relationships between them, as well as complex motifs inspired by nature (*Natural Derivation*). It can be done by implementing the biological code of the form that designer wants to reproduce - approach called *genetic algorithm*s - or by generating it, imposing constraints and interdependences in a generative algorithm. Until now, the best results were given by the application of a pattern, especially a natural pattern, to a simple form, like e.g. in the cases of *Watercube* in Beijing, where the facade is characterized by a bubble pattern (Fig. 28-29). Different is the Herzog & De Meuron approach for the

Olympic Stadium in Beijing, where the pattern of a bird's nest is become not only an ornamental motif, but also the structure of building. Even Jürgen Mayer H. for the Metropol Parasol in Seville (Fig. 30-31) was inspired by the nature, but, as Herzog & DeMeuron, the pattern is also structure and formal configuration. Indeed, even the balance between rectilinear configurations and hybrid ones, testifies the higher use of patterns with respect with more rational configurations, which allow a better adaptation to regular surfaces.

Regarding instead to Deconstruction, there was not an evolution with respect to the former architectural trend born in the '90s, where from a superficial reading of Derrida's thinking in key purely formalist, architects were trying to dematerialize architecture, through disconnections, cuts, rotations, offsets. The only difference is that these operations are arguably easier to act, with respect of the past.

Fig. 30-31. The Metropol Parasol (2011) in Seville by J. Mayer H.

7.6. Architects' profiles

Now, we will briefly report some profiles of the better-known and important architecture studios, classified according to our trends, so as they are represented in our multi-case analysis.

Digital Expressionism

- Zaha Hadid
- Frank O. Gehry
- Coop Himmelb(l)au
- Massimiliano Fuksas
- Ron Arad
- Asymptote
- Peter Cook
- Mario Bellini
- NOX

ZAHA HADID ARCHITECTS

Heydar Alyev Centre, Azerbaijan, 2012

Zaha Hadid, founding partner of Zaha Hadid Architects, was awarded the Pritzker Architecture Prize in 2004 and is internationally known for her built, theoretical and academic work. Each of her dynamic and innovative projects builds on over thirty years of revolutionary experimentation and research in the interrelated fields of urbanism, architecture and design. Working with senior office partner Patrik Schumacher, Hadid's interest is in the rigorous interface between architecture, landscape, and geology as the practice integrates natural topography and human-made systems that lead to experimentation with cutting-edge technologies. Such a process often results in unexpected and dynamic architectural forms. Collaborations with artists, designers, engineers and clients that lead their industries have advanced the practice's diversity and knowledge, whilst the implementation of state-ofthe-art technologies have aided the realization of fluid, dynamic and complex architectural structures.

Zaha Hadid and his partner Patrik Schumacher.

FRANK OWEN GEHRY

Lou Ruvo Center for Brain Health, Las Vegas, 2010.

Gehry established his practice in Los Angeles in 1962, which eventually became the Gehry partnership in 2001. He first drew notice in his adopted city with works deploying commonplace industrial materials in unexpected ways, but he came to international prominence with works which exploded the geometry of traditional architecture to create a dramatic new form of expression. He deployed cutting-edge computer technology to realize shapes and forms of hitherto unimaginable complexity, such as the startling irregularities of his Guggenheim Museum in Bilbao. In these monumental buildings, the uninhibited whimsy of his pencil sketches took shape in powerful structures of gleaming titanium. The firm relies on the use of Digital Project, a sophisticated 3D computer modeling program originally created for use by the aerospace industry, to thoroughly document designs and to rationalize the bidding, fabrication, and construction processes.

Frank Owen Gehry.

COOP HIMMELB(L)AU

Busan Cinema Centre, South Korea, 2012.

COOP HIMMELB(L)AU was founded by Wolf D. Prix, Helmut Swiczinsky, and Michael Holzer in Vienna, Austria, in 1968, and is active in architecture, urban planning, design, and art. In 1988, a second studio was opened in Los Angeles, USA. Further project offices are located in Frankfurt and Paris. After Michael Holzer left the team in 1971, and with the retirement of Helmut Swiczinsky in 2001 from COOP HIMMELB(L)AU's daily operations and in 2006 from the office, Wolf D. Prix is leading the studio as Design Principal/ CEO. Over the course of the past four decades, COOP HIMMELB(L)AU has received numerous international awards. Recognized as seminal for the architecture of the future, the works of COOP HIMMELB(L)AU have continually been the subject of international exhibitions. Among the largest and most widely known are the solo retrospectives at the Centre Georges Pompidou in Paris and the exhibition *Deconstructivist Architecture* held in 1988 at the MoMA New York.

Wolf D. Prix and the exhibition "Beyond the blue" of Coop Himmelb(l)au works, held in 2009 at MAK Wien.

MASSIMILIANO AND DORIANA FUKSAS

Mab Zeil Shopping Centre in Frankfurt, Germany, 2006.

Studio Fuksas, led by Massimiliano and Doriana Fuksas, is an international architectural practice with offices in Rome, Paris, Shenzhen. The practice employs around 170 professionals, including architects, designers, modellers, landscapers, graphic designers. Studio Fuksas is characterized by an innovative approach as well as interdisciplinary skills and experiences consolidated over three decades through the design of: masterplans, offices, residential buildings, infrastructures, cultural centres, leisure centres, retail developments, hotels, shopping malls, public buildings, interior design and product design. Depending on the peculiarities of each project, a teamwork is created and coordinated by a project-manager that interacts with professional engineering consultants under the direction of Massimiliano Fuksas. Regular internal meetings are aimed at discussing on-going projects as well as promoting dialogue, creativity and common solutions.

Massimiliano and Doriana Fuksas.

RON ARAD

The Big Blue, Canary Wharf, London, 2000.

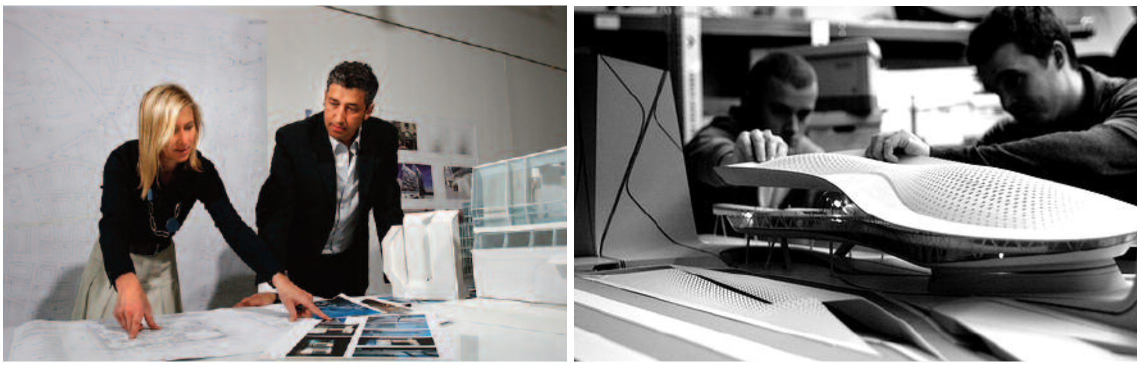
Born in Tel Aviv in 1951, educated at the Jerusalem Academy of Art and later at the Architectural Association in London, Ron Arad co-founded with Caroline Thorman the design and production studio One Off in 1981 and later, in 1989, Ron Arad Associates architecture and design practice. In 2008 Ron Arad Architects was established alongside Ron Arad Associates. From 1994 to 1999 he established the Ron Arad Studio, design and production unit in Como, Italy. He was Professor of Design Product at the Royal College of Art in London up until 2009. Ron Arad was awarded the 2011 London Design Week Medal for design excellence and was became a Royal Academician of the Royal Academy of Arts in 2013. Ron Arad's constant experimentation with the possibilities of materials such as steel, aluminium or polyamide and his radical re-conception of the form and structure of furniture has put him at the forefront of contemporary design and architecture.

Ron Arad sit on a chair designed by himself and his recent exhibition held at Pinacoteca Agnelli in Turin.

ASYMPTOTE

ARC River Culture Pavilio, Daegu, South Korea, 2012.

Founded in 1989 by Hani Rashid & Lise Anne Couture, New York city based Asymptote Architecture is a leading international architecture practice that has distinguished itself globally with intelligent, innovative and visionary projects that include building designs, master planning projects art installations, virtual reality environments as well as interiors and industrial design. Asymptote's approach to utilizing digital tools and technologies, contemporary theory, innovative building practices and advancements in engineering solutions and environmental sustainability have afforded the practice a broad and powerful perspective on all aspects related to architectural building design and city planning. In a rapidly changing world, Asymptote believes in using knowledge acquired both empirically through experience and observation as well as through research and ongoing professional development.



Lise Ann Couture and Hani Rashid, founders of Asymptote, and the studio practice.

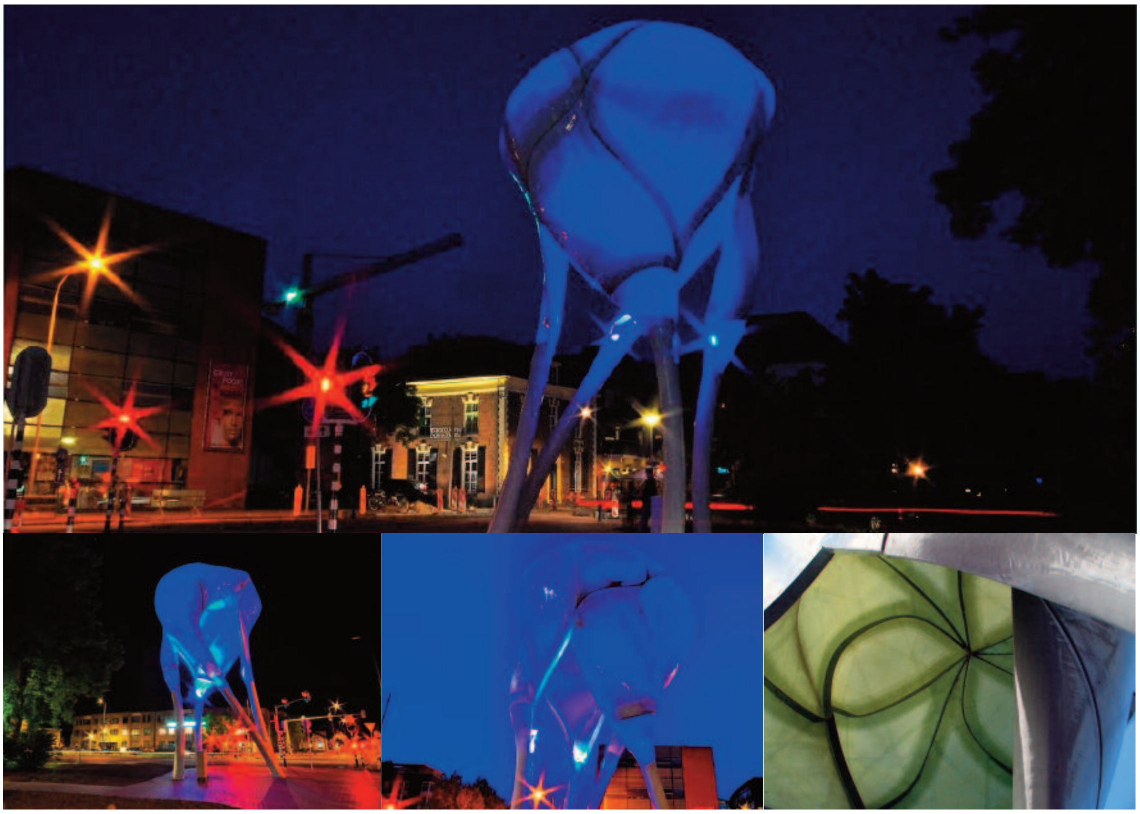
MARIO BELLINI

Verona Forum, Italy, 2011.

Mario Bellini was born in 1935 and graduated in 1959 at the Politecnico di Milano. He lives and works in Milan. His activities range from architecture and urban design to furniture and industrial design. His fame as a designer dates from 1963. He is internationally renowned as an architect and designer and he has given talks in the greatest centres of culture in the world and was editor of Domus. His work can be found in the Collections of major Art Museums. MoMA in New York, which dedicated a personal exhibition to him, has 25 works of his in its Permanent Design Collection. From the 1980s on wards, he has designed projects such as the Portello Trade Fair quarter in Milan; the Tokyo Design Center in Japan; the Headquarter of Deutsche Bank in Frankfurt; the new Department of Islamic Art in the Louvre in Paris and the new Milan Convention Center at the Milan Trade Fair. In the last years his style has evolved, because of the use of digital technologies.

Mario Bellini in his office and during the presentation of the New Department of Islamic Arts at Louvre Museum, Paris.

NOX | LARS SPUYBROEK



D-tower in Doetinchem, the Netherlands, 2004.

After the graduation at the Technical University Delft in 1989, he started NOX-magazine with Maurice Nio, of which four issues were published in Dutch between 1991 and 1994. Since 1995, Lars Spuybroek is the sole principal of the office which carries the name NOX and creates buildings and artworks. Lars Spuybroek broke onto the international scene of architecture with his water pavilion, which is the first building that has an interactive interior where visitors can transform sound and lighting conditions by actively using sensors. It also has a so-called continuous geometry, where floors, walls and ceilings merge into a smooth whole. This form of blobitecture was later officially coined "non-standard architecture" at the large group exhibition of the same name at the Centre Pompidou (2003) in Paris. This architecture advocates a technological revolution where powerful computing-tools are deployed to replace simple repetition of elements by continuous variation.

Lars Spuybroek and one digital experiment carried out during the symposium “Textile Tectonics”.

FOSTER + PARTNERS

The Sage Gateshead, UK, 2004

Norman Foster, founder of Foster + Partners in London in 1967, is one of the most known british architects. Over the past four decades the company has been responsible for a strikingly wide range of work, from urban masterplans, public infrastructure, airports, civic and cultural buildings, offices and workplaces to private houses and product design. From the beginning, the studio has experimented a strong technical approach to design, which,in the last years, was translated into an wide attention to sustainibility. By working together creatively from the start of a project, architects and engineers combine their knowledge to devise integrated, sustainable design solutions. From appointment to completion, the teams are supported by numerous in-house disciplines, including project management and a construction review panel. The claim and quality of work have led Norman Foster to win the Pritzker Architecture Prize in 1999.

Norman Foster in his office, during design meeting.

GRIMSHAW ARCHITECTS

Southern Cross Station, Melbourne, Australia, 2006.

Grimshaw was founded by Sir Nicholas Grimshaw in 1980. The practice became a Partnership in 2007 and operates worldwide with offices in New York, London, Melbourne, Sydney and Doha. Grimshaw's international portfolio covers all major sectors, and has been honoured with over 150 international design awards. The practice is dedicated to the deepest level of involvement in the design of their buildings in order to deliver projects which meet the highest possible standards of excellence. The company's work is characterised by strong conceptual legibility, innovation and a rigorous approach to detailing, all underpinned by the principles of humane, enduring and sustainable design. The ultimate goal of the firm is to design buildings and environments that work, inspire people and transform communities. Through careful evaluation of relevant opportunities, inspired ideas will drive a good design to something that is extraordinary, challenging, and completely unique.

Sir Nicholas Grimshaw and the company's office in London.

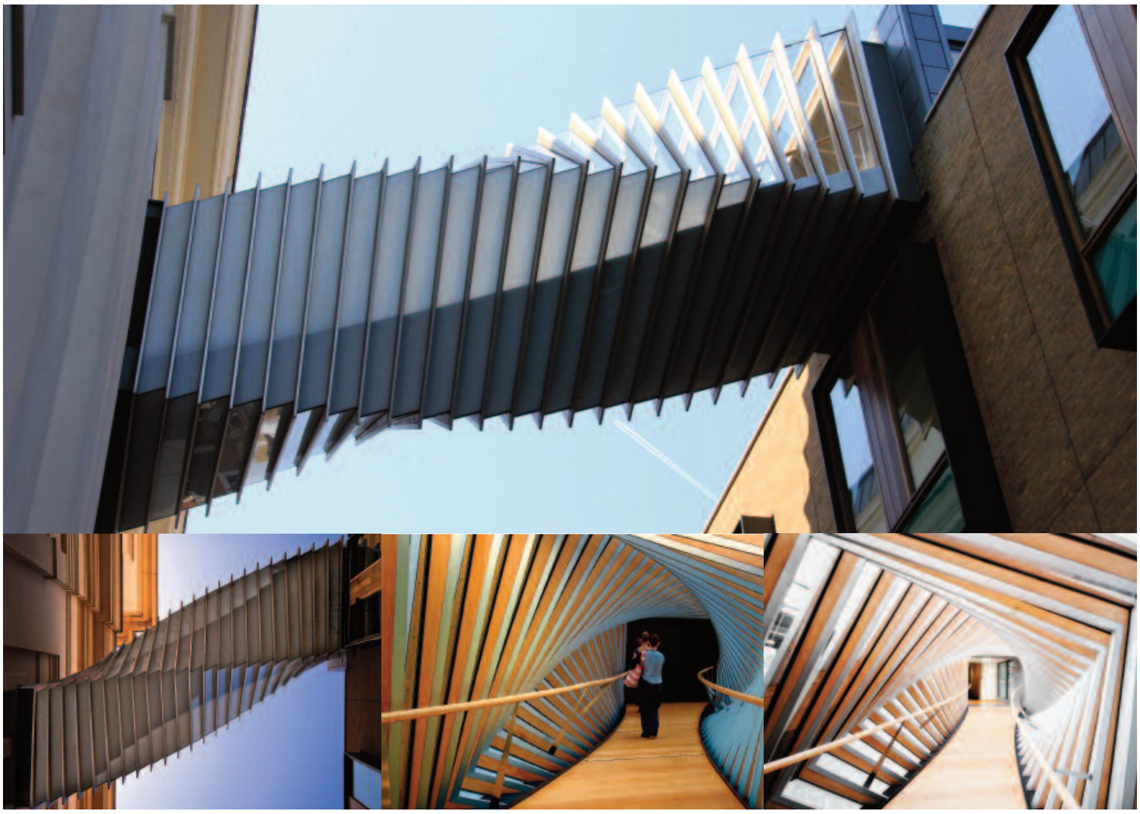
RENZO PIANO BUILDING WORKSHOP

California Academy of Sciences, San Francisco, US, 2008.

Renzo Piano,born in September 1937 in Genoa, Italy, studied in Florence and in Milan, where he worked in the office of Franco Albini. Born into a family of builders, frequent visits to his father Carlo's building sites gave him the opportunity to combine practical and academic experience. In 1971, he set up the Piano & Rogers office in London with Richard Rogers. Together they won the competition for the Centre Pompidou and he subsequently moved to Paris. In 1981, the Renzo Piano Building Workshop (RPBW) was established and it currently has offices in Paris, Genoa and New York. RPBW has designed buildings all around the world. Recognition of his achievements has included awards such as the RIBA Royal Gold Medal for Architecture in 1989, the Praemium Imperiale in Tokyo in 1995, the Pritzker Architecture Prize in1998, and the AIA Gold Medal of the American Institute of Architects in 2008.

Renzo Piano and his office at Punta Nave, Genoa, Italy.

WILKINSON EYRE



Royal Ballet School: Bridge of Aspiration, London, 2003.

Wilkinson Eyre Architects is among the UK's leading design practices, and is responsible for a large portfolio of international projects. It has designed highly successful projects in diverse market sectors including transport, the arts, commercial, infrastructure, masterplanning, bridge design, industrial, retail, leisure, educational, cultural and residential buildings, as well as component and systems design. The architecture is based on an informed use of technology and materials, combining a commitment to the spirit of the new with a strong awareness of context and the approach is based on the establishment of a clear brief and a legible working diagram through close liaison with the client from the earliest stages of a project. The designs of Wilkinson Eyre are widely recognised and have received extensive media, public and professional acclaim as well as numerous awards. The practice's reputation is founded on a commitment to quality, programme and value for money.

Chris Wilkinson and Jim Eyre and their office in London.

PETER EISENMAN

Il giardino dei passi perduti, Castelvecchio Museum, Verona, Italy, 2004.

Peter Eisenman is an internationally recognized architect and educator whose award-winning large-scale housing and urban design projects, innovative facilities for educational institutions, and series of inventive private houses attest to a career of excellence in design. Prior to establishing a full-time architectural practice in 1980, Eisenman worked as an independent architect, educator, and theorist. In 1967, he founded the Institute for Architecture and Urban Studies (IAUS), an international think tank for architecture in New York, and served as its director until 1982. Mr. Eisenman is a member of the American Academy of Arts and Sciences and the American Academy of Arts and Letters. Eisenman's academic career includes teaching at Cambridge, Princeton, Harvard, and Ohio State universities. Previously he was the Irwin S. Chanin Distinguished Professor of Architecture at The Cooper Union, in New York City.

Peter Eisenman, alone and on stage with Mark Wigley and Bernard Tschumi, for 25 years of Deconstructivist Architecture.

UN STUDIO

Galleria Centercity Facade in Cheonan, Korea, 2010.

UNStudio, founded in 1988 by Ben van Berkel and Caroline Bos, is a Dutch architectural design studio specializing in architecture, urban development and infrastructural projects. The name, UNStudio, stands for United Network Studio, referring to the collaborative nature of the practice. As a network practice, a highly flexible methodological approach has been developed which incorporates parametric designing and collaborations with leading specialists in other disciplines. Drawing on the knowledge found in related fields facilitates the exploration of comprehensive strategies which combine programmatic requirements, construction and movement studies into an integrated design. With this network approach UNStudio can set-up multidisciplinary teams from early stages onwards in order to create an efficient and integrated working process. This dynamic nature of the practice enables the exploration of new territories and the adaptation to future challenges.

Ben van Berkel and Caroline Bos working on a project; the UN Studio office in Amsterdam.

OMA REM KOOLHAAS

CCTV Headquarters, Beijing, China, 2012

OMA was founded in 1975 by Rem Koolhaas, Elia and Zoe Zenghelis and Madelon Vriesendorp as a collaborative office practicing architecture and urbanism. OMA's buildings and masterplans around the world insist on intelligent forms while inventing new possibilities for content and everyday use. OMA is led by six partners and sustains an international practice with offices in Rotterdam, New York, Beijing, Hong Kong, and Doha. The work of Rem Koolhaas and OMA has won several international awards including the Pritzker Architecture Prize in 2000. The counterpart to OMA's architectural practice is AMO, a research studio based in Rotterdam. While OMA remains dedicated to the realization of buildings and masterplans, AMO operates in areas beyond the traditional boundaries of architecture, including media, politics, sociology, renewable energy, technology, fashion, curating, publishing, and graphic design.

Rem Koolhaas and an OMA/AMO recent exhibition at Barbican Art Gallery in London, 2012.

DELUGAN MEISSL

House RT, Wien, Austria, 2005.

Delugan Meissl Associated Architects belongs to the Austrian architecture firms which have gained international recognition since the early stages of their development. Among its first big ventures were two significant subsidised residential projects in Vienna. Numerous other projects followed, such as the extensively publicised, but the realisation in 2009 of the new Porsche Museum in Stuttgart Zuffenhausen precipitated a significant leap in terms of notoriety and internationalism. Today, the firm positions itself at the forefront of the global architectural discourse through the impact of its realisations, its eagerness to experiment, its sense of realism and vision, its sobriety and passion. The firm approach is expressed in terms of concern for heightened interaction between buildings and their surroundings that takes the form of a blending of interiors and exteriors and an insistence on an architecture of fluid transitions.

Delugan Meissl Associates

JAKOB+MACFARLANE

FRAC Centre, Orleans, France, 2013.

JAKOB + MACFARLANE architects is a multidisciplinary and multicultural architecture agency based in Paris, France. It's work explores digital technology both as a conceptual tool and as a means of production, using new materials to create a more flexible and responsive environment. Jakob + MacFarlane has been invited to participate in selected international competitions. Their main projects include the Docks - City of Fashion and Design and the Orange Cube. Their projects have been exhibited in museums around the world, including the Victoria & Albert Museum (London, 2003) at SFMOMA (San Francisco, 2004) at the Museum of Architecture (Moscow , 2000) to the Artist Space (New York, 2003), Carnegie Melon (USA, 2001) at the Mori Art Museum (Tokyo, 2004) at the Centre Pompidou, the Pavillon de l'Arsenal (Paris), the Bartlett School Gallery (London, 1997) as well as international architecture festival Orleans / Archilab (1999, 2001, 2003).

Brendan MacFarlane and Dominique Jakob and their office in Paris.

JÜRGEN MAYER H.

Court of Justice, Hasselt, Belgium, 2013.

J. MAYER H. und Partner focuses on works at the intersection of architecture, communication and new technology. From urban planning schemes and buildings to installation work and objects with new materials, the relationship between the human body, technology and nature form the background for a new production of space. J. MAYER H. was founded in 1996 by Jürgen Mayer H. in Berlin. Jürgen Mayer H. studied at Stuttgart University, The Cooper Union and Princeton University. His work has been published and exhibited worldwide and is part of numerous collections including MoMA New York and SF MoMA and also private collections. National and international awards include the Winner Holcim Award Bronze 2005 and Winner Audi Urban Future Award 2010. Jürgen Mayer H. has taught at Princeton University, University of the Arts Berlin, Harvard University, Kunsthochschule Berlin, the Architectural Association in London, the Columbia University and at the University of Toronto.

J. Mayer H. and his team at Metropol Parasol in Seville.

TOYO ITO

-Crematorium in Kakamigahara, Gifu, Japan, 2006.

Toyo Ito is a japanese architect. He began working in the firm of Kiyonori Kikutake & Associates after he graduated from Tokyo University's Department of Architecture in 1965. By 1971, he was ready to start his own studio in Tokyo, and named it Urban Robot (Urbot). In 1979, he changed the name to Toyo Ito & Associates, Architects. He has received numerous international awards, including in 2010, the 22nd Praemium Imperiale in Honor of Prince Takamatsu; in 2006, The Royal Institute of British Architects' Royal Gold Medal; and in 2002, the Golden Lion for Lifetime Achievement for the 8th Venice Biennale International Exhibition. All of his honors are listed in the fact summary of this media kit. He has been a guest professor at the University of Tokyo, Columbia University, the University of California, Los Angeles, Kyoto University, Tama Art University, and in the spring semester of 2012, he hosted an overseas studio for Harvard's Graduate School of Design, the first in Asia.

Toyo Ito, accepting the Golden Lion Prize at Venice Biennal in 2012.

Notes

1) The complete lecture of Norman Foster at DLD Conference in 2007 is available at TED website: <http://www.ted.com/talks/norman_foster_s_green_agenda.html>.

2) This extract was taken from a recent Interview with Peter Eisenman, made by Iman Ansari and published on Architectural Review website. <http://www.architectural-review.com/view/interviews/interview-peter-eisenman/8646893.article>.

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Final considerations and open questions

> «Nobody can write the history of the twentieth century like that of any other era, if only because nobody can write about his or her lifetime as one can (and must) write about a period known only from outside, at second or third-hand, from sources of the period [...] My own lifetime coincides with most of the period with which this book deals, and for most of it, from early teen-age to the present, I have been conscious of public affairs, that is to say I have accumulated views [...] as a contemporary rather than a scholar» Eric Hobsbawm, Preface to *The Age of Extremes: the short twentieth century*, 1914–1991

It is always difficult analyzing a period while you are living it, especially if that period, as the one analyzed in this dissertation, was so full of happenings and technological developments that suddenly could change the issues you were dealing with. For this reason, it seems me appropriate to report the opening of Eric Hobsbawm's book, not in order to compare my modest work with the greatest historian of our XX century, but to report a problem linked to a certain absence of distance with respect to any analyzed phenomenon.

I have used a methodology of analysis as much as possible objective and based on logical scheme and criteria, by choosing a bottom-up approach and dealing with the actual products of contemporary digital-influenced architecture. By using a vocabulary of parameters and criteria defined by the Art & Architecture Thesaurus, the approach was based on the study of each project, observation of main features, deduction and classification. While some category are more objective, insomuch everyone could attribute the same classification, e.g. about geometrical matters, some others categories have obviously an intrinsic subjectivity, like compositional matters or the definition of conceptual strategies, even if most of the times these issues were resolved just by reading what the designer's say-so about each project.

The first thing that has become evident in each case is that there is no easily discernible approach concerning digital methods and techniques. In contrast to the assumptions underlying design computing research and teaching, there is no predefined process or even clear tactics for each particular problem. The application of digital means seems opportunistic and generally dictated by contextual reasons – as many decisions are in architectural design (Till, 2009).

Such contextual reasons may result into effective, innovative solutions that serve well goals relating to function, performance and, more often, visual impact. Digital means produce novel forms (Colajanni et al., 2006) that attract the attention of a wide public and present opportunities for combining different aspects and elements in ways that interest the architectural public. From our sample it is evident that digital means are used for *differentiation:* just like modernists avoided decoration, digitally influenced designs seem to prefer *curvilinear forms* to indicate their opposition to earlier architecture and show clearly that the design is (partly) motivated by design computing ideas.

This also relates to *belongingness:* our sample exhibits high occurrence of acknowledged digital elements like *folding*, which undoubtedly indicates the popularity of the particular operation but also arguably serves as a badge of not only modernity and awareness of current trends but also of belonging to specific, even if vague, tendencies.

Beyond individual primitives, concepts and operations, the lack of a discernible structure or approach does not mean that there are no recurring combinations of elements, which indeed have constituted the basis for the classification of digital trends, done in the first part of this conclusive chapter.

We can interpret these as accidental concentrations of popular elements, especially when each element applies to a different part or aspect of the design. An alternative is to consider them as bottom-up, unguided explorations of digital composition. Academic research and teaching may be rich in compositional studies and approaches, but if digital means enter practice primarily as design representations, it is inevitable that emphasis will be on what can be done with software and how rather than on why.

In the *war* between conceptualization and morphology, actually the second seems to have the best. Consequently, each design project serves as a testbed firstly for morphological development (which tends to produce similar results to other designs) and secondly for experimentation with different primitives, concepts and operations and their possible combinations. This may suggest an ongoing transition from possible and popular combinations to permissible combinations on the basis of yet fuzzy morphological criteria and variable contextual relationships.

At the end of the game, it remains that, despite of a general expressionist tendency, recognizable in the majority of cases (*Digital Expressionism*, *Hi-Tech Evolution*) we cannot anymore talk in terms of language, style or aesthetic beliefs. What the digital revolution has effectively produced is a free way to intend the project, with endless geometries, materials, building systems present at the same time and in the same places, without any consideration about a shared Architecture's identity (Riccobono et al., 2013).

The use of real-world, prominent designs of our casuistry shows these digital influences in critical, high-risk situations where designers tend to pay more attention to project success, client requirements and overall appeal than to any computational principles and approaches or to the context. As a result, we consider that our sample verifies the claim that digital means have become a ubiquitous part of architectural design tools and that their current common use has caused the birth of new figurative trends. It is clear that the influence of CAAD software on design was profound and also it modified other existing trends in pre-digital architecture, insomuch as we recognized that new digital trends have solid basis on what architecture produced before. The only factor that join all these tendencies is the evident return of *curvilinearity* in architecture, even if the conceptual starting point is often very different in each case, and of a morphological approach to design (Riccobono and Pellitteri, 2013).

Still, we do expect a higher impact: morphological elements that indicate not merely intelligent and efficient use of digital means but also innovation and exploration – two of the main traits of digital designs. Current architecture appears to present abundant examples of this. The analysis of our sample verifies the claims and assertions made by their designers and architectural critics: digital influences play an important role both in the overall form of the designs and in critical details, primarily with respect to visual impact and secondarily concerning performance and construction, or better the augmented capacity to manage building process, above all in presence of complex projects.

Since digital technologies have become an ubiquitous part of designer's arsenal, it is undeniable that their use in architecture will keep increasing. From our research it is unclear whether it will be accompanied by increased compositional awareness and more intensive use of digital methods in synthesis (as opposed to representation). Without a syntagmatic analysis and a clear demarcation of methodical from contextual considerations in a design process it is not possible to establish how designers employ digital means in solving various problems. Such research, e.g. through protocol analysis, has the unfortunate tendency to bound design activities in a laboratory sphere that may put too much emphasis on the questions asked and lead to descriptions that ignore the real context of a project. For this reason we believe that paradigmatic analysis similar to the one done in this research could yield more reliable results, albeit with a significantly larger sample and at a slower pace, provided that it manages to distinguish clearly between the motivation of different actions, in particular with respect to different contexts (physical, social etc.).

Open questions and further research field

The final proposed classification of digital trends in current architecture is a result of an interpretation of simple data, given by the analysis. We are living in a period where it is difficult to understand what direction architecture is taking under the huge influence of IT, confirmed and testified in our casuistry, so as everyone develops his own style and wants to *be different* from the others.

Of course it is not a definitive classification, even if, as Hobsbawm said, we are living years of changing and there is no enough distance to have a full overview. However, since that, as said in the introduction, academic research was lacking of a comprehensive overview, that effectively links IT, morphology, composition and aesthetics, and that academic research are split up between opinions and research in digital tools and design, I guess that this work could constitute a complete - until now, of course - panoramic of the digital influence in current architecture. Hence, it can be useful for students, but also for practitioners, who see these instruments just as a tool to produce forms and representation, focusing more on how to produce forms, rather than on why.

To conclude, I think that a new frontier could be represented by younger architects who have had the benefit of early exposure to the computer and formal education in design computing (even if it is restricted to practical skills). On one hand if it is unavoidable that digital influences on architectural design will keep increasing, but what is probably unpredictable is which kind of expressivity will be reached by new generations.

The recognized digital trends, treated in the first part of this chapter, driven by international firms, obviously introduces new degrees of complexity in profession and also in education. Indeed, during the development of a project, it could happen that practitioners and students will tend to keep merely the style or the formal configuration of some fashion designs, forgetting and not considering other aspects related to design conception, such as cultural references and contextual choices. For this reason, projects as those reported in this research, where the taxonomic values are strong and where the designers tend to develop their own style, could conduct to a simple reproduction of *beautiful forms*.

Up to now, just by giving a superficial look at architectural websites like Archdaily.com or Europaconcorsi.com, where practitioners can upload their own projects, we can note strong similarities in some professional projects with international firms designs. Hence, we would conclude this treatise with a series of open questions. Will architectural scenario become analogue to Fashion or Industrial Design? Will we choose our future style as we normally choose a clothes? Probably only the time can give us the right replies, but now it seems fundamental that we will begin to question about that.

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AFTERWORD

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The research work carried out by Alessia Riccobono and presented in this dissertation, serves to put attention and to critically discuss about the great transformations that the Digital Era has led in architecture in the last years, and then to imagine some possible future scenarios. It is a reflection based on an accurate study of many emblematic cases and with a desire, by any means, to *go inside* the designers occupied in the challenge towards the new digital frontiers.

The digital media allow to explore the architectural space and directly control its transformations in all phases of the project. Therefore the designer's skills increase and the quality of the project takes advantage of them.

Representing the reality that surrounds us, land or built, landscape or city, means modelling all the factors used to describe the same reality. Through current modelling software you can get even more complex forms of representation. Indeed they add up to traditional graphics media and an additional system of information is directly available. They become a stimulus to our conceptual skills, activating them to govern the complexity and to give free rash to design creativity.

Designers are now conscious of the innovations arising from the use of digital media and when they are not conscious, because belonging to a generation that was born and has lived in the digital age and therefore is completely inborn with it, in any case they can take advantage of cognitive capacities, which go beyond the mere graphic representation.

In the description field of the existing reality and of the design, the available software allows in-depth analyses, which extend the physical description of architectural object or territory through the management of materials, light, superficial treatments, of building features of constitutive elements or of the peculiarities that compose the landscape. The designers can count on operational continuity, anticipating all the possible conditions of realization and fruition. In recent years this sometimes has led the architect to a radical change of its relationship with the project.

The classical conceptualizations, previous to the substance of that will be the final form configuring and expressing architecture, are now almost in parallel with the expression of the form itself. The temporal detachment between thinking and representing no longer exists. On one hand, the synchronism between the two moments can lead to express the whole complexity of idea, without the simplifications due to the act of drawing in the past. On the other hand, this celerity can let risk to little reflecting. You can now have formal solutions complex and satisfying, but neglecting interpretations of the mind and less immediate aspects that the design invention, however, requires.

While most of the architects has introduced the new software in their design habit without significant changes, trying to take advantage of all the instrumental possibilities offered in order to increase the productivity of their work, others, instead, have pushed these possibilities towards the research of expressive solutions, never earlier explored with the traditional representation instruments.

Through the possibilities, also interactive, to manipulate forms allowed by new programs, architects have acquired a capacity to deform shapes in a *topological* way. The purpose is to have surfaces that in other ways cannot be buildable, neither representable and thinkable, if not as a result of a generative process with an unpredictable outcome. The final goal is a deformed surface, the quality control of the final result and not the process behind it. It needs that the effect of deformation is evident, in order to gain originality and therefore positivity of the architectural outcome obtained.

Philosophical theories and reference models serve only to elaborate design tools inclined to generate diverse shapes, based on rules imposed by needs of creative originality, to obtain a *special effect*, rather than by an actual opportunity to explore many solutions and then to choose those closer to the design intentions. To have different variables does not mean to have more opportunities of selection, but rather a proliferation arisen from a genetic dispersal already less selective in the start.

The limit is the partiality of approach, which almost always occurs in the simplifications necessary to reading and interpreting the context and leaves little space for many important variables involved in the project. When the context is more filled of meaningful values, it is more difficult to establish relationship with itself. The risk of get carried away by events isolating from the context is greater, going to purely formal abstractions. The results may also be incompatible with signs and values that the architectural and urban space can communicate.

Alessia Riccobono, with her accurate and meticulous work, has wanted to investigate exactly that limit, beyond which we risk to go out of the architecture world, to abandon it and go towards other aspects which are instead rather marginal to architecture itself. With scientific and methodological rigor, she has used the knowledge of the elaboration tools available and of the history of contemporary architecture, in order to critically *read* what new is happening in the worldwide architecture and therefore identifying these new trends.

Palermo, 14.01.2014

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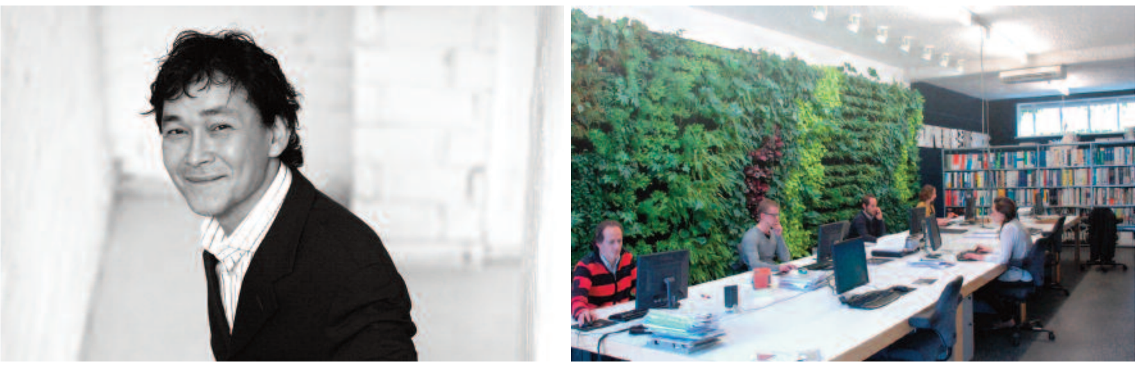
Appendix I

interviews with Dutch designers

NIO ARCHITECTURE

Touch of Evil, Pijnacker, the Netherlands, 2004

NIO Architects is a Rotterdam company with its roots in architecture, founded by Maurice Nio in 2000. With a team of around eight architects led by Maurice Nio and Joan Almekinders, the office works on projects involving sports and leisure, retail, infrastructure, culture and private housing. The studio practice strives for innovation and aims to create an inspired and inspiring environment, which generates development that is both functional and above all emotional. Each job has its own, specific features, searching for solutions that may be unconventional but are certainly appropriate and goal-oriented. In practice, each project is carried out by a small team of designers, led by a senior architect, who actively participates in the design process. In this way, there is a better contol of each project, at every level, from the concept to the details, also producing a number of variations. The resulting digital models are constantly tested against scale models so that the design will remain clear.



Maurice Nio and the NIO office in Rotterdam.

Interview with Maurice Nio, founder of NIO Architecture.
recorded on 08/11/2012

When have you started work as an architect?
I think in 1991. What I did first was to ask money as a student to develop myself for one year, as a scholarship. You get money to develop yourself, I did a lot of videos and also computations. We started NOX at that time to produce the first NOX magazines and then I needed more money. So, I started the job in a city which is called Lelystad and then I continued to work for this studio. My first project was a parking garage.

Where did you graduate?
I graduated cum laude as an architect in 1988 at the Faculty of Architecture of the Delft University of Technology, presenting the design of a villa for Michael Jackson, the most curious final project of that year.

Tell me about the beginning of your profession. Did you work on your own or did you have a studio? If yes, how was the work organized in the studio? Did you work alone or with collaborators?
I started collaborating with Lars Spuybroek/NOX of course, working on books and then we had the first commission that was the Fresh Water Pavilion on the island of Neeltje Jans. After that I did something else separated and I worked for an Architectural Office in Zwolle. Then I moved to another office in Rotterdam and in 2000 I started my own studio, NIO Architecten, in Rotterdam, with many people who helps me in architectural practice, a big office as nowadays.

So, when you started, collaborating with NOX, you already had the computer as a mean to develop the design idea.
Yes, we started with a big computer, maybe with the first Windows software, so slowly!

When you started the profession, did you follow any trends or thinking about architectures? As usual, when a younger starts working after university education had many ideas, conceptions about architecture. Some are own, others derives from the influence of a master or a teacher.

No, no, I didn't follow any trends or better, a few. I had so many reference points, really like Neil Denari - I think he's still teaching in Los Angeles, but he's one of my heroes - and, of course, Lebbeus Woods, died recently in New York, just a few days ago, I think on the same day of Gae Aulenti. If I should think about other influences in my life, not always regarding to Architecture, I studied a lot the post-Renaissance period and I was always fascinating by the work of the painter Pontormo (Jacopo Carracci) and by architects such as Giulio Romano. That period is very interesting for me because they were changed the rules of Renaissance, playing with the concepts of symmetry, ornament, structure.

How did you design at that time? Regarding to new computational media, of course.
What I'd like to tell about the new media is that it opens new ways for designing, instead of the pen or the ruler, which is very orthogonal tool. You can use now 3D modeling, but also we work with computer not to make a perfect product, but rather to make unexpected things, not conventional shapes. For example, what I like of program Morph, of the morphing technique, is that you go from one shape to another one through in-between shapes, which is much interesting rather the start and end form. So, the start is definite, the end is definite, but about the in-between shapes, you don't know what they are.

So, you started with the morphing operation. This is more a visual approach.
Yes, it's very visual. But, at the same time, it is very theoretical and useful for our work because at that moment we only were producing books, writing and re-thinking what architecture is about. And it is necessary because before you cannot just make shape, you need to think before. You need to think what am I doing? What is the position of architecture in our culture? Or what is culture? And then you can make something that will be good.

Interview to Maurice Nio in his office in Rotterdam.

And did you use any algorithm during the design phase?
Yes, of course. But now, not ten years ago. The approach was only visual. We only had Photoshop and a little bit of AutoCAD, that now is also 3D modeling, but quite difficult to deform, to get the splines.

When did you buy your first computer?
I think in 1985 and it was a really small Macintosh with floppies, it seems a century ago. The technology has made rapid progresses, but, also before '85, I typed translations of books on a paper-sheet. But, of course, the digitization of drawing and architectural design took more time than video-writing and related software programs. Above all due to the costliness, both of hardware and first commercial software, which then became more accessible to everybody.

How did the studio work change after computer aid? Have you changed your ideas or have you been influenced by new digital means? If yes, in which way?
First of all, what I like is the endless possibilities of shapes, of course. Everybody likes opening a door and watch at a shape never seen in front of you. But what is really important is: when do you stop working on possibilities of shape? Because the computer is a tool, you can generate every form you like, but it's important that you know when you have to stop and then to elaborate the work and this is quite difficult, of course, because you have everything possible. And this is the reason because I don't like architects who work on fluid forms: you have "non-formed" shapes, in between configurations absolutely undefined, and you become to ask "what hell is this?". But you cannot realize it, so have also to think how to make it, at the same time. You cannot just produce forms and after that ask "how can I make it?". No, it is an unique process, you have to be able to talk with people and answer to "How can I make it?", with "You make it with concrete, polystyrene, polyester, ect.". So, that's the positive side, but also it's a danger.

When you're working on a shape, refining and improving it, how can you decide when you have to stop working on it?
We decide with our team, it is not a decision you can do on your own. You talk and you say “Shall we now stop work on this? Or shall we go on?". It's not a decision of one man or woman.

If you can predict the future, what should you image? Towards which expressive horizons are we going?
I hope we can produce more ourselves, you're not depending on an architect or people who are going to general contractor, but to get to produce it yourself, that's you have a 3D Model, here, somewhere a 3D printer, big one, so you can produce building yourself. So you just say to the contractors "You are too expensive and we are going to do it ourselves". That's my dream.

Watching at nowadays, we can't see a unique trend in contemporary architecture, but different approaches to the same theme. What do you think about it?

I agree, we have probably a thousand languages. I think they are derived by culture, for sure. Because, for example, when I come to Italy there is a totally different culture or thinking about architecture, while in Holland it is more conceptual, in Italy it is more about, I think, looking at the history and returning to architecture. United States are also completely different, the approach is more theoretical but also more esthetical.

So, if you would design in different places, you had different approach.

No, we have always our approach. Of course, we are influenced by the context, but, i.e., the context of Prato is different by the context of Firenze, despite they are both in Italy and in Tuscany. We try to express freely our way of thinking.

Do you think we are in between a revolution, like the post-Renaissance period?

I hope so, I really don't know in which period we are! I think we are in a difficult period, we are not in a period but in between and in between. You really don't think if we are going to work. We don't have distance now, to analyze the moment.

Could you tell me about the Bus Station Project in Hoofdoorp? How was it born?

We started to design it in 1999 and the completion was in 2003.{*He showed the maquette, editor's note*}.You could see this elevated road, devoted only to high speed bus, and, next to the viaduct, a very ugly hospital. At first, the municipality asked me to make a little bus station for the local buses, which circulate in the roads under the viaduct, and even to connect the local bus transport with the high-speed bus line and the hospital. We made ten proposals, starting with a simple glass roof above and then, a little bit more strange, more strange, but in the academic style, and the tenth was the realized proposal. We said to the client that we thought they needed this kind of object because it could change the image of what public transport is. Normally we have a glass roof and nothing else. And this is something different and it would change the image of public transport. They liked very much the proposal and said us to go on.

The concept of the shape was not derived by 3D modeling, but first of all we tried to get all the decisions that look perfect, from both sides, to have the benches where people could sit also in the right position. We made only this small model, we cut it, we scanned it and we put it in Rhino. It was a manual approach, we modeled with the hands, after that we worked with computer. For me it is not a novelty, when we design, most of the time we make models and scan it, because what I like about the hands is that you make a lot of mistakes, while the computer is too perfect, too smooth, too shiny. I like to make mistakes, because you deal with the physical dimension of things. The computer helped us to refine and improve the shape.

What about the realization?

The bus stop is realized in fiber-glass. We made a Rhino model derived from physical model at that time, in 2001. It was difficult to get a solid shape, to get a perfect solid that could be good for the one who cut this polystyrene model, because he needed to have a blocks there, cutting and glued them together. It was quite complicated to get a good model that we could give to the construction company, sure that they could work on it. Also it was very difficult to find who could do it. The envelope was realized by boating company and it is very funny! At first we didn't know that we could ask to boating sector, we are architects, we were not informed about this part of industry! But of course, if we look at the boats, we could see that they are designed to optimize the navigation, with shapes often curved and thought for the sea. At first we wanted to realize the bus station in concrete, but it was too expensive. So we decided for the fiberglass and the total project costed 1.000.000 €, including all things, production, assembly, covering. I have another curiosity: at first we used neutral polyester, no color, because I don't like put color, I like seeing the shape, the potential of sculpture. After some time the administration told me that the structure had some problems: in fact with the sun, the upper part of the covering was become green, the building seemed sick and they didn't like it. They told us to do something, also because this hospital is very ugly, almost all is grey, there is a parking garage. So they wanted that we changed the sadness of the place, giving color to the environment. Of course we accepted their requirements and we decide to give the orange color.

About this project, what did you inspire?

Of course we studied the situation of the site at that time, focusing on flows, on the movement of passengers and vehicles. But also I was just returned from Brasilia, where I saw the projects of Oscar Niemeyer and I wanted to make something like this.

Above, Oscar Niemeyer's Concha Acùstica in Brasilia (1973). Under, the Nio's bus station in Hoofdoorp, the Netherlands (2003)

ONL [OOSTERHUIS_LÈNARD]

CET building in Budapest, Hungary, 2011.

Architect Kas Oosterhuis and visual artist Ilona Lénárd are directors of the multidisciplinary design office ONL [Oosterhuis_Lénárd], where architects, visual artists, web designers and programmers work together and join forces, practicing the fusion of art, architecture and technique on a digital platform. ONL is an office where reality and virtuality meet. Kas Oosterhuis is professor at the Delft University of Technology, director of the Hyperbody Research Group and director of the Protospace Laboratory at the Faculty of Architecture, focusing on buildings as Complex Adaptive Systems [CAS] and on multi-player gaming techniques for Collaborative Design and Engineering. The portfolio of ONL exists of a variety of projects in divergent fields of experience. This includes housing projects, exhibition pavilions, corporate business buildings, city planning tools, online experiences, interactive installations, and works of art both for private collections and for the public domain.

Kas Oosterhuis and the Hyperbody Protospace at TU Delft.

Interview with Gijs Joosen, senior architect at ONL [Oosterhuis-Lènard]
recorded on 11/01/2013

Most of the questions which were thought for the founder of the studio, in this case were not applicable. The interview was carried out by analyzing some projects of ONL, exploring the design process from the conception until the construction.

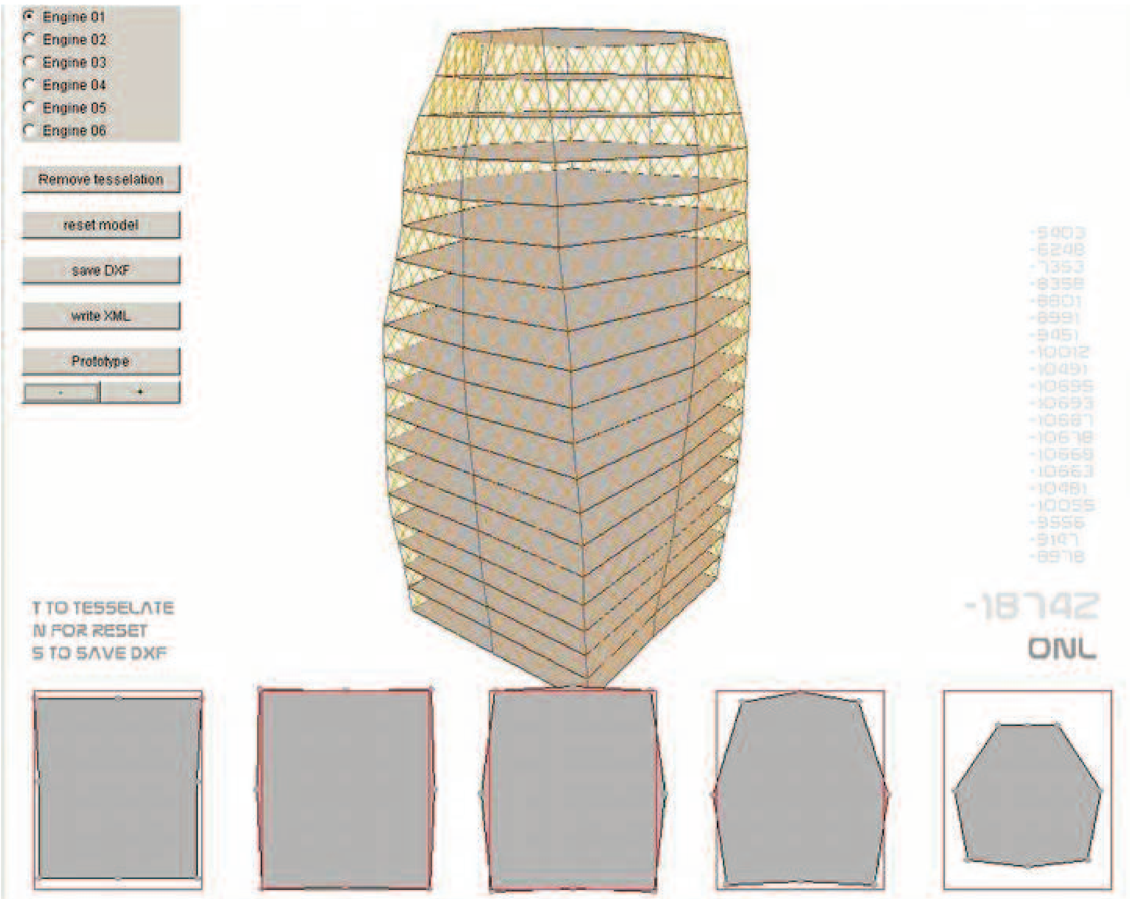
Could you tell me about your recent project of the Liwa Tower in Abu Dhabi?
Yes, that is what we are currently working on. Basically this is how we start to work on a project: we start with collecting data. The demand, come from the client, was to build 21.600 m^2. The simple reason was that he was paying the city of Abu Dhabi, basing on the actual amount of square meters that he could make on that spot. Then it was exactly defined this measure in the masterplan. After that, there was the analysis of a given masterplan, so we had to work in a certain context (urban plan, masterplan, instruction regarding the envelope). They wanted a tower and the limits of the envelope of it were given, so we couldn't cross those limits. Also the maximum height was given and, then, the dimension of the body. We thought that the envelope we had to make had to fit the 21.600 sqm of the building.

We started collecting data and then we created simple tools to manipulate the data in each phase of the project. Even in the first design phase, when we collect all the information about the project, we immediately translate it into data and spread it. In this case, I have a small tool that I can use to view the envelope of the tower. It's a small visualization tool. We cropped the entire tower into five crops of three or four storey and, from that, the software calculate the floor space for those stacked floors. If you look at this {*he shows how the tool works, editor's note*}, we could make 31.000 sqm for the whole plat. If you had all the floor space of the envelope given in the urban plan, we have to make 21.600 sqm to make something we effectively can make. Then, we have a podium, eventually if we combine the numbers it means we had to build 90% of given area or the maximum area, in order to reach that number that also was imposed by the client.

That's the first start. So, before we even think about design or architecture shaping, we first have to know about dimensions, and so on, in a very pragmatic way. Then, if we have those data, we wanted to translate it into architecture. We want to explore immediately what we can do, where is the design freedom. In the tool, we activated just a few points: you see the points highlights and if I drag that point, I can change it, I can quickly shape the volume and the perimeter of the envelope. In such way, it gives me a direct feedback of the amount of sqm that I'm making, in order to remain consistent with the program. It is a direct feedback between my program, my perimeter and my work. In this phase I am able to quickly come up with a sketch: this is the way how we sketch. The tool that allow to manipulate the data and to shape is a single JavaScript, created by a collaborator of the studio.

But in this way the approach is also visual. I already have an idea in my mind about what to do and how to do, the style I wanted to have, the shape.

Yes, but it is always based on data. I think that it is the key of everything we do. We have data, we stored it in a place that we can reach and all the tools and everything to do to manipulate the data have always a feedback loop into the database, spreading numbers. In this case also we created that tool and then I know that the starting point is basic shape, this volume. Now I really want to shape, I want to do the architecture. We confront the data from one manipulation to another and in such way I can see the exact result of my work. It just translates it into another way and then I am able to encore it in our design software, where we can start shaping those curves. But still I know that the volume I created has a relation with the original program. In that way you are able to shape the tower, control that curves, make sure that it gives a lot of dynamic effect. Especially in the front facade you



The JavaScript tool to generate the final formal configuration of the Liwa tower,, keeping the consistency with the demand.

can see the taper of the tower, you higher are, you get more taper, which also plays with your perspective. But if you look at the section, you see that it is almost a straight building.

Why?
The reasons for that is again that program. Indeed, then we did the entire floor plans. It also has to do with the organization of the program because it's a private client, it's a tower that he has to use for himself - the Al Nasser Group, which is an industrial steel building company. They wanted to rent out all, but they wanted to keep the top six floors for Al Nasser Group. They did a detailed analysis for how much floor spaces they wanted to have, so the entire top two floors is only for offices and it was huge. So that's why we curved the building, by reducing the space of floors on the top of the tower.

This was about the conception phase. You have chosen the data, shaped the envelope of the building, decided the form and the number of floors. Which was the subsequent step?
Then we used Revit to making the drawings, to get what now in the building industry is called BIM. We used Revit, but we don't call it BIM. BIM in our practice is much more a container for everything that has to do with manipulating data. Revit was one of the tools that we used. In this case the base for the project was scratching with data, which can be Excel sheets or database, the raw data, and not containing within a closed system like Revit.

I think Revit could be useful especially to control the construction phase because you use a coherent model.
You don't have a coherent model at all, it's impossible. I can show you why. I don't want to produce any drawing anymore ever and when the moment comes that my contractor won't need drawings, I won't need Revit because there are much better ways to communicate data from the design process to the building process. After the first part of collecting data and shaping the building, I have my model and I have my tools, Revit is just one of those tools. In this case it's the tool used to make the drawing set for the building process. That's the only reason because we used Revit.

Here you can see that we have a 3D model in Revit and this is the interface of the program, where we have all the information of the whole project. We could produce pdf for visualization, that we made for the documentation about the steel structure and the skin, where the model is integrated. It's a simple pdf, anybody can open it, but the file contains crucial information and contains the model. Based for visualization purpose only, but it has also a contract document inside.

The only thing allowed by the 3Dmodel is that it shows reference lines of the entire project. So, we have a reference lines for the nodes, for the skin and for the steel structure. We have a model, but every element that you see is unique: the philosophy behind each element is the same. We still have the data, so the next step to create the overall data was to connect and translate that into geometry. In this case, it is the reference lines, points and nodes.

Therefore, when I have such a reference model, then I can connect it to geometry, but it still always based on digital information data. This explains the logic behind the building, it doesn't say that you have to do it in this way, but it describes the relation between the elements and, one of the most important things, I think that's something totally different from the way that architecture is done at the moment. That is we set up the system in such a way we want that detail and not detail that you see here, is the same detail we did for the entire building. All the nodes, the angles and the elements can be customized and they are all different, but the way how we connect is always the same, the principle is the same, but the actual dimensions are always different.

You mean that you have a variable dimension in the sticks and all nodes are the same?
No, also the nodes are different. Everything is customized, but it is customized within a certain bending, so we have a minimum node, with the minimum angles that connect sticks together, and we have a maximum. The nodes are all different, but all within the same bending. The same method is applied for those triangulated panels. What we illustrate in the tender with the model is that we have a steel ring at the perimeter of the floor, the ring is connected to the main structure in the facade and the main structure is synchronized with the skin. There is a relation between those elements.

Through a 3D model, which goes on with the full description, we explain that this is the base of our architecture. The parallel lines create a surface, which is then tessellated, and we made the surface in such a way we converted to the building components, that have nodes, skin, thickness. That's related to the building process, so we don't want to create small panels instead of something we cannot produce. You have to limit it in such a way, so that you can have a few big panels.

Interview to Gijs Joosen in ONL office in Rotterdam.

Also to reduce the costs, I imagine.

Yes and also to reduce the cutting loss and so on. So, then we describe the system, this is the model, how it works, these are the nodes, these are the panels and their number. The panels are all different, but everything follows some simple rules. After showing everything, we asked to the contractor that if he follows these simple rules, he is able to manage every single node. It is important that everything has the same detail. The same is true for the cladding.

Basically we have a triangle with his reference lines, that are the components. There is an opening, a window, and the relation of the window with the edges of the triangle is always the same, but the dimension of the triangle and also of the window varies, but always following this logic. The only thing that we explained was that we didn't do a thousand drawings, but we just said: "this is the logic, if you follow it you can actually build the architecture".

How did you apply this texture to the envelope surface?

The simple thing is that if you have the reference lines, the hard lines of the steel structure, you need to create an offset. If you follow the offset and you create a perpendicular to the surface of the triangle, it means that I have two triangles that connect two different angles and if I extrude them, the problem becomes much bigger. The thick of the package becomes the corner detail, because at this point you never have a direct relationship with the offset of this other point {*he indicated a point of the corner of two different facade, much more higher; editor's note*}. So we created two models: one for the steel structure and one for the skin. These two are completely different models, but they are related. We wanted to make sure that all the nodes, all the skin panels, above all on the corners, were connected exactly on the corners. In the most complex situation, six triangles has to connect on just a point. So, to develop this, we started from the corners and then proceeded with other triangles. It is a design relation, it is not a simple mathematical and algorithmic relation, because you will get huge problems when things get thicker.

The starting point was the road lines, but we had an opinion on those lines. These were the architectural instruments that we used to shape the building. You can see it in a project like the highway, where that line that folded and that shaped the sculptural form of the envelope, is full of purpose: we wanted those lines at that spot. That is not algorithm based, it is a generated shape, so it's an actual designed shape.

Then I have to go back on the history of the office, also because Kas Oosterhuis and Ilona Lènard were used to be a separate practice. Kas Oosterhuis were doing the architectural part Ilona Lènard is a visual artist and there was a lot of overlap between the two working feelings. So the sculptural part and seeing a building like an object, the unique body design, has a great overlap with the visual arts, and that's why the sculptural aspect that you see reflected in the buildings had a great influence of the aesthetic work of Ilona Lènard.

The way you look at buildings {*he is showing the IWeb project in Delft; editor's note*}, if you define a main structure, so defining the visual appearance of the building, you cannot just simply play a daring game, cutting out parts of that skin and putting in just a frame and a window to illuminate inside. You have also to rethink those kind of elements and bring them back in architecture.

Maybe I'm wrong, but it seem that your work is very much related to the structural aspects of the architecture. Or do you take into account both, the visual and the structural aspect?
I think that, because of the design and the architectural envision that we have, we have to go into the core of the building, to make sure that everything supports that architectural appearance that the shape of the building is what you want to make. Let's look again at the Cockpit for instance. This is the shape, this is the design we wanted to make. We wanted to have a fold line following the car along the highway {*he shows a video of the project; editor's note*} and gradually guiding you eye, playing with the way that the reflection works on the surface and controlling the position where this line is.

That's what we want architecturally. But if you translate it into what was the concept for the building components, this is the section, which is different in any spot we made. So, you have one and half a kilometre trajectory and there is no section of that trajectory that is the same. If you translate it into building components, that means that there is no building elements that is the same. Everything is different. And if you just say: "Ok, this is my design", the final design stage, as far as we can go. Then you have to go into the building industry and they have to solve this, nobody is able to make it, because also the contractor says everything is different so everything is expensive. I have to make fifty thousand drawings in order to make this building. So you really have to rethink the materials that you use to produce it. So in this case again we go back to the core of the structure. That's a points cloud and the points that you see are the translation of architecture into the structural system. So every X meters we have foundations that goes into the ground and we created a segment to explain it. Eventually you have to translate in something that somebody else can make.

The soundbarrier and Cockpit design concept.

This is the segment of the barrier, each corner of the segment we have foundation put on the ground. The segment is 9,10 m, we created all these elements and then when you put together all these elements you make the barrier. But every elements is different, so we started with doing the engineering part. Then we created the algorithm that connect each node with the neighbour that has a relation with it. If you have a triangle, the software constructs the triangle basing on the algorithm and on the nodes.

And how did you define the change of each section along the trajectory?

Basically by using the computer again. By starting with the tool that show how the barrier appear from a car along the highway, we created a lot of these kind of animations when you play with that line. we used the computer to visualize where is it and what we exactly wanted to see. But also that shape, the fold line, defining the position of that line, was a top-down process. We are the architects and we decide where this line are going to be.

As in each design, when you're working on a shape, refining and improving it, how can you decide when you have to stop working on it?

That's your interpretation and your feeling, that's your job as an architect. There are lots of designs that I see using computer algorithms and definitely I think exactly the other way run. When you start, when do you stop running the algorithm? And which point you take over? What's your input? What's your opinion? Or how does that system function? I think it should always be some kind of top down opinion of the architect. That's part of experience, that's part of conception. And all the tools that we use is to reach that final goals.

What we see in the last 20 years, is that this computer provides a really helpful tool, especially if you talk about big data. Basically it means that the only way to control that data is using computers and that's exactly what we do. You have 15.000 steel elements and 15.000 glass pieces, for a contractor such a big data means that there is no possibility to manually control the process. So you have to really rethink how to set up the system. You do engineering and the thinking only once and anything that follows is based on one simple set of rules, which you can eventually give to the industry. It also depends on the company you are working with. In this case for the sound barrier, we worked with a local steel company, we had a really good working relationship with them, but it also depends on people. We had two guys in our office that connected directly with some other people in the building factory. We connected our model, the 3D point cloud, a wireframe model, that was created with an autolisp and if you look closer you can still see the reference lines. Finally, we wondered what we need and how do you need it and in this case we decided that, given that we had to communicate a dxf model, we made set of rules, which are visually shown by different coloured layers for each element with different geometry. We prepared a model in such a way and, based on that, we created the macro script which generated all these components. Then, you don't have work with drawings at all, for this project we didn't use any drawings.

Instead of it, I have a database that contains all the data and I want to connect it with different experts. Instead of create a huge 3D model with everything in it and just throwing the data to them, and the experts have to figure out by themselves about the project, we sit down with our structural engineers and we asked which was the minimum information that they need to do their work. (36.50)The basic is always to set up the system and to allow a data visualization, so that we can also see what happens if I change a parameter, also to reduce the cost. With such a system, I can vary the density of the grid, or impose a length of the pieces, and so on, and see how the design is changing.

If you can predict the future, what should you image? Towards which expressive horizons are we going?

I think that one of the main revolutions is that we can make our own products. You are making a component and that component can as well can be a door, can be a window, can be floor, etc., depending on the way that you implement it. For example, one for our last projects was a Parametric Climbing Wall, designed for one of the main climbing centres in the Netherlands. First we started again with data, that in this case was the angles of that wall, and then we started to shape that wall. You are visually able to create interesting rules. Then we controlled the structural system and the elements of the skin, everything is based on one simple element. We create algorithm to can execute and realize those elements.

So that's how we are going, you need algorithms to be able to control that amount of data and facilitate it, connecting design to execution. You can create a wide design freedom because also the guy that was making these panels, he normally makes customized kitchens. He has this CNC machine and a good workshop and therefore he is able to create custom panels for kitchens. In this case, since because we knows the predefined limitations of the machine, he really doesn't care what I do with my design. So I can create my system with a complete design freedom within that set of rules, I have not to limit myself. We can create customized elements for the client, I have not to choose my elements from a catalogue and compose them anymore. Finally, I think that customization is one of the most revolutionary things come up with the digital technologies in our profession.

Parametric Climbing Wall, Amsterdam, the Netherlands, 2012.

RENÈ VAN ZUUK ARCHITEKTEN

Entrance parking and pavilion in Roosendal, the Netherlands, 2007.

René van Zuuk Architekten bv is an office that works on diversity of projects since 1992. The work process is characterized by a search for a building system that connects to the program requirements and the context of the specific task. The design process always starts with the making of a urban model of the site. In this model, the shape and the size of the building is determined in relation to the surroundings. During this phase the concept is formed and the first idea for the constrcution system. Then spatial structures and physical layouts are examined at the level of the building. This is done via use of models and 2D / 3D computer drawings. The advantage of computer graphics is the high dimensional stability while the models offers more design flexibility. Both methods have their own contribution to the process. In this stage the design is further developed in strong relation with the concept. The concept is also a leading role in the further development and detailing of the project.

Renè van Zuuk and his office-villa Psyche in Almere, the Netherlands.

When have you started work as an architect?
I started to work as an architect in some offices in London and America, after the completion of my education. I started this office in 1992.

Where did you graduate?
I started University in 1982 and I finished in 1988.

Tell me about the beginning of your profession. Did you work on your own or did you have a studio? If yes, how was the work organized in the studio? Did you work alone or with collaborators?
In 1989 I won the competition for the construction of this house {*placed in the Almere's The Fantasy district, an area for experimental housing; editor's note*}. I was able to build this house, I spent two years building it and when the construction was finished I could start the profession on my own. About the competition, the first was launched in 1982 and it was for this area with this ten plots. Well, they said "Ok, you wannabe builder of your dream house and you don't want to be subject to the dwelling regulations and you are able to do it here". So that's why it started. You could stay here for five years. So after five years you had to turn around and then the place started to be clean. But after five years there was such a success for the study that tourists came and the they decided to keep it. around 1987. In 1989 they did a second competition for two plots which were still available and I won the competition, so I could build this house here. At first it became a house, and now it is my studio. In 1989 I begun the profession on my own building this house and, once I finished it, I started the studio practice.

So, when you started, did you already have a computer? When did you buy your first computer?
Yes. It was a very bad drafting, because at first the only way to produce a clean drawing was to do it with pen plotter. We had a CAD software that was a very simple program, probably the first software we used. Initially we used the computer only as a drawing machine.

When you started the profession, did you follow any trends or thinking about architectures? As usual, when a younger starts working after university education had many ideas, conceptions about architecture. Some are own, others derives from the influence of a master or a teacher.
To be honest, when I was at University the software was very raw, the only thing you could do was actually to make boxes and shape roofs. It wasn't usable, reliable, we didn't use it that much during my studies, but we worked a lot in models, making models as way of design. Since I have started my studio I have still worked on models and on the computer, working both ways. So I make a model, put it on the computer, changing it in the computer, make the model again, changing the model, putting on the computer again. So that's how we design more or less. In terms of language or style, I changed my style but not because

of the computer, but because of the way you look differently on architecture. For example, we are in my former house and that is my second house {*he indicates the Project X, his new house built in 2006; editor's note*} and this is completely different from the second, not only because of the new way to conceive architecture. This is very expressive house and it is difficult to have an expressive house for nineteen years.

How did you design at that time? Regarding to new computational media, of course.
At that time we more or less designed with models, making models, working with models, with physical models. Firstly the computer was only to refine. The computer is very precise, you draw one-to-one; the model is very raw. In model you can work more intuitively, you put it in the computer and you see that it doesn't fit, if it doesn't work that well. Sometimes the computer is just too precise to express something because most of the times you already have to know what you are making, especially when in some programs you have to know exactly what operation to do, in order to build it in the computer.

Did you start with a visual approach or using some algorithms or specific other software?
I start from the visual approach: I want to design an abstract idea in my mind, by use a visual modelling, with a physical model most of the times, and then the computer helps the develop of that idea, refining it, making it one-to-one, and you hope to save yourself from the programs. The form you can make is much more complex: in a physical model you can do a very complex form. The only problem is that the contractor wants to know the exact size and the costs. In this sense, you have algorithms, if you have a system, it helps to define the costs. It is very important to work with a system, in order to cut down the costs, if it is necessary. So, just try to find the system which save your money so you can make different forms and very difficult forms.

And did you use any algorithm during the design phase?
I work a lot with students with parametric design, working with Visual Basic script and then they have to generate their own architecture. We have a software that didn't use algorithms, because most of the times the program is too dumb. Most of the times when you design the program know which algorithm you can use. The algorithmic design is the contrary of normal way to proceed: normally you produce a form with a software, that use an algorithm

The Project X, van Zuuk's private villa in Almere, the Netherlands.

to produce it. With algorithmic design you have to create an algorithm to generate a new form and it is very difficult because you don't know the way to end up. So, i.e., we made use of algorithms for Block 16 project. We designed that more or less on the computer and the model, but also on the form, which is a very difficult shape in the sense like. It's a pattern technique when panels are on top of each other, but after you have to start on the lower corner and end at other corner on the other side. So you have to put the all the panels together and then you know what the shape will be. The difficulty is that if you want to change something you have to start from the bottom again, which is not very difficult for the computers, because they can change it very easily. But it is very difficult to do it with programs like AutoCAD on the computer because it waste a lot of time. We have some structural programs that generate elements which is easier, but the only thing you have to do by using these programs is like how to have a repetition. So, the first time you do it you spend most of your time making the algorithm and making everything and then you save time, but, to be honest, we never have done the second time. If the project is all unique, it takes a lot of time to do it.

How did the studio work change after computer aid? Have you changed your ideas or have you been influenced by new digital means? If yes, in which way?
Yes, it is. For example concerning deformation, that has a lot with what you do manually. It is a mix of what we do, which is for us important. It is changed just because of the medium you work with. You make models, you make drawings, you work on a drawing machine, but even a drawing machine has its own architecture. It's different on drawing on the computer and drawing by hand. And now medium is very much the computer, mostly modelling. So, yes it changed, but also it has to adapt by working on. The approach is changed a bit because most of the things I do could not be possible without the computer. Most of the projects are too complex to build without the computer, it allowed a possibility of control which undeniably aids our work. Also, even if you use something to draw just on paper, it is important to use different kind of media. We never use only the computer or only the model or the sketch, because you get stuck. If you work on the computer for a lot of time, you recognize something that could be, but then if you make a sketch, looks different? So, you get different ideas by sketching, different ideas when you makes models again. It helps you to explore the space, what you want to do. If you do this only with the computer, at the end you run into a loop.

When you're working on a shape, refining and improving it, how can you decide when you have to stop working on it?
When we make a design, first model looks like shape, really looks like shape and it's very bad. Every time we make a model, sometimes we make 20 models before to have the final model. It's just like a feeling, "now everything fits together", and you start when you think it's ready. Sometimes you know that you have to present something to the client and you have to work a little bit more on it to make it perfect, so you can say to the client "Ok, this is the

project". But it's a feeling, you think that this is the best you can get and most of the times when you make models, putting on the computer, you can see if the change doesn't get any better. By the time you are changing it and it doesn't get any better, you know when to stop. By the way, first everybody needs a good concept. If you don't have a concept it's arbitrary what you do: you can do this, you can do that. Especially when you generate with the computer programs and then it is very difficult because the computer generate, but anything is too definite. You have to have a concept and say "I do this for this reason" and if it doesn't fit in the reason, if it doesn't work, you have to do something different. In the end making architecture is always solving problems, and not like most of the computer artists, who create problems. You a problem to solve and you have to solve it in a good way. If you didn't solve the problem, even if the project looks very good, you have to work on it, because otherwise it doesn't work. If you don't have a good concept with which the project is consistent, then is very difficult, it also difficult to say what is good and what is not good. For example in the morphing, starting from a shape and getting another one through a thousand operation, it is just a question of shape. What about structure? How can I build? How is the function going to work? And if you get all those things together and you find out that the amount of possibilities never down and at the end you have the feeling that this is the answer. Of course you can have ten different answers, but this is the answer good enough for this project.

If you can predict the future, what should you image? Towards which expressive horizons are we going?

A big problem with the computer is that you can design almost anything you want. If you look at the projects we make, you can note a few similarities. I have studied building technology, so my interest is how to build every project. I think the biggest change in architecture for me would be that in fact you can print. The whole relation with how we build now, which is by putting bricks on top of each other or with making something almost always in a rectangular space, after by spending money you can try to escape from the rectangular space by bending it, but the starting point is always the rectangle, that also ends up with the kind of architecture. So the rectangular architecture is also because you use geometrical panels to build it up. Once you print it, you don't have those rules anymore, so you can make anything you want and then you get a new kind of space.

Especially the 3D printers, because the complexity of the shape is not a problem anymore. For printers it doesn't matter, it could be complex or simple, they just print. Like a normal piece of paper where we can print a very simple piece of music or a very complex one, the printer doesn't care. At the end what would be very important how to set a new set of rules for how to print, how expensive is the material with you print and how much material can I use. Those are the only variables which you have in that system. I think it will change architecture automatically, because the shapes we have are rectangular shapes, but probably if we print them it could be more expensive than the curvilinear and less strong. In the end the architecture will change because of the way we can produce it and with the computer you can almost do anything or everything, it doesn't matter how difficult it is. The link to reality is not built yet. It will be even different than the CAD-CAM systems, which modify the rectangular panels, that means a building of Zaha Hadid comes from the cutting of rectangular panels and in the factory this means that one track of material goes to the product and one track to garbage, you loose so much material. If you print you don't have this loss. The Zaha Hadid buildings are already expensive because you only use half the material. Once you can print it you can just make any form wanted. I think that could be a big change and even for cheap buildings it could be a change. Even the cheap buildings, if you print them you really optimize them and you can make use of cheap materials, even available e.g. at IKEA stores, and create something different.

Also, what is happening now in architecture is that the information is joining together so you have the consistency to calculate how much will cost, to already calculate the structure, the timing. Double changes as well because until now the architects were designing most of the times in an abstract way, without caring about practical things, like costs, that the client want to know. The computer systems can control these information and give you the right answer. You can that if you do this it will cost 5.000 €, if you do that 2.000 € and the design will begin much more cost-effective than now. By having everything in one model, you can reduce mistakes and have a consistent design.

If you would design in different places, will you have different approach?

To be honest, when we start to work on a design what we do first is to investigate the site. We don't want make something out of space without a location. Instead we use the location as starting point for our design process. That's how we get the concept also, asking what it is a good building on this site? What is good for this site, not for me as an architect. Of course you want to make something which is good for your kind of architecture, but the site

Interview to Renè van Zuuk in his office in Almere.

is the most important thing. You adapt the building to the site. We start this building {*Psyche villa in Almere, editor's note*} that was the first house I have designed and then we have designed the second house. When we start to design the second, we already knew that we were opposite to this house, which is a very expressive house, and putting an expressive house next to that you would have killed the first one. So, I have to take into account what the site is. I am not like the kind of architect that think that the fluid architecture is the only architecture: I think it is very nice for some places, but sometimes it's not appropriate. You have realm and the sense of the place, you are not going to build a blob, which doesn't fit the site and after five years will be maybe selfing, it wasn't that great. If we are talking about the star architects, who have the trick and they've been asked for trick, because everybody comes, even in that case it could be good to give a look to the context. Also it makes the design process so much easier because at least you have criteria, that define what it is good and what is bad. If you look at our work, our method is more or less the same, we always have the same way of working but the outcomes are different. We know what to do, we also know if we work in this way, how much time it will take and say to the client the timing.

Do you think we are in between a revolution, like the post-Renaissance period?
I think we have just left the revolution, I'm afraid. At least in Holland, between the end of the '90s and the beginning of 2000s, there was a real optimism in architecture. We all wanted to do different things, it was a focus time in architecture. Now it's more difficult. Since 10 years, there is crisis in the real estate. Before they could sell everything, everything it's gonna be sold anyway. But now not, they have to look at what is good for sell, most of the times the more traditional buildings than the modern architecture. They don't want to experiment too much. It's different looking at big structure. Zaha Hadid's buildings are not real estate and often are in countries that want to say "Look, I also have Zaha Hadid!".

Could you tell me about the Block 16 in Almere? How was it born? What about the realization? What did you inspire?
Block 16 is in the Almere city centre designed by Rem Koolhaas. They already had a big effort to do something. We were lucky because we were the last building in that part, which meant that it had to be built within a few months. To do a thing that was more experimental, if we would have had enough time and they could stretch the time, but with these conditions

Skyline of the new urban centre in Almere and the Urban Entertaintment Centre by William Alsop.

nobody would have had the time to change anything in the project. First we looked at the building site, where on one side there is a building by Klaus en Kaan, the Silverline; on the backside you have the Side by Side by De Arkitecten CIE., which are two towers. These architecture are very rectangular buildings and we have William Alsop's building {*the Urban Entertainment Centre, editor's note*}, who sprawled free form elements. We were in that context, we had to design something. For that context a blob was the best solution, because we need a building that didn't have a front side or a backside, which has only public space around it. We wanted to have a building with balconies, which was very difficult with that shape. We had to make decisions "how-to", which becomes the front, which becomes the back. We decided to have two layers houses with corridors in the middle and we could make a whole side building. Then we shaped the building. On the top we wanted to have a patio, but that would have meant that you have a small living space because of the patio, so we expanded the building longer, we make the hole in the middle saving enough space for the interior space. So, because of the site and of the functional program we shaped the building. In the beginning we had a smooth building with wood on top of it, but there was no budget and we had to find a way to make it with a very cheap budget. We find out that if you make panels that cover the whole exterior wall, then it was very cheap. When we had just the form, I wondered how can I build it and we found that the cheapest way to build houses in Holland is to use a temporary tunnel system, with a C section that means that you build two walls and one floor with one prefabricated element. It goes very fast and it is very cheap. If you look wider at the tunneling system you can very easily change the length, so we used this property to shape the building. We could make a cheap fluid form on the front, fluid form on the back, and the we put panels, and that's how we built the project. The only limit was that we were able to do a fluid form just on the front and back side, but not on the shorter sides because the tunneling system is too rigid.

Could you tell me about the ARCAM Museum in Amsterdam? How was it born? What about the realization? What did you inspire?

The ARCAM was already the third design, so we started from the convergence of a pavilion from Renzo Piano, which was used to be another entrance to his Nemo, but it was never used and originally the ARCAM had to be in that building. The only problem was that it was a very Italian building, an open space hide from the sun but in Holland there is more rain than sun and we don't want those spaces because they become very down. They really want to change it. The first design was only a reconversion, we had a very limited budget because the Berlage Institute went from Amsterdam to Rotterdam and the budget was erased. The shape of the building has a lot to do with the regulation on the site, everytime you have a set of rules. In this case, it has to be a very closed building, we were allowed to have just one window on the street side; the waterside had to be lower than street side. What we did, was to put all these regulation together and we started shaping the building, on the model but also on the computer. We had a really normal budget, so we had to contain costs, by maintaining a good expressivity, by choosing cheap solution and materials. This was a nice thing. We adapted our time in the ARCAM building, we worked with AutoCAD, which is actually a very stupid program, it is very limited, which helps very much to reduce the costs because you really have to use a rational software. If you use Rhino, you can almost do anything, but it doesn't help to cut the costs. If you look at the shape of the ARCAM building which looks a freeform, but there are all perfect curves, there is a single curved surface, that makes everything much cheaper than a double-curved surface, because in the single-curved surface you can make use of just a machine that can bend the profile just in one radius, instead of having flexible radius, that is very difficult to control.

So, we realized that by putting it in the AutoCAD was helped us to rationalize the whole thing and also we reduced the amount of steel we used, because generally I don't need much structure anymore if we rationalized. The nodes are easy, instead of having each node different, that generally means an increase of cost. You need to think that you have to find a system before and then you have to think "what is easier to change?" "How is the building industry at the moment?". So, for buildings, for which it is not very difficult to make a stick which is two inches or two inches and ten, that doesn't cost much more. But it is very difficult to have different nodes and different angles, because they become very expensive. If you can make a universal know-how, which can almost works with all the different angles you can have and you only have to change the length of the stick, that makes it visible and reduces the costs. You get a program of that the building costs depend on what of the project is gonna be built or not. If the cost is too big it's not going be built. It's a sort of ethic program: or you are superstar, like Zaha Hadid, who almost can do anything, even if very expensive, or you have consider that. But also these companies are looking at the costs in the sense like: they have started to reduce the amount of double-curved surfaces, which are sometimes even 60-70 times more than single-curved surfaces. The structure is made of four H standard profiles in one sense and two in the other sense, bended to shape the final configuration, and the wall section is about half a meter, with steel surface. About the final forms, since we have started from the Renzo Piano's pavilion, we wanted to earn more space: that's why we have decided to bulge the surface above the entrance, which was limited by the regulation, and then create a unique folded surface which covers the building, which is complete open space, but not that big. We had to take into account that we were on the port and next to impressive and big buildings, like the Maritiem Museum and the Nemo itself, so we cannot compete in terms of scale and then we had to find a forms which attract attention.

Skyline of Amsterdam port at night, with the ARCAM museum on the left and the renzo Piano’s Nemo on the right.

Appendix II

glossary

CONTEXT

Central business district
The high-density cores of cities, where activities are principally retail, commercial, service, and often governmental.

City center
Largest core areas within the incorporated limits of metropolitan areas; often used to distinguish the center from the suburban or newer outlying sections of metropolitan areas; generally excludes the central business district and inner city sections.

Industrial Area
Refers to areas set aside for or occupied primarily by buildings that house industrial activities.

Inner city
Refers to the usually older and more densely populated central sections of cities.

Old town
Older, often historic, sections of cities or towns, generally distinguished from newer parts by clear boundaries and distinctive architecture.

Rural area
Settlement areas characterized by country life or agriculture.

Urban area
Areas within city limits or closely linked to them by common use of public utilities or services.

Urban fringe
Settlement areas lying at the periphery of cities or suburbs where urban land uses meet rural land uses.

TYPE

Agricultural structure
Buildings used for the science or art of cultivating the soil, harvesting crops, or raising livestock, not used for human habitation, employment, or processing, and not used by the public

Cerimonial structure
Structures built or used primarily or exclusively for religious ceremonies or related activities.

Commercial building
Use broadly to refer to buildings associated with any aspect of the various activities and business relationships of industry and trade; when referring to structures associated with the purchase, sale, or exchange of goods in business, use "mercantile buildings."

Communication structure
Buildings designed or used for the equipment and personnel necessary for communications, such as telephone service.

Entertainment structure
This category includes those buildings properly deputies entertainment, such as theaters, cinemas, etc..

Exhibition building
Buildings built or used exclusively or primarily for exhibitions, which are organized displays of works of art or other objects of human making. Exhibition buildings may be permanent facilities or temporary structures, as at a world's fair.

Industrial structure
Refers to buildings or groups of buildings intended to house the machinery and activities associated with modern industry and machine manufacture that arose after the Industrial Revolution, beginning in the mid-19th century.

Information handling facilities
It refers to buildings deputies to provide information and cultural services, including architectural centers, libraries, archives, documentation centers, information centers.

Institutional building
This broad category includes buildings venue of national and international institutions, such as schools, correctional institutions, institutes, health and welfare buildings (hospitals, clinics, medical centers, etc.).

Monument
Structures or edifices of importance or historical interest, typically erected in memory of the dead or of an important event.

Multipurpose building
Use only for buildings designed to be flexible enough to serve different purposes at different times.

Office building
Buildings constructed or used primarily for offices, which are spaces where business, administrative, or professional activities are conducted.

Public accommodation
This category includes buildings that can accommodate people, such as bed-and-breakfasts, hotels, hospices.

Public building
Buildings or groups of buildings owned and operated by a governing body and often occupied by a governmental agency.

Recreation structure
Distinguished from "entertainment buildings" by more broadly designating buildings designed for or containing equipment for amusement, exercise, sports, or some pastime.

Research structure
Buildings built or used primarily to house space and facilities for scientific or other research.

Residential building
Buildings or portions of a building designed exclusively for human residential occupancy, but not including hotels or other buildings intended for use by transients.

Social and Civil building
It includes assembly halls, community centers, cultural centers, congress centers.

Storage facilities
Buildings or other structures designed or utilized primarily for storage.

Temporary Pavilion
Structure built for particular events that could be host several functions

Training center
Buildings, often containing educational, research, and recreational facilities, erected by corporations specifically for the training of corporate personnel.

Transportation structures
Buildings designed or utilized for the needs of boarding and unloading passengers and the transportation vehicles transporting them, such as a train station, bus station, or airport.

Urban spaces
It refers to the projects of the public spaces, such as squares, pathways, parks, etc.

Workshop buildings
Building where goods are manufactured or repaired.

SOFTWARE

Software name	Developer	Software Type	Category
3D Modeling 3D	Unknown	Modeling and Visualization	Complete Program
Algorithmic Design	Unknown	Generative Design	Add on tool
ArchiCAD 3D	Graphisoft	Modeling and Visualization; BIM	Complete Program
AutoCAD	Autodesk	CAD; 3D Modeling and Visualization	Complete Program
BIM	Unknown	BIM	Complete Program
Catia	Dassault Systèmes	3D Modeling and Visualization	Complete Program
GEM	ParaCloud	Generative Design	Add on tool
Generative Components	Bentley	BIM; Generative Design; Analysis and Simulation	Complete Program
Generative Design	Unknown	Generative Design	Complete Program
Grasshopper	Mainsoft	Generative Design	Add-on tool
Maya	Autodesk	3D Modeling and Visualization	Complete Program
MicroStation	Bentley	CAD	Complete Program
Parametric Design	Unknown	Generative Design	Complete Program
Performance-based design	Unknown	Performance-Based Design	Complete Program
Reverse Modeling	Unknown	Reverse Modeling	Complete Program
Revit	Autodesk	BIM	Complete Program
Rhinoceros	McNeel	3D Modeling and Visualization	Complete Program
Shape grammar	Unknown	Generative Design	Add on tool

PRIMITIVES

Primitives	Geometry	Digital-derived Yes/No
Cone	Curvilinear	☐
Cube	Rectilinear	☐
Cylinder	Curvilinear	☐
Ellipsoid	Curvilinear	☐
Free-form solid	Curvilinear	☒
Helix	Curvilinear	☐
Mesh	Rectilinear	☒
None	Not applicable	☐
NURBS Surfaces	Curvilinear	☒
Parallelepiped	Rectilinear	☐
Plane	Rectilinear	☐
Prism	Rectilinear	☐
Pyramid	Rectilinear	☐
Solid of extrusion	Both	☒
Solid of revolution	Curvilinear	☐
Sphere	Curvilinear	☐
Tetrahedra	Rectilinear	☐
Torus	Curvilinear	☐
Wedge	Rectilinear	☐

OPERATIONS

Operations	Definitions	Digital
Align	To place or arrange in a straight line or into correct relative positions.	☐
Boolean	The original application for Boolean operations was mathematical logic, where it combines the truth values, true or false, of individual formulas. Natural languages such as English have words for several Boolean operations, in particular conjunction (and), disjunction (or), negation (not), and implication (implies). Solid modeling systems for computer aided design offer a variety of methods for building objects from other objects, combination by Boolean operations being one of them. In this method the space in which objects exist is understood as a set S of voxels (the three-dimensional analogue of pixels in two-dimensional graphics) and shapes are defined as subsets of S, allowing objects to be combined as sets via union, intersection, etc.	☒
Break	To divide something.	☐
Bulging	To swell or protrude to an unnatural extent.	☒
Copy	To make a copy of.	☒
Divide	To separate or be separated into parts.	☐
Extrusion	Extrusion is a process used to create objects of a fixed, cross-sectional profile. A material is pushed or drawn through a die of the desired cross-section. In 3D modeling it indicates the creation of a solid by pushing a plan figure or a region along the Z axis, specifying a value, or along a direction previously defined.	☒
Folding	Describes objects designed to bend over onto themselves into a compact form.	☒
Interrupt	The action of interrupting the continuity of an object.	☐
Loft	Loft is a variant of a wireframe volume of the 3D object, a technique used in 3D modeling packages. It's developed from planar sections spaced along an approximate path.	☒
Mesh	A tessellated, or subdivided object type that is defined by faces, edges, and vertices. Mesh can be smoothed to achieve a more rounded appearance and creased to introduce ridges.	☒

Operations	Definitions	Digital
Move	Describes objects, particularly tools, machines, or components, that change position relative to other objects or components within the same object, or relative to a coordinate system.	☐
Offset	To replicate an element (line, surface figure) inside or outside with a given distance.	☒
Overturning	The act of turn over and come to rest upside down.	☐
Repeat	The act or an instance of repeating or being repeated.	☐
Retract	In topology, a branch of mathematics, a retraction, as the name suggests, "retracts" an entire space into a subspace. A deformation retraction is a map which captures the idea of continuously shrinking a space into a subspace.	☐
Revolution	A solid of revolution is a solid figure obtained by rotating a plane curve around some straight line (the axis) that lies on the same plane.	☐
Rotation	A rotation is a circular movement of an object around a center (or point) of rotation.	☐
Scale	To reduce (or increase) something in size, number, or extent.	☐
Slicing	Slicing is the separation of a physical object, or a portion of a physical object, into two or more portions, through the application of an acutely directed force. In 3D geometry it indicates the division of a solid in two or more parts.	☐
Sliding	Use to describe objects which, in contact with another surface, move tangentially in a smooth, continuous, gliding motion by means of gravity or momentum.	☐
Smooth	Having an even and regular surface; free from projections or indentations.	☒
Stretch	To be made or be able to be made longer or wider without tearing or breaking.	☒
Sweep	A solid or surface created in the shape of the specified profile (the swept object) swept along the specified path.	☒
Taper	To reduce in thickness towards one end.	☐
Tilt	To move into a sloping position.	☐
Translation	Movement of a body such that every point moves in the same direction and over the same distance, without any rotation, reflection, or change in size.	☐

FORM AND COMPOSITION CONCEPTS

Alignment
Arrangement in a straight line or in correct relative positions.

Articulation
Use when referring to the manner in which contiguous shapes are joined or formed in architectural or decorative designs or in works of art; also, the clarification of an architectural design by emphasizing certain elements of the structure.

Asymmetry
Asymmetry is the absence of, or a violation of, symmetry.

Axiality
The quality of forming, relating to, or around an axis.

Balance
The impression of visual equilibrium in a composition.

Complexity
The state or quality of having many intricate or interrelated parts.

Contrast
The juxtaposition of dissimilar elements, properties, or qualities in a work in order to heighten expressiveness through the differences revealed by comparison.

Deconstruction
In architecture, the style is characterized by a purposeful displacement of structural elements, resulting in buildings with no specific purpose.

Disproportion
A lack of symmetry or proper relation.

Frontality
The quality possessed by a sculpture, building, or other structure that is designed to be viewed from directly in front; in pictorial compositions, the quality possessed by figures that face directly out of the picture.

Gesture
Use of motion of limbs or body as means of intentional expression.

Harmony
Refers generally to a pleasing, orderly, and consistent arrangement of the parts of a whole. With reference specifically to art and architecture, refers to the concept of aesthetic description in which architectural proportion or artistic design displays congruity.

Horizontality
Parallel relationships to a horizontal axis in designs for graphic works, objects, and structures.

Linearity
The reliance on line for the principal effect in a drawn or painted composition, rather than on color or tone.

Monumentality
Describes the impression of grandeur, nobility, permanence, and often, though not necessarily, size in a work of art or structure.

Obliquity
In form or position, the state or quality of being oblique. Also, a deviation from a parallel state, or perpendicularity.

Plasticity
The three-dimensional quality of a form, its roundness, palpability, apparent solidity, or quality of relief.

Proportion
Relation between respective parts or between parts and the whole, in a building or any work of art, whether considered purely visually or numerically.

Rythm
A continuance, flow, or sense of movement achieved by repetition of regular or patterned units.

Scale
An expression of the ratio between the size of the representation of something and that thing, such as the size of the drawn structure in an architectural drawing and the actual built work. May also refer in general to the concept of relative size.

Simmetry
Balanced arrangement of compositional units on either side of a central axis.

Simplicity
Absence of intricacy or excessive ornament in form, structure, or appearance.

Unity
Appearance or condition of oneness or wholeness.

Verticality
Parallel relationships to a vertical axis in designs for graphic works, objects, and structures.

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The research concerns the field of the contemporary architecture evolution related to the increasingly massive use of digital technologies in the design process. The introduction of computers in architecture has produced a real revolution in design methods and processes, which contribute to the generation of architectural shape. It was understood that the pervasive use of software has substantially altered the architectural language in the last years. Therefore, main goal of the research has been to understand how architectural expressivity is changing, how much pervasive are digital influences on architectural design and which may be future developments. The research is carried out through the development of an analytical database with sixty recent case studies, recognized digital influenced architectures, as expression of what is really happening inside architectural scenario. The case studies have been studied and classified according to a logical theoretical framework, consisting of different categories and parameters, that allows to analyze several aspects. The results suggest that a new era is coming, where the conceptual starting point of designers is often born in the digital space, taking advantage of the augmented representation skills to control and manipulate form. Starting from a critical interpretation of the results, we have identified some transversal trends, representative of contemporary digital architecture.

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