Los siete mitos del detalle arquitectónico que están cambiando en la era digital

The seven myths in architectural detailing that are changing in the digital age

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The recent availability of automated design and production techniques is changing the role of architects in the making of buildings. With the use of digital fabrication new players take part in the design process and new abilities are required for the development of architectural details. More than ever, details play a fundamental role in the building to ensure *utilitas, firmitas and venustas*.

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Abstract

Although not always given the necessary attention, architectural detailing is of extreme importance for many aspects of a building. It can define its theoretical expression, production processes and sustainability issues. The objective of this paper is to discuss the changes in the practice of architectural detailing with the recent introduction of new technologies in the design and construction processes, such as digital modeling, rapid prototyping and digital fabrication, based on a review of the literature on the subject. The paper starts with a summary of architectural detailing concepts and theories from three different points of view: the design studio, building technology and theory and criticism. Next, some recent projects that use digital fabrication are described, with a focus on detailing issues. Finally, conclusions are drawn about what is changing in architectural detailing, what abilities are now needed, and how they can be incorporated in architectural education.

Keywords: contemporary architecture; architectural detailing; new technologies; digital fabrication; design process.

Resumen

Aunque no siempre se le de la atención necesaria, el detalle arquitectónico es de suma importancia para muchos aspectos de un edificio. Puede definir su expresión teórica, los procesos de producción adoptados y su sostenibilidad. El objetivo de este trabajo es analizar los cambios en la práctica de los detalles arquitectónicos con la reciente introducción de nuevas tecnologías en el proceso de diseño y construcción, tales como el modelado digital, el prototipado rápido y la fabricación digital, con base en una revisión de la literatura en el area. El artículo comienza con un resumen de los conceptos sobre el detalle arquitectónico desde tres puntos de vista diferentes: el diseño, la tecnología constructiva y la teoría y crítica arquitectónicas. A continuación, se describen algunos proyectos recientes que utilizan la fabricación digital, con especial atención a su detallamiento. Por último, se extraen conclusiones acerca de lo que está cambiando en el detalle arquitectónico, qué nuevas habilidades son necesarias, y cómo se pueden incorporar en la educación de los arquitectos.

Palabras Claves: arquitectura contemporánea; detalle arquitetónico; nuevas tecnologías; fabricación digital; proceso de diseño.

Introduction

Although not always given the necessary attention, architectural detailing is of extreme importance for many aspects of a building. It can define its theoretical expression, technical character, production processes, sustainability, work organization and social issues. Contemporary architecture shows a new interest in detailing, which should not be confounded with a return to the appreciation of the artisan´s work (Kolarevic and Klinger, 2006). This new interest is related to the recent approximation of the architect with the physical making of buildings, as a result of the use of digital technologies (Celani, 2012). The new "digital master builder" (Górczynski and Rabiej, 2011) counts on file-to-factory processes, in which detailing is literally making.

The objective of this paper is to discuss the changes in the practice of architectural detailing with the recent introduction of new technologies in the design and construction processes, such as digital modeling, rapid prototyping and digital fabrication (Figure 1), based on a literature review about this topic. It aims at describing what is changing in architectural detailing, what abilities are now needed, and how they can be incorporated in architectural education.

Figura 1. An architect learns to use a CNC router at the University of Campinas, Brazil.
Fuente: Fotografía de Gabriela Celani.

Architectural detailing: three points of view

There are at least three different approaches to architectural detailing: from the point of view of the architectural design studio, of building technology and of theory and criticism. The architect's work during the design and building process is usually divided in five steps: (1) conceptual or schematic design, (2) design development, (3) construction documents phase, (4) negotiation with contractors and manufacturers, and (5) construction administration (AIA, 2007). In this traditional subdivision detailing and discussion with manufacturers is never present in the initial phase. Details are usually developed only in the third phase, and they are typically changed in the 4th and 5th phases, due to budget or time limitations, or simply to the realization, that those details were impossible to build.

Good construction detailing is acknowledged as a synonym of quality in architecture. However, the methods of generating details are rarely considered as a subject for academic study or research by educators and practitioners. Details developed in practice are rarely communicated or integrated in teaching, and information developed in universities rarely reaches professionals. The traditional way of addressing this subject in architectural education, if covered at all, is in the building technology courses, often by civil engineers.

A good example of a textbook on Architectural Detailing is this one, by Allen and Rand (1993). It is organized in three parts, Function, Constructibility and Aesthetics, which are inspired by Vitruvius's categories of *utilitas, firmitas and venustas*. The first part of this book includes concepts related to the correct functioning of the building, such as controlling water leakage, air flow, heat losses, sound transmission, and the passage of mechanical and electrical services, among other issues. This part is subdivided in 63 sections. The second part, Constructibility, relates to assembly, tolerances, maintenance, durability and the efficient use of construction resources. It has 25 sections. The third part, Aesthetics, has only 6 sections. But although this book gives more importance to the functional and constructive aspects of detailing, the authors do understand the role of detailing as a way of communicating ideas. They say that "Details must contribute (...) to the character and content of the building. (...) details are the voice of the concept, the means through which the concept is expressed." (p.200)

Another important issue that is present throughout Allen and Rand's (1993) book is sustainability. The authors stress the importance of good detailing for reducing energy consumption through thermal insulation, thermal break, multiple glazing and the use of the thermal mass concept. They also remind us of the need for using renewable materials, reducing waste and understanding the life cycle of building parts. They suggest the use of recyclable materials for parts that have a shorter service life, which must be replaced periodically, such as carpets and roofing membranes. They also think about social sustainability, encouraging the use of local skills and customs, and suggesting that architects should encourage the pride for craftsmanship. They say that "A building's details should reflect knowledge of the labor force that will construct the building" (p.191), and that "Workers appreciate intelligent details that make the best possible use of their skills" (p.195)

Differently from Allen and Rand's book, this book called **Principles of Architectural detailing**, by Emmit, Olie, and Schmid (2004), has a more generic content. It aims to help students and practitioners understanding the underlying principles of detailing. The issues of social and environmental sustainability are constantly present in this book, with recommendations about working conditions and building lifecycle and disassembly. They show how details are important for conserving energy, minimizing waste, increasing durability, making disassembly and maintenance easier, and facilitating recycling, reuse and disposal of materials. Their philosophy of detailing consists of incorporating, in a single "knot", issues of function, comfort, morphology, materials, energy, components, environment, ecology, production processes and human factors. The joint is defined as "a situation where there is discontinuity of matter within the continuity of space and time", and they categorize three types of joints: (1) control or expansion joints, (2) connections and (3) tolerances for manufacturing and positioning.

Now let´s see what these books talk about the use of digital fabrication. In Allen and Rand's (1993) book there is only one mention to CNC equipment, in a section called "Timeless features". They say: "The means of production often become the date stamp on the building." They warn us that the initial uses of new materials and tools are often second class imitations of their predecessors. They mention that sophisticated CNC machines are used to carve classic columns out of plastic foam. To avoid that, they suggest that "detailers should actively participate in the exploration of new materials and construction processes, in order to distinguish between formal possibilities that are timeless and those that are merely today's fashion."

Emmit, Olie and Schmid (2004) also mention superficially the new possibilities opened up by CAD/CAM techniques, but they criticize the "race towards complete automation", asserting that "our attention to the machine-made is often at the expense of the hand-made", and that the use of automated techniques is not always sustainable. In fact early uses of milled Styrofoam for making concrete molds, for example, spent too much material (see for example, Gehry and Maschlanka, 2001). But people are presently developing ways of using this technique with as little waste as possible (see, for example, Brell-Cokcan et al., 2009). Also, with digital fabrication, sustainability may be present in other issues. One of the possibilities brought by digital fabrication is to produce building parts at closer manufacturers, instead of bringing them from far away (this is what is meant by the saying THINK GLOBALLY - PRODUCE LOCALLY).

If architectural detailing books are still skeptical about the use of digital fabrication, it may be necessary to combine their concepts with information from manufacturing theory textbooks. For example, Liou's (2007) book Rapid Prototyping & Engineering Applications: A Toolbox for Prototype Development emphasizes the importance of prototyping, design for assembly (DFA) and design for manufacturing (DFM) in a successful product development. Liou says that product prototyping serves as the integrator and evaluator of an idea or a concept. A design often needs to be validated by building several prototypes to produce a quality product. However, prototyping often is very costly and time consuming, so it can be a bottleneck in the product development process.

Another popular book in this field is **Product Design for Manufacture and Assembly**, by Boothroyd, Dewhurst and Knight (2010). It focuses on the importance of taking production issues into account when developing designs, and presents the design for manufacturing and assembly (DFMA) method, with many examples of redesign for easiness of automatic orientation, feeding, insertion and assembly. The authors assert that "the most obvious way in which the assembly process can be facilitated at the design stage is by reducing the number of different parts to a minimum." They show many examples of parts that had to be redesigned in order to make automated manufacturing possible and economically viable. I think we architects have a lot to learn from them.

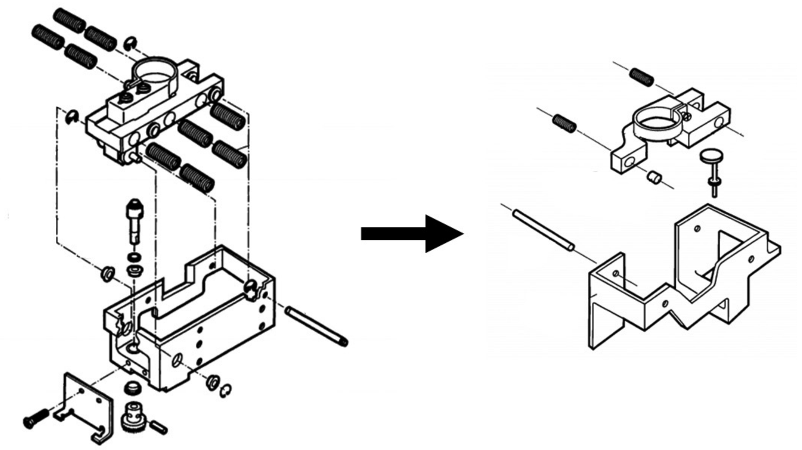

Figura 2. Reducing the number of parts. Fuente: Boothroyd, Dewhurst and Knight, 2010.

In the field of theory and criticism few authors have looked specifically at architectural detailing as a source of theoretical discussion. Edward R. Ford, a practicing architect and professor at the University of Virginia, is one of them. He is the author, among other books, of **The details of modern architecture** (1990), **The Details of Modern Architecture**: **Volume 2** (2003), and **The Architectural Detail** (2011).

In his last book, Ford proposes a categorization of architectural details according to their rhetorical purpose in the building. Regarding its role in communicating architectural ideas, a detail can tell the observer how the building was constructed or it can completely deny any ornamentation. A corner of Mies van der Rohe's Alumni Memorial Hall at IIT (Chicago, 1946) is presented by Ford as an example of detail as representation of construction. Although the steel columns are covered by concrete for security reasons, the concrete was then covered with a steel plate to pretend the structure was visible, for rhetorical reasons. Rem Koolhas, on the other hand, deliberately makes his buildings look as if they had no details, in order to deny any ornamentation. Regarding its relation to the whole, a detail can reproduce the overall building form, or it can have its own rules and purposes. Frank Lloyd Wright houses illustrate what Ford calls "detail as motif". The detail is a miniature of the house. Other architects make what Ford calls "autonomous detail". This door knob by Alvar Aalto, for example, is not related in any manner to the overall building form. It is beautiful in its own manner.

But Ford believes that the essence of the architectural detailing is in the representation of connections, which he call "detail as joint". He says this is how architects can express big intentions. In the Amsterdam stock building, by Beurs van Berlage (1903), for example, the essence is in the connections between the brick walls and the steel structure. It was important to stress them in a moment of transition between the old load bearing construction and the new independent iron structures. For this reason, Ford (2011) shows concerns about the constructive perfection allowed by digital fabrication, and he fears that this could mean the end of the detail. He says that the joint is out of fashion in the contemporary world, and that we would be entering an era of no tolerance and no gaps. He says

“The future of the joint does not appear particularly bright at present. We are told with increasing frequency that, due to digital fabrication, we are on the edge of an era of jointless buildings with zero tolerance. This statement is usually delivered with no explanation as to why this is desirable, on the assumption that anything digital or anything perfect is inherently good. It is my hope at some point in the near future to hear how digital fabrication will make it easier to articulate joints.” (p.306)

Ford’s concern is acknowledged by Kolarevic and Klinger (2008) in the introduction to their book **Manufacturing material effects**. They say that “in the early 1990’s, the ambition in the material realm was to express the seamlessness and the smoothness of form”. To illustrate this concept, the Media Center at the Lord´s Cricket Grounds in London, by Systems Architects, is cited both by Kolarevic and Klinger, and by Ford, as an example of a seamless building.

Another example of seamless buildings is Bernard Franken´s BMW pavillions. According to Kolarevic and Klinger (2008) they show “an explicit attempt to hide the connections between components and achieve the smooth appearance of the cars manufactured by BMW”. In those projects the architects wanted to call all the attention to the overall form: “nothing was allowed to distract from the articulation of the expressive and atypical geometry of the exterior skin”.

But in the early 2000’s this “infatuation with complex geometry was replaced by the exploration of highly crafted, non-uniform surface effects based on complex patterns, textures and reliefs”, usually applied to very simple overall forms. Kolarevic and Klinger (2008) call this movement “ornamented minimalism”. In some of these projects the joint is not only visible but it is an ornamental detail and a manufacturing challenge.

For Kieran and Timberlake (2004), the authors of **Refabricating Architecture**, joints could have still another important role, related to a new construction system. They say that “joining theory was once hierarchical, with most materials being joined at the place of final assembly (…) In a contemporary theory the focus is instead in disassembling the process into smaller integrated component assemblies”. They propose a building process that is inspired by the production system of ships and airplanes, in which different manufacturers make sub-assemblies that are connected to other sub-assemblies in the construction site. In this system, joints are primarily related to a question of hierarchy of the supply chain. They say we used to have dovetail and butt joints. Now we have Tier 1 supplier joints; Tier 1.5 supplier joints; and so on (Figure 1). Differently from the modernist module, the new module is conceived as a complete, independent structure.

In summary, we can say that we can learn a lot from traditional architectural detail knowledge, but we need to look also for information on manufacturing and prototyping, and for state of the art applications of digital fabrication in architecture. Now let´s look at some examples that illustrate this point. Rivka and Robert Oxman (2010) have suggested that the recent interest in fabrication techniques is related to a “cultural shift” in the order in which buildings are defined in contemporary architecture. According to them, in the modern tradition, the design process started with the definition of form by the architect alone, followed by the definition of the structure and the material in collaboration with engineers. In a recent phenomenon they call "the new structuralism" material and structure have acquired a greater importance in the design process, with form emerging as a consequence of working with the right material in the correct way. The same inversion applies to detailing, which is now often developed before the overall form is born.

Figura 3. A hierarchy of joints. Fuente: Kieran and Timberlake, 2004.

Architectural detailing and the new technologies

The design and construction process of a tree-structure canopy described by Agkathidis and Brown (2013) is a good example of how the use of digital fabrication changes architectural detailing (Figure 1). This canopy with non-standard elements has been recently built in front of a modernist building in Frankfurt. Since the conceptual phase, the design was optimized for structural performance and fabrication. According to the authors,

"it was not designed in a conventional top-down design process, where the architect determines design and passes it on to engineers and fabricators for further processing. It was developed in a bottom-up interactive process, where all different team members agreed on a negotiated co-decision process through which they could enrich the procedure with their expertise. Architects, engineers and manufacturers were linked together in a constantly updated common flow of information".

Decisions about drainage, cladding and the structural knots were taken together between designers and manufacturers. The dimension of the branches, for example, was defined by the size of the galvanizing pools in which they had to be coated. This example illustrates what Deamer (2010) means when she says that "contemporary practice revitalizes, through the new detail, the interest in 'those who build them' and offers the opportunity

Figura 4. Tree-structure canopy. Fuente: Agkathidis and Brown, 2013.

to readjust the psychologically diminishing roles that all players in the design-to-build continuum have come to know" (p.86-87). Deamer refers to the participation of digital fabrication manufacturers in the design process.

The Wiki House (2013) is another extreme example in which details are developed in order to fulfill manufacturing and assembly requirements. The idea is that anybody can download the files from the internet and fabricate a house in any place, using just plywood and a CNC router. The parts are small enough to be cut by the machine and the joints don´t use any screws or nails. Plywood is the only material and routing is the only manufacturing process. The joint details reflect the fabrication method.

In a paper about the use of new technologies by architects, Rivka and Robert Oxman (2010) have asked "How do we educate architects to function as material practitioners?" We can also ask ourselves - how do we prepare them to develop details that can take advantage of the new means of production, taking into account sustainability and functional qualities? We need to redefine the knowledge-base of the architect, which now must include what the Oxmans call "digital enabling skills".

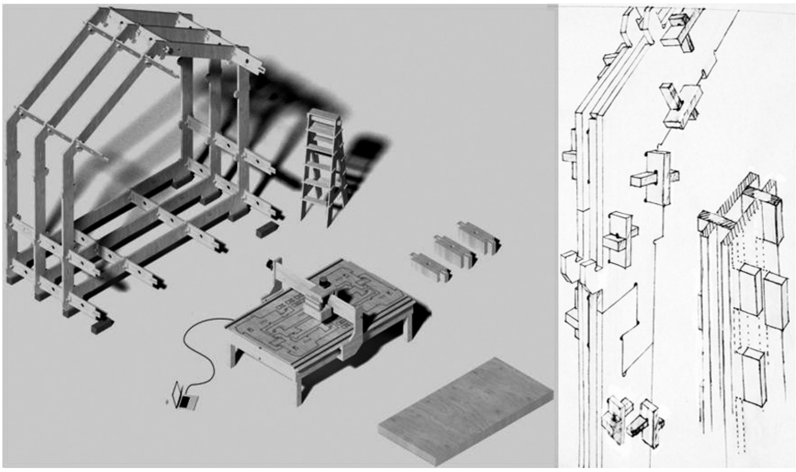

Figura 5. The Wikihouse and its details. Fuente: http://www.wikihouse.cc/.

Gabriela Celani

Seven myths about architectural detailing

What has changed in architectural detailing with the present availability of rapid prototyping and digital fabrication? I believe the introduction of these techniques in the architectural design process is challenging 7 myths about detailing:

Myth 1: Detailing happens after the conceptual design has been finished
When we consider the possibility of digitally fabricating custom parts for a building we need to predict from the very beginning if these parts can be put together and how; we cannot just count on a pre-existing solution or risk developing a concept that cannot be built. Detailing must be developed in parallel with conceptual design. This approach is easier to implement in small practices. In larger offices the two phases are usually developed by specialized professionals. In an integrated digital design process it is easier to start detailing in the conceptual phase. Parametric modeling allows using provisional dimensions and changing them later, without having to remodel everything from scratch.

Myth 2: The authorship of a detail belongs to the architect
It is an illusion to think that an architect can develop a good detail alone. Good details can only be developed in conjunction with manufacturers and materials or mechanical engineers. Plus, digital fabrication instructions are now also part of detailing, because the specification of tools and machine parameters can interfere in the final effects.

Myth 3: Detail design is less important and less interesting than conceptual design
Design studios value more creativity and conceptual issues than details, which are left for technicians. Synergy between concept and detail is vital to a successful building. Published examples show how building details can be incorporated in the design process from the early stages of design, in an intellectually challenging process.

Myth 4: Details must be represented in orthogonal sections
The typical 2D section drawings are becoming unnecessary. We still need traditional construction details because a significant part of the assembly is still done on site by construction workers. By using the Single Building Model concept, it is possible to generate 2D drawings dynamically from a digital model. Architectural details are now often generated by scripts, sent to manufacturer in the form of computer numerical control file, such as G code, and presented to the construction team through sequences of perspective drawings or animations that show the assembly steps. With digital fabrication we can send design files directly to the manufacturers for production.

Myth 5: There is always a standard solution to a detail design problem
The detail is gaining a new status in contemporary practices, and becoming an important part of the design. It can add value to a building, so there is no need for using a standard detail.

Myth 6: Details exist to disguise material imperfections
Details exist to communicate something, not to disguise anything. With digital fabrication there are no imperfections.

Myth 7: With digital fabrication there is no need for detailing
With digital fabrication we may be able to produce seamless buildings, but even those buildings need good detailing. Detailing is still a way to add value to architecture.

Concluding remarks and some suggestions

Based on the present literature review it is possible to conclude that any study or course on architectural detail must, from now on, take into account references from **3 different areas**: theory and criticism, building technology and manufacturing techniques. Traditionally, only the building technology aspects were considered, but mechanical and production engineering aspects must now be taken into account if we want to consider the use of digital fabrication techniques in the production of building parts. Besides, by considering architectural theory aspects of the details is the key to making them meaningful on top of functional. Since there are still no textbooks that integrate these three fields, it is important to show case studies and how successful they are in regards to those three issues.

In a world where time is becoming more precious than ever, the **Single Building Model, parameterization** and **scripting**, are becoming fundamental concepts in the development of details. If we want to avoid standard details, we must provide as much information as possible. When details are automatically generated there is less probability of mistakes. Scripts were used, for example, to generate most of the details of the Swiss RE building. Hugh Whitehead, from the "Specialist Modeling Group" at Foster and Partners says that this building forced them "to address the problem of how to design and produce details that are programmed rather than drawn. At each floor, the rules are always the same, but the results are always different." The automation and parameterization of detail-drafting makes concurrent engineering possible, where advanced details can start being developed while initial definitions, such as floor to ceiling height, are still being decided.

With the availability of cheaper 3D printing machines, rapid prototyping can be used since the very **beginning of the process**. Considered too expensive and time consuming not long ago, the use of physical models during the conceptual design phase can have a huge impact in the result. A design usually needs to be validated by building several prototypes to produce a good quality product.

Finally, it is extremely important to understand deeply the new **production processes**. Edward Ford points out the difference between conception and reality among architects whose ideas came from the way "they believed cars and planes were built". He affirms that "few ideas were drawn from an analysis of the building industry as it actually existed." Mass production resulted in the separation of design and production and between designers and factory workers. To avoid repeating the modernist misconception of the integration between design and production, we need to understand digital fabrication processes, so we can design details that are appropriate for the automated production techniques.

As Robert and Rivka Oxman (2010) have said, Architecture is reformulating itself as a profession. They point to the fabrication of material systems as a new area of design practice and research for architects and structural engineers together. New abilities are required for the development of architectural details with the use of digital fabrication techniques. This can evolve into a new field of specialization for architects. As educators, we need now to start thinking about strategies to develop the required skills in the academic environment, and to create opportunities for interdisciplinary work.

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