Developing a Methodology for Investigating the Design of Award Winning Industrial Architecture

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Theme: Workspace Design II

This paper reports on research currently being conducted to investigate the methodological structure of the design of industrial buildings. A comparative analysis of a selection of exemplary industrial buildings is being used to investigate the relationship between the design process and the quality of the design proposal as realised. The evaluation of any realised design remains as tangible evidence of the success or otherwise of the design process that generated it. Therefore, to develop a conceptual framework linking design methods and building quality should contribute to a greater understanding of how the designer's interpretation of a design problem influences the structure of the design process. The effectiveness of the design process in producing industrial buildings of high quality can also be evaluated.

The aim of this research project is to identify possible common themes in the design methods used to generate a selection of exemplary industrial buildings. Once identified, the next stage of the research will be to establish the nature of these common approaches and determine the influence they have both on the design process, as a whole, and the quality of the building. For this purpose, four areas for comparison across the case-studies have been proposed. They are:

- the structure of the design process itself and the mechanisms utilised by the designers of each building to generate and develop their design proposal,
- concepts of what constitutes quality in the design of industrial buildings, and the use of value-judgement in design decision-making [1],
- cause and effect in design; the nature of the relationship between the designer's method and the quality of the design proposal and,
- the form and quality of industrial buildings.

The research project extends existing studies in the area of general human problem-solving, by using the findings of previous studies to analyse and explain a specific example of problem-solving, namely the design of industrial buildings regarded as the best of their building-type. Figure 1 illustrates how this research project relates to previous studies in this field of knowledge and extends the hierarchy of research into design activity as a particular incident of the general phenomenon of design.

Modern architecture generally and industrial architecture in particular, has been thought of as (Richards 1950, p. 14) deriving;

> Its nature from the acceptance by architects of the principle that the process

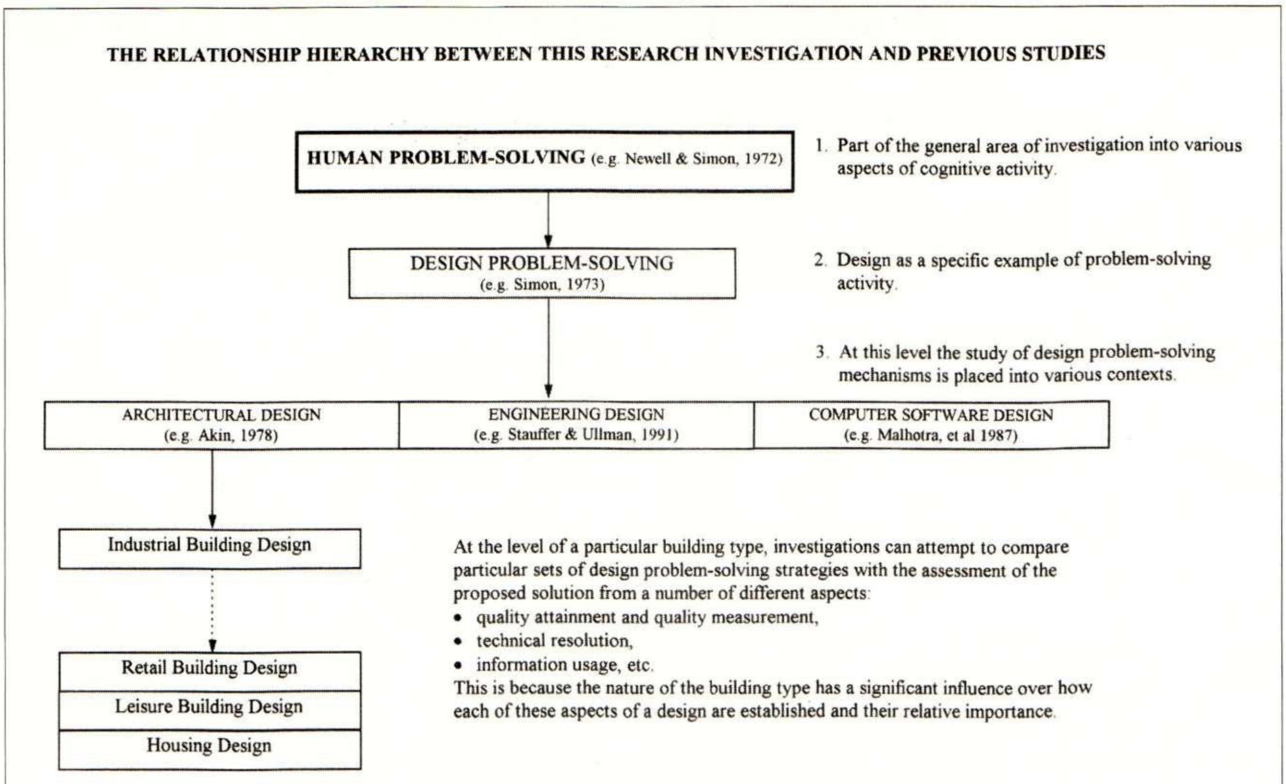


Figure 1.

> of designing a building begins with a close analysis of the needs it is to serve.

However, industrial building has a long history; some of the earliest examples being medieval granaries which drew heavily on the forms and details of other contemporary building-types. With this use of existing building-types as precedents, Brockman (1974, p. 15) commented that;

> It is not, therefore, surprising that the forms and structures of the great spans of medieval churches, supported by stout walls, where the tendency to overturn under the thrust of a timber roof was countered by buttressing, were adopted by the builders of these early warehouses.

This would suggest that the original nature of the industrial building design process was not entirely based on developing forms logically derived from the building's functional requirements, but was in part based on a process of making analogies with existing building types. Broadbent (1988, pp. 30–35) has termed this "analogic design"; and occurs when the form and detail of an established building archetype (i.e. church) is used as the basis for the design of a new building type (i.e. granaries). The designer makes an analogous connection between some specific aspect of the function of one with the other.

The rapid industrialisation that took place during the eighteenth and nineteenth centuries saw the increase in the number and importance of industrial buildings. Prior to the mid nineteenth century, it was engineers who lead the way in "uncompromisingly functional" design. Again Brockman (1974, p. 20) has rationalised this position by saying;

> The services engineers were much in demand for one very solid reason; once the industrial revolution had got under way and steam became the normal source of power, it was the engineer who was employed to provide the engines which produced it and also the machinery it served. In most cases these engineers knew very well how to provide the structures which supported the long runs of

machines, floor by floor, and the brick and masonry walls and timber roofs which enclosed them.

It appears that from an early stage in the Industrial Revolution, an understanding of the potential of the new machine technology, together with the knowledge of how to utilise new materials to provide suitable internal spaces to accommodate this technology was an essential part of the design process. However, such an approach to the design of industrial buildings was usually adopted by engineers. It was not before the mid nineteenth century that architects began to adopt similar principles in designing industrial buildings. Up to that point architects, when involved in the design of industrial buildings, were pre-occupied with the application of various styles and the aesthetic expression derived from them, rather than the pure functional requirements of manufacturing.

Design Quality Assessment in Design Methodology

The question of the evaluation of design methods is one which has rarely been confronted by design methods researchers. It appears to have been taken as an act of faith that adopting systematic procedures would inevitably lead to better design solutions; but how are better designed products to be judged? Rapoport (1969, p.136) was among the first to draw attention to this question, when he wrote;

> Nor has it been demonstrated that the new methods work better. We need, of course, to define what we mean by "better". We can look at this in two ways; increased efficiency in terms of man hours, lead time and the like, or a better product. In these terms a method is only better than another (whatever it may be) if it produces a better building or environment. The concept "better" involves judgement – better than something else – and is related to goals and values as well as knowledge.

One reason for the lack of any sustained attention being given to this question, and implicit in Rapport's statement above, is that building design quality assessment is as complex and problematic a question as that of the nature of the design process itself[2]. If the assessment of design quality was mentioned at all then, not unexpectedly, it was in terms of quantifiable performance measures. Indeed, in response to criticism made about the lack of interest in the evaluation of the quality of completed buildings, Moore (1970 p. XII) conceded that the papers presented at the First International Conference of the Design Group, took a narrow behaviourist approach to the question of quality assessment. They focused exclusively on the measurable performance attributes of building quality. However, the reflections of many design researchers[3] affirm that it had always been their primary objective to improve the quality of designed artefacts and not just the efficiency of the process. They could also readily acknowledge the interpretation made by Rapoport (1969, p. 136), in his criticism of design methods research that;

> In much discussion on methods, the quality of the architecture or physical environment is not discussed at all. The methodology seems to become an end in itself, sometimes almost scholastic in its lack of relation to the real world, its concerns and motivations.

Of the few studies that have been carried out in the area of quality assessment in building design, Murta (1991) has found some evidence to suggest that a non-contingent relationship does exist between method and design solution quality. He concluded that (Murta 1991, p. 799);

> buildings of quality have a design procedure which differs from the conventional plan of work, particularly in the way in which basic creative work is applied to the problem.

However, this relationship may not be a simple linear causal one, as Murta (1991, p. 801) goes on to imply;

> In the context of motivation an essential ingredient is knowledge and understanding of what constitutes quality, and the pre-familiarisation with the inherent attributes of quality should form part of the first stages in any methodology which is intended to produce fine buildings.

If Murta is right, then ideas about what constitutes quality in building design does play an important role in design method formation, whether the designer is conscious of this or not. Therefore, a detailed description of recurring quality themes could certainly contribute a new dimension to our understanding of how quality achievement relates to various methodological approaches to building design.

Design Methodology in Industrial Building Design

The study of industrial buildings has largely been confined within studies of architectural design history and aesthetics or in relation to social and economic developments. Symes (1984, p. 276) has also pointed out that;

> An important difficulty, both for theory and research seems to be that there is no agreement on the relative importance of economic factors and cultural qualities in determining design decisions.

One would naturally assume that for industrial buildings the former would predominate. However, if decisions in design depend crucially on values and concepts of quality, then the situation becomes problematic once more. Masser (1982) highlights this problem by introducing the concept of "espoused theories". Symes (1984, p.277) cites an example;

> economic rationality, a theory which architects or potential clients may use to justify decisions or choices which an independent observer might have suggested were made on intuitive or other irrational grounds. Alternatively it is possible of course that those making design choices might sometimes believe they are following cultural prejudices about design quality when in fact they are using an economic logic to which they do not admit.

During the early period of the Industrial Revolution, innovation in machine production and materials technology played a major role in determining the structural and constructional development of industrial building design. However, it was not until the end of the nineteenth century that the architecture of industrial buildings began to be more expressive of the new technology of machine production and the new materials which came with it. This would suggest that the impact of this new machine technology on the design process was limited to developing and evaluating the detailed measurable functional aspects of the design. These would include: increasing the maximum span and allowing greater loadings of the floors at the same time; providing fire proof construction, and integrating the building structure with the new technology of building services. The design of the building envelope however, remained largely a matter of the application of suitable design dogmas, if the design process was predominantly architect-led.

In contrast, Kammerer (in Ackerman 1991, p. 41) characterises the design process of contemporary industrial buildings by saying;

> Industrial buildings become significant when an attempt is made to control and unify the total design process, when the design of a larger span structure and the components used in its construction are all pulled together into a recognisable and understandable whole.

The emphasis here is on the way a designer organises the process of design, and suggests a link between design method and quality of design solution. At the earliest stages of the design process there is usually only a limited amount of explicit information on how quality is to be assessed. Any information on quality assessment is usually contained within the quantifiable requirements made by the client. As no project consensus on the appropriate relationship between measurable and non-measurable quality attributes is available at the start of the design process, the designer's own concepts of quality must play a decisive role in shaping the design process, and ultimately the quality of the final building. As mentioned above, functional considerations have predominantly determined the success or otherwise of industrial building design. Therefore guidance on the design of industrial buildings, not surprisingly, has been concerned with the quantifiable aspects of the design task [4].

The designer's position in determining quality and where its attributes lie in the design of industrial buildings, is further reinforced when the basis of decision-making about industrial buildings is considered. A study conducted by the Cranfield School of Management (1980) found that most industrial clients base their decisions about industrial buildings on measurable requirements. This was the case even when difficult to quantify attributes, like flexibility, may be just as important. Despite all these difficulties, the relationship between building-type, concepts of quality and the design process needs to be clearly defined before an attempt to explain the way design quality in industrial architectural design is achieved.

Methodological Issues in the Study of Industrial Architectural Design

In another study of buildings for industrial production, Manning (1966A) implied that theoretical propositions are significantly more decisive in determining industrial building design than the manufacturing process that the building is to accommodate. Such a proposition, if confirmed, could have a major effect on the way design methods (as realised in the design of industrial buildings) are perceived and the role of various types of knowledge used in the design process. This would undermine one of the central axiom of modern architectural design that the form of a building be determined by its functional requirements. As a consequence the knowledge base on which this interpretation of modern architecture was founded would have to be re-evaluated. This causal link between building function and architectural form is one that has dominated much of modern architectural design thinking. Richards (1958 p. 14) makes this point quite strongly and goes on to say that modern architecture;

> has as its object the fulfilment of such needs as logically and economically as possible, by taking full advantage of the means and materials available. Its aesthetic character is created as part of the same process; nor does the exercise at every stage of personal preferences and aesthetic taste, which is inherent in all architectural activity, in any way invalidate the functional basis of modern architecture.

Therefore, a key methodological concern will be how to devise a data collection and analytical mechanism which will allow a causal link to emerge, while safe-guarding against designers post-rationalisation and selective memory which may distort the research findings. One way of attempting to ensure validity in the information elicited from designers is to obtain their conceptual models of their expertise in industrial building design and compare it with the reports they give of the actual design process followed during a specific project. The conceptual model (or personal construct) and the method for obtaining it (repertory grid technique) are discussed fully by Fransella and Bannister (1977). As to the question of its appropriateness to the identification of commonality of approach among a group of individuals, research conducted by Latta and Swigger (1992) confirmed its effectiveness in identifying commonly held expert knowledge constructs [5]. From their analysis of the sets of constructs obtained in their experiment, Latta and Swigger (1992, p. 126) concluded that;

> The fact that one of these sets of constructs was a common set provided credence to the idea that the grid can be used to represent a consensus of knowledge about concepts which lie in the realm of communal knowledge.

Also, as a necessary consequence of investigating quality achievement in the design of industrial buildings, this research project has to work backwards from the identification of suitable award-winning industrial buildings, through to the design process which produced them in the first place. Therefore the study can only be based on a retrospective analysis of the process itself, as reported by the designers involved, during semi-structured interview sessions. Thus, the research process will essentially be a qualitative study comprising a series of case studies. This research technique has been used in recent investigations into design and construction [6] and is particularly suited to comparative analytical evaluations of classes of events retrospectively. The case-study method allows the connection between the data and its contexts to be maintained and locates the analytical framework within the setting of the particular case-study. Other reasons for adopting this method include:

- the need to understand a specific phenomenon in great detail within the context of the phenomenon,
- a large amount of information can be obtained from a few examples,
- restricted research where there are only a small number of cases but the results have significance beyond the cases studied.

As the process of design problem-solving itself still remains relatively poorly understood, this research project is fundamentally descriptive and interpretive in nature. Its aims are in essence, to formulate a general descriptive framework of a particular design task by attempting to uncover recurring patterns and/or themes in the approach to the design of industrial buildings, by a sample of designers. Only until a descriptive framework has been described can an attempt be made to hypothesise an explanation. Figure 2 outlines the research method formulated for this study.

Objectives of the Case-Study Analysis

The initial data obtained during the early stages of the research will be used to formulate a descriptive framework of the relationship between intuitive and rational procedures in the design of industrial buildings of high quality. The analysis process therefore, will

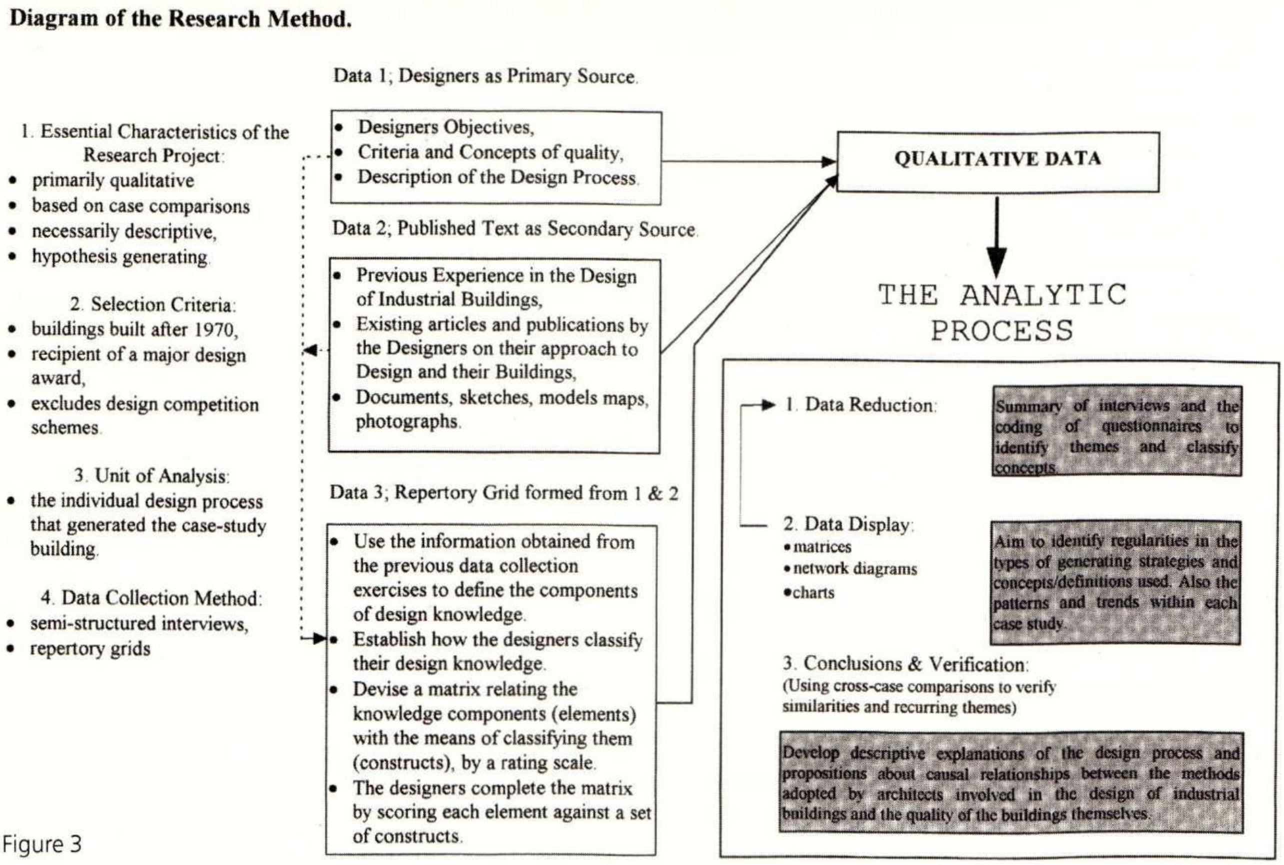


Figure 3

have to assume a "symmetry of choice" between the two approaches. A designer could be either scientifically rational or intuitive, or alternate between the two approaches at different stages throughout the process. Indeed, research conducted by Stauffer et al (1987) showed that designers do vary between the two approaches as they progress through the process. However, Stauffer et al (1987) made no attempt to establish a link between this pattern and the assessment of the quality of the design solutions. Therefore, an additional task of the data analysis process will be to identify recurring patterns of use of these two approaches in the design processes that form the case studies. If a characteristic pattern in the way designers structure the design process, when designing industrial buildings of high quality, can be detected, and can also be shown to be absent in the design process adopted by designers of other industrial buildings, then this can be used to support the proposition that particular relationships in the design process are more likely to achieve high quality solutions than others in the design of industrial buildings.

There exists a significant gap in establishing causal relationships between methods and concepts of design quality, in current research in design methods. The way intuitive and systematic approaches are balanced in the design process may be determined by prior concepts of quality. Conversely, the pattern of the design process may just reflect programmatic and pragmatic concerns about design resourcing. Therefore during the analysis of the data from each case-study, an attempt will be made to establish the pattern of the relationship between the quality of the solution, pattern of the design process and concepts of quality in the design of industrial buildings (see figure 3).

THE INTUITIVE/SYSTEMATIC BALANCE IN THE DESIGN PROCESS

The matrix is used to classify and analyse the interviews. Sections of the data which refer to the different tasks performed during the design process are used to infer what decision-making mechanisms were in operation at the time.

communication			
concept realisation			
incisive/instrumental conjecturing			
perspective on problem			
speculation within frame of reference			
establish frame of reference	e.g. The 'Machine Aesthetic' as a principal concept provided the framework for the design process.		
initial problem interpretation.			e.g. The rationalisation of the client's operations by a detailed analysis of the existing racking process.
DESIGN TASKS			
SEARCH MECHANISM	Intuitive (experience/internal logic)	(an even combination of both approaches)	Systematic (analytical/ external logic)

Figure 3

Case Study Example; Racking[7] Plant for Greene King Brewery, Bury St Edmunds, UK

This section outlines one case-study which forms part of the data for the investigation. A series of semi-structured interviews were conducted with the client, architect and building services engineer to ascertain where the major influences on the design concept occurred during the design process. The building was selected as a suitable example of industrial building design because it has received a number of design awards (see figure 4), and that it had not been designed as a competition submission, therefore reflecting the normal design situation for all the consultants involved.

Each interview consisted of a series of open questions designed to elicit factual information and strategic description of the design process. This was done by encouraging the respondents to discuss at length their involvement in the design development process. A specific set of objectives was identified for each group of questions. These were:

For the client:

- to establish the priorities for the building,
- to establish the process the client went through to assess the suitability of the design proposal,
- to obtain the assessment criteria on the design of buildings to accommodate their production processes.

For the architect:

- to establish how the architects interpreted the client's requirements to form design priorities,
- how they used these priorities to develop the solution,
- how the designers assessed the suitability of the emerging solution during the design process,
- to evaluate the balance between intui-

BUILDING DESIGN AWARD SCHEMES

Building: Racking Plant for Green King Brewery;(Bury St. Edmunds, UK)
Architects: Michael Hopkins and Partners

Award Scheme	Area of Concern	Criteria for Assessment	Method of Assessment	Information used	Aim of Scheme	Classes of Award
Schemes for design/environmental excellence						
RIBA Awards (1980)	Architectural Design (design)	Design in relation to: • purpose, • surroundings, • materials, • longevity,	Local Juries (architects and lay members) National Jury (eminent architects)	A summary of: • client brief • planning matters • construction • photographs • visits	To give public recognition to outstanding examples of current architecture and thereby to achieve greater public appreciation of good architectural design.	Regional & National
Financial Times Architecture at Work Awards (1980)	Major new buildings that enhance both the urban or rural landscape of Britain and the lives of the people who work in them.	• architectural merit, • enhancement of the urban or rural landscape, • contribution to the lives of the building users.	Two eminent architects and one lay assessor.	• key drawings to describe the scheme, • photographs, • a written description of the building covering the client's brief, town planning context, materials and method of construction.	To encourage higher standards of architectural and environmental design for industrial and commercial buildings,	Main Award & Commendations (occasionally)
Scheme for excellence in the use of materials						
Structural Steel Design Awards (1980)	The use of Structural Steel	• efficiency, • cost effectiveness • aesthetics • innovation	Single Judging Panel (ICE. RIBA. Government Organisation reps.)	• drawings (plans , sections etc.) • photographs • visits	To recognise the high standards of structural and architectural design attainable in the use of steel and its potential in terms of efficiency, cost effectiveness and innovation.	Single & Two Storey Buildings Buildings over Two Storeys

Figure 4

tive and rational approaches to the design process for industrial buildings.

For the building services engineer:

- how the engineering services priorities were identified and the implication for the design of the building's enclosure,
- the process of developing the services design with that of the building enclosure.

From the responses obtained in each interview, an initial data display in the form of a conceptual matrix using descriptions to link design tasks to conceptual units (codes) was undertaken, (see figure 5). This formed the first step in the data analysis phase and is intended to identify the important themes within the case-study and provide the basis for cross-case analysis.

An initial analysis of the data indicated some interesting areas for further analysis. The architects outlined a number of key concepts in their approach to the design of the building. The development of an understanding of the racking process was significant in determining:

- that conceptually the industrial process was linear (a rationalisation of the previous process),
- and the identification of a conceptual design unit (the movement of casks through the racking process).

These were important because they formed the basis of a conceptual diagrammatic representation of the racking process. The constant refinement of this diagram was a feature of the architects design process and mention of it often occurred during the interview.

Another important element of the design process was the architect's experience in designing buildings based on an on-going theme. This was the source of the architect's *principal concept* (machine aesthetic for the total enclosure of all functional activities). This was used in two ways:

- as a generator of ideas and,
- as an evaluative mechanism to test the appropriateness of the design proposal.

A feature which appeared to permeate the design process was the establishment of clear working definitions for abstract concepts; for example efficiency in building design was defined as using the minimum number of components necessary to achieve the required functional performance. However, experience and professional judgement was still reported as playing the decisive role in assessing the non-quantifiable aspects of the design proposal. The location of the building seemed to play a less prominent role in the design process than either the architect's design theme or the racking process to be

CONCEPTUAL MATRIX; DESCRIPTION OF TASK DETERMINANTS IN INDUSTRIAL BUILDING DESIGN

Building;	Racking Plant for Greene King Brewery, Bury St. Edmunds, Suffolk, UK.
Architectural Practice;	Michael Hopkins & Partners, London, UK.
Date of design;	1978

DESIGN TASKS CONCEPTUAL UNITS	PROBLEM INTERPRETATION (Influences on the interpretation of the problem and the development of design priorities.)	FORMULATING A SOLUTION (How the initial interpretation was used to generate a potential solution.)	SOLUTION EVALUATION (The criteria for assessing the emerging design solution during the design process.)	STRUCTURING THE DESIGN PROCESS (The balance between the use of rational and intuitive methods in industrial building design.)
CLIENT INPUTS & INFLUENCES	Accommodation of the existing process rather than re-organising the process itself. Specific dimensional and equipment requirements to be accommodated in the new building. Also, required sensitivity & modernity for this historic provincial town.	Client defined the manufacturing process. Drawings & diagrams used to analyse the process. No design input from the client, they just set the performance parameters for the required building	Continuous interactive process with the client; *'feed-back'*. Must provide secure and suitable environmental conditions. Cost & environmental requirements prohibited initial concept of a glass box to put the racking process *'on show'*.	The manufacturing process fixed by the client before considering the enclosure to accommodate it. Improvement to the racking process, as it relates to a building enclosure, was limited by the late inclusion of the designers to the team.
SITE HISTORY & CONSTRAINTS	There were serious conservation considerations linked to the chosen site. Space restrictions on both the city centre and the chosen site. A 100 year old manufacturing process which has prompted piece-meal development through-out the town centre.	Building raised off the ground, to be above flood-plain; developed as part of the architectural expression. Restricted site requiring: lorry parking and turning circle. Also room for future building expansion.	Allow for the expansion of the building to double the capacity, if required and to maintain the site as a flood-plain.	The designers used their experience gained from previous work to get a *'feeling'* of the scale of a new project in relation to its site.
DESIGNER GENERATED PRE-CONCERNS	The *'Machine Aesthetic'* as an appropriate expression for industrial architecture. Universal enclosure of functional spaces. Strong precedent in previous work: building form, aesthetics and use of materials.	Making buildings like *'products'* & using factory-made components. The building as *'Umbrella'* for the manufacturing process. Look at other buildings with a machine aesthetic, as precedent.	Established a *'principle concept'* (Machine Aesthetic) which is used as test criterion for the design proposal. The building seen as a continuous *'extrusion'* by the designers. The building is a *'simple form'*, merely acting as an *'umbrella'* for the racking process.	The concept of an *'Industrial Aesthetic'* informed and gave direction to the design process. It provided a starting point for the design process. Intuition used to conceive the initial ideaa, then a rigorous process to develop the functional rationale and refine the details was adopted.
INDUSTRIAL PROCESS (actual and conceptual descriptions)	Rationalisation of client's present process. The basis of the process is the movement of barrels along the manufacturing system. Technology of the manufacturing process in harmony with the technology of the new building enclosure.	Originally conceived as a U-shaped process with entry and exit at the same point. Final design creates a physically linear movement of the barrels through the process to reflect their conceptual movement than the existing contorted one.	Allowance for future expansion precluded U-shaped organisation of the process in the building. Limiting the number of components to the minimum necessary for the functional objectives to be achieved.	A building finely tailored to the client's existing manufacturing process v flexible loose-fitting space. The building design is all about understanding the racking process.
MATERIALS & COMPONENTS (concepts of appropriate usage)	Quality established through the appropriate use of materials, based on their mechanical and visual properties. Efficiency in the design achieved by materials and components being able to perform more than one function.	Aim for a consistency in the use of materials in the external envelope. Extendibility in two modes either by adding extra bays or by an extrusion of the building's cross-section.	Materials used to exploit their mechanical and visual properties fully. Components able to do a number of functional tasks; *'material efficiency'*. Focus on the details & finishes construction & assembly process.	Use of materials, detailing and finishes strongly influenced by *'machine aesthetic'* philosophy. Efficiency in a design proposal; *'everything must earn its keep'* i.e. must have a functional reason for being used.
QUALITY CRITERIA (Operational concepts and methods of assessment)		Different functional areas required varying levels of quality.	The quality of the design is in the sophistication and appropriateness of materials used, detailing and finishes. Quality in design is a product of the use of appropriate materials, building form and spatial planning in relation to required performance levels.	The ability to devise ideas intuitively which then become the basis for rational functional elements of the building. Use of professional judgement to identify architectural opportunities then developing functional benefits from then.
WORK SPACES (concepts on suitable conditions for workers in industrial buildings)			Focusing attention and available resources on areas having the greatest visual and functional impact, i.e. where employees spend most time and therefore of most benefit.	The designers had to work within parameters set by the client, so they had no input in the analysis of the racking process requirements.

Figure 5

accommodated. The site set up constraints which the architects responded to in a pragmatic rather than idealistic way, i.e. raising the building up on piles to allow flood water to pass underneath the building. The architects characterised the design process as being a very rigorous process of testing ideas from both functional and constructional perspectives. The design qualities of the building were suggested to have been derived from this highly rational process. The client's input into the design process was crucial to the quality of the building. Greene King outlined a number of important aspects of their racking process which had a major effect in determining the buildings form. These included the following:

- the client was developing a number of innovations in the storage and packaging of their products and therefore required a building which would assist in the implementation of these innovations,
- they had developed a precise description of their operational flow of activities by utilising a series of detailed studies of their existing process operations,
- the client was prompt in making decisions about specific operations which had a direct bearing on the design, e.g. loading of lorries was to be done by the drivers themselves. This required a loading bay that would allow each driver to select the individual delivery items.

Greene King saw the specification of the building's performance and functional requirements as an ongoing process which they allowed to evolve during the early stages of the design process. They emphasised the need to commission architects who would develop the design in detailed consultation with them, and spoke positively about the intensive analysis the designers gave to the detailed aspects of the racking process. This forced the client into a continual process of justifying the requirements for the building on entirely rational grounds. This process of rational justification was itself continued in the clients design evaluation criteria which included:

- establishing a direct operational flow through the building,
- the effective compartmentalising of the activities to separate the dirty returned empty casks from the clean casks ready for packaging and dispatch,
- simultaneous loading and unloading operations,
- and the flexibility to introduce innovations at any point along the packaging process; i.e. the most effective point to introduce *finings* – a traditional methodological term for clearing fine particles from the beers.

The initial analysis of the client's description of the role they played in the design process reinforced the rigorous procedures outlined by the architects. By confining their input to purely measurable functional matters, Greene King provided an explicit and detailed basis for the building's functional assessment without necessarily pre-determining its form or architecture.

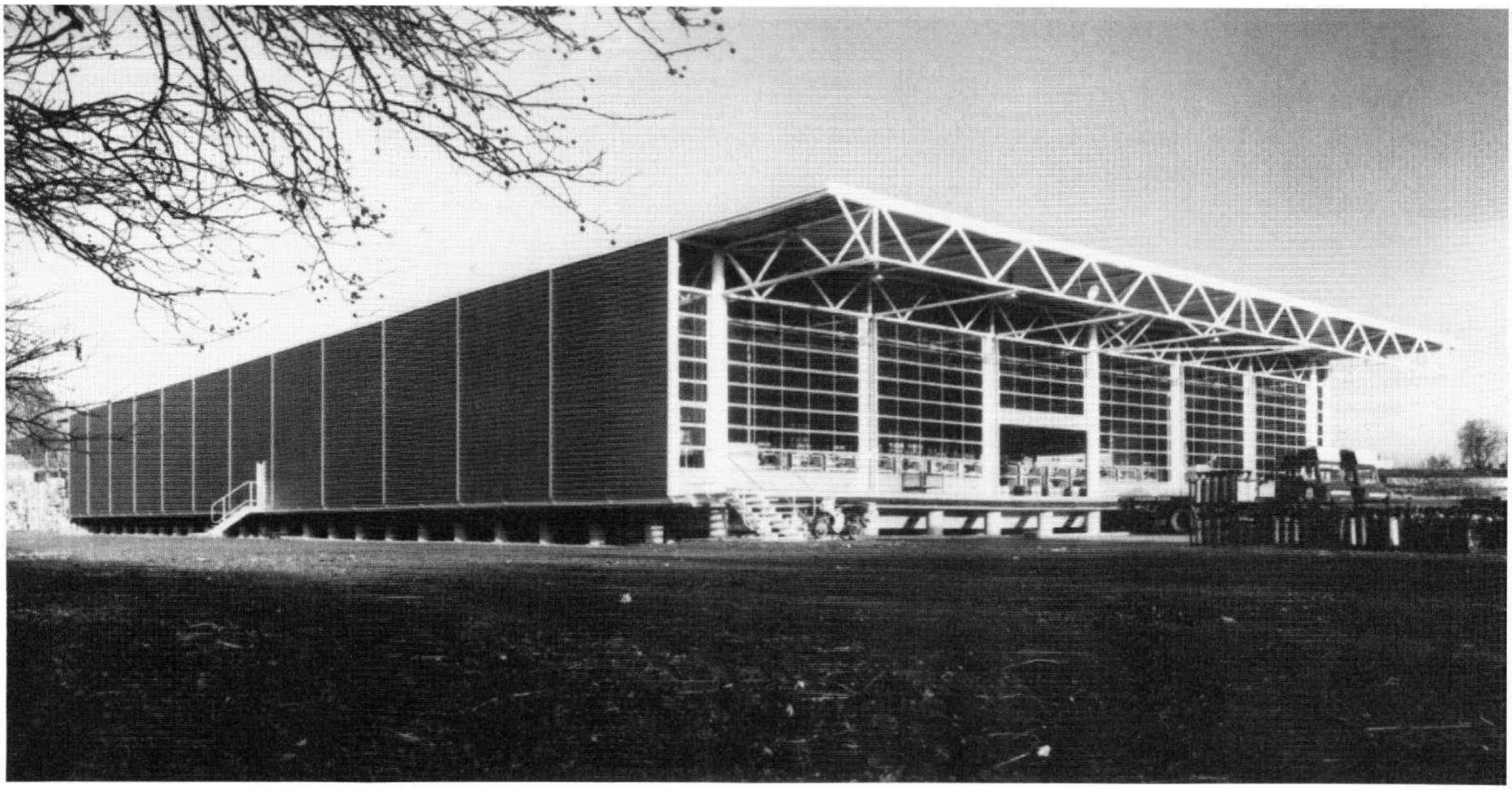
The description of a highly rationalised design process was also continued in the design of the building services, where the services engineers emphasised the importance of formulating a diagrammatic representation of the client's racking operation. This representation had two functions: firstly, as a means of locating the major building services loads along the racking process operation line; and secondly as a means of maintaining the close integration between the building services and building fabric design within one overall concept. This enabled the engineers to devise a number of technically feasible design options within the objectives set by the design concept. These concepts were:

- the building services systems as expressions of the dynamics of the racking process, and
- to expose the building services within the building to directly communicate their functions.

The main feature of the building services design was that it was considered as an integral part of the overall design of the building with both the architect and engineers sharing in the development of the design concept right from the start.

Conclusions

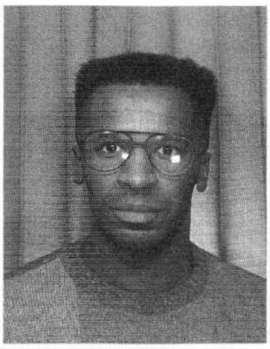
The analysis of the case-study outlined above has suggested that there were a number of key components in the design process for this building. Perhaps the most significant was the dual role of the design concept. Not only did it provide the generating mechanism for the building's form, but significantly it acted as a means for effective communication between client, architect and



engineer; helping to co-ordinate their inputs into the process. The functional analysis of the requirements of the racking process was set within the context of this conceptual overview of the design aims. Although functional considerations played a significant role in determining the building's form, their main contribution to the process was as the mechanism for establishing the criteria against which the developing design proposal was constantly tested. The next stage of the investigation will be to describe the network of relationships within the design process itself and then use this as a basis for the cross-case comparisons, where conclusions about the nature of high quality industrial building design can be obtained.

Notes

1. For a detailed discussion on the relevance of value judgement in determining actions and explaining patterns of events during the design process see Lera (1982).
2. For further information see Burt 1978, Seymour & Low 1990, Low 1993.
3. For example see Alexander 1984, Archer 1994.
4. See Manning 1966A, Manning 1966B, Manning 1966C.
5. A construct is a personal model of the world or a particular aspect of it which a person uses to predict and organise their behaviour (see Fransella 8t Bannister 1977).
6. See Sinister 1995.
7. The term *Racking* refers to the process of filling the casks and bottles with beer.



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Rererence

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