STEEL News & Notes
SINGAPORE STRUCTURAL STEEL SOCIETY

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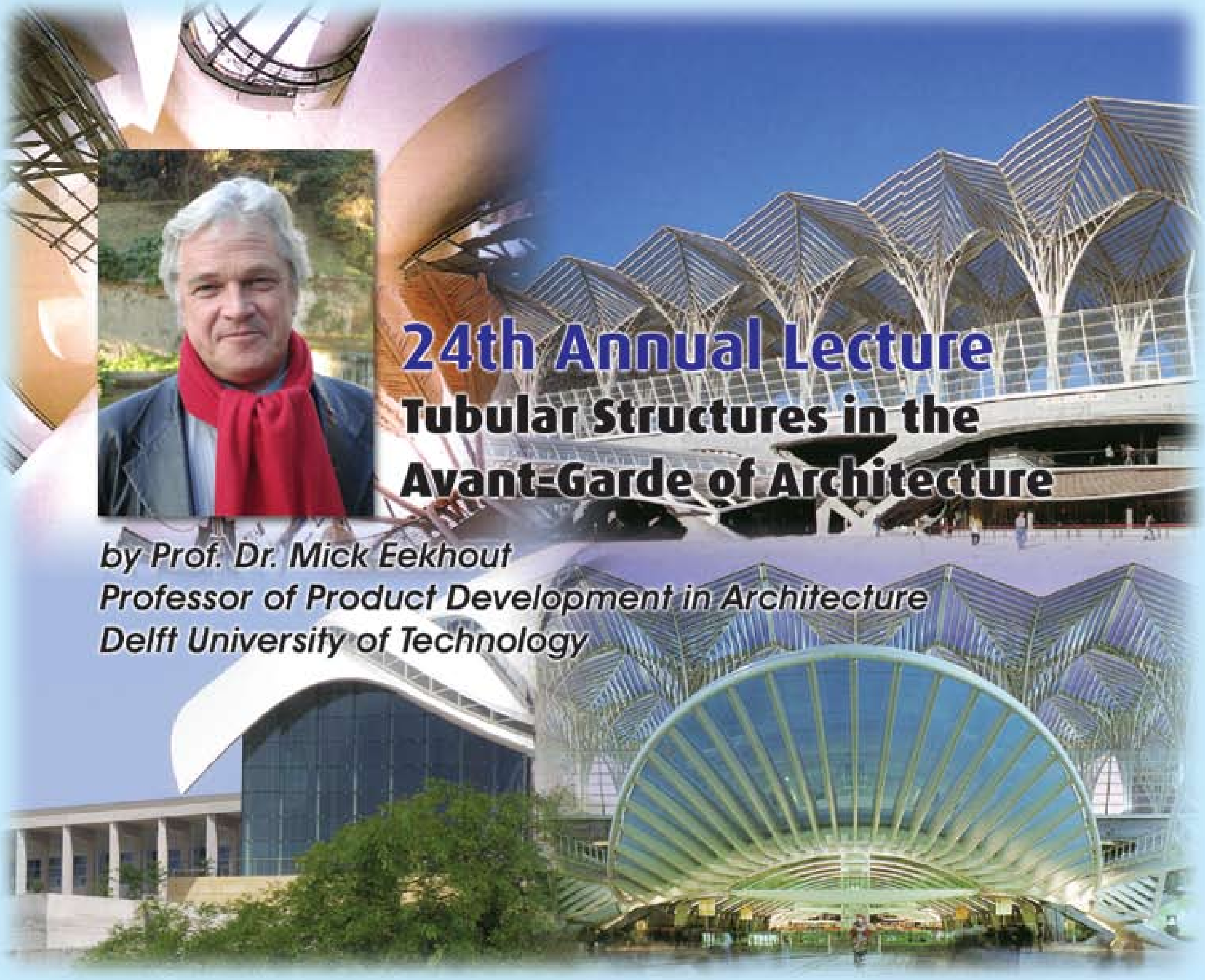

24th Annual Lecture

Tubular Structures in the Avant-Garde of Architecture

by Prof. Dr. Mick Eekhout
Professor of Product Development in Architecture
Delft University of Technology

Contents

The President's Corner

Dear fellow-members,

We celebrated our 24th anniversary of the Singapore Structural Steel Society with the Annual Lecture and Dinner on 28th August 2008 at The Meritus Mandarin, Orchard Road. Professor Mick Eekhout of the Delft University of Technology will speak on "Tubular Structures as the Avant Garde of Architecture." An architect who specializes in steel structures, Prof Eekhout will show that the sculptural design and free form of many projects would not have been possible without tubular hollow sections. Excerpts of his lecture are included in this issue of the SN&N.

It's also time for the council to start preparing for our 25th Anniversary celebrations. But as we do so, we should also take stock of the society's achievements, our members' needs and SSSS's future plans. We have come quite a long way. Today, the SSSS has 457 individual members and 95 corporate members. We have a comprehensive training, education and registration programme for steel engineers and structural steel supervisors. Scholarships are given out by the society to deserving tertiary students annually. The Steel Fabricators' Accreditation scheme is thriving. We play an active role in many initiatives to upgrade the industry. For example, we are helping to prepare the industry for the switch to Euro-codes for structural design. We assisted in drafting of Design Guide on use of Alternative Steel Material. We are now looking into helping to identify steel mills and fabricators who meet minimum standards of quality specifications of the authorities. We have become a significant player in the construction industry, especially its structural steel segment.

But this means greater responsibilities and commitment to our members and the industry. Our council will have to review its roles and responsibilities and think of the society's plans for the next lap of the journey, as we move into our 25th year of existence.

Warmest Regards,

Tan Tian Chong

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BCA Advisory Note on Measures to Enhance Safety of Structural Steelwork

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Dear Sir/Madam

ADVISORY ON MEASURES TO ENHANCE SAFETY OF STRUCTURAL STEELWORK

The safe erection of structural steelwork requires concerted effort by many parties during the fabrication and installation stages. Instances of poor quality welds and other shortcomings in the steelwork, which if not detected and rectified early, could compromise structural safety and the consequences could be catastrophic especially for long span or cantilevered structures.

2 Proper fabrication and installation of structural steelwork requires specialised knowledge, appropriate equipment & resources and a comprehensive testing regime and inspection. There are a number of measures that could be taken by the project parties to enhance the safety of structural steelwork. The engaging of accredited steel fabricators, qualified site supervisors who have a sufficient level of competence in structural steelwork, and Independent Testing Agencies (ITAs) are some of these measures that would enhance the safety of structural steelworks.

<u>Accredited Steel Fabricators</u>

3 One very important aspect in ensuring quality steel construction is the careful selection of steel fabricators with the necessary resources and equipment. The Structural Steel Fabricators Accreditation Scheme, managed by the Singapore Structural Steel Society (SSSS) is a good source for selection of a reliable fabricator. QPs are advised to specify in the contract specifications that the steel fabricator to be employed should be accredited under the Structural Steel Fabricators Accreditation Scheme in the category appropriate for the project. Details of the Structural Steel Fabricators Accreditation Scheme and the list of accredited steel fabricators could be obtained at SSSS website at http://www.ssss.org.sg

<u>Qualified Site Supervisors trained in supervising structural steelwork</u>

4 QPs supervising major structural steelwork should ensure that the qualified site supervisors they appoint are experienced or suitably trained in supervising structural steelwork. The SSSS is conducting training for qualified site supervisors in the supervision of structural steelwork which comprises a 30-hour course and they have to pass a written examination before they are put on its Registered Steelwork Supervisors register. These SSSS registered steelwork supervisors also have to meet continuous professional development requirements to ensure continued and updated

5 Maxwell Road #02-01 Tower Block MND Complex Singapore 069110
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competence in this specialised field. QPs could look up the SSSS website for the list of Registered Steelwork Supervisors.

Independent Testing Agency (ITA)

5 A comprehensive and thorough testing and inspection regime is vital for the safe fabrication and erection of structural steelwork. For major projects with steel structures, it is advisable that an Independent Testing Agency (ITA) accredited under the Singapore Accreditation Council (SAC) Accreditation Scheme for Inspection Bodies (Structural Steelwork) is appointed to -

a) review the welding procedure specifications;
b) check on the joints fit-up, size, dimensions and material quality of the steel members;
c) conduct inspections prior to welding, during welding and after welding;
d) conduct post welding tests on the welds; and
e) check on bolted connections.

(The list of accredited inspection bodies can be obtained from SAC's web-page at www.sac-accreditation.gov.sg)

6 I would appreciate it if you could disseminate the contents of this letter to your members. Please contact Senior Executive Engineer/Mr Patrick Choy at Tel: 6325-5019 or email: patrick_choy@bca.gov.sg if you need further clarification.

Thank you.

Yours faithfully

K THANABAL
DEPUTY DIRECTOR, BUILDING ENGINEERING DIVISION
for COMMISSIONER OF BUILDING CONTROL

Acknowledgements

Singapore Structural Steel Society 24th Annual Lecture and Dinner, 28th August 2008
The organising committee would like to record our grateful thanks to the following generous sponsors:

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Society Events

30th Aug to 7th September 2008	BCA SSSS Industry Delegation to UK
1st September 2008	Certification Course for Structural Steel Supervisors (StS) (www.bca.gov.sg/academy <http://www.bca.gov.sg/academy>)
13th October 2008	Certification course for Structural Steel Engineers (StEr) (www.bca.gov.sg/academy <http://www.bca.gov.sg/academy>)
October 2008	2nd Corporate Members Nite 08
26th March 2009	SSSS AGM

SSSS Scholars 2008
One joint SSSS/BCA tertiary student, Mr Zhang Kailong to study 1st year Civil Engineering at NTU worth $10,000 per year.
Two diploma students, Mr Chee Pei Nen and Mr Sim Zhen Rui from the 1st year Diploma in Civil Engineering and Management (DCEM), Singapore Polytechnic worth $2,000 each per year,

Book Prizes 2008
NTU - Chen Yingying
NUS - Chen Yuhang
Nee Ann Poly
Singapore Polytechnic

SSSS awarded One Book prize per year worth $300.00 and One Grand prize per year worth $500.00. The winner of the Book Prize is Ng Kaihong.

This year the School of BE is organizing few competitions such as Structural Competition (Bridge making), Earthquake competition and Lantern making competition. In all these competitions participants need to use sound knowledge of structural engineering.

Secondary school students are invited to take part in these competitions in order to create awareness and interest in Civil/Structural engineering among school students. The response from school students in the past years had been overwhelming. The Singapore Structural Steel Society's (SSSS) name is also publicised among the school students as the Grand prize is named "SSSS Grand prize".

24th Annual Lecture - Tubular Structures in the Avant-Garde of Architecture

Mick EEKHOUT
Professor Product Development in Architecture
Delft University of Technology, Delft, The Netherlands

1. Challenge

The Singapore Structural Steel Society arranged for this essay on tubular structures in architecture. I took the liberty of introducing a number of considerations on a new field of expertise to the audience: the effects of Free Form designs for the future. This topic was new for most audience members. The USA and Europe are world leaders when it comes to many of the trends in architecture, both financially and artistically. The solo crusade of Frank O. Gehry, which has now been joined by designers in Europe, has led to a new way of designing buildings accompanied by a revolutionary new vocabulary: Free Form Architecture. Free Form Design has been widely published all over the world in the last decade. Experimental designs have been erected. The Venice Architecture Biennale of 2004 was filled with Free Form designs. Many Free Form Design ideas have been abandoned. These developments will inevitably reach Singapore. The cultural centre on the Singapore harbour and Moshe Safdie's Giant flowers on the harbour pier are examples of this new type of architecture. Does Free Form Design have the potential to become a new architectural language, an architectural style even, or are we seeing nothing more than a series of out-of-scale, one-off object designs? How deep will the influence of Free Form Design be? Will the challenges inherent to formal experimentation with Free Form Design eclipse the 20th century's achievements in Functionalist Design? Will Free Form Design finally vanquish 80-year-old Functionalist Design, which survived the sieges of Post-Modernism and De-Constructivism? What will be the extent of digital design in the lives of the younger generations and how will these young designers express themselves in Free Form buildings? In common language Free Form designs are referred to as 'Blobs'. The earliest mention of the Blob was a cult film from 1958 "The Blob".

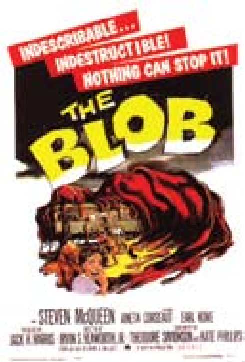


Fig. 1: "The Blob" [3]

Fig. 2: De-constructivist design [4]

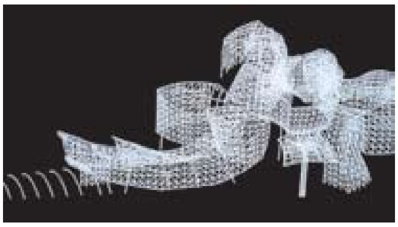


Fig. 3: Free Form structure of Guggenheim Museum [4]

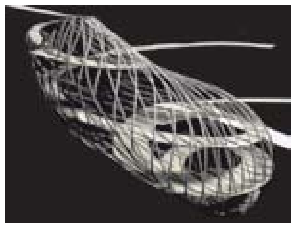


Fig. 4: Kansai Library design proposal [5]

2. Introduction

SSSS was founded in 1980s to disseminate knowledge on and insight into the design, analysis and realisation of steel structures. There have been many changes in fewer than three decades. The balance between material and labour costs has tumbled, industrialisation has taken a much more individualised path, and architecture has become more frivolous. In architecture the unitised, industrialised era of space frames was gradually superseded by that of a more individualised industrialisation. Space frames shifted toward spatial structures. From then on the focus was on all structures that were designed with a high degree of clever thought behind them: intellectual structures, going from pioneers of the first generation to the second generation. An initial characteristic of the SSSS membership was that a part was made up of practical structural engineers with experience in the field, and another part of academic theoreticians, sometimes combined in one person. And many members combine these characteristics today.

Fig. 5: Olympic Stadium Munich, Architects: Günther Behnisch & Frei Otto [6]

Fig. 6: Millennium Dome, London, Architect: Richard Rogers [6]

From the start the focus had been on the economic feasibility of load bearing structures with minimal material. Spatial structures were logical structures in the material usage sense. We recall projects like the Olympic Games roofs of Munich (1972) designed by Günther Behnish and Frei Otto and others. The Millennium Dome in London, designed by Richard Rogers and Buro Happold, is another example of a

purely minimal material manifestation.
Even before the advent of Frei Otto's minimalist theories, a number of sculptural architects had shown what they were capable of designing. We may consider the beautiful Chapel of Ronchamps (France) by Le Corbusier (1953) and the TWA terminal at JFK Airport (Idlewild) in Queens, New York, designed by Eero Saarinen (1962). Beautiful structures and sculptural buildings. Their sustainability was in their permanence, not in their flexibility to be adapted to others forms of use. The airport terminal quickly became outdated since it could not be adapted. Still, it is an impressive sculptural building. In due time, labour costs increased. The increase was present both in the design and engineering side of the building industry, as well as in off-site production processes and on-site construction. Material costs gradually decreased even while labour was getting more expensive. The economies of Europe and Asia were expanding, and the total costs for space structures no longer significantly impacted the economics of architecture, no matter how hot the economy became. Archigram proved an intellectual booster, but never built any of their proposals. It inspired the Pompidou Centre.

Fig. 7: Walking City, Archigram [7]

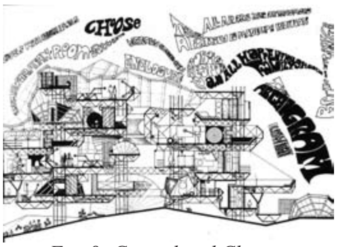


Fig. 8: Control and Choice Archigram [7]

The focus shifted to design as a token of intellectual progress. Architects started to invent their own spatial structures for specific projects, combined with intelligent spatial schemes, which could be recognised as the High Tech Structures of the 1980s. In the 1990s regular space frames were mostly substituted by project-designed spatial structures, revealing the intelligence or genius of the project designers: mostly the architect and his project partner, the structural engineer. They worked together by striking a balance between specialisation and mutual respect. The Centre Pompidou in Paris (1976), by architects Renzo Piano and Richard Rogers and structural designer Peter Rice (Ove Arup) ushered in the High Tech Architecture era, which was formed for a large part by the British High Tech architects and many local followers. It propounded intelligent technology in structural design in well-balanced buildings.

Fig. 9: Centre Pompidou Paris, Renzo Piano

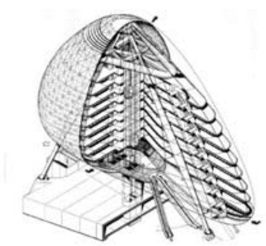


Fig. 10: Green Building: by OVE Arup and Partners [8]

This High Tech era lasted for about 10 years. The computer then made its appearance next to the draughting table in architectural firms. Originally a speedy drawing device, enhancing efficiency in the draughting process, the computer soon took off as a tool for creating designs of increasing geometric complexity. It could be used to dissect a design and reduce it to individually producible units, even when all components were of a fundamentally different form. The computer could calculate the standard but also the non-standard, and do so with the same blinding speed. So why stick to the standard? At the end of the 1990s building budgets became a bit more accommodating. Both architects and clients were ready to take a step into the phase of individualisation
Kanzai Airport in Osaka, designed by the architect Renzo Piano, was one of the last prominent High Tech Architecture buildings, yet it also preceded the Free Form era through its two-dimensional curving, its emphatically cool elegance: repetition, yet a step in the direction of individualisation. The tubular structures made it the most free-form structure of High Tech era. Architects like Daniel Libeskind started with unlikely de-constructivist designs: tangles of collapsed metal frames, which initially were impossible to realise as they all had to be drawn by hand. Proper application of computer-aided design tools meant that these structures could be constructed as complex material artefacts. Coop Himmelblau of Vienna designed its way through the manual period of drawing and is now designing and building very complex structures that are still loosely influenced by de-constructivist philosophy.
But architects went on and discovered NURBS, the fluid 3D line and its undulating product: 3D planes. Architectural designs were treated as chewing gum on the computer screen: stretched, twisted, pushed and distorted. The architect played with these designs.

Fig. 11-14: Kanzai Airport Osaka, showing the major impact of the tubular structure.

The building industry was still unaware of what architects had up their sleeves for them, and the industry was initially unable to erect these rippling dreams. The traditionally narrow gap between design and building opened up wide and called out to be bridged over. A number of architects took the requisite engineering and computer-aided manufacturing into their own hands (Greg Lynn, Frank O. Gehry, Kas Oosterhuis). Others were confident that the slow start of Free Form technology would ultimately lead to efficient processes for erecting Free Form designs. It took a decade before this Free Form technology became mature.

One decade ago the first serious Free Form building was designed and built: The Guggenheim Museum in Bilbao by Frank O. Gehry (1997). Although Gehry's critics could have expected this type of building, its extreme contrast in form and its prominent location just outside the 19th and 20th century city of Bilbao shook the world of architecture.

Fig. 15: Guggenheim Museum, Bilbao, Frank O. Gehry [3]

Fig. 16: Inside view of the Guggenheim Museum [3]

Bilbao's Guggenheim Museum was like a spacecraft that landed next to a rather dull European town. The very contrast between this bold design and the buildings in the existing city was overwhelming. Even adjacent buildings that were still under construction became obsolete overnight. The confrontation was primarily due to the Guggenheim Museum's proximity to this dull European city. Its Free Form Design also caused a shift in the world of structural design.

Fig. 17: Prototype chairs at Gehry's [9]

Fig. 18: Design process model at Gehry's [9]

Gehry has his own characteristic way of working: he models in clay and cardboard to scale. The model is then scanned and digitalised in perfect detail. The digitised scans then become the fundamental design on which all computer-aided engineering work, manufacturing and construction is based.

Gehry's subcontractors must also work in CATIA. Being the first large-scale free form design in Europe, this American design for the Bilbao museum was built according the Spanish building tradition (and priced in pesetas) and the result was an imbalance of architecture and technology. Nevertheless, it was a harbinger of things to come. This new and sculptural Free Form design vocabulary was not created by a technology with an equally intellectual and advanced status. The steel structure had its own logic, but lacked any aesthetic appeal.

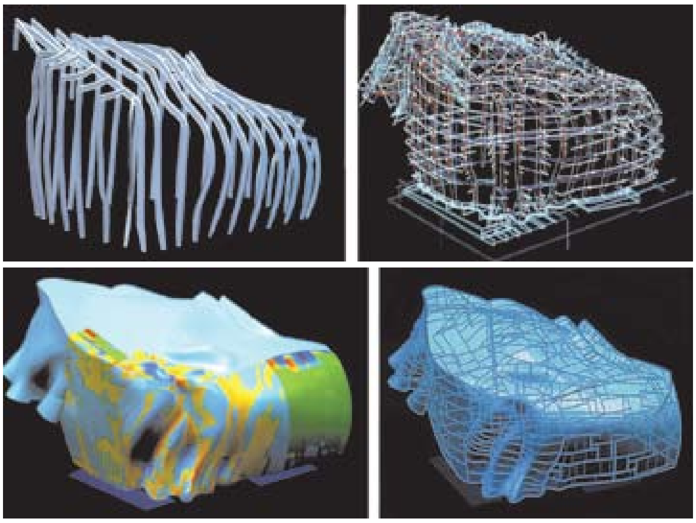


Fig. 19,20: Gehry engineering in Catia from models [10]. [11]

The gap between architectural design and construction technology had been widened by the enthusiasm for perfection that the CATIA design programmes generated in Gehry's engineering department. The Spanish builders did not have the same tools, nor the time to prepare for building at a similar level of perfection. Construction technology lagged behind architectural design. The architect had more foresight than the engineers and contractors. The steel structures behind the facades were blunt and simple; they were disguised. An immense gap between perfect architectural digital design and material realisation had to be bridged.

Fig. 21: Construction photographs Walt Disney Concert Hall, New York, Architect: Frank O. Gehry [9]

In the last ten years a number of Dutch Free Form buildings have been constructed that were subject to the same gap between design and construction. Many lessons were learned concerning methods for working together during the entire building process. The initial reaction of shock among engineers and contractors – 'Free Form Nightmare' - soon faded away. The eagerness of young architects to explicitly broadcast their names through their designs obscured the importance of engineering, production and the physical realisation of these complicated Free Form Buildings. An ego-driven change in fashion, with many neglected aspects in the later stages of the building process. These Free Form designs have seldom come to fruition as part of a completely controlled and balanced process from initial idea to the very completion of construction. At TU Delft a small research group called 'Blobs' was established in 2001 to narrow this gap between design and production & realisation technology. The lessons learned are communicated to the audience and they are incorporated in this essay.

Fig. 22,23: Hydrapier Hoofddorp, The Netherlands, Asymptote Architects [11]

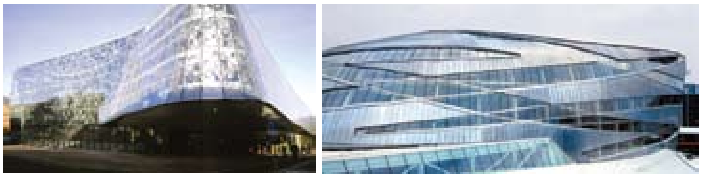


Fig. 24,25: Town hall Apphen aan den Rijn, The Netherlands, Architect: Erick van Egeraat

For the first time in the last three decades of SSSS, the balance between Structural Design and Architecture has definitely shifted to a point where Architecture dictates Structural Design in the case of Free Form buildings. A producer-dominated 1980s technology called 'Space Structures' has therefore gradually been substituted first by a producer/consumer-balanced 1990s technology called 'High Tech Structures' and finally by a consumer-induced 21st century technology called 'Free Form Structures'.

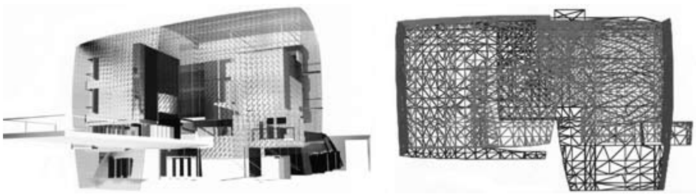


Fig. 26,27: Pallas house, Malaysia, Architect: Decoi [5]

3. Initiating Technological Impulses

Space frames were first constructed in the 1970s. Computer programmes that were advanced for the time were used to assist in the design process. These programmes used Finite Element Methods for the analysis of forces and deflections in a space frame under external loading. The programmes used punch cards: every command and every sentence took one card. There was no graphical i/o interface. Yet the most complicated space frames were analysed: from my own experience one time (1978) with over 5,000 nodes, using IBM's highest night priority. The programme ran the whole night and it cost a huge sum of money. This programme has been out of date for at least 20 years. The very existence of the FEM programmes gave a tremendous boost to the use of space frames in architecture. Space frames could not have come into existence without the FEM programmes.

Fig. 28: Convention Centre New York, I.M.Pei

The current FEM programmes like SAP 90 are refinements of the earlier programmes, they are linked to graphical programmes, and they can be run on personal computers rather than on mainframes. They calculate in real time and they are so fast that they can graphically display deformations in exaggerated sizes so that engineers can interpret and understand them properly. The FEM programmes are incorporated in the CAD/CAE/CAM/CAB range, assisting the complete engineering of load bearing metal structures. Space frames are still interesting for large spans. But in the Western world architects now prefer designing a project-based structural system first and then having their engineers run their calculations before tendering, rather than contracting the design and engineering to specialist producers after tendering. In recent decades there has been a shift in power from the specialist producers to the project architects and engineers, parallel to the consumer market: a shift from producer to consumer. This has everything to do with the expanding economies in Western countries that have reached new levels of luxury. No need to scrimp on steel. The architect's ability to express himself is the important thing. The most extreme example is the Bird's nest Stadium in Bejing designed by Herzog & De Meuron. It boosted China's steel consumption: the steel usage is 40.000 tons, 8 times more than an average stadium of 5.000 tons.

Fig. 29, 30: Hangar 8, Salzburg, Architect: Volkmar Burgstaller [12]

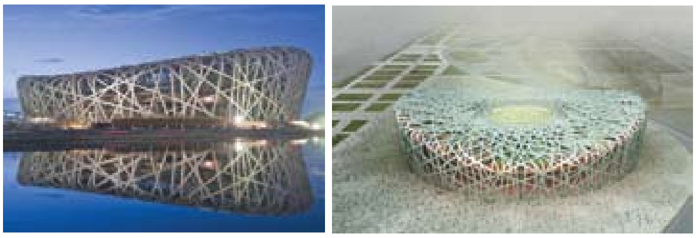


Fig. 31, 32: Olympic Stadium, Beijing, Architect: Herzog & De Meuron

This development is similar to the theory of clinical psychologist Abraham Maslow (1908-1970): as described in the famous Maslow's pyramid, [see figure 33] and published in 1943 in 'A Theory of Human Behaviour' [1]. An individual develops starting with the primary biological needs, to the needs at the top of the pyramid of self-actualisation. As this is valid for an individual, it is also valid for a group of individuals, say architects as the leading party in the design process.

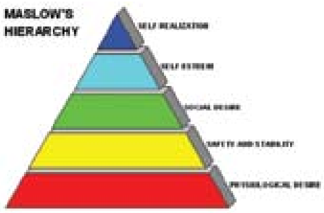


Fig. 31, 33: Pyramid Maslow

Something similar could be asserted concerning the position of a building project as part of the greater economy. Buildings in Western societies still fulfil the basic needs for sheltering people (houses). More and more, the desire for self-esteem and self-actualisation leads to contracts for architectural designs in which the design itself is preeminent and its function, simply housing people, is secondary: people have to feel safe, they need a clean and healthy environment in which to live. The next level focuses on the more intimate needs of friendship, family and intimacy. This was the philosophical focus of the 'structuralist' generation of the famous Dutch architects Herman Herzberger and Aldo van Eijck. They were the champions of architecture based on human needs in the social context of living communities. Other architects opted for sculptural expressions: Le Corbusier and Eero Saarinen

Fig. 34: Le Cobusiers' Chapel in Ronchamps, France [13]

Fig. 35: TWA Building, New York, Architect: Eero Saarinen [13]

The socially-minded generation of architects was followed by a new generation which had an even greater need for recognition and respect: they wanted to be valued as a new generation. At the age of 34, Renzo Piano and Richard Rogers started to design their entry for the Pompidou Centre and invented their architecture of the inside-out structures. As Piano admitted in a general discussion in Sydney in 1986: "We wanted to change fashion in architecture" [2]. And Pompidou did change architecture. (See figure 9). It was a bold statement of a new generation of architects. And many contemporary architects followed.

As a rule, architects of a new generation who want to show what they are made of, have to win design competitions in order to attain their goal. Their older peers must not just judge them but also give them opportunities, by recognising new qualities in the competing designs and being prepared to give new visions a chance. The new generation can reveal its consciousness by initiating a new architectural language based on axioms they favour. The new generation is, in essence, a generation that must fight its way onto the architectural scene. Each new generation can initiate a new language in architecture by exercising its right as a new generation to establish a new vocabulary, new means of communication, a new vision and a new material expression. How will tubular structures fit in this picture? See the pictures in this contribution as a marketing recognisance for tubular structures.

Fig. 36: JVC-New Urban Entertainment Centre, Mexico, Architect: Coop Himmelb(l)au [14]

Fig. 37: Musée des Confluences, Lyon, Architect: Coop Himmelb(l)au [14]

Fig. 38, 39: Analysis and Detail of the skin [14]

Free Form design has come into its own thanks to the available computer design and engineering programmes, many of which have been derived from the cartoon movie industry. This is a technical injection in the craft of architecture. A parallel is the way the Dutch 'De Stijl'

movement of the 1920s and the International Modernism movement that followed it were strongly stimulated by two technical developments: the first was the development of reinforced concrete slabs and walls which could be stacked together or cast together to form horizontal cantilevering floor or roof planes and which would lead to a much more horizontal expression than the traditional vertical expression in architectural façades. The second one was the development of bituminous roofing, which could be used for nearly all flat roof surfaces, even in rainy climates. These two developments stimulated designers to 'think outside the box' and led, for example, to the much admired 'Maison d'Artiste' as designed by Theo van Doesburg en Cor van Eesteren in 1923. These technical developments stimulated a new architectural approach, that later was recognised as a new architectural style.
It is too early for us technicians to proclaim that Free Form design will lead to a new architectural style. At this moment in time one could only conclude that Free Form design, in its turn accelerated by new computer programmes, is leading to new technology and a new, forced way of building process collaboration to accomplish these complex Free Form buildings. Whether Free Form design will come to be seen as a technological fashion or obsession, rather than an architectural style, will be decided by architectural historians in the decades to come.

Fig. 40, 41: Maison d'Artiste (designed in 1923), built as 1:5 scale model by students of TU Delft in 2003

4. From De-constructivist to Free Form Designs
Post-Modernism was based on philosophical axioms. It contradicted the functionalist society with reason and positioned itself to oppose that mode of living. In architecture it would soon be called a style, much more than a fashion. Post-modernism had a relationship with Modernism that was sometimes angry, sometime humorous. Gehry was a post modernist during part of his career.

Deconstructivism is another style of architecture that is based on the many facets of society. Deconstruction was started by the French philosopher Jacques Derrida. Construction and deconstruction both allow for logic and reason. Truth is a many-splendoured thing. The first example of de-constructivism is considered to be the design competition for Parc De La Villette in 1982 (Tschumi). Many of the earlier de-constructivist architects who attempted to create non-functional and eye-catching objects like Peter Eisenman, Frank Gehry, Bernard Tschumi, Daniel Libeskind, Zaha Hadid, Rem Koolhaas and the firm of Coop Himmelb(l)au, put on an exhibition at New York's Museum of Modern Art (Moma) in 1988. They denied being members of any De-constructivist school, have developed themselves further and are using very sophisticated computer programmes these days (see also fig. 2). Nevertheless, their designs have kept their intracable chaotic logic leading to form.

Fig. 42: Beachness - Boulevard and Palace Hotel, Noordwijk, The Netherlands, Architect: NOX [5]

Fig. 44: Model of BMW World - Munich, Coop Himmelb(l)au [11]

Fig. 43: Resi-Rise Skyscraper, New York, Architect: Kolatan / McDonald [12]

Fig. 44: Grad_8 Installation, Architect: Ocean D, Graz, Austria [11]

Most of them have designed Free Form buildings with the aid of powerful design programmes. When they are later labelled 'Free Form Design' or 'Blob' architects, they get furious. Not a single architect wants to be put in a group he did not invent himself. Their egos are too big for any category. The transition from De-constructivist Architecture to Free Form Architecture has not so much to do with a new philosophy, but rather with the availability of computer programmes with increased power and more accessibility, simplified and adapted from their original purpose as animation aids, to become powerful design tools for architects.
A number of Free Form Designs have been erected in the Netherlands since 2000: a pop music hall in Breda and a town hall in Alphen aan den Rijn designed by Erick van Eegeraat, a hotel extension in Almere by Will Alsop and two pavilions at the 2002 Floriade in Hoofddorp (Fig. 22,23) designed respectively by Kas Oosterhuis and Asymptote Architects from New York. The designs were brilliant, but they lacked adequate 'Free Form' technology. Either new technology had to be developed for the project at hand, or the architects

decided to employ traditional building techniques. The only Blob design that subsequently led to the development of a new technology was the Rabin Center in Tel Aviv, designed by Moshe Safdie, followed by technological re-design, development and research in the Netherlands by Mick Eekhout and Octatube (Fig. 48,49), with technology transfer from yacht building and astronautics, leading to the introduction of a structural composite sandwich technology, the renaissance of the shell structure.


Fig. 46: Pop Music Theatre, Breda, Architect: Erick van Egeraat


Fig. 47: Hotel, Almere, Architect: Will Alsop

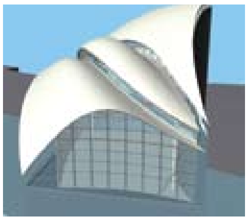
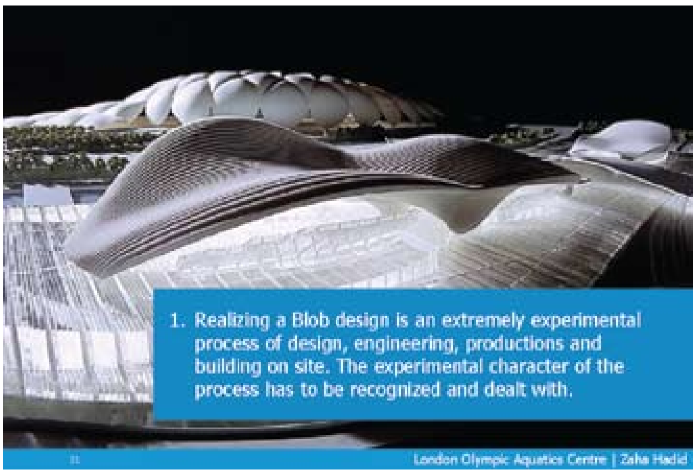
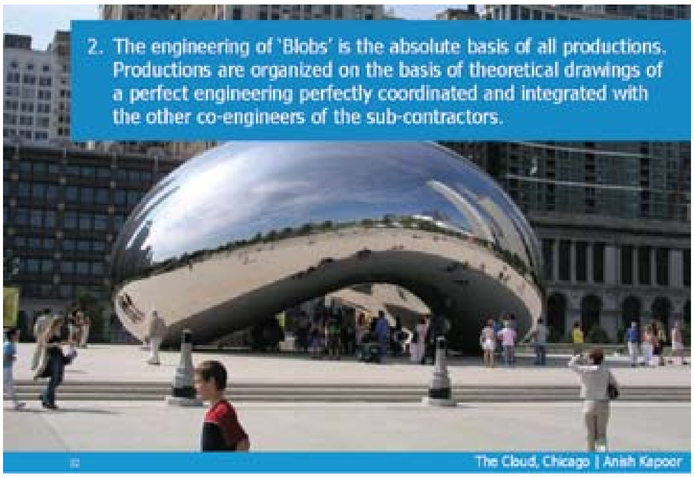


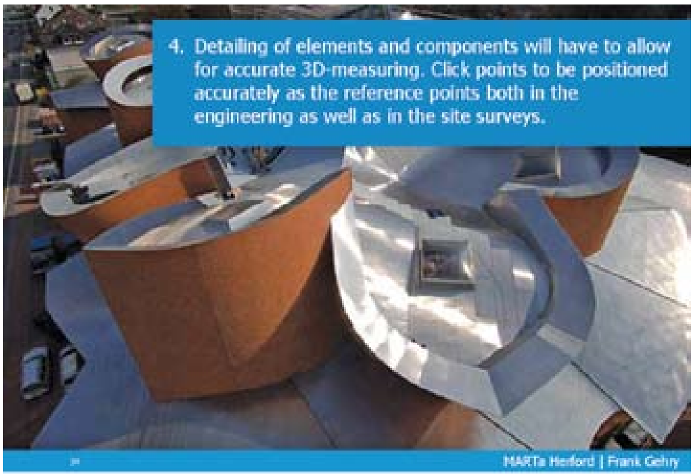
Fig. 48, 49: Rabin Centre, Tel Aviv, Architect: Moshe Safdie

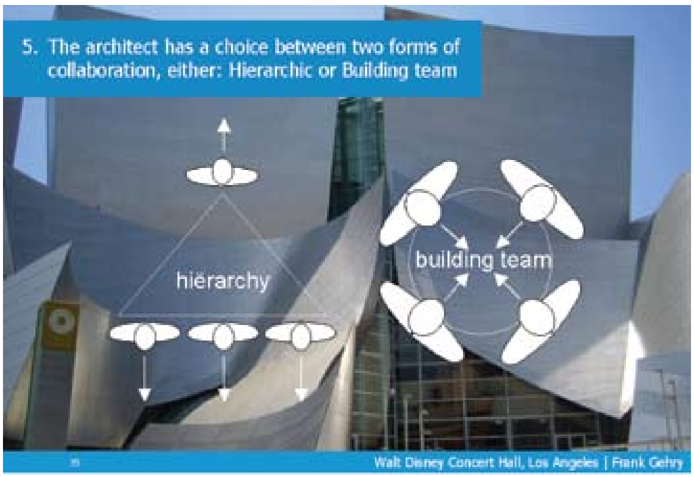
5. Unravelling the Inevitable Chaotic Free Form Design Processes

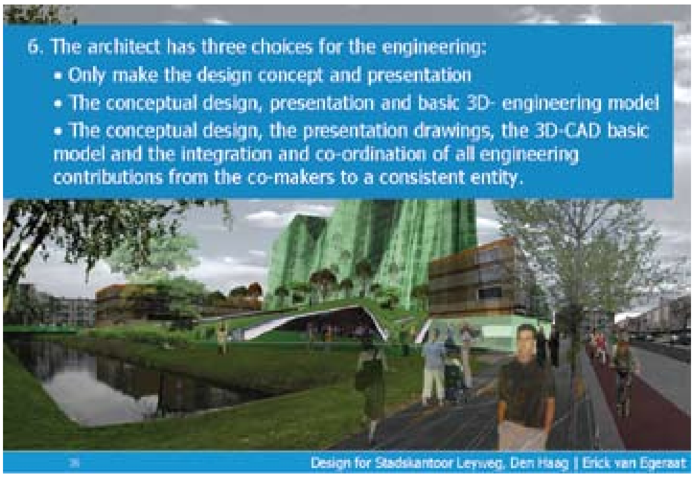
Drawing on my experience of a number of completed Free Form Design projects, I can assert that the communications needs, information provision, avenues of collaboration and process development path are regularly grossly underestimated, that these factors are much more complex than ever anticipated and in fact cause much embarrassment and unnecessary extra costs, even leading to severe losses for the parties involved. Some even go bankrupt or are expelled from the site (including managers and architects). There are therefore a number of suggestions for organising a proper Free Form Process:



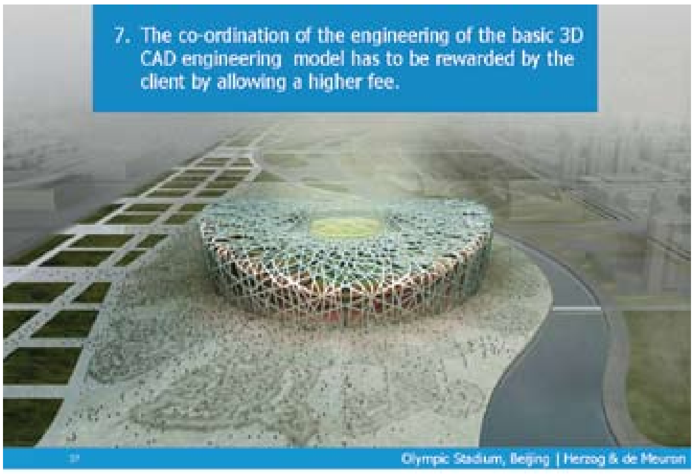






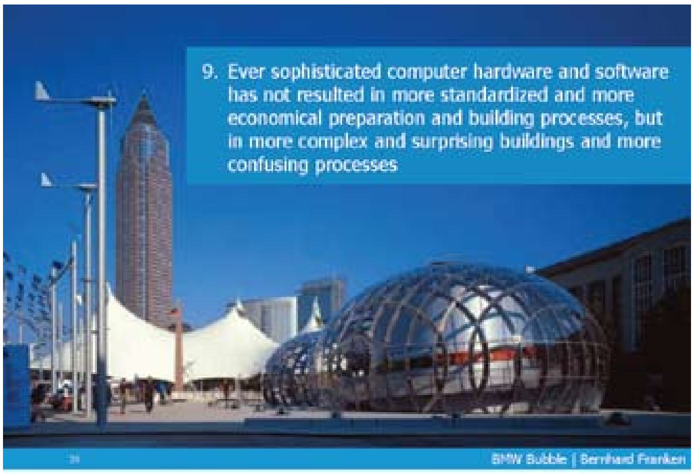


Design for Stadskantoor Leyweg, Den Haag | Erick van Egeraat

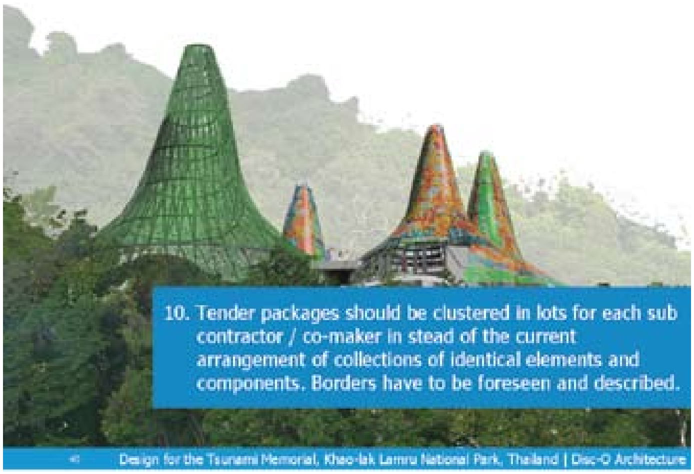


Olympic Stadium, Beijing | Herzog & de Meuron

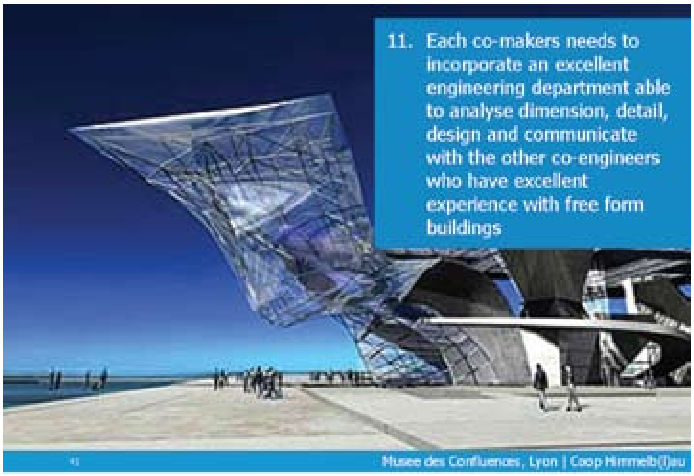
Olympic Stadium, Beijing | Herzog & de Meuron



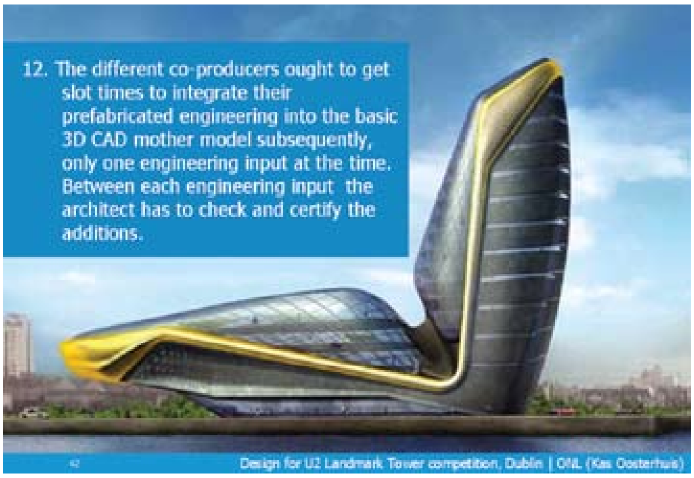
BMW Bubble | Bernhard Franken



Design for the Tsunami Memorial, Khao-lak Lamru National Park, Thailand | Disc-O Architecture

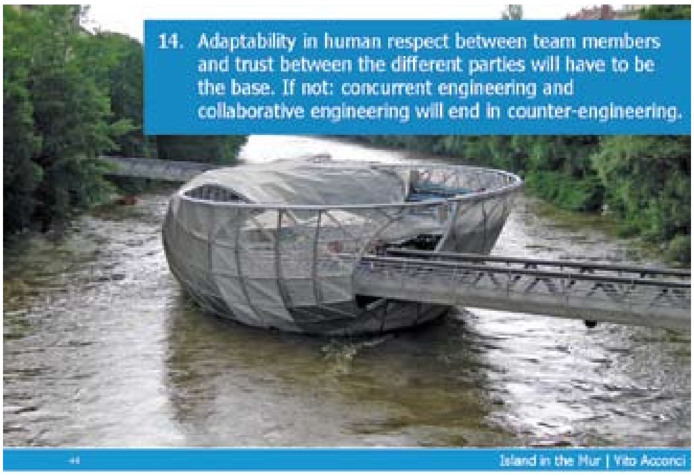


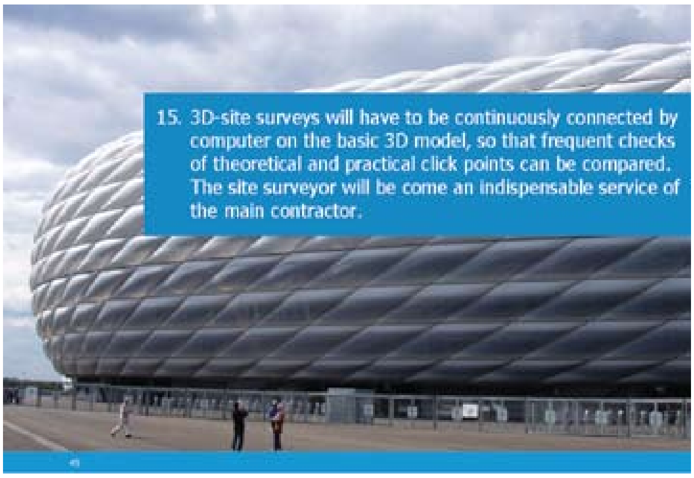
Musee des Confluences, Lyon | Coop Himmelb(l)au

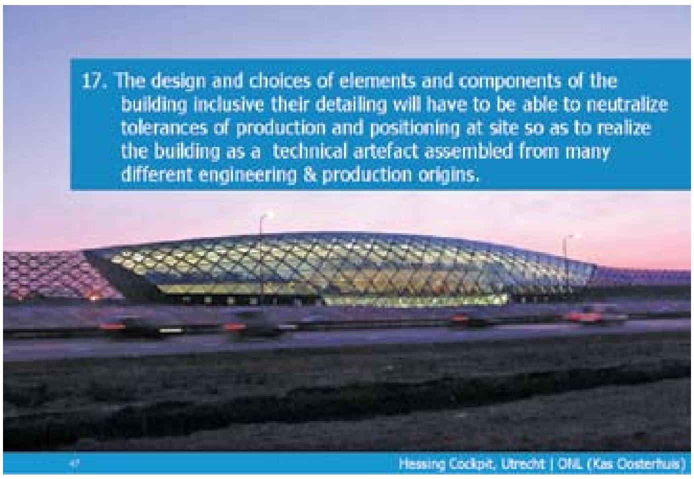


Design for U2 Landmark Tower competition, Dublin | ONL (Kas Oosterhuis)

Yitzhak Rabin Center, Tel Aviv | Moshe Safdie







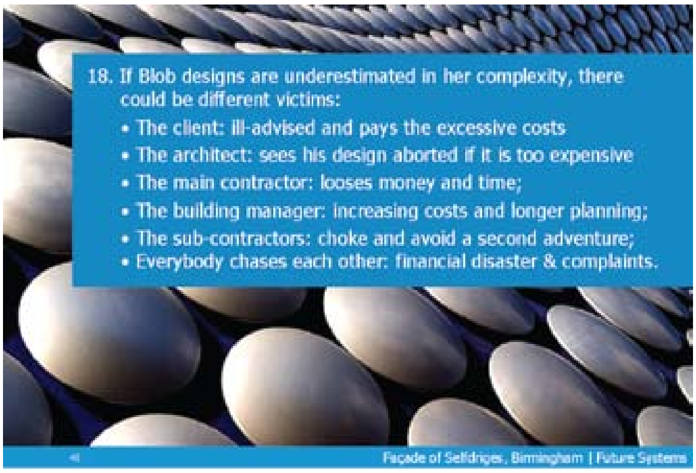


Fig. 50 to 68: 18 recommendations for efficient Free Form processing

6. Free Form Design and Sustainability

An extra complication in Free Form Design processes is formed by considerations of sustainability. Is the building reusable as a building, and in what way? How is the building reusable at component level, and is there any profit to be gained in reusing materials from a Free Form building? These questions run parallel to the questions one could apply to any new building. In the near future we will have to develop buildings that do not consume energy, but are energy-neutral or that even produce energy. Within ten years European legislation may prohibit the construction of energy-consuming buildings. In this regard Free Form buildings are comparable with all other new buildings. The choice of materials should be guided by sustainability, both when it comes to constructing the building as well as in the building's later maintenance requirements. Reusing the building after an initial period of service is can best be arranged within the building itself. It would be impractical to try to reuse one-off components: the tailor-made components will never fit into any other building. And stripping the building of its materials only to discard them by crushing them for asphalt or landfill purposes, does not make much sense either, since the bulk of the building's real value is in the materials. The architect and the entire building team just have to develop buildings that are spacious enough to be adapted to other functions in a next generation of use and that are made of materials that are so durable that two or more subsequent generations (20 / 30 years each) can be endured, even with a change of users in between. In this aspect Free Form buildings are not different from orthogonal buildings.

7. Free Form Design and Tubular Structures

This lecture and article have been composed with the purpose to acquaint the Singapore Steel Society with new tendencies occurring in the world, in the intellectual birth rooms of new architecture. In pure form or in pragmatic derivates this tendency will come to Singapore in the coming years. The 'Durian' Theatres at the Singapore habour were the first proofs; the Habour Flowers in the Marina Bay Sands (Moshe Safdie) are another example. More will come.

Fig. 69: Valencia Opera House, Architect: Santiago Calatrava [15]

Fig. 70: Interior view Musée des Confluence, Coop Himmelb(l)au [14]

Fig. 71: Mercedes Benz Museum of the Automobile, Stuttgart, Asymptote Architects [14]

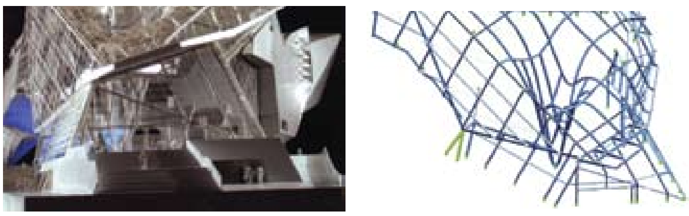


Fig. 72: Musée des Confluences, Model and steel structure of the entrance to the crystal [12]

8. Conclusions for the Free Form Future

Free Form design is a trend in Modernist Architecture that is inspired by the countless opportunities presented by digital design computer programmes, where the architect / designer can freely form a spatial envelope around a building as a sculptor, keeping the restrains of production and construction and of complex processing in mind. Free Form designs are almost impossible to reuse in another form: the final form developed by the architect and his partners has to be 'classical' in quality to be seen as a new monument. Looking toward the future, however, it must also be spacious enough

Fig. 73: Orient Station, Lisbon, Architect: Santiago Calatrava [15]

that sustainability can be guaranteed when it comes time to reuse the building for other functions.

The ethics of Free Form design do not prevent designers from winning competitions with their designs as long as they are knowledgeable about the production and erection side of the design and as long as their clients are prepared to pay the premiums associated with projects like these. The Free Form design process is usually much more complicated, since communications between the different building partners is made all the more complex due to the building's unique geometry. Designers and manufacturers must work together to produce the Free Form Design in components, for otherwise the architecture will not be sound. And this must be done without alienating process partners, which could mean that the entire trend proves to be nothing more than a short-lived and meaningless fad. As production technologies, computer-aided engineering and erection processes are improved, the current price level, which reflects the current experimental phase of Free Form design, will come down, although it will remain higher than traditional orthogonal buildings.

Fig. 74: Airport Station, Lyon, Architect: Santiago Calatrava [15]

Tubular structures are the most versatile of steel structures, especially structures made of circular tubes. Architects ideally consider them to be thick lines that can be curved in several dimensions, twisted, bent or curved as a NURB. The cylindrical form of the abstract line if the circular tube with fixed material characteristics in cross dimensions as being constant. Architectural detailing based on these 3D, curved tubes can always be kept standard in cross section, since a circle always remains a circle in cross section. This presents distinct value in the case of complicated technical compositions when compared to other, more efficient tubular cross sections like the square, the rectangular and the elliptical hollow section.

References

[1] A. Maslow, Toward a Psychology of Being, Wiley, 1998

[2] Renzo Piano, during a speech at the LSD conference [recorded by Mick Eekhout], Sydney, 1986

[3] John K. Waters, Blobitecture – Waveformarchitecture and digital design, Rockport Publishers, Glouchester Massachusetts, 2003, ISBN: 1-59253-000-1

[4] James Steele, Architecture and computers – action and reaction in the digital design revolution, Laurence King Publishing, London, 2001, ISBN: 1-85669-220-5

[5] Peter Zellner, Hybrid Space, Thames & Hudson Ltd., London, 1999, ISBN: 0-500-28256-0

[6] Oliver Herwig, Featherweights, Prestel Publishing, Munich, Berlin, London, New York, 2003, ISBN: 3-7913-2856-5

[7] Peter Cook, Archigram, Princenton Architectural Press, New York, 1999, ISBN: 1-56898-194-5

[8] Martin Pawley, Future Systems – The Story of Tomorrow, Phaidon Press Limited, London, 1993, ISBN: 0-7148-2767-3

[9] Mildred Friedman, Architecture + Process - Gehry talks, Thames & Hudson, London, ISBN: 0-500-28393-1

[10] Jörg Schlaich, Rudolf Bergermann, Leicht Weit – Light Structures, Prestel Publishing, Munich, Berlin, London, New York, 2003, ISBN: 3-7913-2918-9

[11] Joseph Rosa, Next Generation Architecture, Thames & Hudson, London, 2003, ISBN: 0-500-28452-0

[12] Peter Cachola Schmal, Workflow: Struktur-Architektur Architecture-Engineering, Birkhäuser Verlag, Basel, 2004, ISBN: 3-7643-7095-5

[13] Hugh Aldersey-Williams, Zoomorphic – new animal architecture, Laurence King Publishing, London, 2003, ISBN: 1-85669-340-6

[14] Peter Noever, Coop Himmelb(l)au – Beyond the Blue, MAK Wien and Prestel Publishing, Munich, Berlin, London, New York, 2007, ISBN: 978-3-7913-3962-7

[15] Anthony Tischhauser, Stanislaus van Moos, Calatrava public buildings, Birkhäuser Verlag, Basel, Boston, Berlin, 1998, ISBN: 3-7643-5627-8

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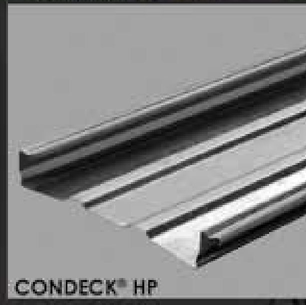
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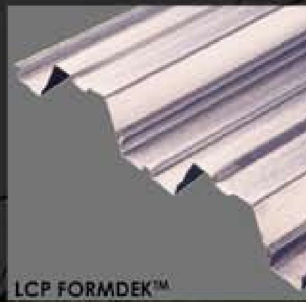
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Kimberly Clark @ Tuas, Singapore

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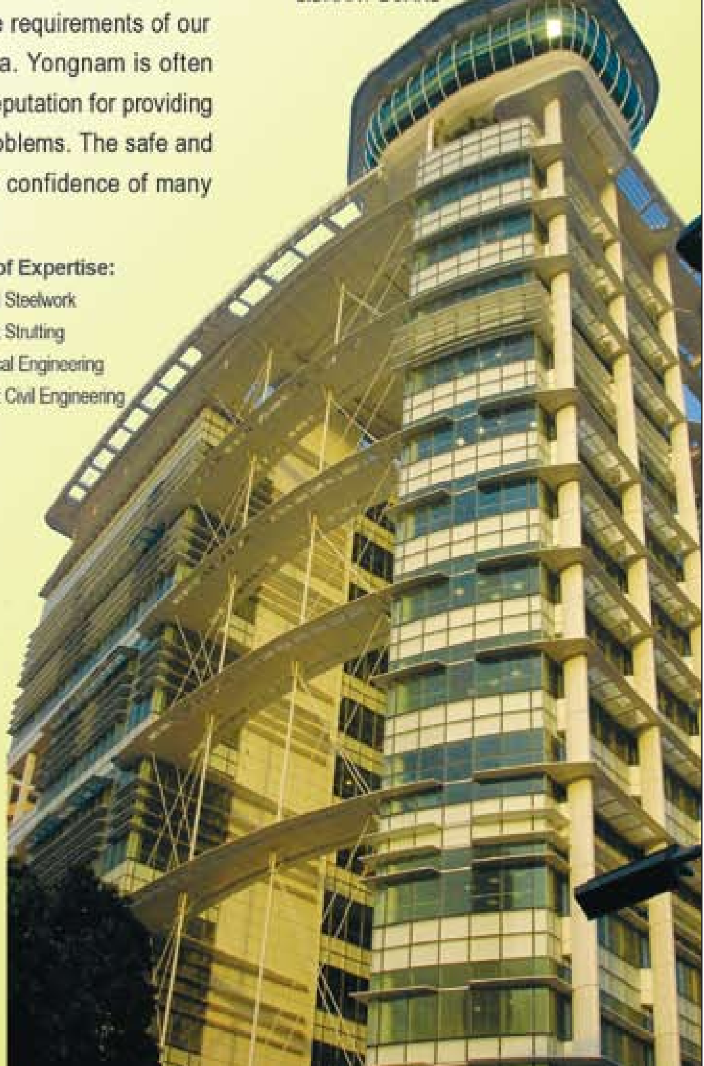

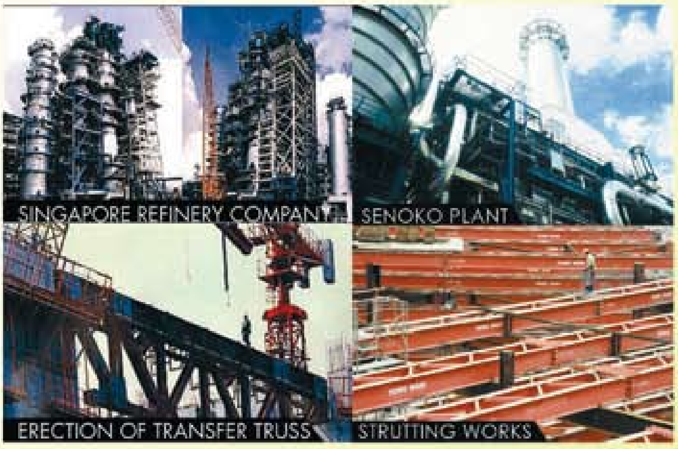

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