THE TURNING POINT OF BUILDING

Prof. Alan J. Brookes
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Mijnheer de Rector Magnificus
en overige leden van het College van Bestuur,
Collegae hoogleraren
en andere leden van de universitaire gemeenschap,
Zeer gewaardeerde toehoorders,
Dames en heren.
1. Introduction.

We can learn a lot from the spider (fig. 1). Not only does it plan the size of its web and the sequence of its construction according to the amount of amino acid in its stomach but also it designs the web to take the force of a fly travelling at around a meter per second by using small springs oiled by the morning dew. Having done all that it even makes the web beautiful to look at. I note that the Americans have now found a way of reproducing spider silk using the milk of genetically engineered goats. Some industries develop technology faster than others. In automobile design or even the design of a simple vacuum cleaner there are 40,000-80,000 different materials available (fig. 2). We can now design an aircraft fuselage which can change its thickness in accordance with the speed of the plane in order to reduce vibration and increase passenger comfort. Who would have thought 10 years ago that I can now pass through customs at Schiphol using on my eye retina recognition (premium plus).
In the building industry we are much slower to accept change.

H.G. Wells wrote in 1902: ‘I find it incredible that there will not be a sweeping revolution in the methods of building during the next century. The erection of a house wall, come to think of it, is an astonishingly tedious and complex business: the final result is exceedingly unsatisfactory’ (1)
Even today most building sites are still dirty even dangerous places where the knowledge of new materials is hard to find in the average building operative. In most design offices we can count the number of materials of our palette of constructional language on two hands and we are only just beginning to explore concepts of intelligent building facades.

However in the last 50 years there have been many changes, particularly in the use of prefabricated or industrial components led principally by the architect Renzo Piano. For example the beautiful mixture of ferro concrete and cast iron roof panels at the Menil Collection USA (fig. 3).

In my book ‘The Building Envelope’ (3) when describing the construction of Hong Kong and Shanghai Bank (architect Sir Norman Foster) (fig. 11) I show that each element of the construction was developed in conjunction with the manufacturers, with claddings from the USA, fire protection from the UK, staircases from Japan, external sunsclops from West Germany, inner sunsclops from Austria, floor finishes from Finland and refuse disposal from Sweden. Each element was designed and developed from scratch in collaboration with the manufacturers. Mock-ups and prototypes were built and tested until their performance met with the architects’ approval. In some respects therefore one could regard this building as the ultimate in custom-made component assembly.

Martin Pawley, in his thesis on technology transfer, has made reference to how much we can learn about industrialisation from the automobile industry. It is true that the building industry also uses factory made products. The essential difference however that whereas the design of a car is a prototype for many similar models, the design of a building is usually one – off.
There has also been developments in industrialised building systems. My early career in 1963 (incidentally the date of the birth of my first son) was working for the central government at the Method of Building Branch (MOB), developing an Open System of Building for use in Government offices and military buildings (fig. 4). To some extent we were following in the footsteps of the Californian Schools System, developed by Ezra Ehrankranz in the 1960s, which was an ‘open’ system of interchange-able components and used performance specifications as the means of procuring components from manufacturers, not necessarily confined to those within the building industry. Two of the main features of the system were an open roof structure (space frame) and a series of clip-together demountable ceilings and partitions. One such sub-system developed at that time, proposed by E.F.Hausermann Co, later became widely used by the ‘High-Tech’ architects throughout the world. Many of the ideas for the SCSD, which is well described by Barry Russell in his excellent book on industrialised building (4), were based on ideas originally proposed by Konrad Waschnmann in ‘The Turning Point of Building, Structure and Design,’ (5) and it is to this book which I first read in 1961 and still have on my bookshelf. This work constantly excites and inspires me, and it is to the memory of Waschnmann and his influence on technology in Architecture to whom I dedicate this lecture.
In my education as an Architect, as with many others of my age, I was very influenced by Jean Prouvé and in particular his work in metal composite construction. Oddly, although Jean Prouvé had been working in prefabricated metal assemblies since as early as 1938, there was little interest in Britain at the time in developments in metal composite construction. It was not until the maverick idea of Jan Silva in the development of Oxford Regional Hospital Board system in 1958, that Prouvé’s ideas were at first really exposed within the UK. Even then it was not until 1971 that Prouvé’s ideas and early designs became widely known due to the book by Huber and Steinwegger (6). See for example this early use of curtain walling anticipating the use of neoprene which wasn’t commercially available until 1947 for the Harrisburg Interchange in USA (fig. 5). Thus it took some 30 years for Prouvé’s ideas to become accepted by the Architectural profession. Renzo Piano has also been influenced by Jean Prouvé. He had been introduced to Prouvé’s work when he was teaching at the Ecole des Arts et de Métiers in Paris in 1966. Later, during the construction of the Pompidou (now Beaubourg) Centre, they became friends due to the nearness of the location of their offices in Paris. And similarly, Sir Norman Foster, when designing the Hong Kong Bank building, invited Prouvé to his office to inspect the drawings.
Thus by the time I came to be a consultant at Heathrow Terminal 4 developing a cladding system manufactured and assembled by Joseph Gartner I was already labelled as a 'High Tech Architect', a term even now I refuse to accept. My life and work is essentially to seek a relationship between design and production. I see technical detailing as a means of describing design intent. I see High Tech not as a style of architecture, but more of an attitude towards design taking account of and being involved in the process of construction.

This is the main dilemma of teaching building technology to architects. It has to be presented as part of the conceptual process and there undertaking this role as a teacher must also have confidence in informing the design process.

Our main job as teachers involves getting out of the way of the good students once they have gained enough knowledge to become autonomous and trying to give the less gifted a sense of the importance of what the better ones do.
2. Thames Water Tower

Equally for good design the architect must become involved with the building process which of course takes time and energy, and is not normally part of the Architects role – or for that matter their fee scale. Where innovation in Architecture occurs there is always a requirement for the Architect to apply continuous love and care, testing, mock-ups, going back again to get it right. The philosophical gain lies in the fact that some parts of the modern building industry are now spiritually geared up to experimenting with new solutions. Maybe they see a benefit of their products being associated with more innovative architectural practise, and the old argument for standardisation of the production process can be overruled by the use of more sophisticated computer controls of manufacturing techniques. However it is still the case that most building components are manufactured off site (fig. 7).

In the design of the Thames Water Tower in London (architects Brookes Stacey Randall) the key technical issue was the relationship between the inner stainless steel tube acting as a surge pipe for the London Water Main and its surrounding glazing. This required a bracket capable of being adjusted to provide for an accurate and aligned facade using curved 10 mm glazing with 10 inch silicone joints taking account of the tolerances of the inner stainless steel facade by others (fig. 8). The solution was an adjustable bracket using cast stainless steel with tubular stainless steel rods. This bracket then had to be prototyped and tested. At the time of design it was not clear whether the section sizes could be achieved using conventional lost wax casting processes.
On many 'mainstream' projects the time for testing is simply not available, and the architect is encouraged to seek 'tried and tested' solutions to ease the tight programme for design and construction. The exceptions to the rule may be exhibition buildings or landmark projects where the clients want a building that reflects the importance or status of their organisation. Here the architect may be encouraged to use mainstream technology but in new and original ways. Thus the suspended glazing fittings at the Water Tower although of a standard principle were modified partly to save cost whilst at the same time maintaining a flush facade. The innovation was the use of blue water within the facade, powered by the P.V.-cells on the top of the tower, all to produce the effect of an intelligent building which tells of tomorrow's weather- like a giant barometer.
3. East Croydon Station

It has always been my view that good design depends on precedents, and I have always encouraged my students to seek previous examples of their design problem and to seek to build on or expand the ideas of others. Isaac Newton has said: 'We stand on the shoulders of giants.' Thus when we designed the open, mainly glass station at East-Croydon we were concerned with the means of suspending the 10 mm clear toughened roof glazing below the tubular steel structure using stainless steel twin armed castings. Learning from experience at the roof glazing at the school of Architecture at Lyons (Architects Jourda and Perraudin, ref.7) we knew we needed a method of controlling the accuracy of the silicone joints between the glass roof panels.
Similarly the head detail connecting the aluminium glazing mullions which support the suspended glazing to the roof trusses had to take up the deflection of the bottom boom of this roof truss. We knew from previous experience at Stanstead Airport that a complicated and therefore expensive knuckle joint could do this job. The much lower budget for the glazing at East Croydon meant we couldn’t afford such a complicated detail and a simpler sliding joint within an angle section was seen to do the job.

All the component parts of the glazing assembly were designed, prototyped and tested by the architect using performance specifications (fig. 10).
Even though the glazing contractor MAG took responsibility for the performance of the assembly it was necessary for the architect to provide indicative details of how it could work. We should give our students similar confidence to sketch their ideas which have a reasonable chance of success in practice.

The concept of the glazing support was not dependant only on the structural engineer who of course had to produce the necessary calculations. The means of support depended on the principle of tensegrity which in turn was an idea borrowed from Buckminster Fuller.

At the end of the time it is paraphrasing Primo Levi the pleasure of seeing your creature grow, bolt after bolt solid necessary and suited to its purpose and maybe as an old man you will come back and look at it and it will seem beautiful and it doesn’t matter that it will only seem beautiful to you and maybe as an old man you will look at it and say maybe another wouldn’t brought it off.
4. Federation Square, Melbourne Australia

This refinement of an idea from an initial design solution is often part of the design process. When designing the fixing detail of Federation Square Australia (fig. 17) where we were struggling with translating the architect (Bates and Smart) idea for using an apparent random arrangement of stone, zinc and glass panels based on fractal geometry, we decided on a three point pinwheel to fix the panels rather like changing the wheel on a car (fig. 12).

The first idea was a complicated fixing device for taking account of three dimensional tolerance. The final solution was to buy in a few hundred car tow bar caps which were much cheaper as they were mass produced for the car industry, and did the job of the three-dimensional movement perfectly well.

In the teaching of technology it is important to encourage students to have an open mind towards the opportunity for innovation. Thus it is dangerous to teach by rules. The essential dilemma is how to introduce basic techniques of construction and calculation method whilst at the same time encouraging freedom of thought. In practice of course because of the risks involved in innovation it is necessary to prototype and test ideas. The better architectural practices do this although usually introducing not more than one innovation on each project at a time.
5. Chris Lowe House

An exception of this principle was the flat for Chris Lowe (Pet Shop Boys) (ref 8) where we (Brookes Stacey Randall) introduced several innovations on the same project. The unusual nature of the architect/client relationship in that Chris having been once my student at the Liverpool University School of Architecture, was an understanding client who knew the value of new ideas.

Thus we were able to enhance the space of his living area by using a hinged roof with hydraulic arms for lifting it so Chris had access to the roof space (fig. 13). His notion of adaptable space led to a series of filing cabinet type storage spaces which could be rolled out to allow a kitchen, clothes storage or sound studio (fig. 21). The glass staircase was a folded plate toughened glass stair which needed prototyping and testing. The client thus had to pay for two staircases instead of one. To allow privacy as well as open view we designed large laminated glass louvres which pivoted to give a translucent coloured screen using laminated beech between the glass.

The glass staircase was a folded plate toughened glass stair which needed prototyping and testing to destruction. The client thus had to pay for two staircases instead of one (fig. 14).

His notion of adaptable space led to a series of filing cabinet type storage spaces which could be rolled out to allow a kitchen, clothes storage or sound studio and finally the delight of bathing in the shower with fibre optic lighting is an experience I would recommend to you all.
6. Aspect cladding system

Although architects have often designed specific items of furniture, it is rare for us to be involved in the development of specific building products or systems. An exception to this would be the Aspect II system of cladding developed by my practice in conjunction with Cosely Building Systems (fig. 15). We as architects were responsible for the design, sourcing of materials, and prototyping of a system which could then be applied by others. An extensive period of Research and Development was spent in the search for an improved fourway crossover junction that would not require the use of ladder gaskets (as at the Sainsbury Arts Centre or Gatwick North Piers) or of site-applied sealants. These were set as the fundamental design aims in the design of the new cladding system, and necessitated several prototypes for the gaskets being fabricated before a suitable extrusion was selected. The Aspect II system of interchangeable facade components offers the opportunity of rearranging or adapting the building envelope at any stage during the construction process or after the building is occupied. Panels can be interchanged with glazed panels, louvres or doors.
Then of course there are other performance requirements to be designed for and tested. In Aspect II the weather seal is formed by the primary gasket framing the perimeter of the panel. The inner seal is formed by a horizontal air seal mounted to the top and bottom edges of the panel. This in turn is clamped against the vertical air seal mounted to the rear aluminium carrier. A still air zone exists between the primary gaskets and the air seals. Drainage continuity is maintained using sealed joints in the rear carrier. The cill detail is designed to drain moisture from within the assembly to the outside. Testing intended specifically to confirm this principle of assembly was carried out at the British Standards Test Laboratories. All components, including windows, louvres and doors, have a common method of joining and as mentioned above are secretly fixed. The overall design achieves a system of co-ordinated components, united through their means of joining, resulting in a coherent assembly of diverse elements. Throughout these elements the finish can either be made common or highly varied, depending on the needs of each project and the requirements of the specifying architect.
Even loading-bay doors can be relocated. The method of fixing panels is via an aluminium clamping plate located within the UPVC edge profiles and behind the primary gaskets. The clamping plates are secured with a stainless steel counter-sunk socket head machine screw to a rear fixing block which slides within the vertical rear aluminium carrier. The system is entirely secretly fixed and avoids any problems of aligning fixings, sealing fixings, or possible panel damage by fixings.

The panels can be easily assembled or dismantled by a skilled fixing team. The clamping plate has been carefully engineered by the structural engineers, Whirby and Bird, with allowances made for thermal movement, rotational effects and tolerance. The interface of the clamping plate and the UPVC edge section has been designed to minimise thermal bowing of the panel. The number of clamping plates is dependent upon wind loading and panel size. All this in itself involved extensive Research and Development by the project team, including testing of the clamping plate at Bath University.

The panels thus lock together using entirely dry components. No sealants or mastics are necessary (fig. 16).
Barry Evans commented in the Architects’ Journal on our work for the Aspect II system:

‘Although ... (the) degree of involvement with this manufacturer is certainly unusual for an architect, it is perhaps no more than an overstatement of the current trend in construction industrialisation. Manufacturing is moving away from the box-shifting supermarket of products towards being a custom products service. In the process manufacturer and designer are drawn together, the architect learning more of the ways of the manufacturing industry, the manufacturing industry increasingly stepping into the world of design’. (9)
7. Singapore arts centre

At Singapore Arts Centre our role was slightly different (fig. 18). Here we were consultants to the client assisting the German subcontractor Mero to devise a system capable of meeting the clients requirements not only for appearance of the performance requirements for weathering and wind loading. The concept originally developed by the engineers Atelier One for the sculpted non-linear form if the concert hall and lyric theatres were formed from a space frame grid with glazed infill and aluminium shading devices. The modelling of surface geometry using Micro station creates a mesh of equal-length elements to standardize their manufacture.

Working closely with the architect MWP/DPA a generic solution of a double layered jointing system at the edges of the triangulated glass panels with their moveable sunshades.

The main problem was the large potential number of variants in the aluminium sunshades and the need to respond to the complex geometry whilst at the same time providing assurance that the building would not leak particularly if the Prime Minister was sitting in the audience at the time of a heavy Singapore rainpour.

The system eventually developed and constructed by Mero Germany consists of a series of nodes and chords with a ingenious net of e.p.d.m. drained gaskets to form the joints between the triangular shaped panels. All this needed careful prediction of the forces at each node condition which would only have been done using CAD prediction methods. Even the forming and shaping of the aluminium sunshades was possible by the use of such techniques.
The system eventually developed and constructed by Mero Germany consists of a series of nodes and chords with a ingenious net of e.p.d.m. drained gaskets to form the joints between the triangular shaped panels (fig. 19).

As I get older I have learnt never to believe what I write or say one year is cast in stone. Always be prepared to rethink your position related to changes in technique or even social behaviour. This is what makes working at a University so interesting, in that sometimes students can propose problems or give solutions which might have been totally unacceptable a decade earlier.

To some extend H.G. Wells could still be right. We are still too conservative in our choice of materials and techniques. Research at the University into new materials such as carbon fibre components and structural glass assemblies can offer the means of extending the design vocabulary, which I constantly search for.
8. Boat House

Finally I finish with the boathouse at Streety as this is still my favourite building and one I see from my house in England every morning when I am in residence there.

This steel and glass pavilion on the banks of the River Thames in rural Berkshire is the perfect spot for watching the boats drift by. The boathouse cantilevers off one of a series of existing stone retaining walls which form a raised, grassed terrace surrounding an existing landing stage. Sufficient hard landscaping to convince the planning authorities that a building could sit naturally in this context (fig. 20). The building relates as much to the garden as to the river, with trees providing a natural canopy, and a gentle curve allows views up and downstream. A pair of cruciform columns frame the entrance, and are echoed by a pair of circular columns inside the building. A galley unit supported off the left-hand column hovers over the floor plane. Two tapering solid timber legs and an exposed copper-clad hull are reminiscent of an airborne boat.

The technical innovation was the use of laminated glass to stabilise the construction and the sliding toughened glass forming the sides which are operable to allow cool ventilation in the summer. This small building has been widely published partly for its clarity of design but partly for the romantic way it sits within the landscape and the choice of materials (fig. 22).

I was particularly pleased with the way the water drains from the roof and how it stains the copper below emphasising the change of the building with time and nature.
Fig. 21 Adaptable space achieved by a series of filling cabinet type storage spaces

For this is the very root of my philosophy towards detailing and architecture. Construction should be used to enhance and further describe our desire for architecture. Often design is described as the innovative conceptual task and detailing is seen as fixed answer to respond to design. I see it as a reverse situation. I believe that innovation in detailing and construction can put a new light on design which can be developed in an innovative way to improve and develop architectural intention for this reason...

I finish with a quotation from Peter Zumthor (10) who I regard as one of the greater living Architects:

'Architecture has its own realm. It has a special physical relationship with life. I do not think of it primarily as either a message or a symbol, but as an envelope and a background for life which goes on in and around it, a sensitive container for the rhythm of footsteps on the floor, for the concentration of work, for the silence of sleep.

If we work towards this goal, we must constantly ask ourselves what the use of a particular material could mean in a specific architectural context. Good answers to these questions can throw new light onto both the way in which the material is generally used and its own inherent sensuous qualities.

If we succeed in this, materials in architecture can be made to shine and vibrate.'
So ladies and gentleman we must go forward to this new future of technology in our industry with courage. As teachers of architecture and building technology our main responsibility to show courage, integrity and judgement in their designs. If we succeed in this the next generation will achieve the quality and excellence that TU Delft should desire.
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