Designing by Making: Strategies for Developing Architectural Concepts by Means of Process Skills
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The general idea, of course, is that all our thinking and reflections during this event, should be in the perspective of "the future". That we somehow should try to foresee a likely development of our profession for the day after tomorrow or in the next years.

What do we know about the future? Nothing! Or, next to nothing. This means that we are confined to make guesses, which might be qualified, but they will still remain guesses. In this situation we usually extrapolate our present experiences and project the trends and realities of today into the future. If I am asked to give an advice on how to make plans for construction education today, which should apply to students in the next five years, my answer would be to identify a strategy, or rather an attitude, that I am fairly convinced would work, and would be seen as useful. This attitude and the knowledge which is implied, should go beyond and go deeper than the level of pragmatic building construction methods which change rapidly.

I will try to outline some elements of such a strategy, and will emphasize questions of the construction process and of the relationship between a conceptual design and that process. This is about the transformation of materials into construction elements, and of the transformation of construction elements into works of architecture. In another word: it is about technology.

What I can state right away is this: In the future, will continue to teach the properties of materials, we will continue to teach mechanics of materials, we will continue to teach statics and structural systems. Those topics are all at the bottom-line of all construction education, like syntax and grammar in the language of architecture. Large parts of those topics would seem not to undergo rapid changes, but remain a solid basis on which we can develop a more flexible but specific, state-of-the-art education program on construction aspects adapted to the master level.

On what principles should this be based?

I think that the different ways in which different persons will answer this question, to a large extent depend on their views on architecture, or more specificly on the rôle of structures or construction in architecture. Some architectural cultures, or -isms, hold architectural construction to be merely a matter of pragmatics, some necessary tool to keep the building standing upright, and which has no pretensions other than holding the floors, walls and roof in the intended position. Within such an architectural climate, I would guess that among the most important teaching issues would be a thorough knowledge of standardised and efficient building systems and products as seen from the point of view of the building contractors. This attitude doesn't seem to imply a vision for the future other than to follow closely the progress being made in the mass production of building systems and components.

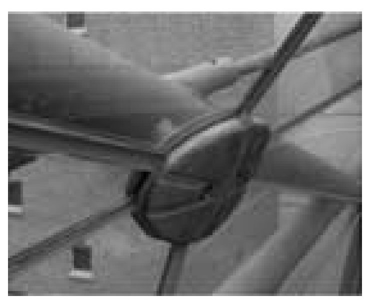
I, for one, take a very different view on architecture and construction. I believe that the structure should play a vital rôle in constituting architectural expression, and that structural elements have the capacity to do so, both with respect to the overall form or shape of the work of architecture, by the very presence of structural materiality, down through the hierarchy of different scales to the structural detail. I believe that the way in which the building *is made* matters a great deal, and that architecture which takes this as a premise may hold a special quality. I therefore take this view as my basic attitude towards structure and architecture when I discuss construction education.

A consequence of this view is a distinction I make between "building structures" on the one hand and "architectural structures" on the other. I postulate that there is always a balance, a very delicate balance between spending time teaching the practice-based knowledge characterising the former, and the more conceptually-oriented latter. I think of the two attitudes of construction, which at least to a certain degree are different, as differences of purpose and of context. While "building structures" are concerned with issues like common building practices, with cost-efficiency and technological efficiency (cheap and easy construction), with structure as a tool, I think of "architectural structures" as having a wider purpose. A true "architectural structure" has a certain individuality, it is part of the architectural concept, it has the potential for conveying architectural meaning by being designed within an architectural framework of a specific expression, whether that be "lightness", "novelty", "materiality" or some kind of "structural iconography". "Architectural structures" belong, not to one architectural style or trend or movement in particular, but characterise the construction of all architecture with a consciousness towards the tectonic.

To further prepare a philosophical platform from which to reflect on the right steps for the future, I will postulate that the study of structures and of construction from an engineering point of view, besides the creative design aspect, can partly be seen as a scientific study and partly as a technological study, and that those are different. The first is the study of load, force and form which essentially follows strict rules based on mechanics and mathematics.

This study of statics mainly operates on what I call the *global form* of the structure, which is the structural system or composition taken as a whole. This level of form is subject to design tempered by scientific/mathematical knowledge. Design proposals are subject to visual or computational analysis in order to predict stability, stiffness and strength for reasons of safety, but also as part of a visual or aesthetic assessment of the proposal at hand. This training usually starts off with studying simple structural systems, and ends up in the study of more refined, sophisticated ones. It seems to me, however, that much of the elaborated and computerised contemporary architecture basicly depends on a limited number of fairly simple structural principles. This likely fact tells me that it is probably wiser to train students by studying a large number of *variations on basic principles,* than spending too much time inventing ever more peculiar structural ideas.

It should, however, be seen as a particular quality of both students and teachers to avoid being conventional, and I want to promote creativity particularly in the study of materials and the constructional potential of various materials. It is good training to try out familiar or known materials



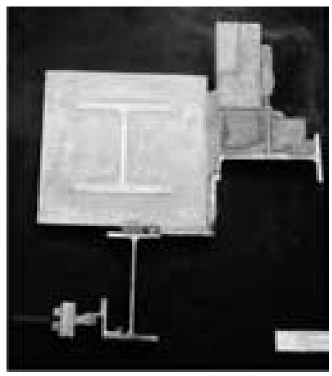
in unexpected situations as well as new or unexpected materials used in situations which are familiar. And I might also add that I find the study of known materials in new combinations highly interesting as a training in how to cope with a possible future of unfamiliar structural settings.

However; and now I come to my main point, *in addition to* training the ability to study constructions as loadbearing, global systems, I think that a serious *technological* study is highly relevant, but often sadly neglected. By this I mean that a knowledge of how things are made, or can be made, is fundamental to bringing architectural projects forward, and this aspect is probably much underrated in architectural schools. An understanding of the means and ways of materials production and process may prevent the architect from being a victim of standardised solutions which make our architectural environment increasingly more similar, not least with respect to structural detailing. A technological study basicly adress what I call the *local level* of form, informing the design on a *detailed level.* This is design in a context of technological know-how. It is on this design level that individual, material specific and often contextual solutions may result. Studying manufacturing processes gives the architect the knowledge and the confidence to propose and design individual solutions fitted to a particular context. It may also prevent the architect from being reduced to playing the rôle of a follower, always being subject to a reality defined by others.

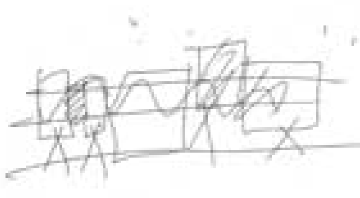
A more process-oriented teaching, aimed at a strengthening of architectural concepts, will pay a lot of attention to what is going on in the building industry, particularily in the part of that industry which shapes materials and makes products. The students should ideally have intimate knowledge of how laminated wooden sections are made, how glass panels are produced, toughened and laminated, how steel can be cast, how aluminium is extruded etc. They should also as far as possible be given opportunities to handle material processing by themselves, so that some personal experiences are gained. By learning a lot about technological processes, the students will be much helped in seeing the difference between what the industry mostly do, and what they are really capable of doing. What they mostly do is a sum of demands from the market, standardised solutions that sell in large numbers, products that adapt more or less well to most of what is currently being built. What their equipment and machinery make the industry capable of doing is another matter. I would very much like for the future to see students and architects with skills that can challenge the industry to make things they usually don't do. Again, I am trying to avoid seeing education as following as closely as possible the outside reality, but instead having visions for an education which inspires investigation and interest, that challenges established truths, and may enable architects in some respects to engage in construction innovation.

And behind it all is the importance of the material. A deep knowledge of materials, and a love for materials, is the back-bone of both the engineering and the architectural professions. This is where the two should really meet. Irrespective of the diffences in professional attention or focus, or perhaps just because of this difference, the two should fruitfully combine in letting the material be a central issue, that which architecture is made of. The strategy I am trying to outline communicates an attitude towards materials that sees materials from an operative, functional point of view, but also having an expressive capacity. Students should be trained in identifying the problems at hand which are overcome by help of materials. We should not start to ask *what* material to choose, but rather *what kind* of material. We should seek out the problems, not jump to solutions. This is probably partly what Peter Rice had in mind when he said:

"This is what I would call examining the nature of things. It is a study of the nature of the structure, rather than the image, which yields the greatest puzzle and the greatest satisfaction when it is understood".[1]



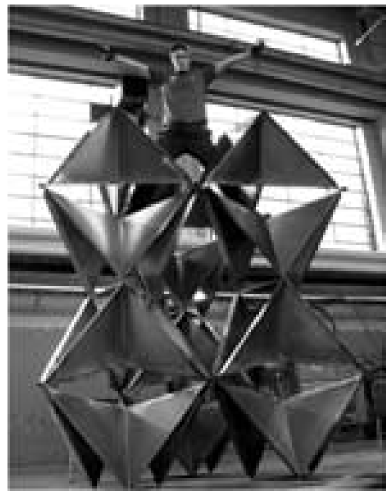
Solutions can often be found in the form of standard products, but architecture would gain from more individuality and variation. Variation will inevitably happen as a result of a conscious shift of focus from the "finished design" to the actual construction process, if that process is thought of as "problem solving" in a particular context, rather than an assembling of standard products which almost fit.



Why this attention to the building process?

I see this as a strategy for preparing students for the future. It is a strategy to avoid a further marginalisation of the architect by educating him or her to know as much as possible about a very critical phase of a project, a phase where the architect is very vulnerable and often in the hands of other expertise who takes charge. I am taking about the difficult *translation* of complex concepts into physical reality. At some point the digital model in the computer or the hand-drawn sketch should be seen as a piece of architecture having size, weight, strength, texture and smell. The form is given shape and dimension. The lines of the drawing become contours of some element to be made of real materials.

It is a translation that takes place, but it is also a transformation. I consider it my responsibility as a construction teacher to contribute to the knowledge the students need in order to make such a transformation with the ideas and intentions for the concept intact or whole. Transformation is in fact what technology really means. In some contemporary architecture in particular, having a complexity of space and form made possible by computer graphics, will we find highly demanding concepts that take great knowledge to further develop into buildable, consistent structures of material substance. I consider this transformation from designed ideas to worked-out plans for actual construction to be, not only a part of the work of an architect, but a *vital* part of the architect's work. It is by this process the architect can take charge of the final result, and make sure that things move forward according to the intentions. It is also by this process that the results can be individual, varied and reflecting the particularities of an industrial culture that show differences from place to place.



How should we do a construction education where one of the goals is that of looking at the actual construction process as a design problem?

Firstly, it is not a question of offering a method that leads to a certain design solution. It is more like following a strategy that will enable students to find out by himself or herself by trying things out and seeking relevant information. It is a strategy that by critical analysis, investigation and questioning will lead to a well thought-out result that may have a surprising form. The more apparently simple the solution seems to be, the easier it is to cling on to preconceived solutions. This is why it is important to make known structures from unusual, or little known materials. They will provoke you to think. Sometimes, we specifically ask the students *not* to make something "beautiful". What is thought to be "beautiful" is almost always designs that are known and pre-accepted. If you want to innovate, you shouldn't make "beautiful" things! (Still, if solutions seem to be "appropriate" with respect to its function and the context, new solutions will after a while be considered "beautiful"!)

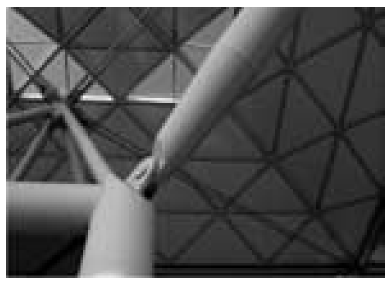
Project reviews should according to this strategy always address also that which you don't see, that which is behind walls and roof ceilings. Architectural critisicm ought to take seriously constructional matters, production and building process.

A part of this strategy is also to propose design exercises that not even the teachers are having a clear idea of what might be the result. This is a way of eliminating as much as possible any preconceived notion of what to expect. Designing and making a stair-case made of nothing but

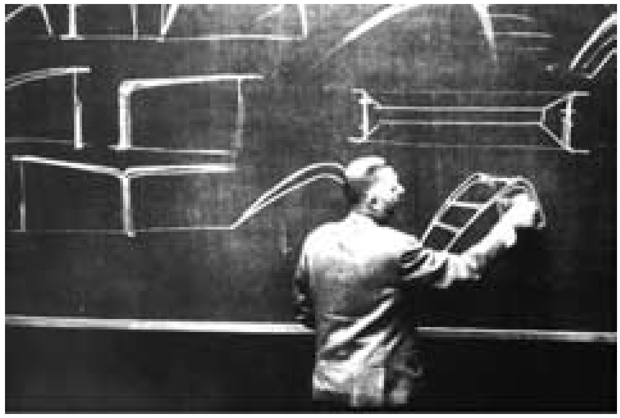
1mm steel plates might be such an exercise. This would call for a re-thinking of stair-case construction, and might put both students and especially teachers off-balance, which might be a good thing!

At Oslo School of Architecture we are quite fortunate to have very generous work-shops for making things, separate work-shops for wood, metals and plastics as well as a large construction hall where building parts and whole structures are made in full-scale. Besides, we have this fabulous Rapid Prototyping machine where small parts like structural details are made by sintering. 3-D drawings from the students' computers are fed into the digital brain of the RP-machine, and out you get the real thing made in a material of your choosing, well, almost of your choosing. The machine sinters plastics, steel and ceramics according to what kind of piece you are making, and what function it has. We are therefore very well equiped in Oslo for a construction education which also takes the actual construction process into account.

I will postulate that taking an interest in production and material processing, today seems to be engaging "traditional" knowledge and values because it seems to be against important architectural trends. When I see this as a strategy for the future, it is because I believe that to engage in the act of building, in how to build, is something that will remain an important aspect of architecture. It is not trendy, nor fashionable, but precisely because of that, is this a knowledge and a skill which may be seen to last.



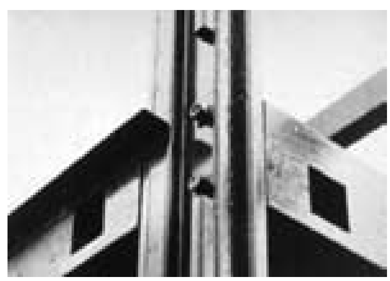
This strategy advocates an architecture which reflects a concern for the construction process. I would like to exemplify these ideas by referring briefly to one figure who can be seen as a very prominent representative of a tradition of builders and constructors, for whome the process was all-important, namely Jean Prouvé.



As it is, the case of Jean Prouvé seems to exemplify a somewhat extreme technological approach to structures. Born in 1901, Prouvé had a working career spanning six decades of the 20th century, sixty years in which he worked closely with architects of three generations. Being neither an architect or a formally trained engineer himself, he called himself a "constructor", which he truly was.

To be able to recognise the particular contribution of Jean Prouvé we must look at structural design at a detailed level. It is by observing the particular shapes of the structural cross-sections, as well as the detailed construction of façade panels, that we are made aware of the influence on structural form of the preferred material of Jean Prouvé, namely thin sheets of steel. The material, however, influences only marginally on the overall, or the *global form* of the structure, but instead has a major impact on how those building elements are actually constructed. *The material shows itself for what it truly is on the more detailed, local level of structural form.*

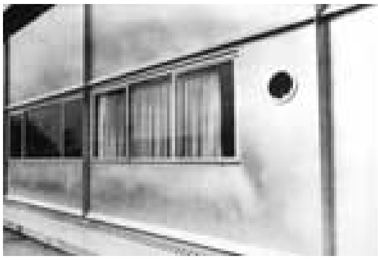
From the point of view of actually testing out the ideas of industrialised, sheet metal building production, the years 1935/36 saw a great success: With architects Eugène Beaudouin and Marcel Lods, and engineer Vladimir Bodiansky, Jean Prouvé designed and built a house for the Roland Garros Flying Club at Buc in France. This was probably the first ever totally industrialised, prefabricated building; structure, external walls, roof, internal partitions and stairs were all made from folded steel sheets. All of this was made in Prouvé's own workshop. The requirements were for a very quick construction and that it should be a demonstration of contemporary architecture. Based on the initial sketches, Prouvé was able to make a prototype of a slice of the building which was erected inside his workshop. After being approved by the architects, they started to work out the final design and the construction drawings.



The simple, rectangular building volume was constructed by the use of a steel skeleton of columns and beams forming cubes of 4.5 m, with also an additional midpoint roof beam. Again, there is nothing of particular interest in this overall structural shape. *On the local* form level, however, we can trace Prouvé's technological mastery: The whole structural frame is made by 3 mm steel sheets, folded so that they form stiff structural elements.

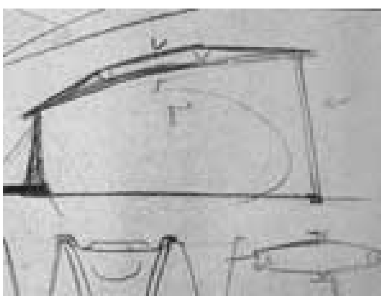
The *jointing* of beam and column, however, had to provide a bending stiff connection in order to brace the whole structure. This particular difficulty was solved by welding pieces of steel tubes to the inside of the column, so that bolts were able to go through, fixing the beam by those. In addition to the stiff column and beam connection, the façade panels provided additional bracing of the finished building.

The particular visual quality of the custom-built structural elements and joints is evident. Beam and column are fitted together, carefully adapted to each other down to the last millimeter. To this structural joint, façade panels are fixed with the same precision. This is perhaps one of the major advantages of the use of sheet metal constructions. As Jean Prouvé said late in his life; "one has to be very competent to know, for example, what it is possible to obtain simply from a tipper press. It is only when one uses

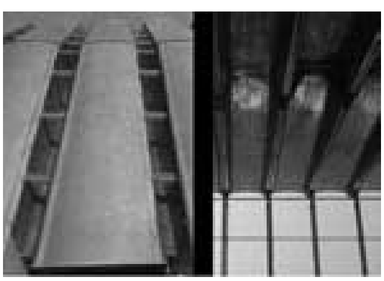


the press as a starting point that constructive inspiration can happen". While accepting this statement as the opinion of a man who depended on a characteristic *intimacy* between the idea and the manufacturing, we may note that he, by referring to his tools, his machinery, addresses the actual *construction* work rather than the inspired conception of a *structure.* His concern is mainly the know-*how* rather than the know-what. He deals with the *technology* of building production and activates primarily the local level of structural form.

The façade for the Roland Garros Flying Club was equally inventive. Towards the airfield were large glasspanes. The rest was covered by huge steel façade panels spanning the whole length between the columns, and consisting of an outer and an inner sheet with insulation between them. To give them enough strength, the two sheets were connected by leaves of sheet steel. Prouvé at the time was panic-stricken by joints; without the modern plastic filling materials, joints were filled with cement. Naturally, this cement would crack when the panels started to move from temperature changes. Consequently, he made the panels as large as possible, 4.4 by 2.25 m, reducing the number of joints. Vertically, the panels were connected along the columns, taking advantage of the recess in the cross-section of the columns. The joints were finally covered by specially made joint covers, a solution which was not foreseen during the design. The windows were fitted into the supporting structure in exactly the same way.



In 1954, Prouvé made the exposition pavillion for the Centennial, the 100th Anniversary of Aluminium. It was a rare occation in that Prouvé himself was the architect, working with two engineers; Henri Hugonet from the aluminium industry, and Armand Copienne, who was doing the calculations and the working drawings. The site was the Quai Alexandre III in Paris, with a width that restricted the Pavillion to 15 meters span. For a man like Jean Prouvé it must have been annoying to be told by the building committee to "design forms in his own style". What he did was rather to design in the "style" of aluminium *detailing,* to let this pavilion uncompromisingly become a demonstration of the potential of aluminium in its various forms. He subsequently used aluminium sheets, extruded aluminium and cast aluminium in different parts of the structure.



Prouvé sketched a large number of different solutions. What he finally decided on was a four-pinned post-and-beam structure, depending on an external strut for stability. The façade facing the Seine is taller than the one on the other side, and the roof is slightly raised at mid-span. It is not a very exciting structural concept we observe, even if some of his sketches seemed promising. The design of larger-scaled, particular structures was probably not one of his strongest talents. On the *local* form level, however, there is no doubt that a master of metal construction has been at work.

114 U-shaped beams span from column to column. The beams are made of 4 mm thick sheets of aluminium, where the two sides are kept at a distance by small aluminium struts. In Jean Prouvé's workshop, they had a pressing machine specially built for this project. The beams are produced in three parts that are connected by help of specially designed splice plates and screws. Those beams also act as rainwater gutters. Two

neighbouring beams are connected by brackets of cast aluminium and bolted. Between them, curving aluminium sheets span the small distance.

The multipurposed columns are extruded. Their intricate shapes reflect their purpose both as vertical loadbearing, as supporting the wind-load, as accommodating the fixing of the façade, as well as their function as drainage pipes. This is a typical example of the often used principle of Prouvé of integrating several functions in one component. At the foundation level, the extruded aluminium column is welded to the cast-aluminium pin-joint.

There is no time here to go into the many structures of his working life. The best ones were created when he was able to draw, to experiment, to make prototypes and to manufacture in a single, uninterrupted process. Jean Prouvé was always critical to the separation of designer and producer, a speciality of the building industry as Prouvé saw it, and very unlike the process of designing and building cars, aircrafts and numerous other industrial products. He had high regards for designers/builders like Auguste Perret and Pierre Luigi Nervi, a list that might also have included Robert Maillart and Edouardo Torroja.

Prouvé's influence on the projects he was involved in was definitely strongest on the level of detailed construction, on how structural cross-sections were shaped, how elements were fitted together, how facades were assembled and adjusted to the main structure, how ventilation and water transport were absorbed by structural components, etc. This area is also where he has made a lasting impression on later generations, and where we can find inspiration today. He was exemplifying perfectly the ability to develop architectural concepts by means of process skills.

Lastly, I will show you a work of architecture made by two former students at Oslo School of Architecture, who are presently both teaching there. It is a church in the outskirts of Oslo, called Mortensrud, and the architects have been Jan Olav Jensen and Børre Skodvin. This is a much praised building; it has received prizes both in Norway and internationally, and is widely published. In many ways this piece of architecture can be seen to embrace values and ideas held by Jean Prouvé. It is a building which tells the story of how it is made, and it is by taking the process and the materials as a premise for the design concept that its particular qualities arise.

Basicly, the lay-out is quite simple: The owners wanted the church "to look like a church", which means they wanted a traditonal plan that did not incorporate rooms for the parish's social events, which has been so very common in the Lutheran churches of Scandinavia. Rooms for social gatherings other than participating in the Sunday Mass were therefore mainly located to a separate building.

The materials are rough slate stones, glass, steel with no surface treatment other than having been oiled, a concrete floor. It is a combination of traditional and very modern materials, working together to make an unmistakenly contemporary expression.

Very simple-looking, even primitive.

Columns change position, giving way to the surfacing rock. A very pragmatic design decision, but it introduces some tension in the project.

Support details for the glass façade of the architects' own design. The geometrical problem of the strut was to change from a vertical to a horizontal direction, hence the twist.

All in all, I think this piece of architecture expresses the quality of having knowledge and a love for materials, as well as skills in the working of materials, making materials yield to the actual practical problems at hand.

A very pleasing and consistent design, that I think illustrates very well my ideas and visions for, at least a part of what I see as being important for a construction education for the future.

References

1 Rice, Peter: "An Engineer Imagines". Ellipsis, London 1994 (1996), p. 146.