XXXIII IAHS
World Congress on Housing
Transforming Housing Environments through Design
September 27-30, 2005, Pretoria, South Africa

Poor materials – simple constructions – complex solutions

Stefan Pollak

Dipartimento di Progettazione e Studio dell’Architettura
Università degli Studi di Roma Tre, Rome, Italy e-mail: pollak@uniroma3.it

Key words: lightweight building | self-organizing structures | involvement of non-experts

Abstract

At a global scale, architects and planners are involved only in a small part of the physical transformations happening in nowadays towns. Most of them are driven by individual decisions which tent to act on single aspects. Are the conventional planning tools still appropriated?

Recent researches tend to recognize the complexity emerging from this continuous overlaying of individuality as a value to work on instead of seeing it as a matter of chaos or disorder to contrast. Understanding some of the systemical rules behind space-users behaviour and about disposable resources should allow to use these same rules in order to act with so called “virtuous impulses”.

We think that non-experts such as end-users, students or non specialised volunteers play a central role in this framework and are leading some experiments to verify this. On one hand the direct contribution of non-specialised manual work, helps to cut the investment costs normally required for the introduction of new technologies, on the other the *non-experts* are – at the same time – holders and vectors of precious information to be considered in construction processes and thus in the transformation of the urban or natural habitat.

These self-organizing processes require “rules of the game”. The present paper shows two experiments involving citizens of a rural community in North-East of Brazil and youngsters from a secondary school in Southern Italy. The information-resource which composes the said rules is given by simple algorithms consisting in cutting patterns, assembly procedures or similar detail solutions; they guarantee certain aims such as feasibility, lightness and sustainability without actually fixing a formal end result.

The actual form emerges in progress as a result of the described technological inputs and the complex framework of local requirements or desires. One of the main focuses of our research is on the possibility to use design for positive influence on this processes without restraining the final spatial quality.

1 Introduction

1.1 background

In the 1970s Victor Papanek believed that “design has become the most powerful tool with which man and woman shapes his and her tools and environments and by extension, society and himself or herself” [1]. In nowadays urban transformations instead of using design as a tool to form environment and society we can observe a large and uncritical reiteration of consolidated spatial and material solutions. Designers and planners are not even involved in the most part of this transformation processes and even when they are, technological, economical and cultural constrains often seem to predict final end results more than the actual peculiarity of the situation to be improved.

In our researches one of the questions we are focusing on is: How can virtuous design impulses penetrate the urban and territorial transformation processes in order to increase environmental and social suitability? Two typical aspects of our contemporary world seem to engrave particularly on these processes: the segmentation of the building process and the deal with information as a resource. Can we turn those aspects into opportunities instead of considering them as limits?

1.2 segmentation of building processes

Recent architecture is becoming more and more complex not only formally. Designers and planners decide to employ technological solutions they hardly know or materials manufactured elsewhere, delegate part of their decisions to specific experts or act themselves as experts on circumscribed issues of larger processes. As Rem Koolhaas says in the introduction of his classic S,M,L,XL “randomness is the underlying structure of all architecture careers: they are confronted with an arbitrary sequence of demands, with parameters they did not establish [...]”[2].

This leads to a segmentation of the decision process which influences the whole sphere of contemporary architecture. Generally architects and planners are sad about this “loss of authority” and prefer contexts where they can act as single playmakers. However, if well managed, the segmentation of the building process can bring the opportunity to host at each step virtuous contributions which can arrive from a diffuse knowledge even if not structured or specialized. Moreover this allows to verify each single step as for its environmental and social sustainability.

1.3 information as building resource

German architect Thomas Herzog considers three kinds of variables we can act on while leading transformation processes: material, energy and information[3]. Actually the availability of energy can make up for the lack of material which could be imported from elsewhere. The presence of material on the other hand can produce energy through combustion processes. In both of cases however we loose these resources. Information on the other hand is a resource which is not consumed during the use.

Modern information technologies help us of course in increasing the information flux but not all contexts are achievable (yet ?).

Considering what we said above, verifying how the inflow of information resources can act on substantially self-organised and spontaneous transformation processes in order to activate virtuous processes seams to be a central question. Can this be addressed towards a structural design solution?

It seams plausible to think about a way of building with a strongly adaptable execution which should be able not only to react at the peculiarities of the site and of the social context but as well at the continuous feedbacks coming from the transformation process itself. Each choice actually conditions the following. In order to benefit from the information fluxes transformation processes can activate, it seams to be useful to find a strategy which allows to fix as few as needed without constraining more than necessary.

This concerns certainly all levels of design decisions from constructive details to questions of interaction with context and resources.

2 subjects and tools

2.1 contribution of non-experts

We are generally induced to think that complex problems require expert contributions. In the last years interdisciplinary teamwork is becoming more and more widespread. Nonetheless some aspects have to be considered:

- **simplified knowledge** – The expert's approach tend to suppose border conditions of specific contexts which are necessarily simplified and thus non responding to the complexity of the system to intervene on in order to keep effective.
- **slow feedback** – The feedback between elaborated and applied proposals and their relative effects on the environment or on the general public is very slow making possible route adjustments difficult.
- **conventions** – Within the apparatus of techniques, disposals or procedures experts use they tend, in favour of a presumed efficiency, to privilege systems with lower performance just because they may appear more easy to apply.

To receive in an operative way the contribution of so called *non-experts* can help to go beyond some of the said limits of approach. In specific contexts the presumed *non-expert* can easily become a deep connoisseur of concrete aspects which could not be considered by the professionals in the field or which at least would be treated with essential oversimplification. Moreover, interacting with the eyes of the dilettante helps the expert to avoid conditionings due to common places or conventions and rather lets transport himself by curiosity while proceeding on the base of observation.

This makes it important to have a good communication level and immediate information fluxes between all involved actors. The joint work of professionals of the field and so called non-experts requires an agreement on a sort of common language to communicate with in order to consolidate the common starting points and exchange the decisions step by step in a profitable way.

2.2 simple technologies

The considerations we made about architect's and planner's non-involvement in the main part of spatial transformation processes suggest to introduce the term of "simple technology". We intend it as constructive approach based on the executive, manufactural, artisan or industrial capacities of the specific context of intervention. This is not necessarily linked to formal regionalisms or "back to the roots"- attitudes, but it has to do with locally disposable skills.

In poor countries, for instance, we can observe a very frequent coincidence between the figure of executer and end user. This is due in large part to specific economic conditions which are often problematic and quite often this way of building doesn't guarantee a sufficient spatial quality as for what we call *habitability* (climatic, hygienic, aesthetic ...). On the other hand, the presence of work force and the attitude to form autonomously the own space can constitute a resource which can bring enormous advantages to poor populations and to the environment.

Involving the end users directly in the design and realisation processes can be valid at all latitudes. Conventional design approaches generally don’t involve the directly interested persons renouncing to precious resources of specific knowledge or information. As we already saw, experts tend to consider simplified border conditions which often don’t respond to the complexity of the system they intervene on in order to conserve a certain effectiveness.

Simplifying technology sounds like a defeat but it is the way to trigger information exchanges and direct technological transfer.

2.3 interaction between external knowledge and local skills

Once we accept the importance of easy and direct information fluxes between all the actors involved in a certain transformation process, we have to care about how those fluxes can be set up. In our experiments, described later on, we try to start from the locally available resources and skills.

The technical skills of the end-user community build the base for the technological choices of the design process. If the end-users are school-pupils their skills are different from those of a rural community in Southern America rather than South-East of Asia were we can find already trained artisans as well as simple volunteers, but the methodological aspects don’t change. Each starting technique can be implemented by technological choices with the aim of defining climatically, hygienically and aesthetically satisfying spaces.

The process segmentation on one hand and the use of local skills on the other form a practicable base for further implementation during the realisation process itself. Aspects like excessive solar radiation, natural ventilation, visual connections, property definition etc.. This specific aspects are the ones which profit the most from a diffuse *non-expert* knowledge on site. On the other hand, cultural constrains and high investment costs prevent technological innovation from reaching some contexts. In our researches we try to find out how external technological knowledge and local skills can come together and build specific, circumscribed technological innovation.

Using lightweight structures has a double value in this logical framework. Using less material to resolve a spatial task is *per se* an environmental improvement as less embedded energy is spent for the realisation of the building; this is even truer if the employed materials are renewable or recycled. Beyond this aspect we found lightweight structures to be more suitable to welcome untrained persons on the building site and benefit from their contribution. The single building components can be lifted and manipulated directly by a few persons without difficult apparatus; in this way also security problems are much easier to manage than on conventional building sites.

Integrated workshops with the participation of end-users, external experts and groups of students from the architecture faculty seam to give good results in this sense. The realisations described in the following chapter are first experimental results our research team is obtaining in this field.

3 experimental results

3.1 tensile structure

One of our most recent experiments is about suitable building techniques for self-built tensile structures with recycled materials.

In Murici, a small rural town of Brazilian North-East, a cultural centre for young people is being built. One part of the complex shell be used for physical activities such as dance, gymnastics or theatre. The architects (Rome based office *s.e.l.f. - officina di architettura*) decided to cover an open air space between two buildings with a lightweight-structure in order to prevent the space below from excessive sun-irradiation and rain while keeping a good ventilation.

As the whole complex has been financed through a private donation, it was a declared intention of the promoters to grant a direct involvement of the local community, especially of the end users. Together with the design team we discovered the planned lightweight-structure to give the best opportunity to develop a specific building solution starting from locally available skills and resources. Among the didactic and cultural activities to be held in the new-built centre sewing-courses and a so-called *oficina de reciclagem* (recycling-workshop) are foreseen and expert tailors are collaborating in the program. This brought the idea of a tensile structure made of recycled membranes.


Figure 1 & 2: prototype for self-built tensile structure

In a first prototyping phase different easily available fabrics were tested as for their material qualities. White woven plastic bags, commonly used for transportation of rise or beans, seamed to be easy to find, and produced a very comfortable diffuse light-effect. The printed letters and logos, if well assembled, form patterns with an interesting *ready-made* character (Fig. 1 & 2).

As the woven plastic bags are not perfectly water-proof, we decided to use waxed fabric. The informal but well organised recycling economy in Brazil helped us to find an inexpensive and well suiting material. Teams of *catadores* are organized among the young citizens of Murici in order to find torn beach umbrellas at the near seaside of the state capital Maceiò, one hour by bus from Murici. The fabric of these umbrellas can be reassembled following a doubled curved form which grants a sufficient stiffness of the whole membrane.

The genesis of the final form is the most delicate aspect in designing a tensile structure. The geometry of high and low vertexes, the border shape and the inner membrane tensions determine complex feedback effects while adjusting the whole form. This conditions also other aspects such as water run-off, material duration and aesthetical result.

Controlling such multiply interdependent aspects with numeric models requires great accuracy and causes a slow-down of design feedbacks on site. A more direct process of morphogenesis can be obtained using a real scale model of cables. The linearity of the cable allows to model it easily by tending it; a single cable assumes a catenary geometry (very close to a straight line, if the distance is not too large), more cables can be disposed in order to forma a double curved surface, a hyperbolic paraboloid i.e..

Working on a wire mesh instead of closed membranes allows a progressive adjustment of the geometry by intervening in a trial and error process on three kinds of data:

- position of the single vertexes, especially their relative altitude;
- total length and tension of the border cable, which causes a homogenous tension on all inner cables;
- tension on each single inner cable.

Once the geometry is considered satisfactory, the membrane can be manufactured. This is done in the following steps:

- At first suitable material has to be selected and cut. Only parts of fabric with a minimum dimension of 45 x 30 cm without rips can be used.
- The cut material can be manufactured in 45 cm large strips.
- The manufactured strips can be disposed directly on the cable net accepting overlaps in order to form a non plane surface.
- In order to fix the form of the whole membrane before sewing the inner joints and cutting away the overlaps, a simple office stapler can be used.
- In the same way it is possible to fix temporarily the reinforced border of the membrane.
- Once this is done the membrane can be displaced and manufactured directly in a nearby tailor workshop.

The Repositioning of the ready membrane is very easy as the geometry is already fixed by the cable net. This net can now partially disappear. By loosening progressively the single cables the inner tension passes from them to the fabric membrane. Only some cables rest in order to grant the structures stability in the case the membrane should torn under unexpected special loads or vandalic acts.

Our fear of not managing the geometrical control without complex software has been disproved by the patient but nonetheless rapid process of progressive adjustment. The whole prototype was built in three days with the help of volunteers who never worked in the field of lightweight structures before.

3.2 shell structure

Another experiment has been run with youngsters of a secondary school in Morano Calabro, Southern Italy. Within an environmental education project promoted by the school and our department we decided to find a technological solution which would allow to build stands for the yearly traditional school-market using recycled material. The material we worked on is laminated cardboard from envelops for milk or juice (*tetrapak* or similar). The design hypothesis was to build a doubled curved shell which had to be stable enough to cover the required space without using extra structural material.

The chosen material is well coping with the skills of the young manufacturers. It can actually been prepared by cutting it with scissors ore simple cutters. In this way the whole school could contribute to the preparation of the building components, like a sort of prefabrication. The drink envelopes have a characteristic layering with coloured prints on one side and a strongly reflecting layer of plastic or aluminium on the other. Several elements generate a texture which leads to interesting light-effects.

In order to guarantee an easy assembly process and to maintain the possibility of intervening on the morphological structure while rising the shell, we developed a special cutting pattern which had to respond at two main requirements:

- The cardboard element has to be folded in order to augment moment of inertia and stability.
- It must be easy to join single elements permitting them homogeneous load transmission without preconditioning the end result during the assembly process.

We developed a cutting pattern which folded in the right way formed a square of 14 x 14 cm with nervures on the four sides. The height of the nervure is unequal; 6 cm for the positions more close to vertical and 3 cm for the flaps which will be placed in an approximately horizontal position. The required measure of 26 x 20 cm is well coping with all of the most used commercial envelope types.

Figure 3,4 & 5: assembly steps of cardboard lightweight shells

The assembly procedure is composed of the following steps:

- At first suitable material has to be collected and washed. In our experiment this has been done directly by the pupils together with their friends and parents.
- Each drink envelop has to be cut following the described pattern; starting from a rectangular form and cutting out flaps to be folded.
- Once all the flaps are folded, the single elements can be joint together in a first step. We used metal eyelets like those used for leather works applied in the middle of each flap. This guarantees a good connection between the elements but does not fix yet the angles and the final form.
- In some strategic points we introduced special pieces in order to increase the curvature once the shell will be lifted.
- The said steps lead to a sort of colored soft carpet which is ready to assume a lot of different forms (Fig. 3).
- The final form definition has to be made progressively by fixing the angle points of each flap after modeling approximately the desired shape. The layer can be shaped by tension using cables fixed in some points in order to lift the whole structure (this requires high temporary anchor points) or by compression posing bulky objects such as tables, chairs or ladders underneath.

- At a certain moment the shell is stiff enough to be lifted in its upright position. The very low weight (about 14 kg) helps in this operation. In this phase it is still possible to intervene on the final form adjusting the relative position of the flaps.
- A secondary structure of small strings tended from border to border and passing through the metal eyelets of the flaps can be used in order to increase the stiffness locally where required.
- The acceptable stiffness of the shell and its very low weight allow to displace it easily which facilitates the manufacturing process.
- Once in place, fixing the lower border on earth gives the whole structure its final stiffness. In our case we obtained this simply by covering the lowest row of flaps with the gravel we found on site.

The whole building process has been supervised by members of the Environmental Design Group but each single step was conceived in order to be feasible directly by the end users without special training but using their specific skills.

4 conclusion

Adjusting techniques in order to trigger diffuse technological thinking can be achieved starting the design approach from local skills. Using the building site as a place of live-experimentation makes it superfluous to have a predetermined idea of final form as well as theoretic training of involved persons. Both of them can be discovered during the building process and will emerge through a continuous transfer of knowledge.

Richard Stallman, the inventor of open-source software, once said that knowledge will develop at its best and realize all its potentialities if it is considered a common good and everyone can freely make use of it. Why shouldn't this be true for architecture as well?

Acknowledgements

The described tensile structure has been developed in cooperation with *s.e.l.f. – officina di architettura, studio Mod,* Dipl.Ing. Marina Kavalirek and the pupils of the Cultural Centre *Madre Leonia,* Murici (Alagoas / Brazil).

The shell structure has been developed with Prof. Piergiorgio Rossi and the Environmental Design Group (arch. Lorenzo Alfieri, Orlando Giglio, Davide Giorgi, Davide Negro, Nicoletta Mosco, Monica Preziuso, Francesca Rango, Elisabetta Romano, arch. Laura Tallarida) and the pupils of the Secondary School *Gaetano Scorza*, Morano Calabro (Calabria / Italy).

Reference

[1] Papanek, V., *Design for the Real World,.* Academy Chicago Publishers, Chicago,1983

[2] O.M.A., Koolhaas, R & Mau B., *S,M,L,XL*, The Monacelli Press Inc., New York 1995

[3] Herzog, T., *Solar Energy in Architecture and Urban Planning*. Prestel, Munich, 1996