Adaptable Typologies for Active Roofs

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ABSTRACT

The main objective of this part of the 6th framework Pan-European EUR-ACTIVE ROOF-er project is to improve the interaction between design participants of dynamic adaptable Active Roofs in product development and Active Roofs from an architects/ customers perspective. Improvements in Active Roof design on the basis of those technological product requirements that architects / customers deem to be the most important product / system benefits. This requires a common framework for information exchange that is scaleable with respect to the level of sophistication of each of the organisations and designers / engineers involved. Moreover, the desired information to be shared must be interpretable (language, terminology and definition) by all designers/ engineers [EURACTIVE ROOFer 2005].

Especially conditions for developing a design method for innovative roof-concepts are an essential result of the research. Part of the project is focussed on special roofs which are adaptable in function, structure or in material. Properties of these active roofs are: tensile / membrane, inflatable or retractable structures. Subscription of the several aspects of design (i.e. building physics), - sustainable energy and use (i.e. maintenance, safety, assembly), is information needed for better innovative products. The knowledge generated in this project directly benefits the Building Services research and education at Eindhoven University of Technology, Delft University of Technology and the department of innovation of renewable energy systems at TNO Building and Construction Research. The developed methodology is also implemented in the 6th European framework program; EUR-ACTIVE ROOF-er.

1 Introduction: changing environment causes adaptive building typologies.

During the end of the last century, the oil crisis made clear that there were limits to the natural wealth of our planet and to the price which we want pay. From that moment on more research started on ‘economy’ and ‘re-useable sources’. Cheaper raw materials, better production methods and a design based on functionality and efficiency were new challenges. Now, nearly 30 years later a number of these aims have been already reached and in the field of socio-economic strongly thinks has evolved. More insight into the possibilities of new materials and technologies generates new possibilities for implement them into new buildings. Clients on the other hand became more and more aware of the changes of the environment and society, this causes a more complex field of requirements. Building typologies who are able to gife form to thes changing requirements are needed for the future.

Intelligent moving systems are new in surroundings where objects are generally static and interactive spatial or functional (form typology and agents typology) adaptability is still nearly unknown. An architecture, and methods to create it, which can contain these kind of systems still needs to be developed. She considers to the changing interaction patterns between the individual and its constructed surroundings and answers to the specific needs of human activity. From the specific question for flexibility our technologically world has to generate new architectural – adaptable – typologies. Buildings which consume less resources and efficiently react complex, related to the specific situation and programmatic requirements, are particular interestingly for an industry, strongly aware of its growing responsibilities with respect to people and nature. Study into objects which appear physical only at certain moments and simply disappears or transforms if they no longer functional will cause the development of ' deployable structures ', adaptable structures which can expand or close to a compact configuration. A more adaptive and 'intelligent' architecture can be developed. [Block&van Mele 2003, Mollaert & Hebbelinck 2000]

2 Changing buiding typologies need adabtable rooftypologies.

An almost forgotten part of the building is the roof. Very little attention is paid to the roof during the building design. There are limited possibilities of optimization during the traditional process, while optimization in the later stages of the process is often troublesome or even impossible. Especially for the roof design this often means addition of many stand alone, mono-functional, technical equipment.

Beside of the poor architectonical quality it means sub-optimal solutions for attainability, lay-out, performance and management of the equipment as well as more possible damage to the building construction and future severe discomfort. The design and performance implications of such a process often include the following practical consequences:
- The building / roof takes little advantage of the potential benefits offered by sustainable energy;
- The building / roof may not be designed to make advantage of its daylighting potential;
- The building / roof do not use the future possibilities to use the roof as an additional space for extra functions and doesn't give space for possibilities to use the roof as an ecological landscape. [Larsson 2001]

Related to the design-process there are many aspects which frustrate a better use of the collaboration between the roofers or roof-industry with clients and architects. First there is a lack of diverse information, language and knowledge. Secondly there are different levels of technical sophistication in the design and building process. Third aspect, if there should be a possibility to innovate; there is a lack of knowledge about innovative roof systems and how to integrate them in the building design. [HBA 1999, EURACTIVE ROOFer 2005, Freedonia 2005]

Referring to the current situation there is a need for change. The word Active Roof is the concept word related to these changes; the possibility or need to change the culture, process and product related to the roof. This means other kinds of knowledge, skills, organization and responsibilities.

3 Design approach needed for adaptable typologies

Within the complexity of problems and solutions a broader view is necessary, an integral approach which which can be continously be adapted and developed [Quanjel & Zeiler 2003]. This integral approach can eventually lead to integral process, team and method – all the required conditions (and parts of integral design methodology) for design and integration of sustainable comfort systems in buildings. Structuring all the requirements, within a process and project, needed for the development of this approach and innovated solutions, is needed.

The framework for structuring actions of team members is found in 'Methodical design' [vd Kroonenberg & Siers 1992], a model which is problem oriented and distinguishes, based on

functional hierarchy, various abstractions and/or complexity levels during different design stages and design phase activities. This framework that proved to be successful within mechanical engineering domain [Blessing 1994], and which makes it possible to explicitly think and act on one specific abstraction level, needs to be adjusted for use in design teams within building design domain.

The concept generation phase is an important stage of the product realization process. This phase dictates the level of innovation and also predetermines the product cost to a significant extent. Recognizing the importance of the concept generation phase, several researchers have focussed their attention on creating generic methodologies for improving the innovative abilities of the designer [Pahl et. al 1996, Jansson 1990]. These methodologies use two common strategies:
- Dividing the design task into smaller tasks, as it reduces the cognitive effort required from the designers and thereby increases their innovative capabilities;
- Generating several conceptual solutions thereby increasing the probability of identifying an innovative solution.

Generating concepts can be done by the use of the morphological matrix. The use of the morphologiceal matrix started fifty years ago [Zwicky 1948] and it is still popular today as an important step in the engineering design process [Pahl et. al 1996, Ullman 1997, Hubka et. al 1988]. The morphological matrix represents a methodology for organizing alternative solutions for each function of a system and combining them to generate a great number of solution variants each of which can potentially satisfy the systemlevel design need. The basic format for a morphological matrix is a grid of columns and rows. The first column lists the relevant functions and the row adjacent to each function lists the possible solutions that will achieve the function. The morphological matrix methodology is an effective way to record information about the solutions for the relevant functions and aid in the cognitive process of generating the system-level design solution.

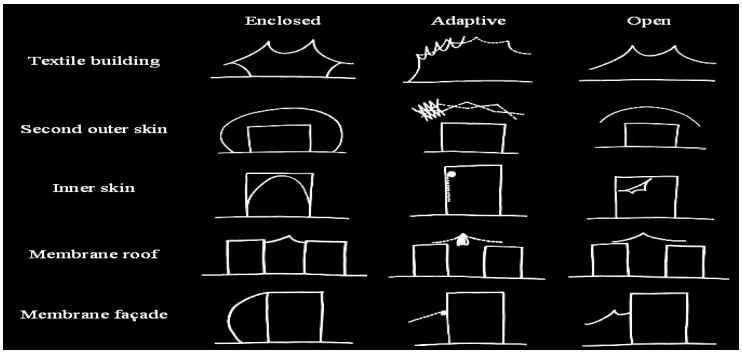
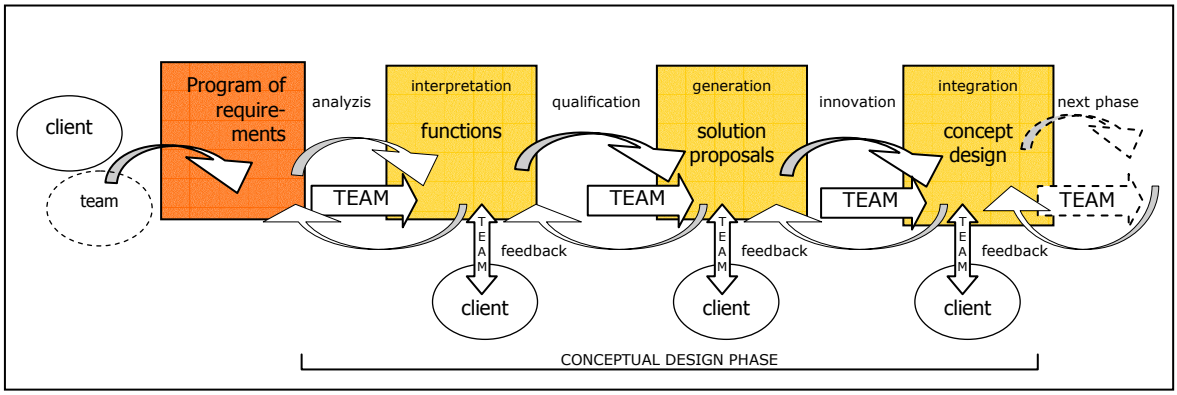


Fig. 1.1 Morphological matrix: typology of adaptable rooftypes (Mollaert, 2000)

4 Development of adaptable roofs by addaptable studies.

In order to develop new innovative concepts the research makes use of the combination of teaching and research. Part of these is the programm with students in first a literature study ‘state of the art roof systems’. The set-up is partly related to the feedback from earlier workshops for professionals, in this field and the theaory of ‘learning by doing’, as part of the professional training supported by the BNA (Dutch Architect Association) and ONRI (Dutch Association Advisors). [Savanovic 2005]

Two types of studies where used so far. The results of the studies with studenst will be used within the future study-programm as well as workshops, to be organized for professionals later this year. All the research is partly related to the the 6th Framework research EURACTIVE ROOFer. Both studies by students where based on ‘research by design’ and the use of the Methodical Design Method with the use of the morphological matrix. The study follows several steps of research: analyzis, classification and finally innovation, all realated to feedback by ‘the client’ and research during each phase.



1.2 Figure: Process set-up for 'research by design' study

The first type of study was related to the use of sustainable energy systems in relationship with the roof and the agent systems which could make them adabtable to the several users. The study gives an overview of the newest technologies related to sustainable energy systems. To make the systems applicable to the requirement of the different users / clients, an agent-system has than to be developed. To guarantee the comfort in the building and to lower the energy-use / costs, automation of several functions is used. For this type of situations Forgiving Technology is used. Through the use of Fuzzy Logic it is possible to work with scores and not only a type of open/close or on/off form, but all its intervening scores are also possible. [Stone et.al. 2005, Benyon et.al. 2005] This automation is done by the application of so called agents.

Some of these results where than used in the second study; a combination of adabtable aspects related to sustainable energy and the use of agents related to possible developments of adabtable roofs; cushion-, membrane- and moveable-roofs (analyzis). Second part of the task was the development of conditions to optimise these systems for the implementation into the total building design. These conditions where mainly related to design aspects, aspects of supplies (assembly, maintenance and security) and possible new alternatives using methodical devising. A third aspect concerned the quality of the different systems and the test of this (classification). By test on a number of criteria with moth succes-rate, the choises where made. From thereone several alternatives where made and combinations with other systems where made, with the use of the morphological matrixes alternative and/or innovative solutions where generated (innovation).

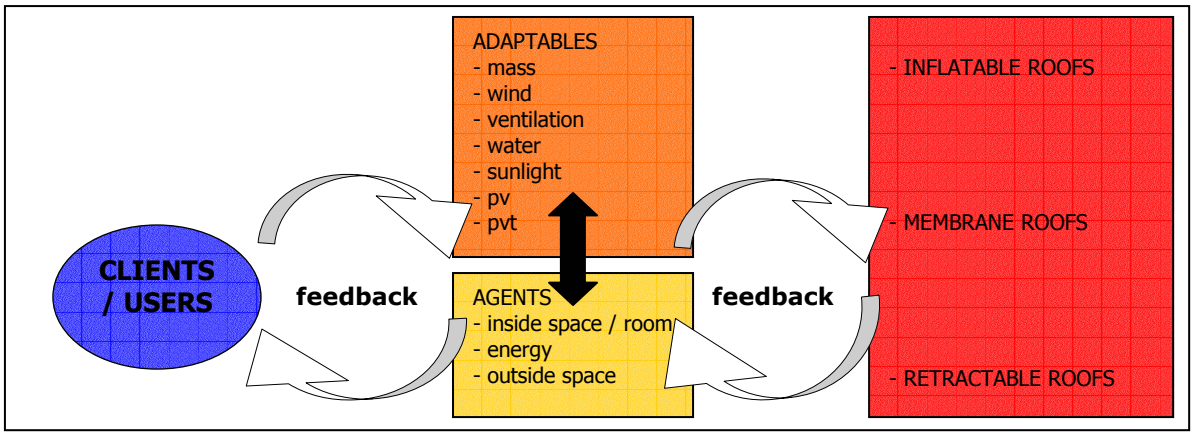


Figure 1.3: Subject set-up for second 'research by design' study

5 Conclusions

The first studies with students showed some possibilities of the use of Methodical Design, the use of morphological matrixes, in combination with developed knowledge of adabtable technologies. These advantages will on one hand be used into the set-up for workshops for professionals and on the other hand into the development of the web-based database structure for the EURACTIVE ROOFer project. The database structure will contain overviews for new design aspects, in order to support the design of more innovative, Active, roofs. The first workshops for professionals are planned for the second half of 2006.

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