Pattern Grammar within the Language of Architecture

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Technology plays an important role in the design and designing process, influencing the architectural expressions and giving an impulse to new developments of architectural language. It has been allways the stimulating push for the generation of new concepts, spaces and technics in architectural design. Especially the developments in the field of material technology and construction industry. Lately, Information and Communication Technology (ICT) pledge to have an important impact on designing practice as well as a part of the technological developments.
In order to widen the application of CAAD in designers realm, it is necessary to interpose new design tools and methods. This means introducing CAAD more as a "designing tool" and making its employment feasible from the very first stages of design process - during the conceptual phase.

Pattern Grammars, which we will introduce in this paper is such a method that provides support to designers, architects and urban planners. These patterns, based on complex 3D spatial geometrical polyhedra and polytopes, when generated, have form and structure at the same time. Parallel with geometry creation, aspects such as accessibility, functionality and integrity of a building should be taken in consideration as well.

Working with pattern grammar within CAAD environment, enables faster generating of concepts and examination of spatial qualities, offering at the same time higher standards of design flexibility and enormous variety. It also introduces new design approaches to stimulate the innovative ideas concerning the design. This, altogether, represents an added value of CAAD.

Key words: *CAAD tools, pattern grammar, substitution method*

Pattern Grammar In Architectural Language Within A CAAD-Environment

INTRODUCTION

The application of Computer science in the 60's started to creep into architects life as a drawing tool, which replaced pencil, ruler, drawing table, but still used in mixture with traditional tools. It was then called CAD. In the 70's this word was replaced by "Building Informatics" which included the use of Information technology in the design process. Nowadays we use the term "Information and Communication technology" (ICT) for the whole building process. In designers realm it is still mainly used as a drawing tool and partially for the information processing. But is it all what we can expect from this very rapid developing technology? Prof. Gerhard Schmitt once stated:

" It is more than a tool, it is a new medium for architects and designers" [RSDC96].

This paper gives an overview about the influence of ICT on architectural design process and focuses on the development and application of a pattern grammar for the conceptual phase of a creative architectural design. It also describes different steps of substitution method that enables architects to comprehend consequences of his/her design decisions.

1. THE ROLE OF ICT IN ARCHITECTURAL LANGUAGE

ICT has a great chance to provoke expansion of new ideas that will support the designing process. In the first place, the ongoing developments of Internet and its possibilities, will surely have an influence on global architecture. Secondly, the developments of virtual reality will bring the architects to new ideas and concepts.

We are already so far that a communication between a living neurone and a chip is established. This extraordinary success to connect living and non-living material will surely open new perspectives and shed a new light on further scientific research in that direction [EOSM96]. Having this in mind, we can expect in the future that the designer will have direct communication with computer without obstacles such as screen and keyboard. It might be even possible that the designer will not only have an optical communication with computer but also tangible communication within computer, where he/she can simulate ideas

directly on a screen. Those are all possible directions we might be heading towards, but where do we stand at this moment and what does it all mean for architecture?

When we look at the developments in architecture during the 20th century, we can state that the innovation in architecture was very high, compared with last few centuries. This has 2 main reasons. Developments in the field of building materials and techniques, on one hand and the developments of computer sciences on the other hand. Result of these developments was that they stimulated exploration of new design concepts and the growing complexity of the buildings and built environment.

In the future, the ICT could have an influence on the designers both during the conceptual phase and the materialisation process (in very first and very last step of design process). Apart from that it can also provide a support during decision making process (consequences of different structure systems regarding costs and time-planning for their executions, or by introducing function-connectivity pattern a number of variations could be created in much shorter time).

One of the methods that could support architects in the phase of conceptual design, is the usage of pattern grammars to explore spatial design concepts. These patterns are based on complex 3D spatial geometrical polyhedra and polytopes. After generating the pattern for their use as an underlayer for the design, next step is to translate the pattern to material components, giving certain properties and attributes to point, lines or surfaces of patterns. This could be possible by using substitution method.

Further in this text, we will discuss the pattern grammar and later on we will come to the subject of the substitution method.

2. PATTERN GRAMMAR IN ARCHITECTURAL LANGUAGE

As it was mentioned before, pattern grammar is for use during the conceptual phase of language creation, but one should not forget other element groups that shape the language as well such as function, connectivity, accessibility etc.

Patterns and main reasons for using pattern grammar as a language generator

The origin of patterns occurs in nature. Their applications in architecture is not new. They were present in every period of architecture and art and in various scales. Think of the cities we live in! The cities are based on a certain pattern. Sometimes it is an organic form that grows into a landscape, sometimes it was enclosed in a very strong geometrical shape (like it was done in the earlier cities), and even today we build our cities

based on a pattern, very simplified but still a pattern - a grid system. [Sari91]

To support their orientation, human beings - by nature - need a certain system of ordering things and hierarchy of importance within that system which brings harmony in design. Within the pattern grammar nothing happens in isolation. One thing leads to the other. Breaks in or between patterns creates other rules which makes observer an active one and gives a sense of orientation. Exactly on these break points concentration of activities can take place. That is where tension is created. For example, in a grid system one element becomes larger and more dominant in the area and its spatial characteristics are different. This not expected change in the patterns keeps an observer awake and it draws attention. [Lync60].

In every human society the application of patterns could be traced. In certain cultures it was more explored and exploited than in others. The most complex patterns can be found in Islamic cultures, because in Islam it is forbidden to draw figures and faces or place the human sculptures in religious buildings. Artists and architects have therefore looked for another solutions. Their answer was ... patterns and with them they have expressed their artistic capabilities up till now. Patterns were applied on the walls, floors and ceilings, lattices for doors and windows, on a textile and carpets but also as a structure of a part of a building. [Sari95]

Regular polygons were used for generating these patterns such as triangle, square, circle etc. in 2-D surfaces. Our starting point for the generation of patterns are the 3-Dimensional polyhedra and polytopes. The irregular patterns were not much used in the history. Probably the main reason for that was, in the past, that it was too complex to generate and manipulate these shapes. All drawings were made by hand and that was time consuming. Nowadays, the computer sciences enables us to use time more efficiently. We can manipulate these shapes extremely fast so that the path from the idea till the realisation becomes shorter and shorter. Using combination of shapes, new shapes can be fabricated. Possibilities to assemble new shapes are endless and with computers, in a very short time it is possible to generate the most amazing spatial structures which go beyond human imagination, as shown in *figure1*.

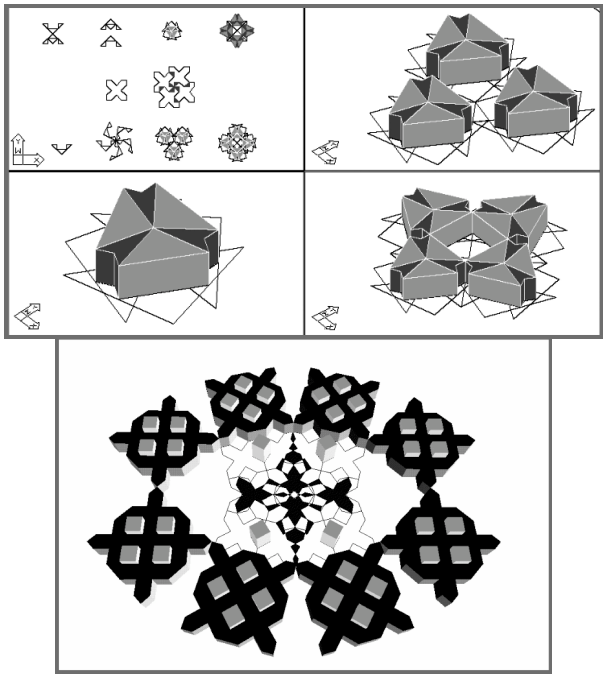

Figure 1: *examples of pattern creation*

One may think that the usage of pattern grammar might restrict the flexibility of a design.

Other may find it too structuralistic. We should take in mind that the patterns are only a design aid. Once a pattern is generated it can be used as an underlayer to determine further the free shapes. It doesn't need to be structuralistic and regular. By geometrical manipulations (transformation, dilatation, rotation, reflection) one can easy generate irregular patterns by means of CAAD tools. Once being acquainted with the logic of patterns, one realises that possibilities of having different variations are endless. Think about what this infinite number of forms and rules could mean for the architectural language!

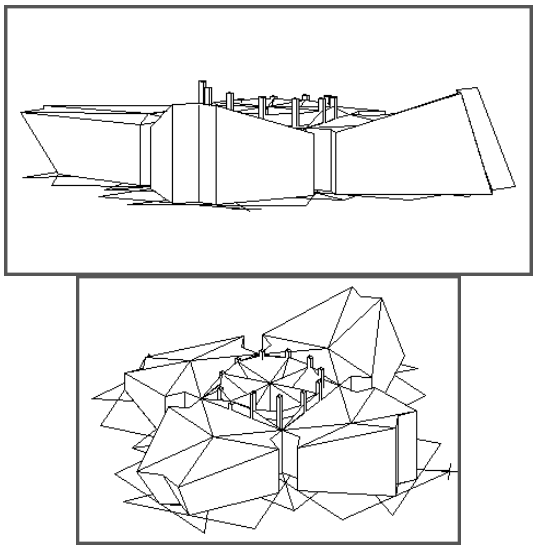

Figure 2 : *creation of an irregular pattern based on the same pattern as in figure 1*

Christopher Alexander wrote about patterns:

> *"Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" [Chri77].*

A key word in this discussion for building construction is "prefabrication". In order to decrease activities on the building sites and to faster "deliver the product" it is impossible to have prefabrication taken out of a building's vocabulary. The main advantage of using regular patterns in architecture lies in repetition and continuation of the rules, which leads us directly to prefabrication of the buildings.

Secondly, main characteristic of pattern is the absence of scale or measurement of the fragments. The grammar of patterns can be used on a different levels of detailing: in regional planning, city-planning, as underlayer for architectural design, till the last details. Architects can choose themselves on which level of detailing they are going to work. As soon as the geometry is created, it has **form** and **structure** at the same time which also brings harmony in design [Sari91]. In that way it is a structure within a structure. Patterns, because of their repetition, have simplicity within complexity which means that applied to architecture this could open possibilities of working with different levels of complexity.

3. THE SUBSTITUTION METHOD IN DIFFERENT STEPS OF LANGUAGE CREATION

Providing a suitable support, it can be possible to design from concept till detail within CAAD environment. Substitution method can be a key to such support. We will describe this method for both phases with an accent on conceptual phase. This method will be illustrated on an example of roof constructions (cupolas).

In substitution method we introduce two "streams" of actions that one may choose to follow. One involves a 2D and the other a 3D working environment. This, we find necessary, for it is not possible to strictly define the design process. Each architect goes differently through the designing process. Some work more confident with 3D models, finding it an important aspect of architectural design. In that way they can easily establish what in their opinion are the spatial qualities and feebleness of design. Other architects have 2D oriented designing deeply anchored in their work, and only if necessary they create 3D model.

We strongly believe that many misdeeds could be prevented during materialisation process and construction of a building if architects would work in 3D from the very beginning of their design process, or at least somewhere on the line before the detailing and the specification of building materials takes place. Regardless of which path the architect

chooses, very soon the two models can reach same level of complexity before they enter a detailing process (global materialisation), that will say, before the model reaches the stage of materialisation it has to become a 3D spatial model.

One or more basic elements are combined and manipulated by means of translation, rotation and dilatation. Depending on number of manipulations a pattern has a higher or lower level of complexity. But even if a pattern seems very complex it is feasible to reduce it to more simple one, merely by creating the priority of the constructing lines. Different patterns can also be generated by choosing different rotation centres. Some pattern creation is given in *figure 3.*

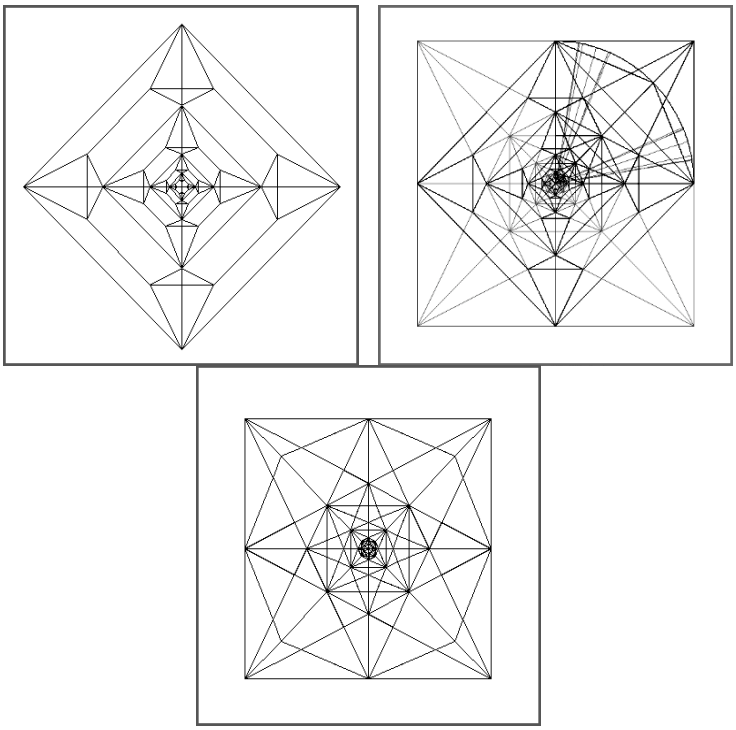

Figure 3: *examples of pattern creation*

As the architect becomes more familiar with this method he/she will favour to begin their work following the 3D stream. In that way the necessary step of translating 2D drawing into a 3D model can be avoided. For cupolas we have developed our own software (within Auto CAD) where it is possible to have gravitational or parallel projection of a 2D pattern on a 1/2 globe surface or on its segment. Basic principal of both projection is shown below in *figure 4.*

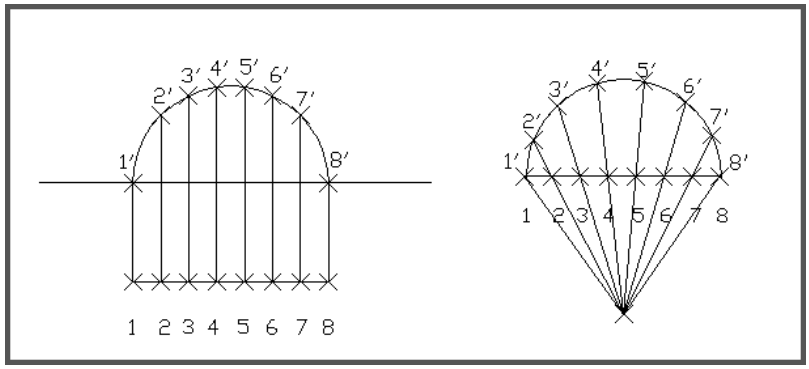

Figure 4 : *Principle of parallel and gravitational projection of a 2D pattern*

Application of this method is shown in *figure 5,* where on a basis of 2D pattern parallel projection is applied. Projection is shown on only 1/4 of a globe (to make it more clear) and in a *figure 6* the result of whole projection is given.

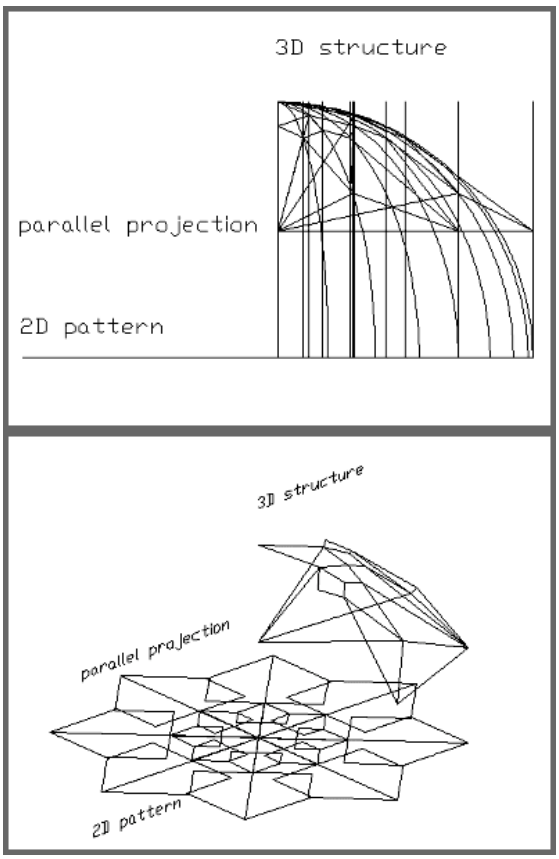

Figure 5 : *parallel projection shown on an example (1/4 projection)*

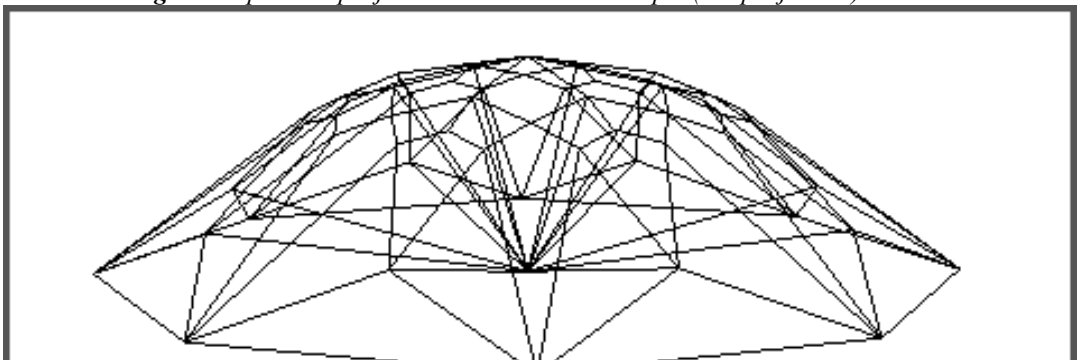

Figure 6 : *result of parallel projection*

Once a spatial geometrical model is created, in the next step it should be globaly materialised. This is where substitution method is applied. Point, line and surfaces have different attributes on different application levels (because detail is build-up on two systems - "MERO" system and second level Al-profiles and glass):

Level one:

- Point is replaced by a globe, line by beams and surfaces are introduced on a second level

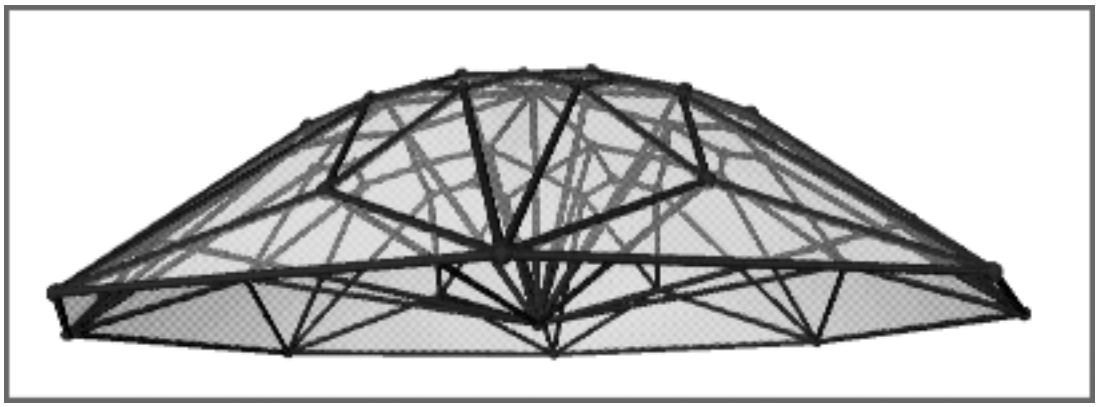

Figure 7 : *global materialisation on first level*

Level two:

- Point is replaced by 3D Al-profile joint, line becomes Al-profile that connects two joints and surface becomes glass.

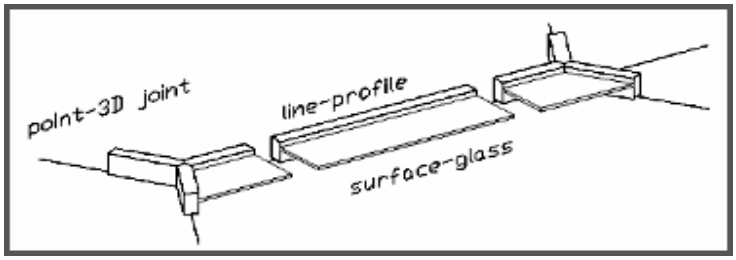

Figure 8 : *global materialisation on second level*

Summary of pattern creation and substitution method is given in *figure 9.*

Figure 9 : *substitution method applied on a pattern grammar*

CONCLUSION

It is possible to develop the substitution method for all architecture areas, so that it can be applicable in domains of urban planning, designing, building technology, interior design etc. In this paper we have concentrated more at developing the substitution method to support the conceptual design and building technology.

Introducing the pattern grammar and the substitution method we can influence the average designers by offering them a new method and medium. Therefore, it can increase the quality of their design and the efficiency of the design process. It is very difficult to introduce new tool for the top-designers and their way of designing, but even they might find the pattern geometry challenging and inspirational for their own designs. Think about one of the greatest architects from the US, Frank L. Wright, who based almost all his designs on pattern geometry!

New concepts and ideas can emerge and refresh the language of architecture just by looking around us and discovering over and again what world of nature and the hands of man have created so far. In that process, the ICT and its further developments can and will play an important role. Using computer science as an extension of our own intelligence, we can explore spatial qualities of our designs more accurate and faster than ever before out of which new shapes can emerge and mistakes could be reduced to a minimum.

The boundary of architecture and its language changes with every society and new technologies that accompany it, but the origin of architecture will never change, for it has always been conceived in the human brain and consciousness.

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