The traditional way of architectural design leads to some shortcomings with respect to the quality of the design and the efficiency of the design process. Therefore possibilities for improvements have to be considered. In order to come to fundamental improvements the application of advanced computer technology in the field of architecture has to be co-ordinated with improvements in the area of design methodologies.

In this paper we suggest a new methodology for architectural design. It is based on an integrated manner of designing. Despite some early design steps the whole design process is executed on the basis of a 3D model which is handled by means of computers. The central data objects in the design process are the different types of models. The models contain all relevant information generated in the design process. A comparison of our approach with the traditional way of designing illustrates the potential of the new methodology.

Key Words: Computer Aided Architectural Design, Design Methodologies, Integrated Design Systems, Computer Support
Approaching a New Methodology: Integrated Architectural Design on the Basis of 3D Computer Models

INTRODUCTION

Many architectural design processes have been successfully performed. Different methodologies have been applied, that are characterised by working without computer tools or by applying them only in a very limited role. In general these methodologies, that we will refer to as “traditional methodologies”, can be considered a suited way of designing. On the other hand there are some inherent problems like for example:

- problems to combine different drawings in order to check the possibilities and to tune the various technological solutions
- impossibility to take into account the distinguished alternatives immediately during the discussions between architect, principal, consultants or authorities
- fast and simple exchange of information between architect and the other partners is almost impossible (at least very limited)
- architect has to take over the tasks of a co-ordinator and therefore less time available for his creative tasks because of the effort needed for the management of the design process
- calculations during the modelling phase require much effort to be taken, but the results remain relatively rough and insecure.

A more detailed description is given in [ScVö96]. These problems and shortcomings may lead to significant quality and efficiency problems. Therefore we have to look for improvements to overcome these limitations. The fast development of science and technology offers some solutions. In order to use information technology for architectural design effectively in an integrated way we will approach a new design methodologies in this paper.

After describing basic concepts and major phases of the methodology we will take into account its advantages and disadvantages. In [VöSA97] a case study is described where this methodology is applied and extensions with respect to integrated architectural and urban design are discussed.

INTEGRATED DESIGN ON THE BASIS OF 3D COMPUTER MODELS
In this paper we suggest a new methodology for architectural design. “Integrated Architectural Design on the Basis of 3D Computer Models” is characterised by the following basic concepts:

- The process is based on an integrated manner of designing. Decisions are made as a result of discussions in a design team, where possible alternatives have been carefully evaluated.

- The whole design process is executed on the basis of a 3D model which is handled by means of computers.

- The availability of support software corresponding to the needs of the architect is one of the key features determining the success of the idea.

- In the design process there are different types of models. These models contain all relevant information generated in the design process. This includes the possibility to deal with several alternatives. Because of their availability at later stages of the design process, definitive decisions can be made “better” and highly qualified.

Generally an architectural design process, following this methodology, can be described with the following model consisting of six major phases.

**Phase 1 “Conceptual Studies”**

This phase is dominated by the initial communication between principal and architect. It also includes an analysis of the feasibility of the project. The result is an initial model defining the project only with respect to general aspects.

**Phase 2 “Generation of a Semidefinitive Model”**

During this phase the level of completeness of the model has to be increased in order to enable its input into the computer.

**Phase 3 “Generation of a Computer Model”**

The semidefinitive model created in phase 2 is placed into the computer in order to generate a 3D computer model to research and to develop the total concept with respect to its spatial characteristics. In this phase it is possible to design the optimum of 3D consequences.

**Phase 4 “Round Table”**

The architect co-operates with different consultants to extend the semidefinitive model. After receiving the needed information from the architect the different consultants prepare separately their recommendations, that will be “performed” during a “round table”. This offers the advantage that all design decisions could be made based on a direct communication between all members of the “design team”.

**Phase 5 “Developing the Model”**
The architect extends the model to complete it. This includes communication with the principal as well as work to get permissions etc. from administrative authorities. At the end of this phase the model is definitive, but not yet completely checked.

**Phase 6 “Final Check”**

The predefinitive model is checked against all demands relevant for the design project.

Figure 1 on the next page describes the major phases and illustrates the input and output information of each phase. Generally there is no linear order of the six major phases during the design process. It is actually an iterative process including different cycles. The most important one is the cycle between the phases 4, 5 and 6. “Round Table” and “Developing the Model”-phases alternate few times till a definitive model is reached. Afterwards, invalid results at the final check may cause further steps to go back to earlier phases.

The different models occurring in the process could be described as follows:

“**Initial Model**”

The initial model defines the project with respect to general aspects. The model contains the results of conceptual studies. It also includes the results of the feasibility study.

“**Semidefinitive Model**”

The semidefinitive model is an extended version of the initial model. It is defined more precisely. The semidefinitive state is reached if the generation of a computer model is enabled.

“**Semidefinitive 3D Computer Model**”

The semidefinitive 3D computer model can be partly considered a computerised version of the semidefinitive model. However there are significant differences with respect to the level of completeness. By means of generating a 3D representation the architect can research and develop the model with respect to its spatial characteristics.

“**Predefinitive 3D Computer Model**”

Through different processes the semidefinitive model has been completed. It is definitive, but not yet finally checked.

“**Definitive 3D Computer Model**”

If the final check shows the validity of the suggested definitive 3D computer model it reaches the state “definitive”.
Differences between the models occur with respect to computerisation, level of completeness and level of checking. The non-computerised models represent ideas, the computerised models represent “real” documents. Therefore non-computerised models could be mostly found in early phases. During the different phases the level of completeness of different documents increases because of the introduction of new results. These “evolutionary” processes may not change the other characteristics of the model at all e.g. the development of the semidefinite model during phase 5. An example of different levels of checking shows the relation between predefinitive and definitive model. They may contain the same information but the latter has already passed the final checking of principal and architect.

[ScVö96] gives a more detailed description of the different phases. The different partners taking part in the building process are also considered there.

EVALUATION OF THE NEW METHODOLOGY

The use of computers, in order to realise a design process on the basis of three-dimensional computer models, offers many new possibilities for quality improvements and time savings. The most significant are:

- The availability of a 3D representation of the design allows the architect a better evaluation of the spatial qualities.

- All relevant information about the design project is available in an integrated way in different models. The information handling significantly improves.

- A fast and simple exchange of information between the architect and other partners becomes possible. The models can be distributed digitally, so it costs less time and money. Data processing and exchange over a long distance is possible in a very short time.

- This methodology provides a basis for the integration of design, construction and calculation process because it offers possibilities for efficient communication and information exchange.

- The position of the architect changes. Once being a co-ordinator, responsible for all separate communication processes, he now becomes a kind of a director. He needs less time for management tasks and has therefore more time available for creative design work e.g. generation and evaluation of alternatives.

- Separate communication processes could be replaced by “round table”-discussions of all members involved in the design process. Because the information can be changed easily it is possible to introduce the modifications immediately into the model. The advisors as well as the architect get direct feedbacks regarding the consequences of modifications. They are able to check the possibilities, to recognise new problems and to tune the various technological solutions during the discussion.

Figure 1: The major phases including their input and output information
In general design steps could be executed with a higher quality without efficiency decrease.

The principal could recognise the influence of administrative authorities or consultants directly on the screen. This offers a possibility to overcome causes for confidence problems, like for example if the principal may think that the architect tries to realise his own wishes by saying that they are based on requirements of the administration or advises from consultants.

Calculating and modelling are integrated activities, so the truth-value will be excellent.

The following table summarises some significant advantages and disadvantages.

<table>
<thead>
<tr>
<th>Traditional Methodology for Architectural Design</th>
<th>Integrated Architectural Design on the Basis of a 3D Computer Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>• much experience is available</td>
<td>• based on the application of software as a supporting tool</td>
</tr>
<tr>
<td>• dominates in current building processes</td>
<td>• existence of information in an integrated form decreases the complexity of communication</td>
</tr>
<tr>
<td>• basis for current education of building specialists</td>
<td>• improved co-operation between the different partners</td>
</tr>
<tr>
<td>• communication problems are a significant limitation</td>
<td>• the role of the architect changes to a “director”, i.e. he has more possibilities to work on the design</td>
</tr>
<tr>
<td>• information exchange very complicated and inefficient</td>
<td>• 3D presentation improves the analysis of the spatial quality of the design</td>
</tr>
<tr>
<td>• the architect has to deal with many management tasks limiting his creative possibilities</td>
<td>• suited for the integration of building and construction processes</td>
</tr>
<tr>
<td>• integration of design and construction processes is strongly limited</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: A comparison between design methodologies

Taking into account the comparison we can conclude that the new methodology of integrated design based on a 3D model supported by means of 3D software offers great potential for improvements in architectural design. It seems not useful to try to develop architectural software for the traditional way of designing because of the inherent shortcomings of this methodology. In order to come to fundamental improvements the application of advanced computer technology in the field of architecture has to be co-ordinated with improvements in the area of design methodologies.

Which changes occur if we apply the new methodology?
- The possibilities to combine materials and structures lead to a wider variation of designs. It is now possible to explore them already during the conceptual design phase.

- The conceptual design should be extended significantly in order to use the new possibilities. It becomes more time-consuming. The effort taken can be easily compensated by quality improvements as well as by less time demands in later phases.

- Because of the integrated way of designing it will be possible to inform the principal, the authority and the consultants on a “digital way”. The value of the calculations is as excellent as the design process.

- The documents can be generated earlier and much more complete so that every member in the design process is informed with the same quality and with the same possibilities of the building. This can take more time but the value of every document is extremely high because the tuning has been done. The definitive design needs significantly less time to be generated.

Additionally the whole design process tends to demand less time. We will illustrate this by a comparison where figure on the right-hand side represents the methodology of integrated design by means of 3D computer software and the left one represents the traditional way:

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Conceptual Design</th>
<th>Materialisation</th>
<th>Definitive Design</th>
<th>Phase to make ready to put out to tender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 2: The influence of the applied methodology on the design process*

**SUMMARY AND CONCLUSIONS**

352
In this paper we have approached a new design methodologies offering significant advantages. The most important differences occur with respect to the quality improvements. Integrated design leads for example to time savings and significant improvements in the communication processes between architect, principal, consultants and administrative authorities. By working with integrated 3D representations it is possible to improve the quality and the security for the principal as well as for the architect and his consultants.

The methodologies is based on the existence of support software that at least partly is non-existent until now. Future work will thus include the application of the results in the development of integrated support software for the architectural design process.

Furthermore, some additional features like the participation of a contractor in the design activities and issues related to the management of the process have to be taken into account more detailed.

References

