An integral approach to façades: a conceptual comparison between different types of facades

W. Zeiler, J. Verdonschot, G. Boxem
Technische Universiteit Eindhoven, The Netherlands

ABSTRACT

In high performance office new buildings and renovations nowadays it is common practice to use multiple façade technology. Double-skin facades are new possibilities for principal and architects seeking creative innovative design that are intelligently adapted to environmental conditions. The new possibilities make it difficult to make choices in the beginning of the design process. Methods to help the designers to make the right decisions are wanted. A method will be presented to support the evaluation within the design process of different façade concepts. Four different façade concepts were analyzed and the performances of the façades were measured. The results of this research are used for developing criteria to evaluate different façade concepts during a building design process.

1. INTRODUCTION

Design is a complex process. At the early design stages, usually only conceptual sketches and schematics are available, often rough and incomplete. Integral design is meant to overcome this problem by providing methods to communicate the consequences of design steps between the different disciplines on areas such as construction, costs, life cycle and indoor climate at an early stage. The aim is to support all disciplines with information about the tasks and decisions of the other disciplines. Supplying this information will improve understanding of the combined efforts. Especially the use of the Kesselring method as a decision support tool will help to structure the decision to be taken and make the process transparent. This method is used in workshops and different MSc thesises at the Technische Universiteit Eindhoven and shows promising results. Some people see design as a problem solving activity where the need transformed to a design problem and its solutions co-evolve. In design the resources consist of knowledge, materials and building processes, while the constrains include laws of nature as well as time, organizational and financial limitations. In the early seventies in the Netherlands a methodology was developed to teach design to mechanical engineers at the faculty of Mechanical Engineering University Twente at Enschede; Methodical design. The methodical design approach was developed and formalize in the seventies (van den Kroonenberg 1978) and elaborated theoretically by de Boer (1989), Blessing (1994) and more practically by Stevens(1993), Siers(2004). Methodical Design is problem oriented and distinguishes, based on functional hierarchy, various abstractions or complexity levels during different design phase activities. Methodical Design makes it possible to link these levels of abstraction with the phases in the design process itself. This framework can accommodate the different subjective interpretations of the requirements, inherent to the design team approach. By structuring the requirements the development of the shared understanding is accelerated and the generation of the possible solutions is aided. Through iteration cycle of interpretation-creation steps, the set of requirements is continuously refined, and with it also the design solution proposals. Methodical Design is considered suitable to be used and taught as a way to solve (at least mechanical) engineering problems more easily by (de Boer, 1989);

- providing a basic problem solving approach for engineering;
- flexibility, because it can be used in many different applications;
- effectiveness, as it assists in obtaining suitable results Also systematic feedback on the use and teaching methodical design;
- enables novices to apply it without much difficulty;
- enables further development by students themselves, depending on their own ideas and preferences;
- stimulate professionals to use and adapt it

Integral design is done by multi disciplinary design teams and aims at integrating all the life cycle aspects of a design. It involves information exchange between participants of the design process in amounts not yet known before. Integral design is meant to overcome, during design team cooperation, the difficulties raised when missing the early involvement of consultants. This is achieved by not only earlier involvement of the consultants but also by providing methods to let the consultants act as designers instead of consultants sec. The design methods and tools let the consultants communicate the consequences of design steps between the different disciplines on areas such as construction, costs, life cycle and indoor climate at an early stage. The aim is to support all necessary designing disciplines with information about the tasks and decisions of the other disc-
ciplines. Supplying this information will improve understanding of the combined effort. At the early design stages, usually only conceptual sketches and schematics are available, often rough and incomplete. Architects tend to develop their designs in a drawing-based, graphical way (prototypes are used to investigate the design concepts). It is important to mention here that (building) design is a creative process based on iteration: it consists of continuous back-and-forth movements as the designer selects from a pool of available components and control options to synthesize the solution within given constraints. As the design proceeds, more information and detail will be developed. But the dichotomy of this system is that at the early stages of design there is little information, even though nearly all the important decisions have to be made at this time, as figure 1 shows.

As one of the convinced pioneers of Design Science, F. Kesselring, worked on the problem of engineering design. With his book Kompositionslehre (Study of Composition) (1954) he developed an analysis of design work. Later he took part in these efforts as committee leader within the Verein Deutscher Ingenieure (VDI Society of German Engineers) and was decisively involved in originating the VDI-guidelines for the design area (VDI-R 2222, 2225). He developed a simple but very effective decision method.

2. METHOD

Decision methods are intended to help designers in making decisions. As people are limited in their capacity to process information, the evaluation should be possible for each criterion separately. Consequently, the determined values have to be aggregated into a score for the ‘overall’ value of each alternative. Kesselring developed a visualization technique, where the different variants can be compared with each other. Within the Kesselring method, criteria are separated into a category for realization and a category for functionality. By doing this the strong point can be seen in a so called S-(Stärke)diagram. To visualize the scores the criteria of the program of requirements are separated in groups with relating requirements. The first group has to do with the functionality of the design and the other group with the realization, see figure 5.

Each group is evaluated and supplementary to this the total score is expressed as a percentage of the maximum score to gain. In the diagram the percentage of the functionality is set out on an axe and the percentage of the realization on the other (figure 5). The best variants lie near the diagonal and have high scores. It is wise to set values to limit the selection area. A practical suggestion is to divide the area in two by a minimum border set by x-
and y-value of 40 and by (x+y)-value of 55% (figure 5). The Kesselring method makes singularities visible, whereas in the normal choice tables and bar diagrams only could be retrieved with much effort. In the Kesselring diagram it is easy to see if the improvements must take place in the functionality or on the realization side.

3. RESULTS

In many MSc-theses at the Technische Universiteit Eindhoven the method of Kesselring is used as a decision support tool during the Integral Design process (e.g. van Schijndel 2006, Verdonschot 2006, Verwer 2006). As an example the study by Verdonschot will be presented as an example of the application of the Kesselring method. Starting point of the study was that the concept of a ventilated double façade is invented with the intention of improving the thermal qualities of a fully glazed façade. The application of a fully glazed single skin façade used to result in a high energy consumption due to the poor thermal properties of the glazing. These properties have improved over the years and are reaching similar values as can be achieved with a ventilated double façade. The aim of this study was to compare different ventilated double facades to a single skin façade and determine which façade has the best performance and on which areas. To compare the façades an evaluation model is created according to the method of Kesselring.

<table>
<thead>
<tr>
<th>Building</th>
<th>Façade</th>
<th>Ventilation model</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bouwhuis office</td>
<td>Ventilated double façade 'multi-storey' type</td>
<td>Outdoor air curtain</td>
<td>OUT, IN</td>
<td>OUT, IN</td>
</tr>
<tr>
<td>Zoetermeer</td>
<td></td>
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<tr>
<td>ABT office (Velp)</td>
<td>Ventilated double window</td>
<td>Indoor air curtain (reversed flow)</td>
<td>OUT, IN</td>
<td>OUT, IN</td>
</tr>
<tr>
<td>Kennedytoren Eindhoven</td>
<td>Ventilated double façade partitioned by storey (corridor type)</td>
<td>Outdoor air curtain</td>
<td>OUT, IN</td>
<td>OUT, IN</td>
</tr>
</tbody>
</table>

Figure 4. Façades and buildings that were compared

Fifteen functional aspects on the areas of thermal and visual comfort, energetic and acoustical performance, ventilation and maintenance have been determined, next to eight realization aspects on the areas of costs, sustainability, flexibility and architecture. The four façades that are compared using this model are: the single skin façade of the Effenaar, the second skin façade of the Kennedy Business Centre, the ventilated double window of the ABT office and the second skin façade of the Bouwhuis. The evaluation of the functional aspects is based on the measurements and on the obtained information about the buildings. Measurements were performed on all façades for a period of one week. These measurements and the gathering of information, result in an evaluation of the total performance of the façades.

The evaluation of the aspects with respect to the realization is based on the obtained information about the buildings.

The result is an evaluation of the total performance of the ventilated double façades concepts. These results are put into the diagram of Kesselring, which directly shows the façade that has the best balanced performance and which façade needs improvement of the functional or realization aspects.

The evaluation criteria are given scores according to the method described in the previous paragraphs. This results in the Kesselring diagram in figure 5.

Figure 5. Kesselring diagram of the four façades
The façade of the Kennedy Business Centre has the highest and well balanced performance of the four researched façades. The Bouwhuis has a similar score with respect to the functional aspects, but a much lower score with respect to the realization. Opposite to that, the Effenaar has a much lower score than the Kennedy Business Centre with respect to the functional aspects, but only a little lower with respect to the realization. The ABT office has the lowest score with respect to the realization and a similar score as the Effenaar with respect to the functional aspects.

This evaluation is only valid for these exact façades. In order to evaluate the façades according to their classification and to be able to give an evaluation of the types of façades, the evaluation is repeated and the possible improvements of the functional aspects and with respect to the realization are analysed for all four façade concepts. The improvements of the functional aspects of the single skin façade are:

- applying daylight compensation and automatic switching
- adding an operable window to the façade
- improving the control strategy and influence of the occupant
- adding an outdoor shading device
- improving the sound insulation of the façade by using glazing with a higher sound insulation
- applying all necessary maintenance provisions

These improvements result in the following changes with respect to the realization:

- The aesthetic is better due to the air intake and the functionality and impression of space can also be improved for a building with a single skin façade
- The investment costs are much higher. Glazing with a high sound insulation is very expensive and a shading device, operable window and daylight compensation and automatic switching equipment also have to be acquired.

The g-value of the ventilated double façades and window are measured under winter conditions and without the influence of the shading device in the cavity. Measurements in the summer with the shading device down, probably result in lower g-values. The scores for this criterion for the façade types are therefore 1 point higher.

The ventilated double façade partitioned by storey with natural ventilation (outdoor air curtain) can be improved by:

- improving the influence of the occupant
- positioning the shading device near the outside glass layer

The ventilated double window with mechanical ventilation in the reversed air exhaust mode can be improved by:

- applying daylight compensation
- improving the control strategy and influence of the occupant
- increasing the flexibility of the façade
- enlarging the windows, which means more light entering the building
- applying all necessary maintenance provisions

And the ventilated double façade multi-storey type with hybrid ventilation and the possibility of an outdoor air curtain or air supply can be improved by:

- applying a fully glazed inner skin, which increases the flexibility, transparency and sustainability of the façade and improves entering of daylight
- positioning the shading device near the outside glass layer

These adjustments result in the Kesselring diagram of figure 5.

Figure 5. Kesselring diagram of the improved types of façades

This diagram shows that the single skin façade can be improved mainly on functional aspects. The ventilated double window and the ventilated double window multi-storey type can be improved on functional as well as realization aspects. The diagram also shows that there are not many improvements possible for the ventilated double façade partitioned by storey.

4. CONCLUSION

The Kesselring method is not only used in MSc-thesis by students but also in multidisciplinary master design workshops for master students as part of their educational training. The workshops in which well over 80 students participated so far, clearly showed the added value of decision support in Integral Design.

Design can be considered a problem solving activity where the need transformed to a design problem and its solutions co-evolve. The designer starts describing what the intended product should do and through reasoning both the problem and its possible solutions co-evolve. This process eventually produces a solution. At the early design stages, usually only conceptual sketches and schematics are available, often rough and incomplete. Integral design is meant to overcome this problem by providing methods to communicate the consequences.
of design steps between the different disciplines on areas such as construction, costs, life cycle and indoor climate at early design stages. The aim is to support all disciplines with information about the tasks and decisions of the other disciplines. Supplying explanation of this information will improve understanding of the combined efforts. Especially the use of the Kesselring method as a decision support tool will help to structure the decisions to be taken and make the process transparent. This method is used in workshops and different MSc thesis at the Technische Universiteit Eindhoven and shows promising results.

The structure of the design process itself however is only one of the factors resulting in a good design. It helps to use a structured method to make the process more transparent, but gives no guarantee to true value or quality. It just helps nothing more or less, but still we think that we designers need all the help we can get!

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REFERENCES