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THE DIFFERENCE IN COMMUNICATION BETWEEN ARCHITECTS AND ENGINEERS AND THE EFFECTIVENESS WITHIN INTEGRAL DESIGN

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ABSTRACT
Traditionally the conceptual building design phase is dominated by the architect. However, due to the clear need for more sustainable solutions, building design is being transformed to a multi-disciplinary design team process. However just putting all the different disciplines together right from the beginning is not enough. Therefore a supportive conceptual design method was developed in cooperation with the Dutch professional organizations of architects and consulting engineers. After testing the method through workshops in the industry the method was applied at the department of architecture by masters students in their multi-disciplinary master project Integral design. This enables us not only to use the method for teaching, but also to use the workshops to look at specific characteristics. In this research the focus was on the differences in communication between architects and engineers within an integral design setting. It proved that the architectural students had more influence and were more efficient in relation to functions but for solutions there is not that much difference compared to the engineering students. The used analysis method makes it possible to detect teams in which the architects played a dominant role and as a result there was no real multi-disciplinary team effort.

Keywords: Integral design, architecture, built environment

1 INTRODUCTION

"One cannot not communicate. Because every behavior is a kind of communication, people who are aware of each other are constantly communicating. Any perceivable behavior, including the absence of action, has the potential to be interpreted by other people as having some meaning."

PAUL WATZLAWICK

Within the building industry there is a clear need for more sustainable solutions, with as ultimate goal energy positive buildings. This makes building design more complex. Building design transfers from a mainly architect led process into a multi-disciplinary design team process to cope with the growing complexity of the design tasks. In these multi-disciplinary design teams as the design of the building evolves each designer investigates and communicates alternative solutions using separate models of the design, using their own representational idioms and use diverse media for transferring design information (Fruchter et al 1996). The communication difficulties that arise often lead to an impact upon quality of the final design and the time required to reach the result (Fruchter et al. 1996). Good communication between the design team members is crucial (van Nederveen et al 2010, Brunsgaard 2011, Kanters and Horvat 2012). Especially communication problems between architects and engineers might lead to inefficiency (Kanters and Horvat 2012). Design processes in the Architecture, Engineering and Construction industry are as a result under-productive (Senescu and Haymaker 2013). In sustainable building projects many architects qualified their design process as an Integrated Design Process (IDP): the architects mentioned mostly early engagement of engineers in the process as a clear sign of this (Kanters et al. 2014). However, this collaboration in the conceptual design phase was not always easy for the architects: engineers 'spoke another language' (Kanters et al. 2014). A process approach is needed in which the intentions of the different designers are transparently linked to the design team whether architect or engineer. Support for all design team members by supplying information more transparent will greatly enhance the understanding of the design process and the outcome of the combined efforts of the design team members. To structure the process

communication between architects and engineering consultants a supportive method is needed based on abstraction of functions and connected solutions.

2 METHODOLOGY

A supportive design method was developed in cooperation with the Dutch professional organizations of architects and consulting engineers. The design method provides overview and helps to structure the communication between design team members. The design method is focused on the creation of proposals in the conceptual phase of building design. After testing the method in workshops as part of a training program in industry, the design method was transferred and applied at the department of architecture for master students for their multidisciplinary Master project Integral Design. Characteristic of the method is the intensive use of morphological charts developed by Zwicky (1948) to support design activities and make them transparent in the design process (Zeiler and Savanovic 2009, Savanovic 2009). A morphological chart is a kind of matrix with columns and rows which contains the aspects and functions to be fulfilled and the possible solutions connected to them, see Fig. 1 A. The functions and aspects are derived from the program of demands. Overall solutions can be created by combining various solutions to form a complete system solution combination (Ölvander et al. 2008). For an example of a morphological chart by an architect, see Fig. 1B.

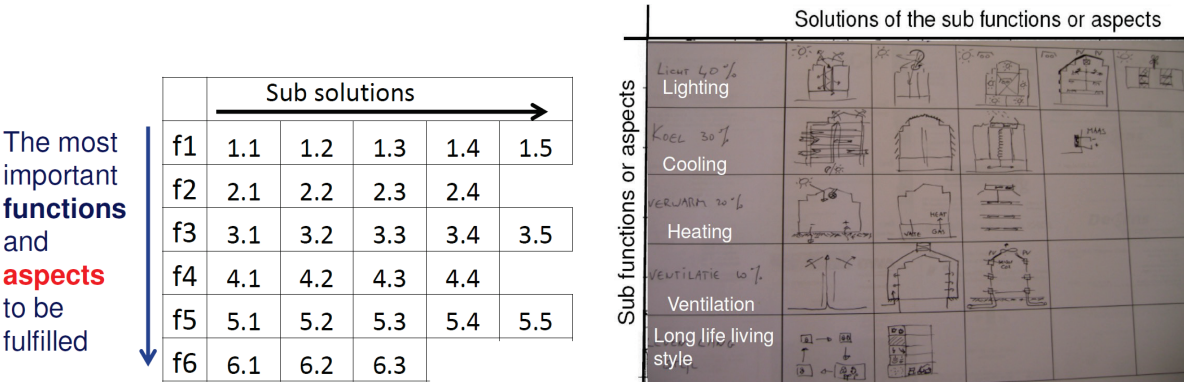

Figure 1.(A) Concept of a morphological chart and (B) a practical example of a morphological chart by an architect

The morphological chart (MC) to visualize sub solution alternatives plays a central role in the integral design approach for design teams. Each participant of a design team develops a full morphological chart from their own specialist point of view. These individual discipline based morphological charts can be combined to one overall morphological chart, called morphological overview, by combining in two steps. First functions and aspects from the individual morphological charts are discussed and the team decides which functions and aspects will be placed by in the morphological overview. Then after this first step, all participants of the design team can come up with their solutions for these functions and aspects from their morphological charts to fill in the rows within the morphological overview. Putting the morphological charts together enables to 'put on the table' the individual perspectives from each discipline about the interpretation of the design brief and its implications for each discipline. This supports and stimulates the discussion on and the selection of functions and aspects of importance for the specific design task.

Within the methodical design procedure there is a combination of a first individual process and a second team process. In the first process step each design team member forms his own morphological chart representing his own disciplinary interpretation of the design brief. This followed by a second process step in which the individual interpretations are discussed and the design team as a whole their interpretation as a team about the program of requirements formulates, which forms the basis for the morphological overview. As such the use of the morphological overview helps the individual designers to form a design team with a share interpretation of the design task. After extensive experiments with different set ups for implementing the Integral Design approach, in which well over one hundred professionals participated (Savanovic 2009), it was concluded that the design method was supportive for professionals in the conceptual design phase.

3 EXPERIMENT

In the last four years each time a Master Projects Integral design was held in which each year 6 teams of 4 students from different disciplines participated: architecture, structural engineering, building physics and building services. The location and the type of building of the design brief changes every year but the goal of the design project remains the same: to design a net Zero Energy Building. The Master project starts with a workshop of two days with design tasks which were on the same level of complexity and had been used in or were similar to the ones of the professional workshops (Savanovic 2009).

During the workshops sessions in the Multidisciplinary master design projects from 2011-2014, students in multi-disciplinary teams performed different design assignments Central element of the Integral Design process is the use of morphological charts by individual designers which were combined into one morphological overview by the design team. This enabled to compare the results of the architectural students with those of the engineering students

4 RESULTS

The generated average amount of functions and proposals mentioned in the MC's and MO's of the session with teams of four students are shown in Fig. 2 and the average result of the students were compared with those of the professionals from the research of Savanovic (2009).

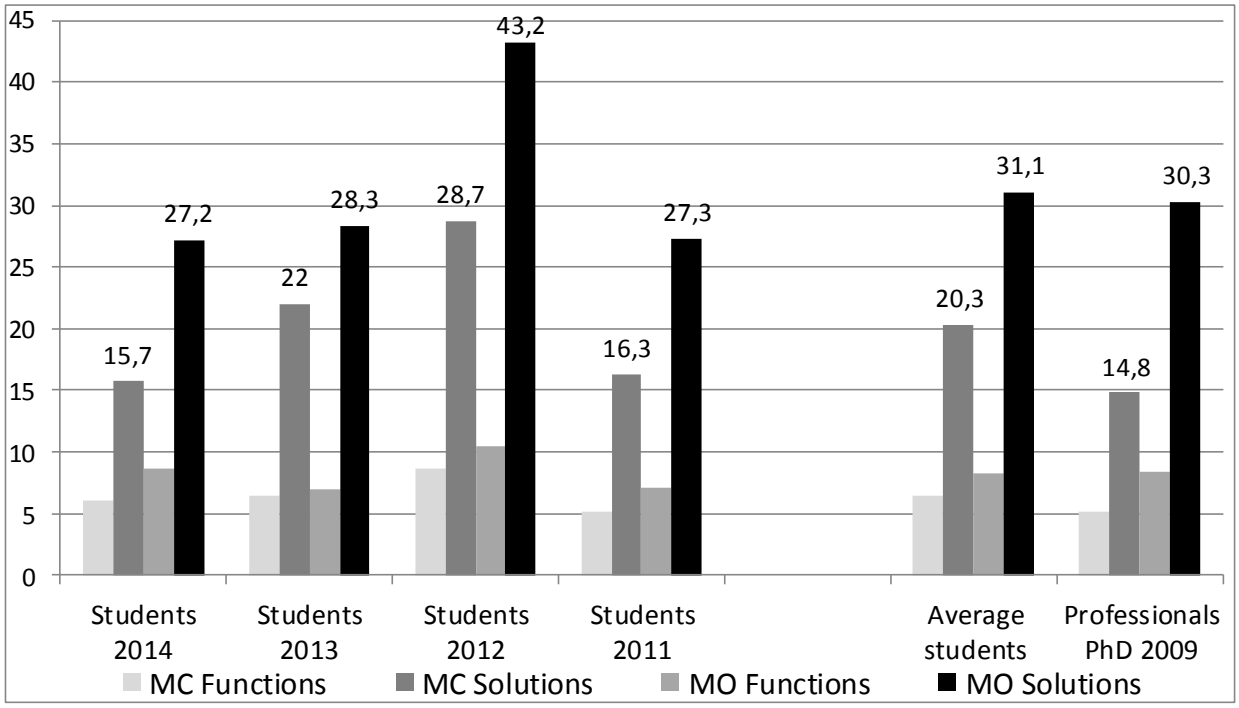

Figure 2. Number of generated functions and solutions as mentioned in the morphological chart (MC) and morphological overview (MO)

It showed in all cases that there is an important increase in the number of generated solutions as well as a small increase in mentioned functions when we compare the individual morphological chart with the morphological overview. The teams of architects and engineers together generate significantly more than just the individual team member alone. With the exception of the student from the 2012 workshops the results are quite simular.

Besides the changes in the number of mentioned functions and proposals, we were interested in the influence of especially the students of architecture on the outcome of the design process, in this case the morphological overview. Therefore the number of functions mentioned by each professional in his morphological chart were counted and checked how many of those were finally put into the design team's morphological overview. The same was done for the notated proposals. Based on these numbers the effectiveness of the archtectural students were defined in a percentage: number of functions/proposals as mentioned by the students from architecture, divided by the total number of functions or proposals mentioned in the morphological overview, see Fig. 3. The results are shown of

the 18 different teams from the MIO project series 2012-2014, number 19 is the overall average of the architectural students.

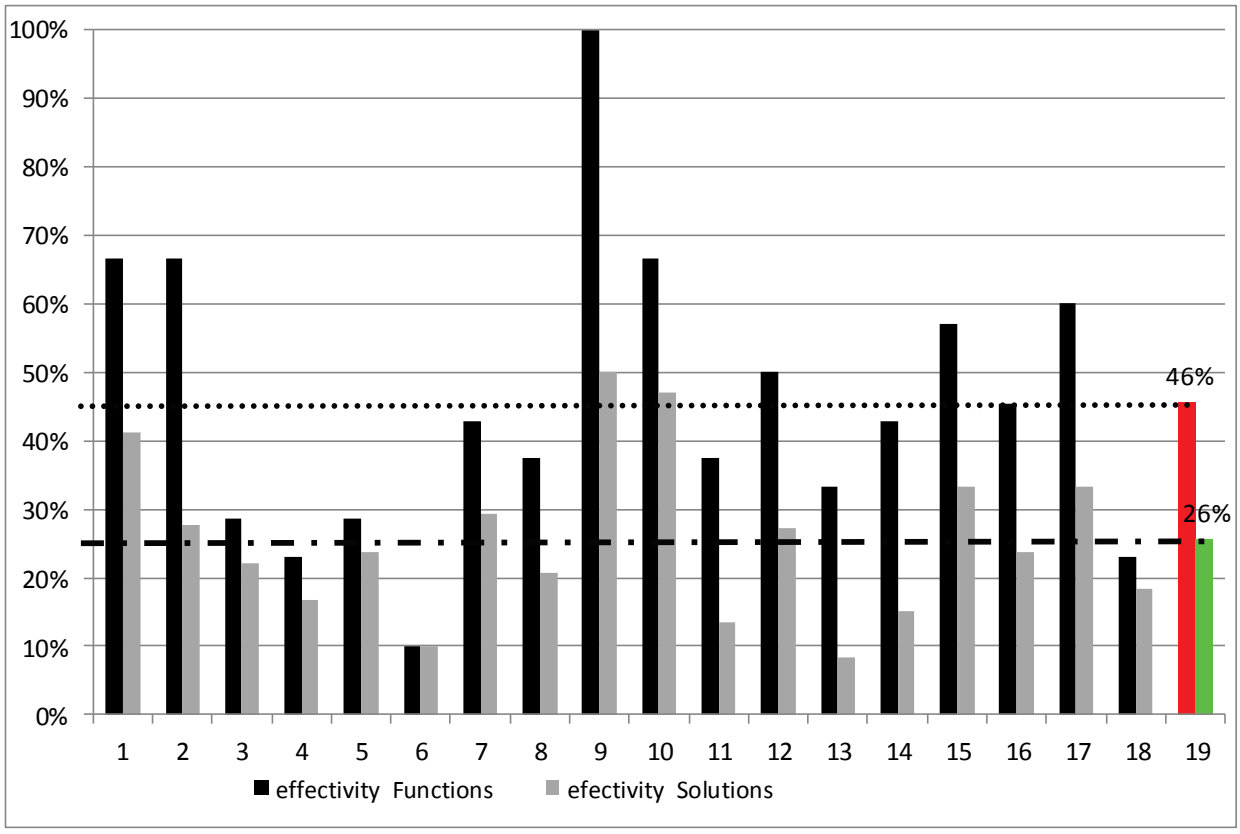

Figure 3. Percentage influence of by an architectural student mentioned functions or solutions related to those mentioned in the morphological overview

It showed that the architectuaral student who had a higher than average percentage of influence for the function in general also had a higher influence for the mentioned solutions. Overall the influence of the architectual students concerning functions (46%) is quite high compared to that for the solutions (26%) which is nearly an equal share within the design teams existing of 4 students.
In the next step the effectiveness of the professionals in the design teams was examined. The effectiveness was defined as the number of mentioned functions or proposals in the morphological chart of a professional, in relation to the number of functions or proposals that were notated in the morphological overview of the design team. Based on these numbers the effectiveness of the architectural students were defined in a percentage based on the number of functions/proposals mentioned by the archtectural student divided by the total number of functions or proposals mentioned in the morphological overview, see Fig. 4. Here it showed that in some cases the architectural student was maximal effective (100%) for the mentioned functions. Overall the average percentage was quite high with 51%. The effectiveness of the solutions was with 30% also higher that the expected average between all disciplines. As can be seen there were quite remarkable differences in outcome between the different teams: effectiveness function (between 100 % - 15%, see Fig. 4) and effectiveness solutions (between 70 – 8%, see Fig. 4))
A comparison was made between the way of communication (words, sketches or a combination of both) of architectural students and the effectiveness of the communication by looking at the proposals that were accepted by the design team, see Fig. 5.

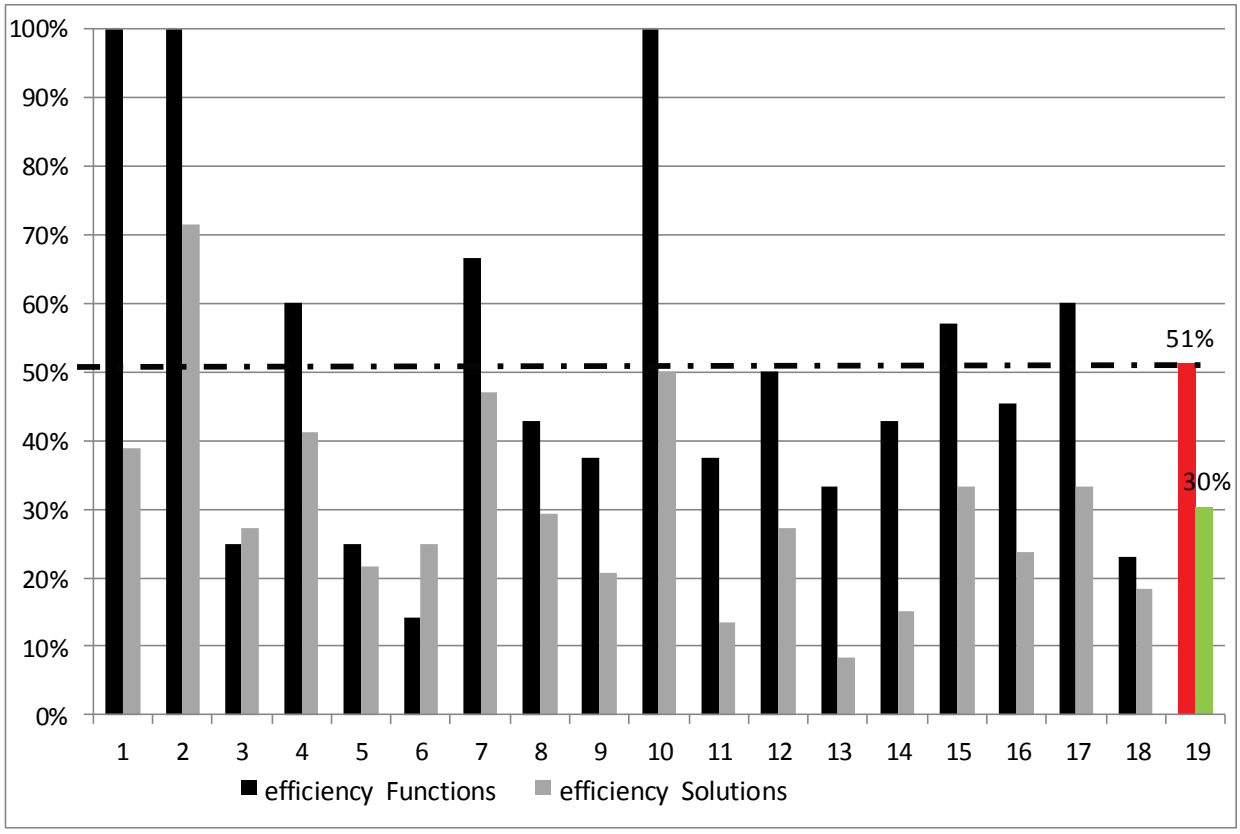

Figure 4. Effectiveness of an architectural student

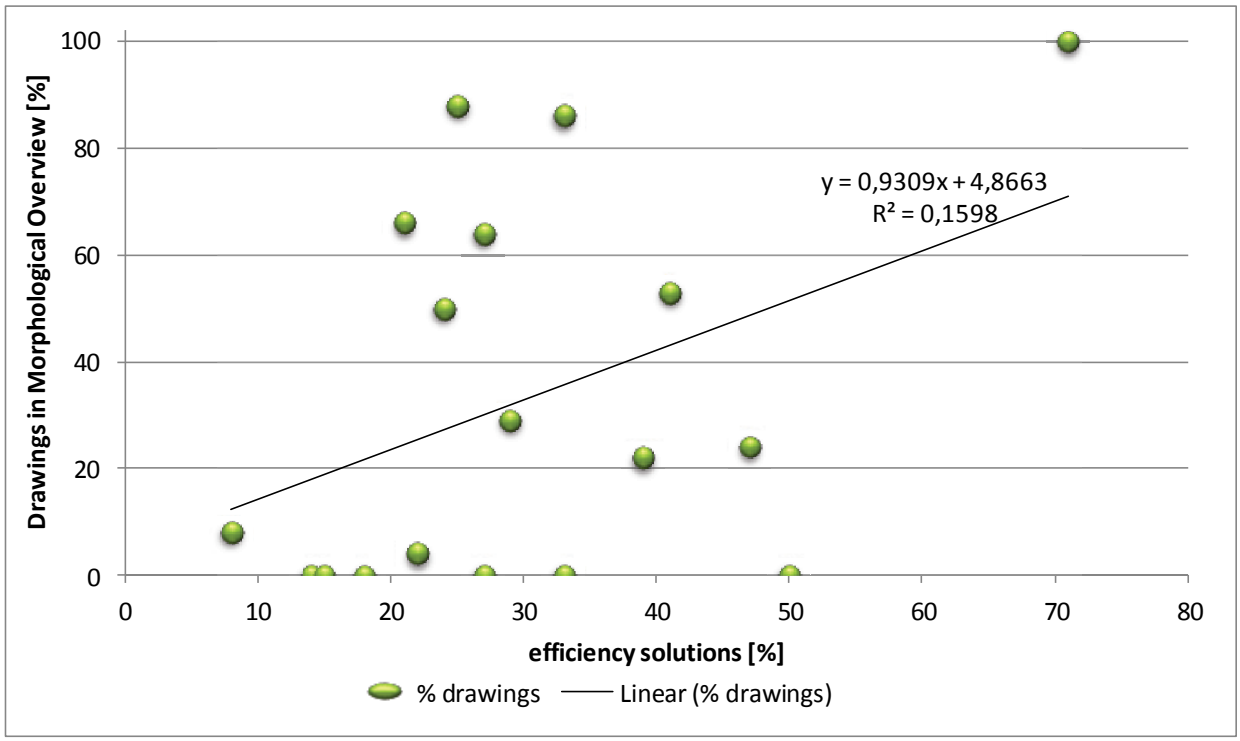

Figure 5. Ratio between the percentage drawings in the morphological charts of the architectural students and the efficiency of their mentioned solutions

5 DISCUSSION AND CONCLUSION

The integral design method provides overview and helps to structure the communication and reflection between design team members. The application of the design method was focused on sustainability and the creation of new sustainable solutions in the conceptual phase of building design. In the last ten years each time a Master Projects Integral design was held in which altogether in total around nearly 200 students participated from 5 different disciplines: architecture, structural engineering, building physics, building technology and building services.

Important aspect of the workshop is a two-day workshop as a start-up for the project. The set-up of the workshops made it possible to compare the role of the architectural students and the engineering students within the workshops, their effectiveness and the way they were communicating through the provided tool during the workshops sessions: the morphological overview.

In this research the focus was on the difference in communication between architectural and engineering students as representatives of their disciplines within an integral design setting. By using the tools from the integral design method, morphological charts and morphological overview, the conceptual design phase can be made transparent and be studied in detail. It showed that the architectural students communicate in a more influential and efficient way in relation to functions. However for solutions there was almost no difference when compared with the result of engineering students. The use of drawings and words in the morphological charts was slightly more effective than using just words.

REFERENCES

[1] Watzlawic, P., Beavin-Bavelas J., Jackson D., 1967, *Some Tentative Axioms of Communication. In Pragmatics of Human Communication - A Study of Interactional Patterns, Pathologies and Paradoxes*. W. W. Norton, New York.

[2] Kanters J., Horvat M., 2012, *The design process known as IDP: a discussion*, Energy Procedia 30: 1153-1162.

[3] Brunsgaard C., Understanding *of Danish Passive Houses based on Pilot Project Comfort Houses*, PhD thesis Aalborg University, Aalborg.

[4] Nederveen S. van, Behesthi R., Ridder H. de, 2010, *Supplier-Driven Integrated Design*, Architectural Engineering & Design 6(4): 242-253.

[5] Senescu R.R., Haymaker J.R., 2013, *Evaluating and improving the effectiveness and efficiency of design process communication*, Advanced Engineering informatics 27: 299-313.

[6] Fruchter R., Clayton M.J., Krawinkler H., Kunz J., Teicholz P., 1996, *Interdisciplinary communication medium for collaborative conceptual building design*, Advances in Engineering Software 25: 89-101.

[7] Kanters J., Horvat M., Dubois M., 2014, *Tools and methods used by architects for solar design,* Energy and Buildings 68:721-731.

[8] Ölvander J., Lundén B., Gavel H., 2008, *A computerized optimization framework for the morphological matrix applied to aircraft conceptual design*, Computer Aided Design 41(2): 187-196.

[9] Savanović P., 2009, *Integral design method in the context of sustainable building design*, PhD thesis, Technische Universiteit Eindhoven.

[10] Zeiler W., Savanović P., 2009, *General Systems Theory based Integral Design Method*, ICED'09, Stanford.

[11] Zwicky F., 1948, *The Morphological Method of Analysis and Construction*, Courant, Anniversary Volume.