

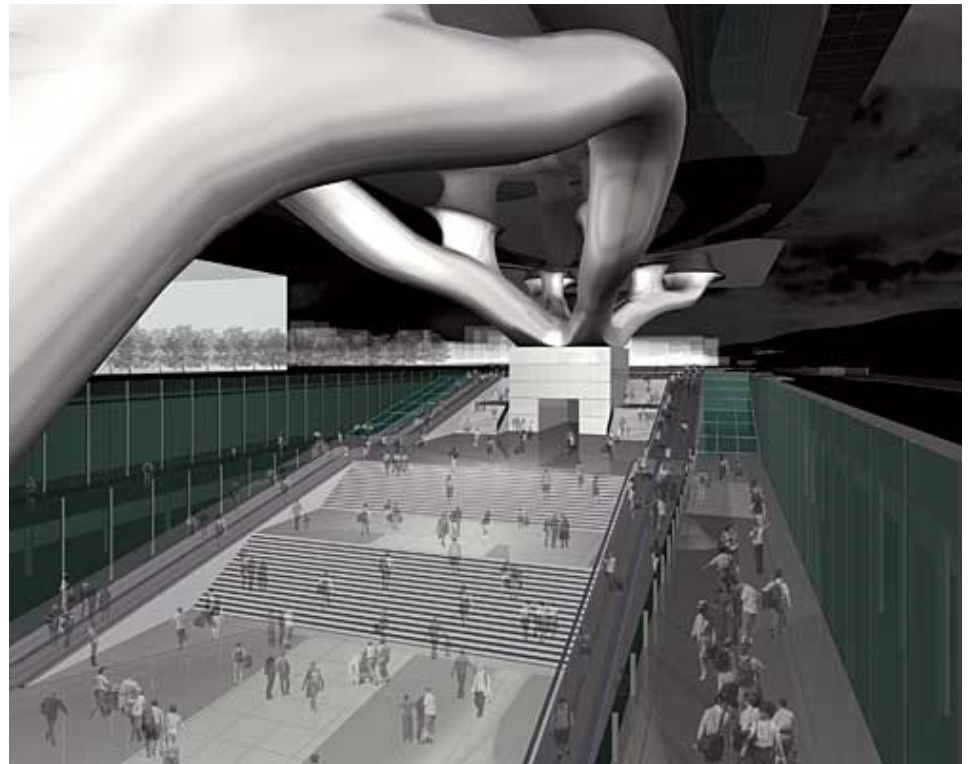
Generative Design with Topologically Optimized Structures

CITA - Centre for IT and Architecture

Norbert Palz and Martin Tamke

<http://cita.karch.dk>

Workshop - Generative Design with Topologically Optimized Structures



Mutsuro Sasak and Arata Isozaki: Train Station Florence

The 5 day workshop will investigate a generative formfinding method for the creation of minimum weight structures with maximized Stiffness. This methodology that is more common in mechanical engineering and aeronautical research projects should be investigated for a potential application in an architectural context. The contemporary awareness of these generative structural processes is growing within the field of architecture, yet their application is very sparse due to the evolving irregularities of the calculated surfaces and volumes and the dependant manufacturing-and economical constraints. Examples of an evolutionary structural optimization in the field of architecture can be seen in the formfinding of Sagrada Familia's Passion Façade by Gaudí (Burry, et al. 2004) and for the 2007 competition proposal of the new Florence train station by Arata Isozaki and Mutsuro Sasaki (Ito, Isozaki og Sasaki 2007).

These structural solvers can broaden the scope of potential design solutions that are conceptually entwined with emerging production facilities of

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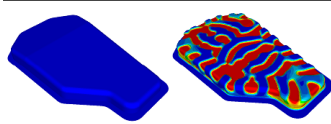
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additive fabrication. The so created design solutions often generate biomorphic geometries that three-dimensionally negotiate the set structural boundary conditions as loads, supports and voids into a meshed geometry. The software extends historical formfinding methods that have been tested by Gaudí and Otto for the creation of a new typology of structural components that fully rely on purely digital processes.

Recent innovations in additive fabrication technologies as Enrico Dini's *Radiolaria Project*, a 3D printing device for large scale stone sculptures, point to interesting manufacturing opportunities for complex geometries in the future. Additive fabrication technologies that can manufacture these biomorphic structures in larger build sizes enhance the architectural repertoire in a significant way. The outcome of the optimisation can then be negotiated with prior design intent.



Bead Optimisation Design
With TOSCA software

The increasing opportunities that computational tools and additive fabrication processes have to offer require a new conceptualization process in the design field to take place. One objective of the workshop is also to investigate new design methods and evaluate their applicability for an architectural task. This process can be identified according to Christopher Frayling as a *Research into Art and Design* (Frayling 1993) since it introduces new material and structural possibilities into the architectural practice, that have to be conceptualized for a new generation of characteristic artifacts.

Design Task

Design a seating structure for the canteen. Design in groups of 2-4 people. The structure should touch ceiling, floor and wall and deliver interesting spatial situations that show the characteristics of the structural solution. Analyse the existing situation and locate a suitable place. Envision the effects and atmospheres and produce a guiding concept being let by your understanding of seating in the special environment and situation you encounter. The structure must have a high surface/ volume ratio that can be created through a lot of branching out of the geometry.

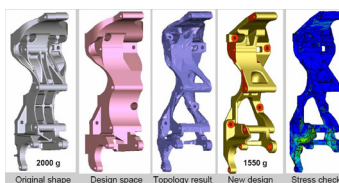
The employed software can be downloaded from <http://sawapan.eu/>.

You can also use DTU's software TOPOPT

<http://www.topopt.dtu.dk/?q=node/11>.

Additional Remarks:

The programs we are going to use is research software that is in a development process. It has some funny peculiarities (as no "undo" function.) Be patient and explore what it can do for you.



Topology Optimised structure of a bracket.

Presentation Requirements:

Physical Models

Try to make a physical model from your design. We will introduce different strategies how to achieve this task.

We can use the Zcorp Rapid Prototyping machine for these purposes.

Make sure that you keep the material consumption in mind. Try to avoid massive volumes, give the surfaces a thickness when possible. When in

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doubt, ask Martin and Norbert. Preferred Sizes (10-15) x (10-15) x (10-15)cm

Martin has reserved some time Wednesday and Thursday on the big school laser cutter to produce some models. Furthermore we can use the small laser cutter for “work in progress” models. We will discuss the selection procedure together since we cannot possibly create more than one, maximum two.

Drawings

Develop a notation system that tries to explain what the structure is doing. The software has the possibilities for these purposes to extract a series of analysis information as FE analysis data, stress-lines and iso-surfaces.

Timeline 26.-30.10.09

26.10.09 Monday

10.00 Start

10.15-10.30 Introduction Norbert Palz and Martin Tamke

10.30-11.15 Lecture Norbert Palz

11.30-15.00 Group Work and development of idea sketches

16.00 -17.00 Lecture Prof. Dr. Ole Sigmund, DTU

17.00-17.30 Discussion

27.10.09 Tuesday

10.00 -10.45 Lecture Martin Tamke

11.00-16.00 Group Work – first Prototypes

16.00-18.00 Pin-up

28.10.09 Wednesday

10.00-16.00 Group Work – refined Working Models

Time on Big Lasercutter

16.00-18.00 Pin-up

29.10.09 Thursday

10.00-18.00 Group Work

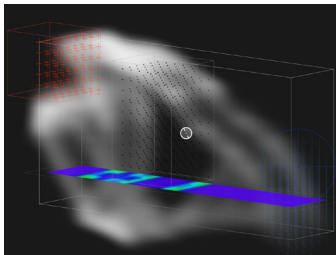
Time on Big Lasercutter

Preparation of final Drawings and Models

30.10.09 Friday

10.00-12.00 Group Work

12.00-16.00 Final Presentation



Density graph of
TOPOSTRUCT solver