8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

FORCEPAD AND OPTIMIZATION - AN IMPROVED TOOL FOR CONCEPTUAL DESIGN

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Key Words: *Conceptual design, Structural Layout, Optimization.*

ABSTRACT

Design of structures such as bridges, wind turbine wings or mechanical components is a very challenging task and involves both finding the structural layout and analysis of the bearing capacity of the structure. The analysis part is almost always solved by Finite Elements and involves defining a structural model and a discretization in elements. This part of the process demands a highly skilled engineer with a good understanding of structural analysis. Finding the structural layout is however a much more intuitive process which relies on many different things e.g. previous design/experience, geometric constraints, aesthetics, production constraints.

Many efforts have been made to ease the intuitive design process. One approach has been the ForcePad system [1,2,3], which in a very intuitive way enables the user to sketch ideas and have them checked by a Finite Element calculation. The benefit for the user is to have a model which is very easy to manipulate, and the change in structural performance for e.g. change in thickness or boundary conditions can immediately be visualized. The system enables the user to learn structural behaviour in a more intuitively way than the traditionel tedious calculations of sectional forces and displacements. The drawback of the ForcePAD system is that the user has to come up with the ideas for the structural layout.

Another approach for an effective design system is based on the idea of topology optimization, see [4] which is authored by two of the pioneers in structural optimization, Bendsøe and Sigmund. The idea in topology optimization is to find an optimum structural layout based on a mathematical optimization criteria. The design domain is discretized in Finite Elements and the algorithm produces a solution which gives the optimal distribution of material in each finite element. The virtues of topology optimization is that the designer does not have to have any ideas of the structural layout. One important drawback of topology optimization is that criteria which can not be quantified such as aesthetics can not be incorporated. Another drawback is that design restraints such as a uniform thickness of a shell structure is very complicated to enforce in a general way.

The present abstract deals with a system which tries to incorporate the best of the two different approaches. The basic user interface is very similar to ForcePAD, which give the user the ability to manipulate the model in an easy way. Topology optimization is incorporated as an option where the user

can get ideas for a structural layout. The system works in an interactive way where the restraints on the structural layout can be put on gradually. The topology optimization in the ForcePAD system uses an improved method described in [5].

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