What is Topology Optimization?

Topology optimization is a mathematical approach that optimises material layout within a given design space, for a given set of loads and boundary conditions, such that the resulting layout meets a prescribed set of performance targets. Using topology optimisation, engineers can find the best concept design that meets the design requirements.

Topology optimization has been implemented through the use of finite element methods for the analysis, and optimisation techniques based on the method of moving asymptotes, genetic algorithms, optimality criteria method, level sets, and topological derivatives.

Topology optimization is used at the concept level of the design process to arrive at a conceptual design proposal that is then fine tuned for performance and manufacturability. This replaces time consuming and costly design iterations and hence reduces design development time and overall cost while improving design performance.

Case Studies in Topology Optimization

Topology Optimization of Reinforced Concrete Beams by a Spread-Over Reinforcement Model with Fixed Grid Mesh

Siradech Surit and Benjapon Wethyavivorn

The objective of this research is to develop a method and strategy of finding the optimal topology for concrete-steel composite beams. Case studies were simply supported reinforced concrete beams with span 4.0 meter with depth 40, 50, 80 and 100 centimeter and 2.0 meter span with 100 centimeter depth, loaded by point load of 1500, 2000 and 2500 kilograms at mid-span, forming 12 load and span combinations. Finite element model was the smeared reinforcement model with fixed grid mesh.

The optimization processes begin with an unreinforced concrete beam then the optimal topology of both concrete and steel progressive emerged at the same time gradually remove in efficient element. The processes continue until the ending criteria were met.

The optimal topology can be found by using two criteria, the minimum weight criteria and minimum cost criteria.
Form Suggestion Process

Topology Optimization as Form Suggestion. In structural design, its aesthetic process seems to be very subjective. One approach is to use topology optimization as “form suggestion”.

Optimal Topology

Design Suggestion (Conceptual Design)

Final Design (Detailed Design)

A process of integrating the method of optimal topology to the structural design was presented. The optimal topology via the material activation was used to assist in visualization of the final form of the structure in design area. Material deactivation is a process where structural material in the low stress area is systematically neutralized and hence resulting in an emerging suggestive form. This form suggestion was then used as a basic for the final design. The study case was the design development of lateral bracing for tall building model subjected to the lateral displacement limitation constraint. The final design derived from optimal topology based design suggestion was archived. The comparison of between the obtained and the tradition design has been made. It can be concluded that integration of optimum topology in the structural design process as form suggestion can be readily practiced in the present design environment and could bring about the efficient use of construction materials.

**FORM SUGGESTION: A PRACTICAL INTEGRATION OF OPTIMAL TOPOLOGY TO THE STRUCTURAL DESIGN**

Siradech Surit and Benjapon Wethyavivorn

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**Conclusions**

By any definition, “sustainability” directly associated with a minimal utilization of natural resources. In structural design, structural optimization has long been the foremost tool of structural designers in the effort towards the best resource allocation. The 20th century together with its exploding computer technology has brought into the structural design arena a new player, “Topology Optimization”. This new technology can alter the “structural design skyline” as the “shape and form” of structures is no longer solely in the designer’s hands. It is partly a result of their self-orientation towards given loadings. This is indeed exciting enough and we hope it is exciting enough to the structural design community such that its application soon prevails.