

A STUDY OF THE DEPENDENCE OF OPTIMUM STRUCTURAL DESIGN ON PROBLEM FORMULATION

André T. Beck and Wellison J.S. Gomes
Structural Engineering Department
University of São Paulo, São Carlos, SP, Brazil
Av. Trabalhador Sancarlense, 400
13566-590 São Carlos, SP, BRAZIL
Phone +55 16 3373 9460
Fax +55 16 3373 9482

ABSTRACT

It is a known fact that the solution of any engineering problem depends on the way the problem is formulated. This is no different in the optimization of structural systems.

Deterministic structural optimization has been extensively used in recent years. Deterministic Design Optimization (DDO) allows one to find the shape or configuration of a structure that is optimum in terms of mechanical behavior, but the formulation grossly neglects the effects of parameter uncertainty and safety issues. As a general rule, the result of DDO will be a structure with more failure modes designed against the limit, that is, a structure with compromised safety in comparison to the non-optimal structure.

Reliability-based design optimization (RBDO) has emerged as an alternative to properly model the safety-under-uncertainty part of the problem. With RBDO one can ensure that a minimum (and measurable) level of safety is achieved by the optimum structure. Moreover, one can enforce that the optimum structure does not compromise safety. The question remains as to what the optimum level of safety should be.

Risk optimization increases the scope of the problem, by addressing the compromising goals of economy and safety. Risk optimization allows one to find a proper point of balance between these goals. This is accomplished by quantifying the costs associated to construction, operation, maintenance of the structure, as well as the financial consequences of failure. An expected cost of failure is computed as the product of a failure cost by a failure probability.

The three formulations of the structural optimization problem are in fact not concurrent, but complementary, each addressing another aspect of the problem. The question to be addressed in this paper is whether the three optimization formulations, when solved independently, lead to the same optimum design as when the problem is formulated and solved in its more complete form. The paper will present some case studies, highlighting the differences in the optimum designs obtained with each formulation. The study should lead to a better understanding of the limitations of each formulation in the solution of structural optimization problems.