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EFFECT OF EXPECTED CONSEQUENCES OF FAILURE ON OPTIMAL STRUCTURAL DESIGN

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ABSTRACT

Defying failure is the primary challenge of the structural engineer. It sounds paradoxical, but in order to achieve a successful design, the structural engineer must think about and account for all possible failure modes of a structure. This is no different in structural optimization. Hence, in structural optimization one has to consider the expected costs of failure. In structural engineering design, economy and safety are apparently conflicting goals. However, when expected costs of failure are considered, one notes that investments in safety are necessary in order not to pay for the expected costs of failure. The optimum point of compromise can be found by a risk optimization, where the objective function includes all costs over the life-cycle of the structure: construction, operation, inspection maintenance, disposal, and the expected consequences of failure. The latter are an undeletable remainder of the failure modes that the structure needs to be designed against.

This paper addresses the optimization of simple structural systems, considering the balance between competing failure modes such as yielding (squashing), buckling, snap-through and brittle rupture. The study shows how different failure modes, associated to different costs of failure, lead to different optimal designs. A plane truss structure is studied as application example. The shape (nodal positions), member size and topology (bar distribution) are considered as design variables. Results show that quite different optimal designs are obtained when the balance between competing failure modes is changed.