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Optimization of frame structures: Topology, shape and sizing.

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We are interested in an approach to combine topology optimization and shape optimization for the design of frame structures in civil engineering. Our goal is to provide a software tool for comprehensive optimization on a high level of automatization. Therefore, we use a phase field model to generate topology first. Next, shape optimization with metaheuristic optimization methods is performed. Thus, topology optimization generates the design concept and shape optimization tunes the structure concerning practical demands [1].

Since the phase field model is a continuum model, the fitness of evolved topologies at this stage of the concept cannot be estimated. An interface uses the topology to proceed with the second step of our concept. Then, sophisticated criteria required by the design code are faced with shape optimization. By considering different demands, e.g., pinned or rigid joints, details in the design space, stress conditions, displacement restrictions, position of nodes, etc., the optimization task becomes more and more complex. Furthermore, in contrast to pure cross-section optimization, some optimization parameters have indirect influence on the objective function only. They cannot be pre-sorted for better optimization results. It is difficult to find the optimum design of such nonlinear problem using classical optimization techniques [2].
By using metaheuristic methods, an optimized design can be found within a reasonable number of iterations without using gradient information of the objective function. Various algorithms have been adapted for the optimization of steel frames, showing advantages and disadvantages [3]. However, using different types of optimization parameters, requirements for the robustness of the algorithm are increased. We want to overcome the disadvantages by combining different metaheuristics to find the most feasible design within the given design space. Finally, examples, where the double-stage optimization yield globally optimized frame structures are presented.

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