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Developing a Formulation of Structural Design Optimization Problems for Quantum Annealing

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Extended Abstract

We investigate a formulation of structural design optimization problems, which aims to be solved by quantum annealing (QA) on currently available devices. In structural design optimization, the goal is to improve the performance and efficiency of structures by finding the best design, e.g., a choice of component dimensions, that meets specific criteria, such as maximizing strength. This process typically involves computational optimization methods to explore various design possibilities. Here, a recently evolving strategy based on quantum mechanical effects is QA. In this context, a suitable problem needs to be provided in a specific formulation, e.g., as a quadratic unconstrained binary optimization (QUBO) model. Therefore, we present a corresponding formulation for structural design optimization problems. In such a problem, an analysis model is required to evaluate the structure's performance. For this purpose, we use energy minimization principles to determine how a structure behaves under applied loads. This allows us to merge the analysis problem with the optimization problem as one overall minimization problem. Finally, mapping this problem to a QUBO problem enables us to solve it with QA.

We apply this approach to a sizing problem of a one-dimensional compound rod under self-weight loading. In this course, we study how specific aspects of the formulation influence the number of required qubits. The accuracy of the obtained results is evaluated by means of analytic solutions. In conclusion, we show that the presented formulation can be used to solve structural design optimization problems by QA on existing hardware.