A dynamic programming algorithm for optimization of composite steel box girder bridges under static and dynamic loading

Breiffni Fitzgerald, Trinity College Dublin

This project proposes and develops a new dynamic programming algorithm for the optimisation of composite steel box girder bridges of single or multi-span under static and dynamic loads.

The dynamic programming algorithm proposed is based on a combination of EXCEL based optimisation solver and finite element modelling for dynamic analysis. In addition supplemental damping devices are optimally designed. The algorithm is as follows. At first, the bridge considered is subjected to static loads and optimised. The optimal parameters obtained from this static optimisation are then used to create a finite element model of the bridge. This model is analysed dynamically to obtain the natural frequencies of the bridge and the mode shapes. Tuned Mass Dampers (TMDs) are then attached to the bridge at critical locations as defined by the mode shapes and are tuned to the natural frequency of the structure to reduce the structural response. These TMDs are tuned optimally. The composite box girder bridge is thus optimised for static and dynamic loading.

EXCEL solver is used for static optimisation Natural frequencies and mode shapes were obtained from a finite element model in ANSYS. Displacement transfer functions for the bridges were obtained based on the ‘fixed-point’ theory of Den Hartog. This project has also shown that it is justified to assume the existence of ‘fixed-point’ frequencies in moderately and lightly damped box girder bridges.

Two composite steel box girder bridges were optimised in this project. The first is a single-span simply supported bridge with a span of 40m and the second is a three-span bridge with equal simply supported spans of 40m. The algorithm achieved minimum weight structures damped optimally to reduce their response at resonant frequencies.

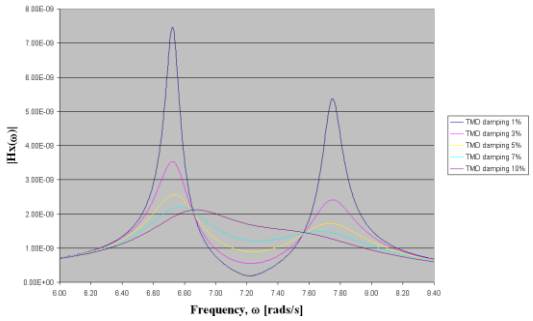

Figure 1. Displacement transfer function at mid-span for damped three-span bridge.

The algorithm is general and can be used for many different structures including tall towers, multi-storey buildings and wind turbines. It can also be used for different types of dampers.