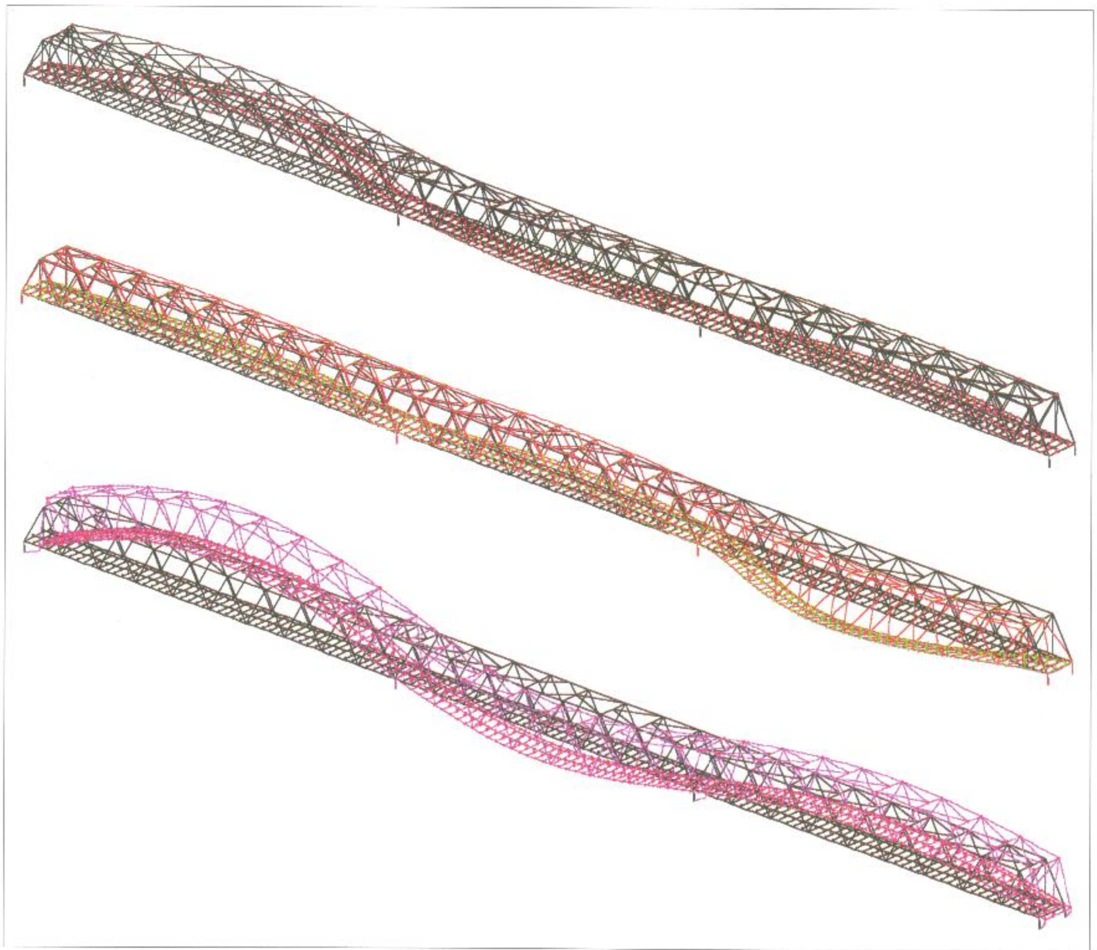
Future forecast

Specialist software company TDV is involved in a research project with the University of Western Sydney and the Graz University of Technology to pursue the inclusion of finite elements in its bridge design package RM2000. The first program prototypes are already being tested and are producing promising results, says TDV. The program will allow the definition of numerical models of bridges, which will include beam elements side by side with components modelled from a library of finite elements, and enable a seamless design approach from the design of the general structural system all the way to the detailed design of individual components.



High speed rail project in Taiwan; snapshots of the displaced shapes of a steel truss girder bridge during a rolling-stock analysis (time history)

This research follows on from continuing efforts by TDV to further improve the dynamic functionality of RM2000. In addition to the previously available modules which included all common procedures for earthquake design (Eigenmode analysis, response spectrum analysis, forced vibrations and linear time history based on modal analysis) a host of new features has been added. These can be grouped into two categories: firstly, the implementation of a general time history algorithm based on Newmark's method for direct time integration; and secondly, an aero-elastic solution for the buffeting problem of wind-loaded bridges.

The features based on the time history module have been applied to a wide range of practical applications so far.

For example, the current draft of Eurocode 1 Part 2; *Actions on structures, traffic loads on bridges* formulates the requirement for rolling stock analyses in cases where the speed of railways on bridges exceeds certain limits. For the Taiwan high-speed rail link between Taipei and Kao Shiung, the interaction between bridge structures and moving loads or moving masses was investigated in cooperation with BPI-Taiwan using RM2000. The experience gained throughout this project is currently being applied in cooperation with Kirch-Muchitsch of Austria to the upgrade of a major rail link between Vienna and Salzburg where the Eurocode 1 requirements have to be considered.

Another example is seismic analysis. The functionality for seismic analysis in RM2000 is complemented by the option to include non-linear material (push-over analysis), geometric non-linearities (P-Delta effects, large displacements) and a number of damper elements, including viscous dampers. The Verige Bridge in Montenegro is a cable-stayed bridge which is currently being designed by Gradis/Maribor of Slovenia using RM2000. The three cable-stayed spans of 130m, 450m and 130m straddle a seismic fault line, which means there are high demands in the design against earthquake loading. Viscous dampers play an important role in the design of this structure.

A second research project which is being carried out in conjunction with the Graz University of Technology concerns the kinematic and dynamic analysis of moveable bridges such as bascules and draw bridges. All structural and kinematic analysis work is performed using RM2000. RM2000 is fully equipped to cope with all necessary features for the design against failure due to wind-induced buffeting.

The structural buffeting calculation is performed in the modal space and the frequency domain and includes aerodynamic damping and stiffness effects due to structural movement caused by the wind flow. All calculations are based on the tangential stiffness of the structure under permanent loading ensuring the inclusion of all non-linear effects which may have taken place before the wind event.

The basis of the new analysis functions are the aero-elastic cross-section parameters of the structural members (drag, lift, pitching moment and derivations) as determined in wind tunnel tests. The dependency of these parameters on the wind direction is automatically accounted for during the static mean-wind analysis and the buffeting analysis in RM2000.

The wind profile is characterised by the mean wind velocity and the fluctuation, or turbulence, velocity where the height profile of the wind velocity is assumed to follow a power law.

RM2000 accounts for the stochastic nature of wind loading (longitudinal, vertical and lateral components of the fluctuation velocity) by using power spectra in the frequency domain (Kaimal, Karman, Harris, Davenport or individually defined). Narrow band analysis as well as broad band analysis with full modal correlation has been implemented.

Spatial distribution (coherence) of the wind loading is determined from an exponential decay function of the frequency and the geometry of the structure.

Peak results for design are estimated combining mean wind analysis results with root-mean-square buffeting analysis results using the corresponding peak factors ■