software option

LUSAS Finite Element Analysis

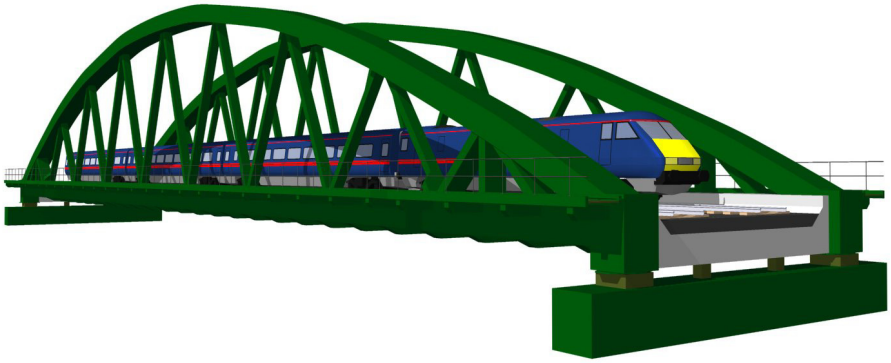
IMDPlus

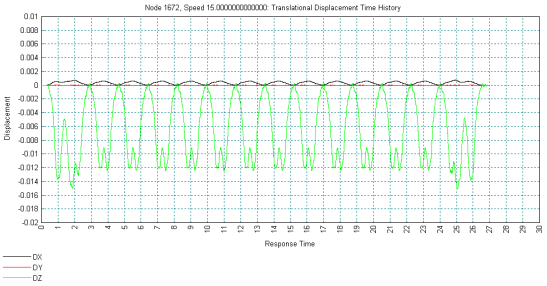
The IMDPlus software option extends the Interactive Modal Dynamics (IMD) techniques available in all LUSAS products. Whilst IMD models a single loading event in a single direction, IMDPlus allows multiple loading events with more advanced loading conditions to be solved. IMDPlus is applicable to both 2D and 3D structures and has three primary uses:

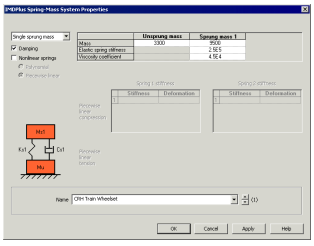
- **Moving load analysis** of structures, such as bridges subjected to moving vehicle or train loads, where the magnitude and configuration of the loading remains constant throughout the analysis.
- **Moving mass and sprung mass analysis** of structures, such as bridges subjected to moving vehicle or train loads, where mass-spring-damper systems are used to represent the vehicle. The configuration of the systems remains constant throughout the analysis but, as they move across the structure, the dynamic response of the unsprung and sprung masses affects the applied loading due to inertia effects.
- **Seismic response analysis** of structures subjected to acceleration time histories of support motion.

IMDPlus analysis

An IMDPlus analysis uses conventional eigenvalue analyses to obtain the undamped modes of vibration for a structure over the frequency range of interest. The modal response in the form of frequencies, participation factors and eigenvectors, together with the seismic accelerations or moving load/ moving mass vehicle loads, enable IMDPlus to compute the dynamic response for each mode of vibration. The assumption of linear structural behaviour allows the IMDPlus facility to utilise linear superposition methods to calculate the total response of the structure from each of the contributing frequencies. As a direct result of this, IMDPlus is of considerable benefit when compared with traditional direct integration time-stepping procedures - in many cases results are obtained in seconds as opposed to several hours. The IMDPlus facility therefore offers large savings in design and analysis time and greatly reduces the computational resources required for lightly damped, linear transient dynamic analyses.







Moving Load and Moving Mass / Sprung Mass Analysis

The moving load and moving mass options facilitate the dynamic response analysis of a bridge for different vehicle or train speeds by maintaining a consistent vehicle motion across the bridge and simply adjusting the time interval for the modal calculations. In a moving load analysis, the loading remains constant throughout the analysis. In a moving mass analysis, the dynamic response of the mass-spring-damper systems, that represent the vehicle, modify the dynamic forces acting on the underlying structure due to inertia effects. For both options the calculations can process a range of vehicle speeds on each execution of the IMDPlus facility. Results are readily obtained for either a single speed to give full time history output, or for a range of speeds to give peak response output.

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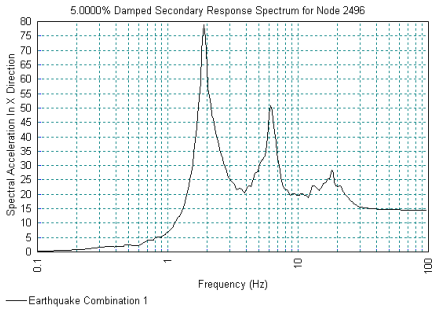
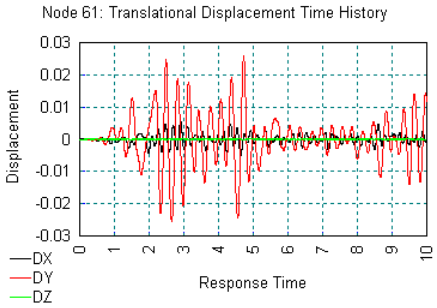
Seismic Analysis

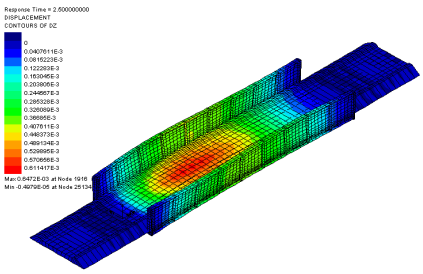
The seismic analysis option calculates the response of a structure to an acceleration time history input applied at the support nodes. A different acceleration record can be applied in each global direction and these can be factored based on design code requirements. All support nodes are accelerated with the same time history record in each direction and up to seven earthquake combinations can be analysed in a single IMDPlus analysis. Time histories, peak summaries, Secondary Response Spectra (SRS), and modal combinations can all be output.

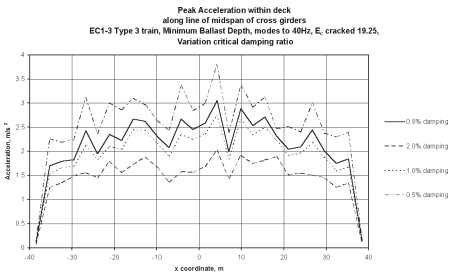




Results

Results can be displayed using the extensive LUSAS graph plotting facilities or using the standard contour, vector or peak value features. Results for individual nodes or elements can be visualised or selections of nodes or elements can be included in a single IMDPlus analysis to enable summed, averaged or enveloped results to be produced. In a moving mass analysis results for the mass-spring-damper systems can be obtained to aid in the assessment of vehicle dynamics. Since both the damping and 'time-step' are specified within IMDPlus there is no need to carry out a series of computationally expensive transient dynamics analyses to assess the effect of these parameters on the structural response.





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Example uses of IMDPlus

IMDPlus has been successfully used on numerous projects throughout the world to assess seismic or moving vehicle dynamic responses on differing types of structure:

- Devonport Royal Naval Dockyard, UK
- Liquid Natural Gas Tanks, Worldwide
- Newark Dyke Rail Bridge, UK
- Bridges for West Coast Mainline, UK
- Sg. Tuaran Road Bridge, Malaysia

... and more

LUSAS
Finite Element Analysis

IMDPlus Option

- Multiple event simulation
- Fast solution times
- Linear dynamics effects
- No loss of contact moving mass analysis
- Support for 2D Plane Strain, 2D Plane Stress, 3D continuum, 2D and 3D bars, 2D and 3D beams, 2D and 3D joints, and 3D thin and thick shell elements
- Displacements / velocities / accelerations / Dynamic Amplification Factors / reactions for nodes
- Forces / moments, stresses / strains, stress / strain resultants for elements
- Displacements / velocities / accelerations / forces for mass-spring-damper systems of a moving mass vehicle
- Vehicle configuration definitions enable multiple vehicle types to be analysed during a single IMDPlus session
- Can solve large and complex modelling problems in a fraction of the time taken by traditional direct integration time-stepping procedures, giving large savings in design and analysis time
- Output of raw results in a number of formats

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