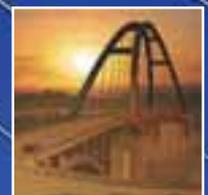


LUSAS
Bridge



Bridge analysis, design and assessment software



Image: ZAP Construction

Overview

LUSAS Bridge is a world-leading finite element analysis software application for the analysis, design and assessment of all types of bridge structures. Whether you need to carry out a straightforward linear static analysis of a single span road bridge, a dynamic analysis of a slender 'architectural' steel footbridge, or a detailed geometrically nonlinear staged erection analysis of a major cable stayed structure involving concrete creep and shrinkage, LUSAS Bridge provides all the facilities you need.

LUSAS Bridge is available in a choice of software levels to suit your analysis needs. Each uses the same Windows user interface, and has modelling wizards, comprehensive vehicle loading and Smart Combination facilities for easy and rapid model generation, load application and combining of loadcase results. Extensive results processing, viewing and report generation facilities give you ultimate control over what you plot and print from your analysis. In short, LUSAS Bridge software handles simple grid/grillage and slab structures with ease and has a full range of additional software options and features for more advanced bridge structures.

Use for all bridge types:

- Slab decks
- Slab / beam decks
- Composite decks
- Straight or curved plate girders
- Masonry arches
- Integral bridges
- Truss bridges
- Ribbon bridges
- Moving bridges
- Cable stayed bridges
- Suspension bridges

Use for:

- Innovative new design
- Cost effective bridge assessments
- Cost-saving re-design
- When design codes can't be used
- Ultimate load assessments
- Development of retrofit solutions
- Erection engineering

Increase Your Efficiency

Used globally, LUSAS is highly regarded in the bridge industry, as demonstrated by an impressive list of clients including many of the top international consultancies. LUSAS is also used extensively by government agencies, local authority bridge departments and smaller to medium-size consultants, many of whom find that the advanced analysis facilities not only expand their capabilities but also give them a competitive edge.

Whether for optimising new designs or providing accurate and cost-effective load rating assessments of existing structures, LUSAS Bridge provides a complete solution. As a result LUSAS Bridge is seen to be the prime choice for organisations wanting to increase their efficiency by using state-of-the-art software and standardising on a single product for all their analysis needs.





Modelling

LUSAS Bridge has an easy to use, associative Modeller for modelling / results processing and a fully integrated Solver which can be used independently.

- The user interface is a full native Windows implementation providing an Open Interface to ActiveX compliant Windows software such as Excel, Access, Word and other software.

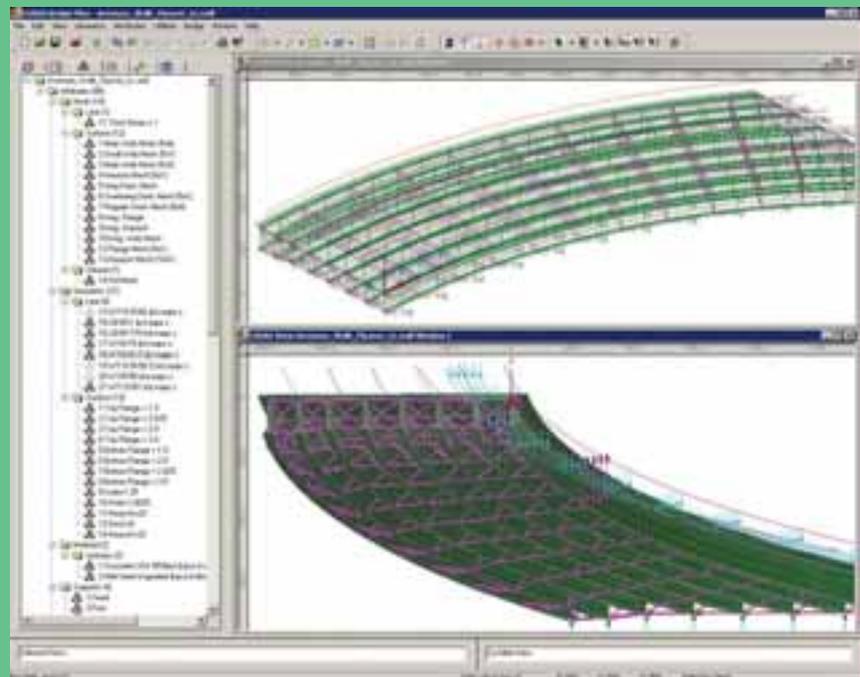
- Customisation of menus, toolbars and dialogs plus the ability to create your own wizards with Visual Basic Scripting provides limitless potential to tailor the software to specific needs.

- Models are formed of layers where the visibility and properties of each layer can be controlled and accessed via the layer name held in a Layer treeview, one of a number of treeviews used to organise and access model data.

- Models are created using feature-based geometry methods and CAD import / export is supported. As the model is built up, model features may be grouped together and manipulated to speed up data preparation or to enable parts of the model to be temporarily hidden.

- Model attributes such as thickness, material, loading etc. can be named explicitly. Once defined they appear in an attributes treeview ready to be assigned to selected geometry of the model using the "drag and drop" technique.

- Automatic meshing with mesh refinement capability.



- Built-in associativity, a key feature of the LUSAS Modeller, ensures that if the model geometry is amended, all assigned loadings, supports, assigned mesh and other attributes are automatically updated to suit.

- Fleshing (the visualisation of assigned thicknesses or section shapes) helps to ensure that the thicknesses and eccentricities of slabs and the orientation of beam members are correctly defined.

- Datatips reveal useful model information such as assigned properties when the cursor is positioned on top of a geometry feature.

- The OpenGL implementation provides fast graphical displays. Multiple graphical windows allow simultaneous displays of different parts of the model at different orientations. Powerful cursor selection options and pan, zoom, dynamic rotation and pre-defined views allow for easy viewing and editing of your model.

- A multi-level undo/redo facility allows quick modelling corrections to be made.

- Detailed on-line dialog help links to additional reference manual material to provide you with the most appropriate level of assistance at all times.



Wizards and utilities

Modelling wizards allow for rapid model generation. Section libraries and a range of section property calculators help to provide for straightforward modelling of grid/grillage and beam models.

- A grillage wizard enables the rapid generation of a wide variety of orthogonal, skewed and curved multi-span grillage arrangements. Cracked sections can also be included.

- A multiple automatic influence wizard permits the definition of all or selected model locations of interest.

- Single and multiple tendon prestress wizards compute tendon forces in accordance with various design codes.

- Loadcase generators for moving vehicle and train loads and the ability to model various dynamic pedestrian loading configurations are available.

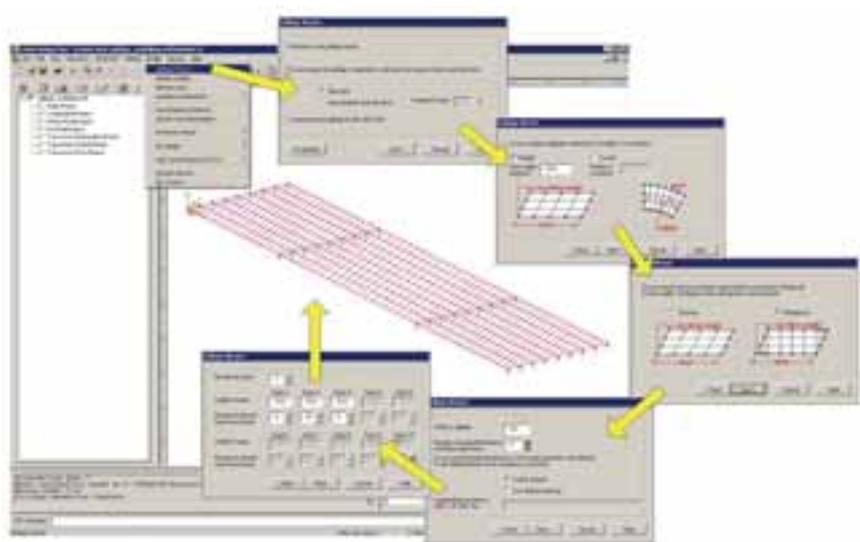
Section libraries and calculators

- Steel section libraries include those for the United States of America, United Kingdom, Eurocode, China, Korea, Canada, Australia and others.

- A precast beam section generator calculates section properties of a range of country and region-specific precast concrete beams. Slab contribution can be included.

- Common standard section shapes such as rectangular, circular, I-shape, T-shape, L-shape, C-shape and Z-shape sections can be easily user-defined.

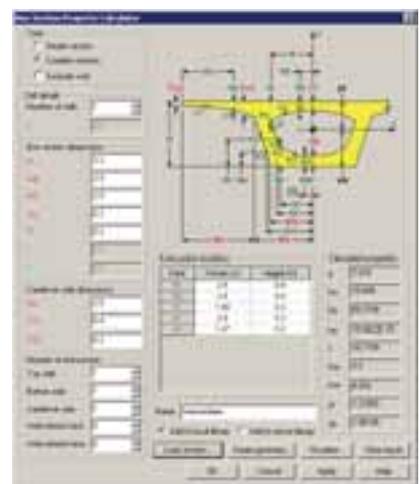
- Section property data for any drawn shape or collection of section shapes can be calculated using an arbitrary section property calculator.



- Section properties of simple or complex, single or multiple box cross sections (with / without voids) can be calculated from entered values.

- Tapering beams can be easily defined by specifying section properties for each end.

- Multiple varying sections can be defined along a path of lines allowing straightforward building of models for bridges having curved soffits or for arch structures having varying cross-sectional thicknesses.





Advanced elements, materials and solvers

Unrivalled state-of-the-art linear and quadratic element libraries; advanced material models; linear, nonlinear and seismic isolator joint models; and direct, eigen and fast solver options allow all types of bridge engineering problem to be modelled and solved as efficiently as possible.

Advanced element libraries

- Plate and shell elements for slab decks
- Beams and shells for prestressed concrete, steel and composite construction
- Solid elements for detailed modelling and studying local effects
- Elements for cabled stayed and suspension structures
- Joint elements for linear and nonlinear joint models

Advanced general material models

- Isotropic including plastic, creep, damage, shrinkage, viscous, two-phase
- Orthotropic including plastic, creep, damage, shrinkage, viscous, two-phase
- Anisotropic and rigidity models
- Temperature dependent models
- Concrete models with opening and closing of cracks, concrete crushing, and strain softening based on fracture energy in 2D/3D
- Concrete creep including *fib* (formerly CEB-FIP) and Chinese model codes
- Geotechnical models including Mohr Coulomb criteria with non-associative flow for soils and rocks
- Volumetric deformation soil model (includes consolidation)
- User-defined models and others

Joint material models

Joint material models are used in conjunction with joint elements to fully define the properties for linear, nonlinear and seismic isolator joints.

- Linear joint models include those for spring stiffness only and for general joint properties having spring stiffness, mass, coefficient of linear expansion and damping factor.
- Nonlinear joint models include elasto-plastic uniform tension and compression with isotropic hardening, elasto-plastic general with isotropic hardening, smooth contact, frictional contact, nonlinear user-defined, and others.
- Seismic isolator joint models include viscous dampers (Kelvin and Four Parameter Solid), lead rubber bearings with plastic yield and biaxial hysteretic behaviour, friction pendulum system with pressure and velocity dependent friction coefficient and biaxial hysteretic behaviour, and others.

Solvers

Direct and eigen solvers are provided as a minimum in all software products and a Fast Solvers option provides three additional solvers for use with particular LUSAS Bridge products.





Load types and combinations

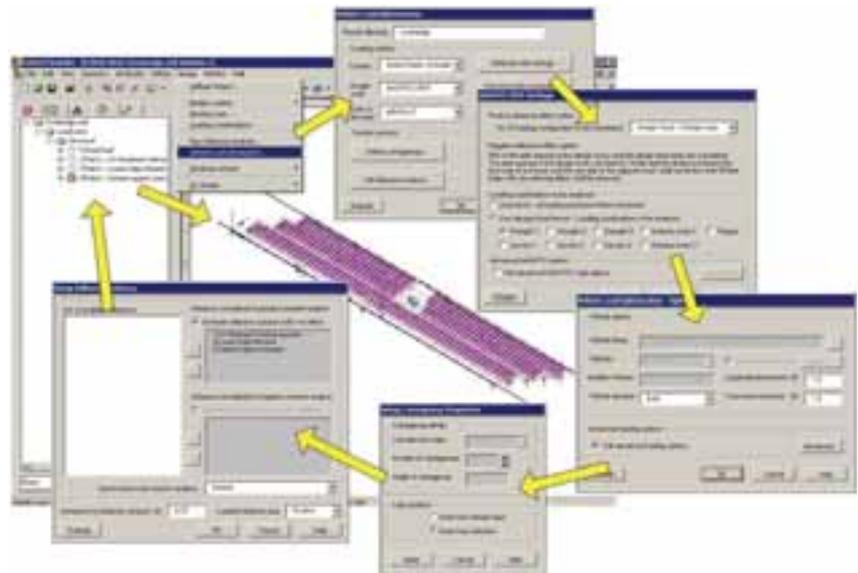
LUSAS Bridge provides a comprehensive range of general loading types to cater for most circumstances. Structural loadings include gravity, concentrated, distributed, face, temperature, stress/strain, and beam loads. Prescribed loading options allow initial displacements, velocity or acceleration to be specified. Discrete loads distribute a loading pattern over full or partial areas of the model, independent of the model geometry. Thermal loads describe the temperature or heat input for a thermal analysis. Vehicle and train loading, and prestress and post tensioning to many international design codes is provided.

Vehicle Loading

Vehicle loading facilities in LUSAS Bridge software make load generation straightforward, significantly speeding up the task of defining the loading on a bridge deck.

- Static vehicle and train loading options for many international bridge design codes including AASHTO and Eurocode are provided. Load trains can be created using a compound load facility. Abnormal load generators are included.

- Vehicle and train loadings can be used either on their own or with a moving load generator to automatically create the required set of loadcases as a loading type makes its way across a bridge.



Vehicle Load Optimisation

Significant amounts of time can be saved with the optional Vehicle Load Optimisation facility which generates the most adverse combination of live loading. The interface consists of a series of dialogs requiring only the input of a few parameters to enable an optimised load pattern to be generated in accordance with a chosen code of practice.

Envelopes and Combinations

- Basic load combinations allow for manual definition of loadcases and load factors.
- Envelopes of multiple loadcases create maximum and minimum results.
- Smart Combinations generate maximum and minimum results, taking account of adverse and relieving effects, substantially reducing the number of combinations and envelopes required.

Load Combination Wizards

Predefined bridge loadcases for design codes help to automate the definition of load combinations. When used in conjunction with a design code template, combinations of load combinations are automatically created to give the resultant maximum and minimum ULS or SLS loadcases.

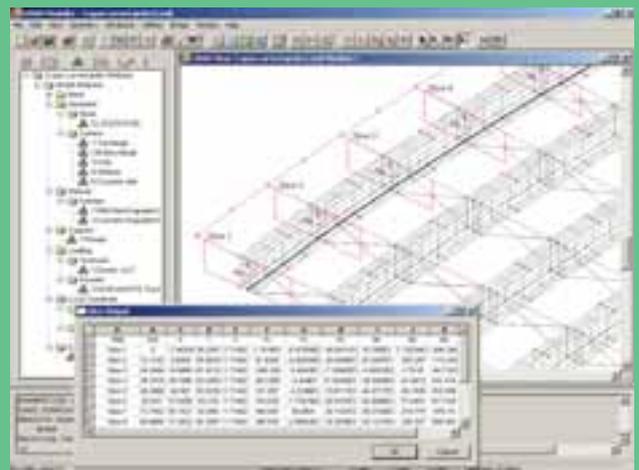
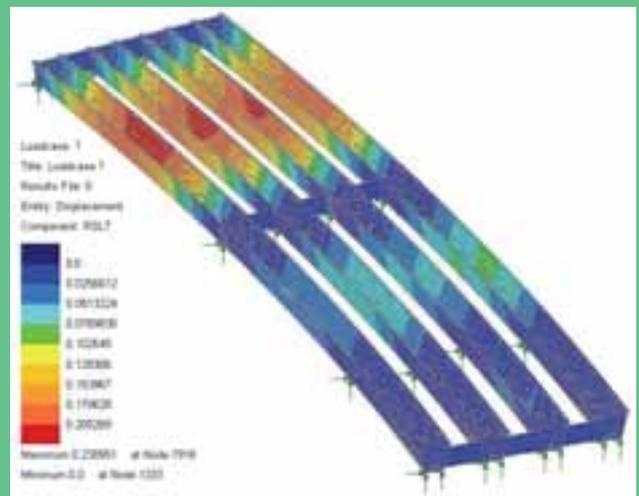




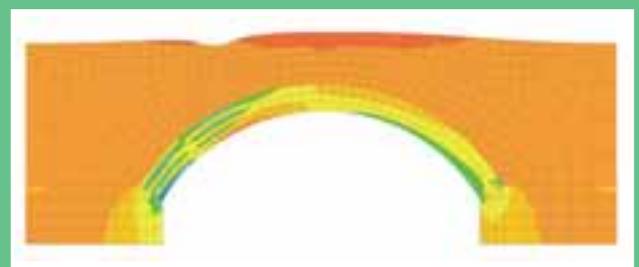
Viewing results

LUSAS Bridge has a host of easy to use results processing and viewing facilities to help you get the most from your analysis.

- Results can be viewed using separate layers for diagram, contour, vector and discrete value data.
- Loadcases are selected on a window basis allowing multiple views of the model with each window displaying results for different loadcases.
- Bending moments, shear forces, and deflections can be plotted.
- Contour ranges and vector/diagram scales can be controlled locally in each window or set globally to apply to all windows.
- Results can be displayed in global or local directions, in element directions, or at any specified orientation
- Results can be plotted on deformed or undeformed mesh plots and on fleshed or unfleshed beam sections.
- Multiple slices may be cut through 3D solid models on arbitrary planes and made visible or invisible in any window.
- A user-defined results calculation facility allows LUSAS model and results parameters to be built into arithmetic expressions giving spreadsheet-style capability inside LUSAS and offering an alternative to external results manipulation.
- Results can be selectively output to spreadsheet applications for additional calculation and graphing uses.



Entity	Expression	Name	Description
FaceMoment - Thick Plate	400	fs	max stress of steel
FaceMoment - Thick Plate	400	fs	min stress of steel
FaceMoment - Thick Plate	1340	As	area of steel
FaceMoment - Thick Plate	1000	S	width
FaceMoment - Thick Plate	$71.1 \sqrt{10^6} \sqrt{10^6} / 10^6$	FS	FSR with
FaceMoment - Thick Plate	$0.071 \sqrt{10^6} \sqrt{10^6}$	Ms	ULS moment capacity
FaceMoment - Thick Plate	MS/As	Usage	Usage ratio





Animations

Animations of results - particularly useful for animating mode shapes, viewing of structural response to moving loads and seismic events, and for investigating the spread of concrete cracking or yielded material - can be created and saved as AVI files for use in other Windows applications.

Graphing

A graph wizard provides a step by step means of selecting results data to be drawn on a graph. Numerical data used to create the graph is displayed in a grid format alongside. Arbitrary line sections may also be taken through any surface model or on a slice cut through a three dimensional solid model.

Slab Design

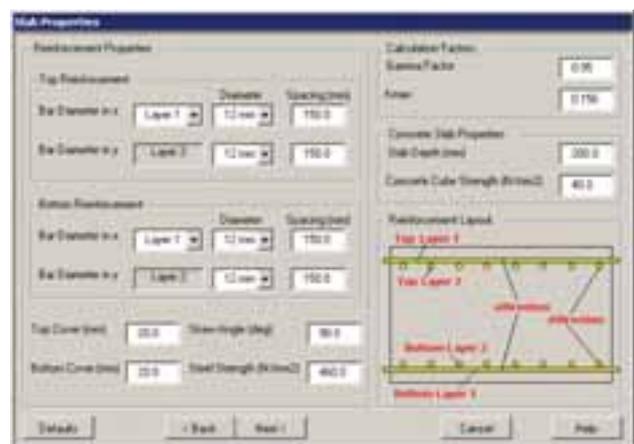
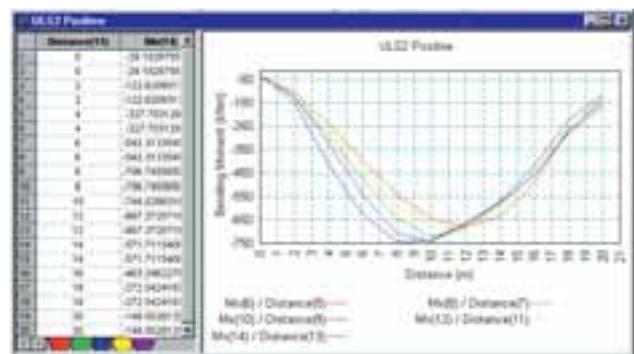
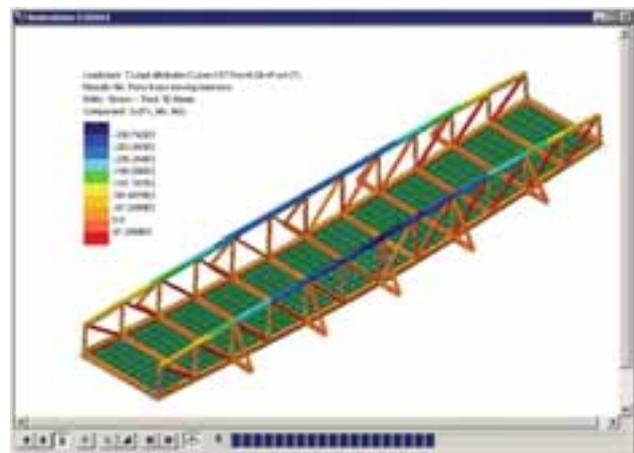
An RC slab/wall design facility calculates the reinforcement requirements for slabs or panels based upon Wood Armer moments. Contours of steel area, or bar diameter and spacing can be plotted to aid in the detailing process. A crack checking facility provides contours of crack widths for a chosen direction and level.

Printed results

Results values for individual results components and entities can be tabulated using the Print Results wizard. These may be transferred to other applications using standard Windows copy and paste operations. Model and results views can be printed directly, saved as high resolution BMP, JPG, or WMF files, or be copied and pasted direct into other applications.

Report generator

Selected modelling, loadcase and results data can be written to a report using the report generator. Report templates hold user-defined information to generate customised reports. Report content can be selected on an element, feature type, group, and loadcase basis. Additional text and screenshots or saved images of model or results can be included. Each time a report is created, up to date modelling and results data are extracted ensuring model and report compatibility at all times. Report data may be exported to Excel spreadsheets as well as be exported into other formats including PDF, HTML and RTF (for use in Word) for quality assurance, model checking, and results listing purposes.





Analysis capabilities

Typical analysis capabilities are described on the following pages.

Linear static

Stresses, strains, displacements, moments, shears and axial forces that result from static loading are easily calculated, displayed and output from any model.

Buckling

LUSAS carries out elastic critical buckling, which is required for the calculation of member resistances. Often it is also required by some codes to determine if a second-order analysis needs to be carried out. If so, a full nonlinear buckling analysis can be undertaken.

■ For existing structures, assessment or load rating to regional design codes can give conservative results showing they 'fail' buckling checks, but detailed buckling analysis with LUSAS can often reveal additional 'hidden' capacity and prove a load capacity.

■ For new plate girder, box or tub girder bridge designs, linear and nonlinear buckling analysis using LUSAS can investigate the girder stability during erection, look at the effects of a slab casting sequence, and also help to optimise the size of the web and flange plates, bracing, stiffeners and position of any temporary supports used.

Fatigue

Fatigue calculations can be carried out using the total life approach. Fatigue life may be expressed in terms of the damage that is done to the structure by a prescribed loading sequence or as the number of repeats of a sequence that will cause failure

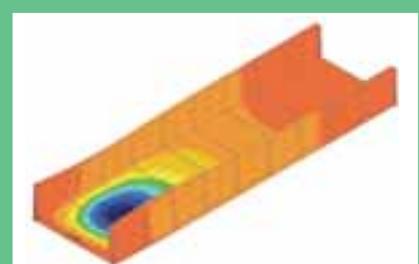
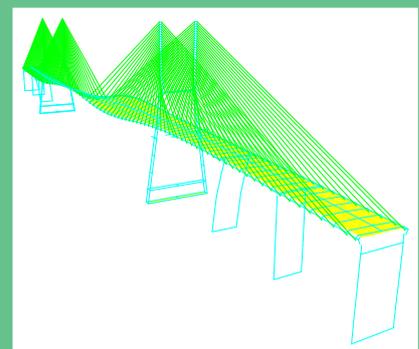
Dynamics

The natural frequency of structures, the effect of dynamic loading, such as pedestrian loading on footbridges and responses due to earthquake or impact loading can all be readily calculated. Capabilities include:

- Pedestrian excitation
- Vehicle pier impacts
- High speed rail dynamic effects
- Blast loading
- Ship impact
- Seismicity

Interactive Modal Dynamics (Modal superposition)

Interactive Modal Dynamics (IMD) allows the natural vibration behaviour of a structure to be combined with a loading regime in order to calculate the dynamic response of a structure to a range of applied excitations. IMD produces results an order of magnitude faster than traditional time-step solutions. Multiple and more advanced loading events (including moving loads and nonlinear behaviour) can be modelled with the IMDPlus and additional software options.





Staged construction

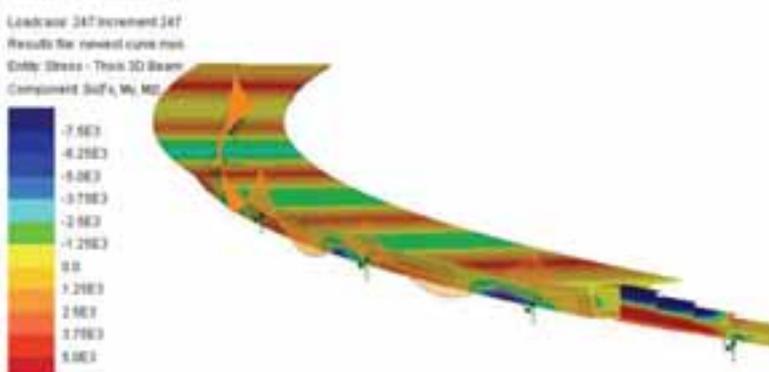
Staged construction analysis is essential for many forms of bridge construction whether it be for carrying out a detailed analysis of an incrementally launched segmentally constructed box girder bridge or modelling cable or hanger replacements for cable stayed and suspension bridges. Staged construction analysis with LUSAS provides you with the means to model the step-by-step construction or rebuilding of your structure over time and evaluate the effects of structural changes, load applications, and if required, time-dependent material changes.

The complete staged construction analysis process for a model is controlled in a loadcase panel of the LUSAS Treeview. When modelling, groups of elements and associated attributes can be activated and deactivated, and supports can be introduced or removed to accurately represent each stage of construction.

With LUSAS Bridge, unlike some software, only one model file need be created and this can contain all of the information required to carry out an analysis of every stage of construction. The effects of geometric and material nonlinearity, and time-dependent material effects such as creep and shrinkage can all be included within the one analysis run.

Use for all types of staged construction methods / bridge types including:

- Staged placement of beams and slab for continuous structures
- Cast insitu span-by-span construction of continuous beams
- Precast segmental span-by-span erection
- Cast insitu balanced cantilever construction
- Precast segmental balanced cantilever construction
- Progressive erection of precast segmental decks
- Incremental launching
- Balanced placement for cable-stayed bridges
- Composite decks
- Extradosed bridges
- Suspension bridges





Prestress and post tensioning

Single and multiple tendon prestress wizards in LUSAS calculate equivalent nodal loading due to tendon prestressing or post-tensioning and assign these forces automatically a model. Computation of tendon forces can be carried out in accordance with various regional codes including AASHTO, Eurocode, China and others. A multiple tendon prestress wizard for staged construction analysis takes into account elastic shortening due to stressing of other tendons according to the design code used or to user-defined percentage losses.

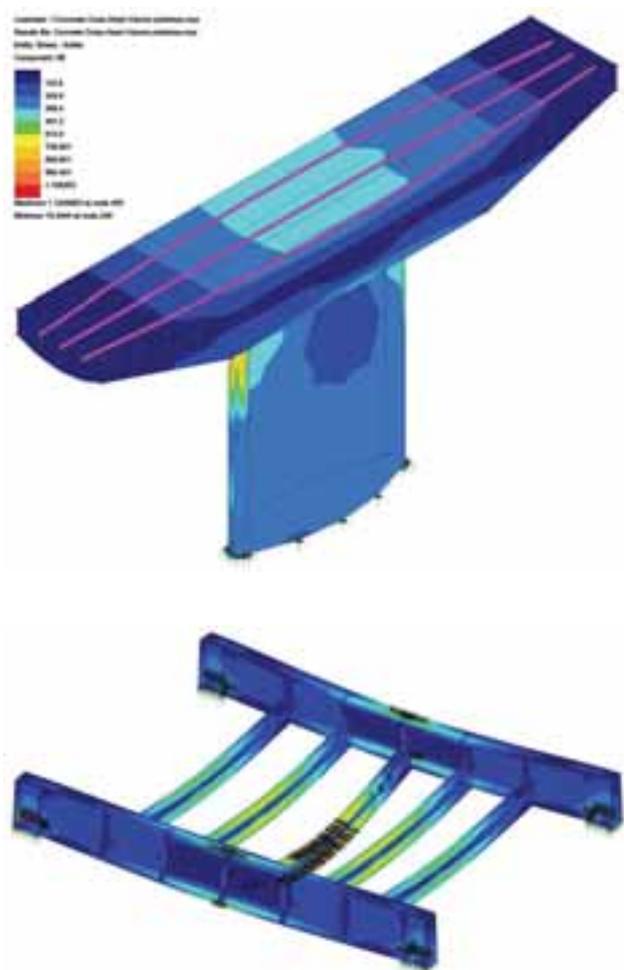
Nonlinear

An analysis will often have to take account of nonlinear materials, geometry, and support boundary conditions to accurately model the structural behaviour. LUSAS Bridge handles geometric nonlinearity, material nonlinearity and contact nonlinearity. Local and global nonlinear analysis with LUSAS helps ensure that bridges are designed economically and safely for any imposed loading. Automatic nonlinear solution procedures simplify the analysis process for applications such as:

- Lift-off of bearings and halving joints
- Lead-rubber bearing analysis, bearing collapse
- Elasto-plastic large deflection plate buckling
- Large deflection cable analysis
- Soil-structure interaction / integral bridge design
- Masonry arch analysis
- Time-dependent dynamic analysis
- Vehicle and boat impact assessments
- 'Push-over' analysis
- Large deflection in cable structures

Soil-structure interaction

Useful geotechnical capabilities make use of a range of soil models. Residual soil stress varying with depth can be accommodated providing useful facilities for soil-structure interaction for integral bridges and culverts. Rock joints, pore water pressure dissipation, consolidation modelling, geotechnical problems involving long term excavation, construction in clays, and temporary works can all be solved.



Customisation and automation

The LUSAS Programmable Interface (LPI) provides the means to customise modelling and results processing tasks to your specific requirements. By using VBScript to access LUSAS facilities and functionality direct links to Word and Excel can be made for data transfer, the parameterisation of structures can be achieved, repetitive tasks can be automated, and results processing procedures can be customised.





Software options

The analysis capabilities of particular LUSAS Bridge software products can be extended by using any of the following software options.

Vehicle load optimisation

The Vehicle Load Optimisation software option complements and extends the vehicle loading capabilities of LUSAS Bridge. It automatically generates the most adverse live load patterns for multiple lanes of traffic against influence surfaces generated by LUSAS in accordance with a variety of international design codes.

Fast solvers

The Fast Solver option comprises three solvers for use with particular LUSAS Bridge products.

- The Fast Multifrontal Direct Solver can provide solutions several times faster than the standard Frontal Direct Solver for certain analysis problems.
- The Fast Multifrontal Block Lanczos Eigensolver can, similarly, return results several times faster than the standard Frontal Eigensolvers for certain problems.
- The complex eigensolver provides efficient solutions for large-scale damped natural frequency problems.

IMDPlus

The IMDPlus option extends the Interactive Modal Dynamics (IMD) techniques available in all LUSAS products, and which model a single loading event in a single direction, to allow multiple loading events with more advanced loading conditions to be solved.

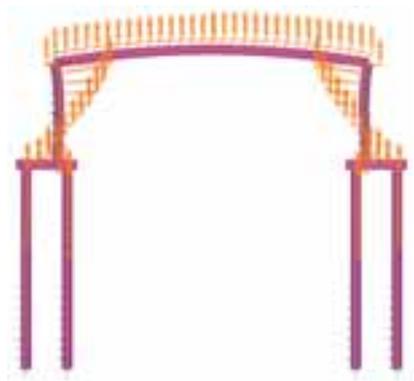
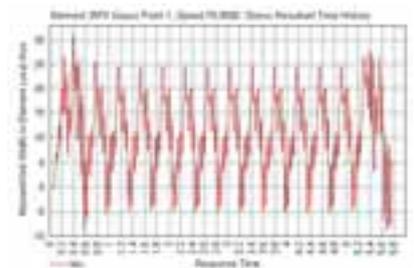
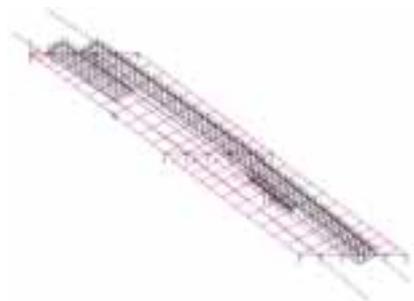
IMDPlus is used for two primary uses: seismic response analysis of 2D and 3D structures subjected to acceleration time histories of support motion, and for the analysis of 3D structures, such as bridges, subjected to constant moving vehicle or train loads.

Nonlinear analysis

The Nonlinear analysis software option provides the very latest powerful techniques for solving problems having either material, geometric or boundary nonlinearity.

- Geometric nonlinearity (large deformations, finite rotations and large strains)
- Material nonlinearity (concrete, steel, rubber and geotechnical material models)
- Contact nonlinearity (point and surface).

The Nonlinear option can be used to solve a multitude of problems having large deformations, high levels of material nonlinearity and complex boundary conditions. It can also be combined with the LUSAS Dynamic and Thermal / Field software options to solve problems in which the effects of time and temperature are important.





Dynamic analysis

Straightforward modal dynamics problems can be solved using Interactive Modal Dynamics (IMD) techniques which are provided in selected LUSAS Bridge products. The Dynamics option contains the facilities required to solve a wider range of dynamic problems in the time domain with a step-by-step solution. Additionally, by combining the LUSAS Dynamic and LUSAS Nonlinear options both high and low velocity nonlinear impact problems can be solved using either implicit or explicit solution techniques.

Thermal / field analysis

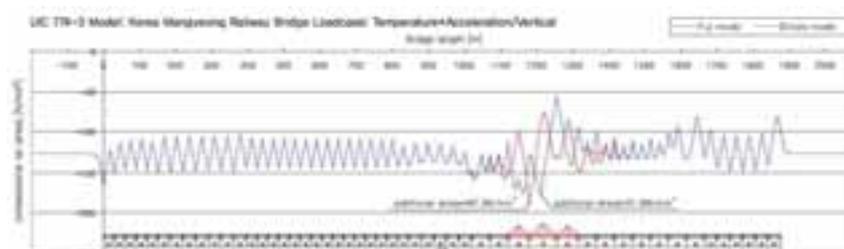
The Thermal / Field software option contains extensive facilities for both simple and advanced steady state, and transient thermal / field analyses. By combining the LUSAS Thermal / Field option with other appropriate LUSAS options, heat transfer due to conduction, convection and radiation can be analysed. In addition, the effects due to phase change of material may also be included.

Heat of hydration

Modelling of heat of concrete hydration can be carried out for a variety of cement types using the using the Heat of Hydration option. Effects due to the addition of fly ash and ground granulated blast furnace slag can also be included. When used in conjunction with Nonlinear, Dynamic, and Thermal software options the heat of concrete hydration can be computed during a thermo-mechanical coupled analysis and the temperatures and degree of hydration can be read in to the mechanical analysis.

Rail Track Analysis

When used with the Nonlinear software option the LUSAS Rail Track Analysis option automates track/bridge interaction analysis for light and high speed rail projects to the International Union of Railways Code UIC 774-3. It allows you to automatically build models from data defined in Excel spreadsheets, run an analysis, and quickly calculate stresses and forces induced in the track from both thermal and train loading. Parametric positioning of train loading is supported, results graphs are automatically created and exported to Excel spreadsheets, and code checking results tables are generated.



...in summary

Vehicle Load Optimisation

- Live load optimisation
- Worst load combination obtained
- International design codes

Fast Solvers

- Direct Solver
- Block Lanczos Eigensolver

IMDplus

- Fast multiple event evaluation
- Seismic response analyses
- Moving load analyses

Nonlinear

- Geometric nonlinearity
- Material nonlinearity
- Contact nonlinearity
- Automatic solution procedures

Dynamic

- Spectral and forced response
- Transient implicit dynamics
- Nonlinear dynamics
- Modal or Rayleigh damping

Thermal / Field

- Steady state and transient
- Temperature distribution / dissipation
- Coupled thermal-structural

Heat of Hydration

- Model a variety of cement types
- Include effects of fly ash and slag

Rail Track Analysis

- Track / bridge interaction analysis to the International Union of Railways Code UIC 774-3
- For light and high speed rail use
- Automated model building and results processing



Software, support and consultancy services

Software product range

Whether your analysis requirements are simple or advanced, LUSAS Bridge can be configured with various levels and options to meet your needs, all of which are fully integrated and easily upgradeable. The configuration can also provide for extra copies of the Modeller independent of the Solver and can be made available as fixed or network (floating) licences over both LAN and WAN for flexible access.

Training services

Detailed LUSAS application training courses get you up-to-speed and also ensure you have sufficient knowledge of the relevant facilities to tackle the analyses you want to do.

Technical support

Our dedicated hot-line technical support engineers will help you to meet your deadlines and to make the most of your company's investment. They are experts in providing sound modelling and analysis advice to fellow bridge engineers in a friendly and informative manner and are regularly praised by clients for providing good and informative assistance.

Web-based support

The LUSAS web site User Area contains a wealth of technical information. Tips and tricks, frequently asked questions and other useful details are provided to assist you in your modelling and analysis tasks. Software scripts and the latest versions of LUSAS Bridge can be downloaded for instant use.

Quality assurance

The accurate and reliable results you get from LUSAS Bridge come not only from our continuous development program but also from our use of an automatic installation and testing system. With our quality control procedures, designed to comply with ISO 9001, you can use each new improved version of LUSAS Bridge with the same confidence as the last.

Consultancy services

If you need more assistance than that available through the hot-line service, then our team of engineering consultants can help. Whether you have a difficult analysis to carry out or need help with a peak workload, our rapid and cost-effective service will ensure you get the best out of your designs.

Find out more

Clients worldwide are benefiting from the commercial advantage that LUSAS Bridge gives them and testimonials on their use of the software speak for themselves. Whilst this brochure provides only a broad overview of the main facilities and benefits of using LUSAS Bridge software, detailed information sheets on key features, analysis capabilities and real-life uses of the software are also available.

For more details, or to arrange a demonstration, please contact LUSAS or your local distributor and find out just what LUSAS Bridge could do for you.



LUSAS