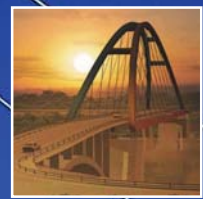# LUSAS
Bridge

Bridge analysis, design and assessment software

UK Headquarters

LUSAS

LUSAS is the trading name of Finite Element Analysis Ltd - a UK-based company that specialises in the development and marketing of high quality, specialist engineering analysis software. Our range of software products, based on the LUSAS finite element system, provide accurate and reliable solutions for all types of linear and nonlinear stress, dynamic, and thermal / field analysis problems. LUSAS users are provided with a first class technical support service and our Engineering Consultancy division offers specialist finite element consultancy services to all branches of the engineering industry.

For structural engineering analysis and design we provide the following software application products:

LUSAS Bridge

for all aspects of bridge engineering analysis, design, and assessment.

LUSAS Civil & Structural

for building, civil, structural, nuclear and offshore engineering.

LUSAS Composite

for the design of FRP or structural composites

LUSAS Academic

for teaching and research at educational establishments

Note that selected LUSAS Bridge and LUSAS Civil & Structural products include geotechnical and soil-structure interaction capabilities.

LUSAS Bridge software products

LUSAS Bridge software is available in a choice of software levels to suit your needs: Bridge LT, Bridge, and Bridge Plus.

1	2	3
LUSAS Bridge LT	LUSAS Bridge	LUSAS Bridge Plus
for frame analysis	for general analysis	for advanced analysis
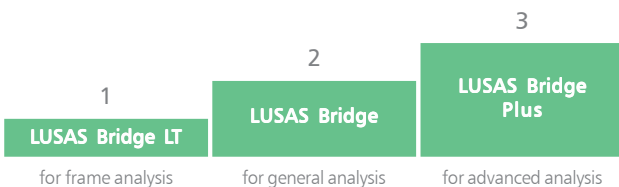
- Use Bridge LT for linear static analysis of structural frames and grillages.
- Use Bridge for linear static and linear modal dynamic analysis of shell and solid models.
- Use Bridge Plus for more advanced analyses using the appropriate purchased option(s).

Element set	Bridge LT	Bridge	Bridge Plus
2D/3D line elements (bars, beams...)	●	●	●
2D/3D surface and volume elements		●	●
Advanced high-performance elements			●

● Element set is included in this software product.

Software options

Extend the capabilities of particular LUSAS Bridge software products by purchasing software options.

|	Software product		
LUSAS software options ⬇	Bridge LT	Bridge	Bridge Plus
Fast Solvers	○	●	●
Vehicle Load Optimisation	○	●	●
Steel Frame Design	○	○	○
RC Frame Design	○	○	○
Composite Deck Design	○	○	○
IMDplus Analysis	n/a	○	○
Nonlinear Analysis	n/a	n/a	○
Dynamic Analysis	n/a	n/a	○
Thermal/Field Analysis	n/a	n/a	○
Heat of Hydration Analysis	n/a	n/a	○
Rail Track Analysis	n/a	n/a	○

● = Software option is included in this software product for new sales.
○ = Software option must be purchased for use with this software product.
n/a = Software option not available for use with this software product.

Cover: Gateshead Millennium Bridge, by Graeme Peacock. Courtesy of Gateshead Council.

Global coverage, users and support

LUSAS software is marketed and supported globally by LUSAS and also through a network of distributors and resellers that cover every continent.

Used by thousands of users, LUSAS is highly regarded in the civil, structural and bridge engineering industries, as demonstrated by an impressive list of clients, which include many of the top international consultancies. LUSAS is also used extensively by government agencies, local authorities 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. Universities and research institutions use the academic version of LUSAS, which provides a steady supply of proficient LUSAS users to support your use of the software in your industry.
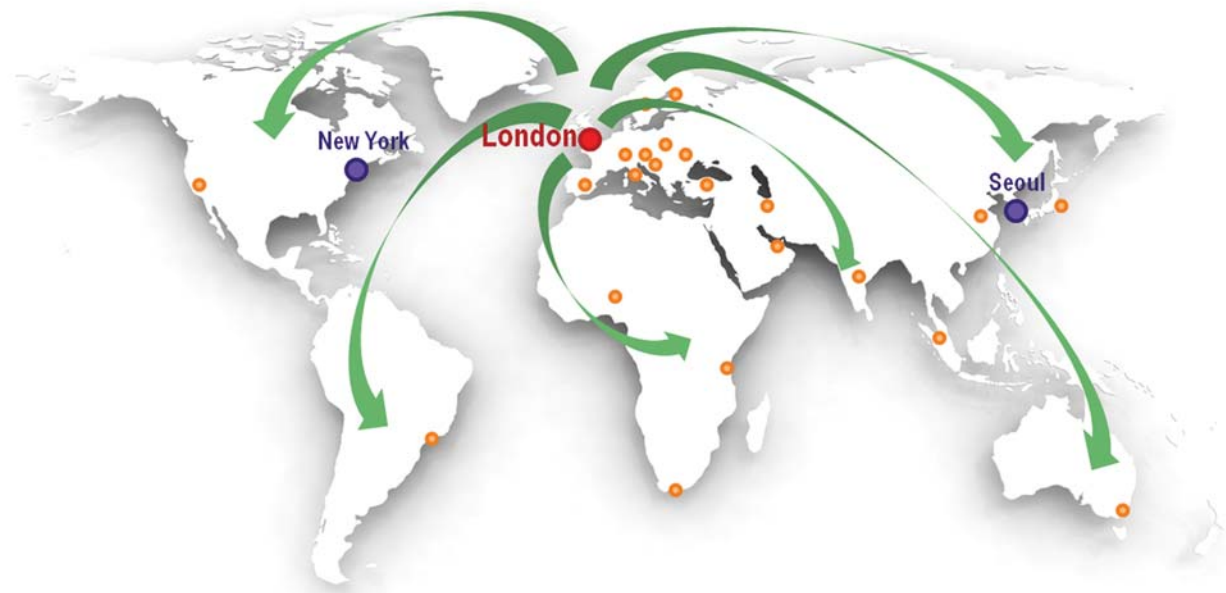
Some typical user quotes

"LUSAS has the best support in the industry. It's not even close with the other software companies." (Brian L.)

"The LUSAS team provide us with the best support I have experienced from any provider. You have gone to a great effort to build a trusted relationship. Your technical support is excellent and appreciated." (John M.)

"I was impressed with the LUSAS help desk. The responses were very detailed, informative and helpful." (Sarah R.)

LUSAS Bridge

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. 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.
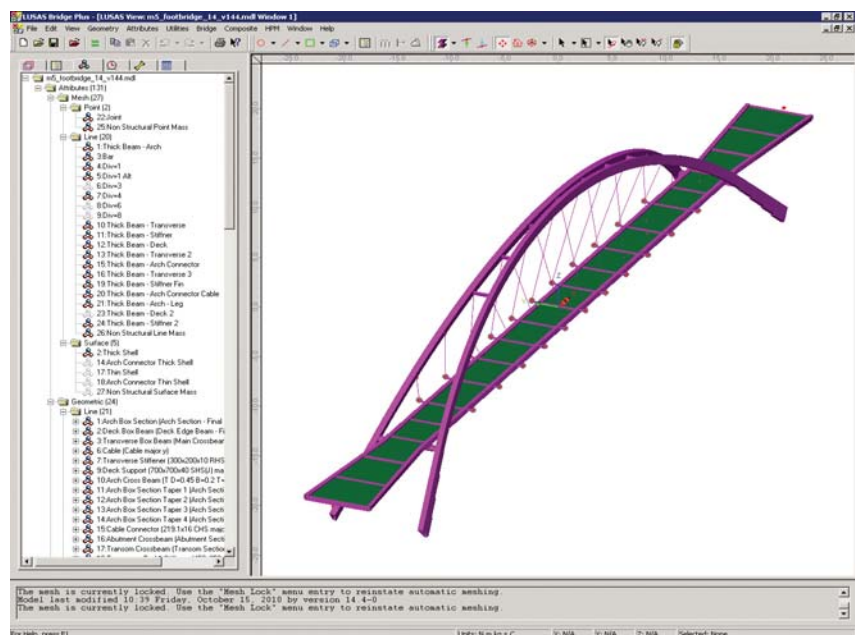
For all bridge types:

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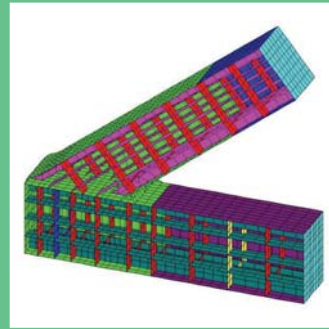- Cable stayed bridges
- Suspension bridges

Used for:

- Innovative new design
- Cost-saving re-design
- Load rating and assessments
- When design codes can't be used
- Development of retrofit solutions
- Erection / demolition engineering

Why use LUSAS Bridge?

LUSAS Bridge provides cost-effective structural modelling and analysis (including soil-structure interaction) of any structure, in one software package. Global and local modelling is feature-based and allows mixing of element types in the same model. Advanced nonlinear geometry, material and contact modelling is a key strength, and the software can also be customised using the LUSAS Programmable Interface. Overall, LUSAS is a trusted provider to industry leaders, and LUSAS Technical Support is stated, by its users, to be simply: "The best in the business."

The software features and capabilities described in this brochure summarize those of the LUSAS Bridge software range. Separate details list the capabilities of each particular software product.

Modelling in general

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.

■ Create models using feature-based geometry methods (points, lines, surfaces and volumes). CAD import / export is also supported. Model features may be grouped together to aid with manipulation, or with the assignment of attribute data.

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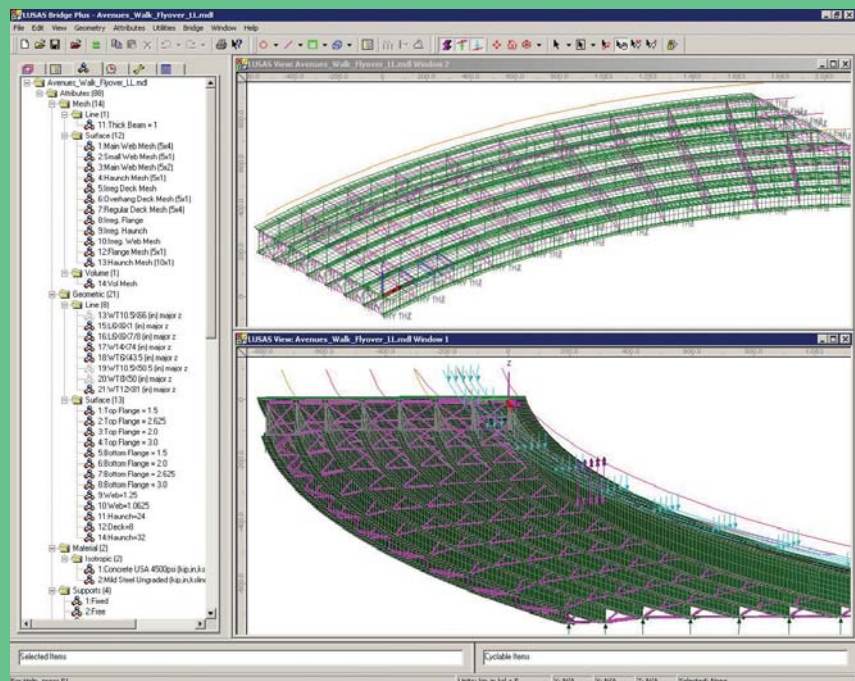
■ Built-in associativity, a key feature of the LUSAS Modeller, ensures that if the model geometry is amended, all assigned loadings, supports, assigned mesh and other attributes are automatically updated to suit.

■ 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 input units expected on dialogs, or assigned properties when the cursor is positioned over 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.
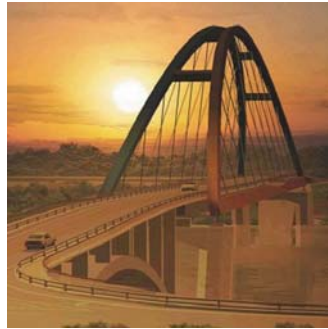
Wizards, libraries and utilities

The use of wizards allows for rapid modelling, generation of loading conditions, and viewing of results. Section libraries and a range of section property calculators provide for straightforward modelling of grid/grillage and beam/shell models.

■ Use the steel composite bridge wizard for quick and easy generation of straight or curved slab-on-beam composite I-girder bridges.

■ Use the grillage wizard to rapidly generate a wide variety of orthogonal, skewed and curved multi-span grillage arrangements. Cracked sections can also be included.

■ Use other wizards to calculate critical road and rail loading configurations, generate dynamic pedestrian loading or design code specific load combinations, and animate, graph and print results.
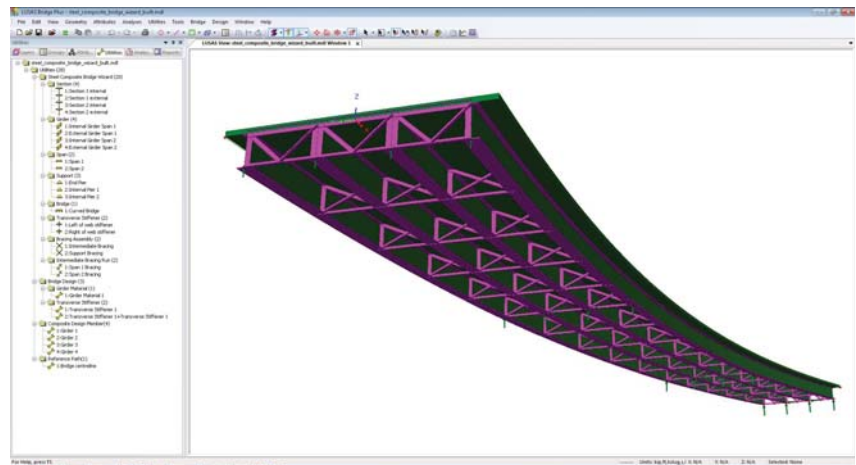
Section libraries and calculators

■ Access a range of steel sections from libraries including those for the USA, UK, Eurocode, China, Korea, Canada, Australia and others.

■ Define standard section shapes such as rectangular, circular, I-shape, T-shape, L-shape, C-shape and Z-shape sections. Riveted, welded, and encased sections also supported.

■ Use the precast beam section generator to calculate properties of a range of country and region-specific precast concrete beams.

■ Define bridge deck (grillage) properties with reference to formulae published by Hambly and others.

■ Use the arbitrary section property calculator to generate section properties for any drawn shape or collection of section shapes.

■ Calculate section properties of simple or complex, single or multiple box cross sections (with / without voids) rom user-defined values.

■ Define tapering beams by specifying section properties for each end.

■ Define multiple varying sections along a path of lines to easily build models of bridges having curved soffits, or arch structures having varying cross-sectional thicknesses.

■ Use the library browser to transfer mesh, geometric, and material data etc. between models.
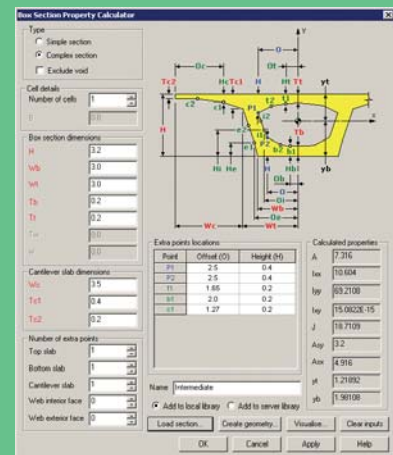
Advanced elements, materials and solvers

Unrivalled state-of-the-art linear and quadratic element libraries; advanced material models; linear, nonlinear and seismic isolator joint models; direct and eigen solvers, and a fast solver option collectively 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
■ Tension only/compression only bar material model
■ Concrete models with opening and closing of cracks, concrete crushing, and strain softening based on fracture energy in 2D/3D
■ Concrete creep and shrinkage to CEB-FIP Model Code 1990, Eurocode 2, and creep only for Chinese codes
■ Geotechnical models including Modified Cam-clay, Mohr Coulomb, volumetric deformation soil model (includes consolidation)
■ User-defined models and others

Joint material models
These are used 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. User-defined force/displacement and axial force dependent curves are supported.

■ Nonlinear joint models include elasto-plastic uniform tension and compression with isotropic hardening, elasto-plastic general with isotropic hardening, smooth contact, frictional contact, a range of hysteretic joints, and user-defined joint models.

■ 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 more.

Fast solvers
A Fast Solvers option (included with all new sales) provides a range of state-of-the-art solvers for use with all LUSAS Bridge software products.
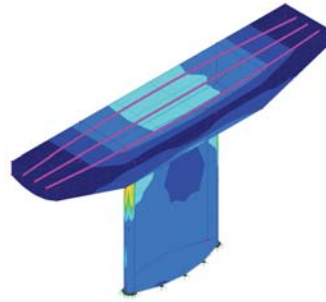
Load types and combinations

LUSAS Bridge provides a comprehensive range of general loading types to cater for most circumstances. Vehicle load types, train loading, and prestress and post tensioning to many international design codes are also provided. Vehicle load optimisation facilities help find onerous traffic patterns. Envelopes, basic and smart load combination facilities help investigate maximum and minimum primary and coincident effects.

General load types

Structural, prescribed and thermal loads are feature based loads that are assigned to the model geometry and are effective over the whole of the feature to which they are assigned.

■ Structural loadings include gravity, concentrated, distributed, face, temperature, stress/strain, and beam loads.

■ Specify initial displacements, velocity or acceleration using prescribed loading options.

■ Use discrete loads to distribute a loading pattern over full or partial areas of the model independent of the model geometry.

■ Define compound loads (to define load trains) from a set of previously defined discrete loads and assign to a model as one loading.

■ Use thermal loads to describe temperature or heat input for a thermal analysis or coupled structural / thermal analysis.

■ Apply variations in loading to all feature load types according to the feature on which they have been assigned.

Prestress and post tensioning

Prestress / Post-tensioning in LUSAS is suitable for beams, slabs and volumes, and incorporates time-stage with creep and shrinkage.

■ Compute tendon forces in accordance with various regional codes including AASHTO, Eurocode, and China.

■ LUSAS calculates losses appropriate to the age of the concrete and the magnitude and duration of prestress and other loading at any selected time - typically at each stage, and at the end of the service life of the structure.

■ For design codes that support time-dependent loss calculations, adjustment of losses to account for prior losses are also calculated.

■ Span-by-span, progressive placement (segmental), balanced cantilever and incremental launching time staged construction methods are supported.
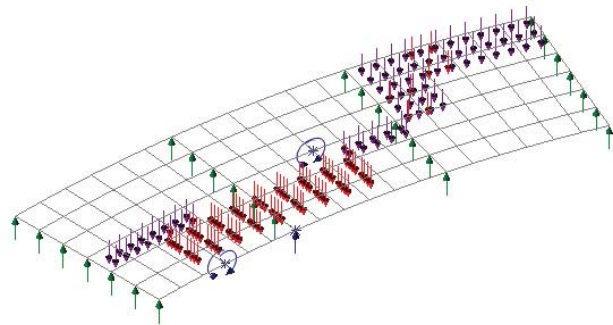
Vehicle Loading

Vehicle loading facilities in LUSAS Bridge software make the generation of live loads very straightforward, speeding up the task of defining the loading imposed on a bridge deck.

■ Apply static vehicle and train loading for many international bridge design codes including AASHTO and Eurocode. Use the compound load facility to create load trains. Abnormal load generators are included.

■ Use vehicle and train loadings either on their own, or with a moving load generator which automatically creates the required loadcases as a loading type makes its way across a bridge.

Vehicle Load Optimisation

Save significant amounts of time with the Vehicle Load Optimisation software option, which automatically generates the most adverse live load patterns for multiple lanes of vehicle (road) traffic, or tracks carrying train (rail) loading, in accordance with a variety of international design codes.

■ Define a few parameters and obtain optimised traffic or train loading patterns for shell/plate element models and line beam models (train loading only)

■ Reduce the amount of time spent generating loadcases to replicate live loading on models, and obtain a more efficient and economic design, assessment or load rating of bridge structures.
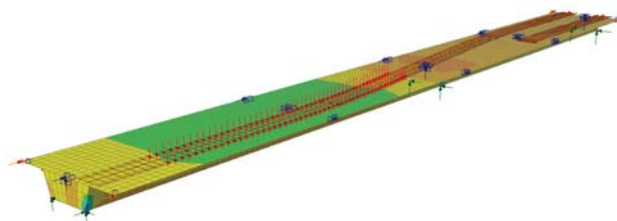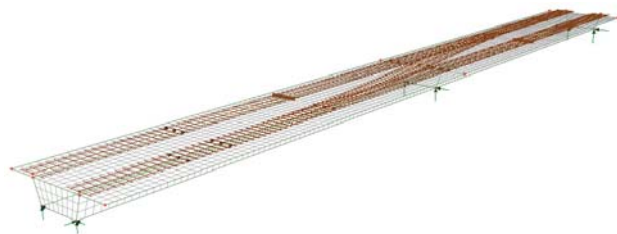
Envelopes and Combinations

■ Basic load combinations allow for manual definition of loadcases to be included and load factors to be used. In situations when superposition may not hold true, the factored loadcases from these combinations can be used to create a single loadcase for a nonlinear solution to be found.

■ Envelopes of multiple loadcases provide 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.

Design Code Load Combinations

Use the Design Combination wizard to assign a loadtype to a loadcase, envelope or basic combination for a supported design code. Based on the assignments and settings made, design code load combinations for those load types are automatically generated by LUSAS Modeller. Design codes supported include AASHTO, Eurocode and many others.
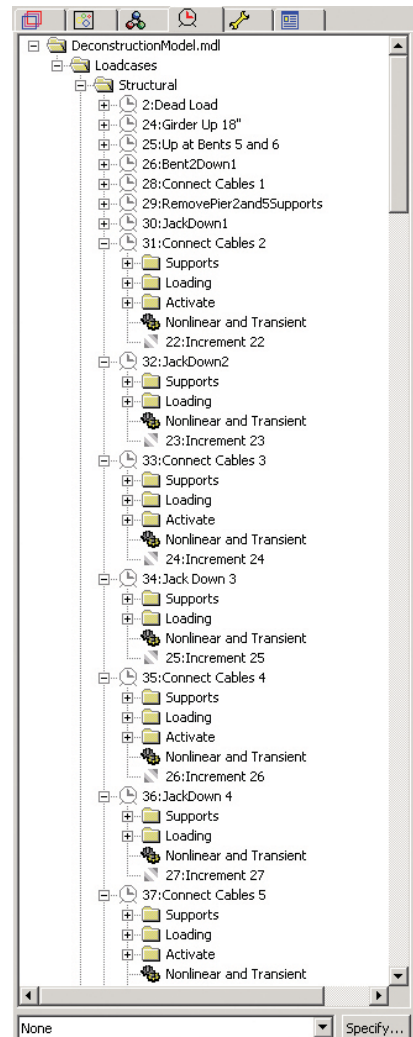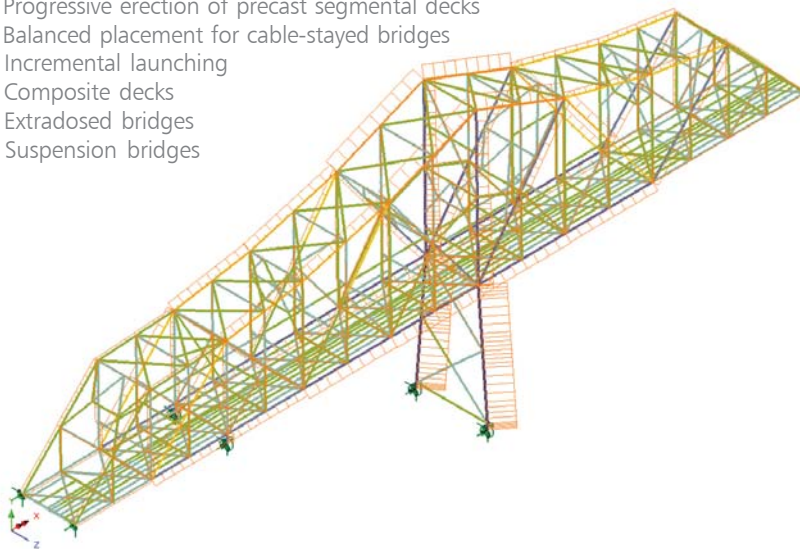
Staged construction modelling

Staged construction modelling is essential for many forms of bridge design and construction. LUSAS provides you with the means to model the construction or dismantling of your structure over time, and evaluate the effects of structural changes, load applications, and any time-dependent material changes.

With LUSAS, 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 bridge construction. The effects of geometric and material nonlinearity, and time-dependent material effects such as creep and shrinkage can all be included.

Control a complete staged construction modelling process inside the Analyses panel of the LUSAS treeview. Use branched analyses to investigate the structural response at chosen stages. Activate and deactivate the chosen parts of a model, and their associated element and attributes. Carry supports forward between loadcases, or introduce or remove them to accurately represent each stage. Produce construction history tables containing displacement history and incremental displacement results.

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
- Balanced placement for cable-stayed bridges
- Incremental launching
- Composite decks
- Extradosed bridges
- Suspension bridges

Dismantling of 1930s steel bridge trusses and cantilever spans involving staged construction modelling of the existing structure incorporating all renovations made during its lifetime, followed by a detailed stage by stage demolition analysis to ensure safe removal of the structure.

Geotechnical / soil-structure modelling

Unlike some structural analysis software, LUSAS Bridge analysis software provides a range of soils-specific and general structural engineering analysis tools to allow 2D and 3D finite element modelling of both ground and structure in a single model.

■ State-of-the-art element libraries, advanced material models, and linear and nonlinear joint models, allow a range of soil-structure engineering problems to be solved.

■ Solve multiple and branched analyses within each model.

■ Constitutive soils models include Tresca, Von Mises, Duncan-Chang, Hoek-Brown, Drucker Prager, Mohr Coulomb, and Modified Cam Clay. Add two-phase material properties to selected materials to permit modelling the deformation of undrained/ fully saturated and fully-drained/unsaturated porous media, and slow consolidation process. Specify draining and filling curves for partially drained materials.

■ 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.

■ Use nonlinear springs to model active/passive soil joints. Interface meshes permit joining of the soil / structure. Gain / loss of contact, and skin friction can be considered.

■ Specify a matrix of properties to represent a pilecap sitting on a group of piles in a 3D model.

■ Use Phi-c reduction analysis to assess the stability and safety factors of soil represented by Mohr-Coulomb or Hoek-Brown material models.

■ Use the tri-linear active / passive earth pressure joint material wizard to simplifiy the modelling of a variety of soil-structure interaction problems, creating a piecewise linear joint material with properties that vary with depth. Define multiple attributes to represent layers of soil or changes in properties due to the presence of water.

$$\sigma'_a = K_a \sigma'_z - 2c' K_{ac}$$

$$k_h = A + BZ^K \qquad \sigma'_o = K_o \sigma'_z$$

$$\sigma'_p = K_p \sigma'_z - 2c' K_{pc}$$

Detailed linear, nonlinear and pedestrian moving-load and steady-state analysis using LUSAS assisted in the development of the first major highway infrastructure project designed and constructed to Eurocodes in the UK.

Analysis and design

When designing your structure, multiple and branched analyses can be defined and solved independently from within one model. This means that, in most cases, there is no need to create separate models, and maintain clone copies of a model, in order to analyse and view results for different analysis requirements. The main analysis capabilities are summarised here.

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

Cable tuning analysis
Perform linear and nonlinear cable tuning analysis. Both cable tuning facilities calculate load factors for cables in order to achieve defined target values set for various feature types or results components. An 'exact' method, an optimisation facility and two best-fit solution methods are provided.

Target values analysis
Use the target values post-processing facility to vary load factors in a linear analysis to try and achieve target values specified for particular feature types or results components.

Buckling
Carry out 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
Carry out fatigue calculations using the total life approach. Express fatigue life 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.
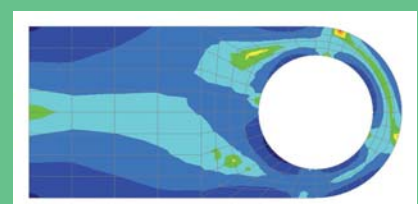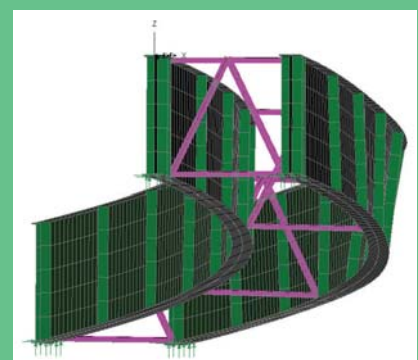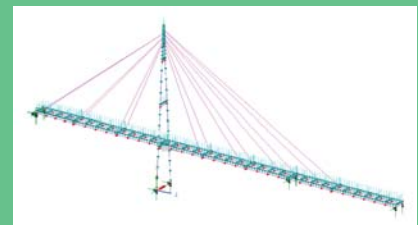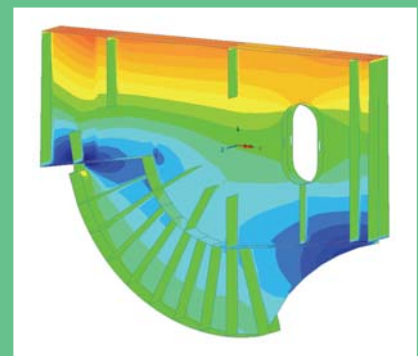
Influence analysis

Reciprocal and Direct Method influence analysis are supported. The reciprocal method, also known as the Muller-Breslau Theorem, or Maxwell's Theorem is a means of calculating an influence by the use of an auxillary structure, to which a deformation corresponding to a load effect of interest is applied. The Direct Method is a general and more powerful way of calculating influences for line beam, frame, grillage, slab and deck models. The effect of a specified point load is assessed at each node or grid location on a loadable area of a structure. The influence can be calculated for any results entity / component according to the elements used, as well as for user-defined results components, and for many locations and quantities within a single analysis.
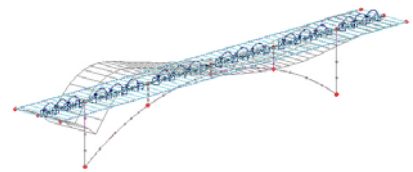
Dynamics

LUSAS Bridge excels in solving seismic and general dynamics problems. The natural frequency of structures; the effect of dynamic loading, such as train loading on through bridges, or pedestrian loading on footbridges; and responses due to earthquake or impact loading can all be readily calculated. Capabilities include:

- Pedestrian excitation
- High speed rail dynamic effects
- Seismicity
- Vehicle and ship impact
- Blast loading
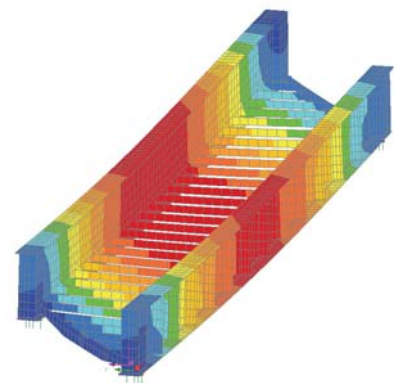
## Interactive Modal Dynamics (Modal superposition)

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. The use of IMD produces results an order of magnitude faster than traditional time-step solutions. Multiple and more advanced loading events including moving loads, moving mass and moving sprung mass, and seismic analysis, can be modelled with IMDPlus and other software options.
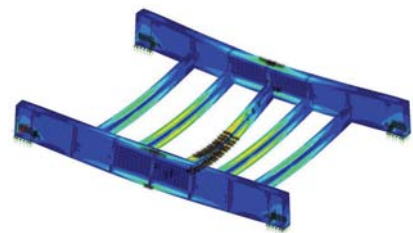
Nonlinear analysis

LUSAS Bridge can handle geometric, material and contact nonlinearity to accurately model structural behaviour. Local and global nonlinear analysis with LUSAS helps ensure that bridges and bridge components are designed economically and safely for any imposed loading. Automatic nonlinear solution procedures simplify the analysis process for applications such as:

- Elasto-plastic large deflection plate buckling
- Large deflection cable analysis
- Time-dependent dynamic analysis
- 'Push-over' analysis
- Concrete modelling
- Masonry arch analysis
- Soil-structure interaction
- Integral bridge design
- Bearing analysis, bearing lift-off, and bearing collapse
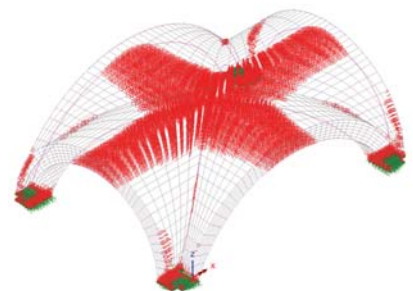
Design code facilities

Two software options allow for design checking of members in steel and reinforced concrete frames.

Steel frame design

The Steel Frame Design software option provides full details of all calculations made, referencing all relevant clauses and equations from a design code - giving a step-by-step calculation transparency normally only found in simple frame analysis software. View results as Utilisation ratios on the model, or as a tabular summary for selected members and loadcases. Results added to a model report are automatically updated each time to match the current state of the model.

Design codes supported include:
- AASHTO LRFD 7th Edition (2014)
- ANSI/AISC 360-16
- AS 4100-1998 Steel Structures (Australia)
- CSA S6-14 Canadian Highway Bridge Design Code
- EN1993-2: 2006 (Bridges)
- GB50017-2017

...with more being added with each release.

RC frame design

Use the RC Frame Design software option to carry out checking of reinforced concrete members subject to bending and axial force at Ultimate Limit State (ULS) and Serviceability limit states (SLS). Regular, arbitrary shaped, tapering and voided members are supported. View results as Utilisation ratios on the model, or as a tabular summary, and drill-down into detailed results and interaction diagrams for selected members and locations. Add results to a model report.

Design codes supported include
- AASHTO LRFD 8th Ed. (USA)
- AS5100.5-2017
- EN1992-2:2005 - EN1992-2: 2005 Eurocode 2
- CSA S6-14
- IRC:112-2011
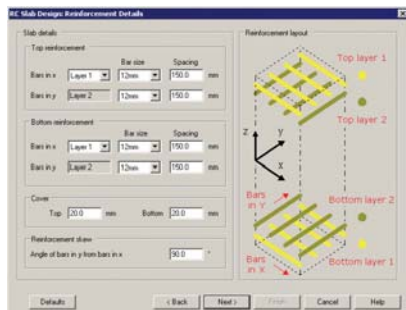
...with more being added with each release.

Daniel Case

RC slab / wall design

Use the RC slab / wall design facility to analyse reinforced concrete slabs and walls, without prestressing, modelled using plate or shell elements. Obtain contour plots and values that indicate flexural reinforcement requirements at Ultimate Limit State (ULS), and calculate design crack widths at Serviceability Limit State (SLS) for those design codes that support this.


Design codes supported include:
- AASHTO LRFD
- AS5100-5-2004
- AS3600-2009
- BS5400-4, BS8007 and BS8110
- CAN/CSA S6-06
- Eurocode EN1992-1-1 and EN1992-2
- GB50017-2017
- IRC: 112-2011 and CBC-1997
- SS CP65: Part 1 and 2: 1999

...with more added with each release.
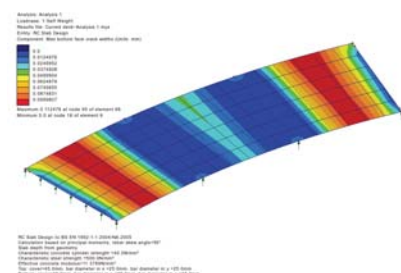
Pedestrian dynamics

Use the LUSAS pedestrian load wizard to create the necessary moving and varying-magnitude load, based on input such as the recommended Bridge class (NA to EN1991-2, Table NA.7):

- Automates pedestrian loading
- Generates all loadcases to model the passage of pedestrian groups
- Print, graph or exported results
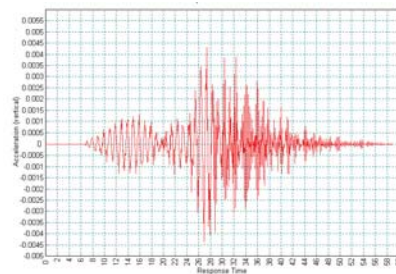
Concrete creep and shrinkage

Calculate concrete creep and shrinkage for particular LUSAS concrete models in accordance with:

- AASHTO LRFD 7th Edition
- CEB-FIP Model Code 1990
- EN1992-1-1:2004 Eurocode 2
- IRC:112-2011
- User-defined.

Tendon properties

Tendon properties for which prestress calculations will include time dependent effects for any stage of construction include:

- AASHTO LRFD 5th to 7th Edition
- CEB-FIP Model Code 1990
- EN 1992-1-1:2004 Eurocode
- IRC:112-2011

Composite Deck Design

The Composite Deck Design software option enables design checking of members / sections along composite bridge decks to AASHTO LRFD 8th Edition, or EN1994. For both, colour coded values easily indicate results that pass or fail.

- For AASHTO LRFD 8th Ed., design check results are displayed in a summary format that allows drilling-down to view full details of the calculations made, referencing all relevant clauses and equations from the design code. Full details of the design checks can also be written to a model report, which updates automatially when it is requested.
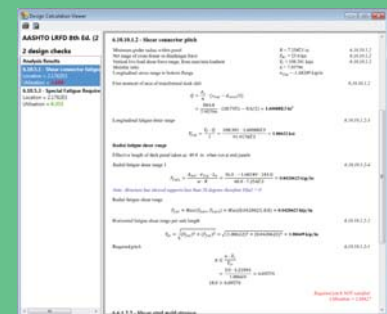
- For EN 1994, design calculations cover ULS bending, stress, shear and interaction; SLS stress, web breathing and cracking, and fatigue checks for main members and connectors. Multiple sections with different properties and bolted connections can be considered. Detailed graphs and reports can be also be output, referencing appropriate clauses from the code.

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.

■ View results for all or selected parts of a model using separate layers for diagram, contour, vector and discrete value data.

■ Select loadcases individually for each view window, and display multiple views of the model, with each window showing results for different loadcases.

■ Manually specify basic load combinations, defining loadcases to be included and load factors to be used.

■ Use Smart Combinations to generate maximum and minimum results, taking account of adverse and relieving effects, substantially reducing the number of combinations and envelopes required.

■ Define envelopes of multiple loadcases to provide maximum and minimum results.

■ Plot bending moment and shear force diagrams and visualise structural deflections.

■ Control contour ranges and vector/diagram scales individually for each view window, or set globally to apply to all view windows.

■ Display results in global or local directions, in element directions, or at any specified orientation.

■ Plot results on deformed or undeformed mesh plots and on fleshed or unfleshed beam sections.

■ Cut multiple slices through 3D solid models on arbitrary planes and make them visible or invisible in any window.

■ Selectively output results to spreadsheet applications for additional calculation and graphing uses.

■ For concrete modelling, plot crack width contours, crack patterns and values for supported design codes.
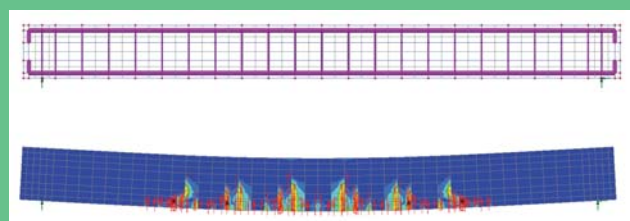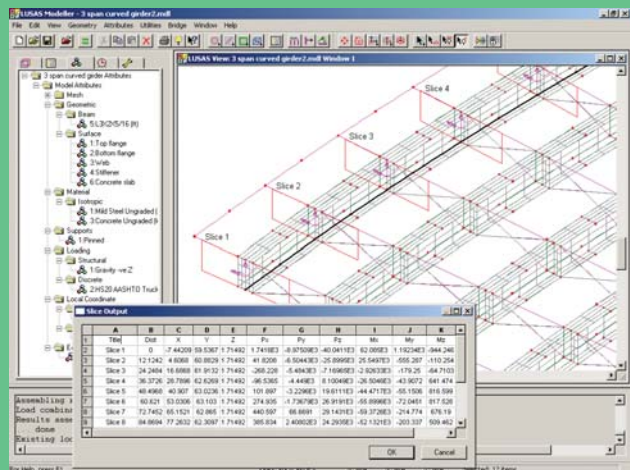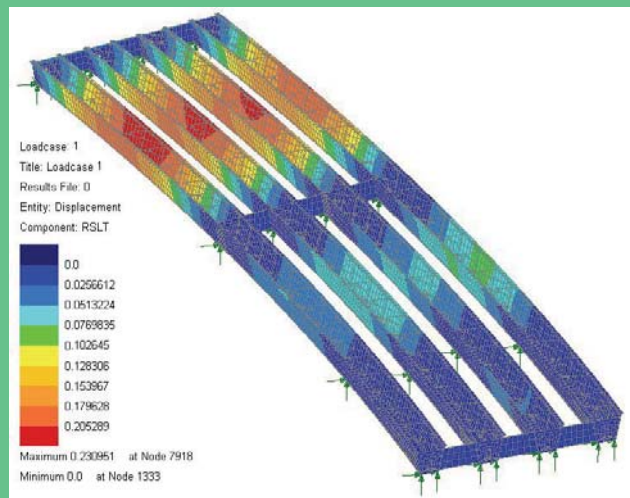
User-defined Results

Use the in-built 'spreadsheet-style' user-defined results calculation facility to include LUSAS model and results parameters in arithmetic expressions to create user-defined results components. Unlike external spreadsheet calculations, because all calculations are done inside LUSAS and based upon current model and results data, the values obtained can be automatically be recalculated at the press of a button if the model data is edited, or if results change.

Animations

Animate the results - particularly useful for viewing mode shapes, assessing structural response to moving loads and seismic events, and for investigating the spread of concrete cracking or yielded material. Save animations as AVI files for use in other Windows applications.
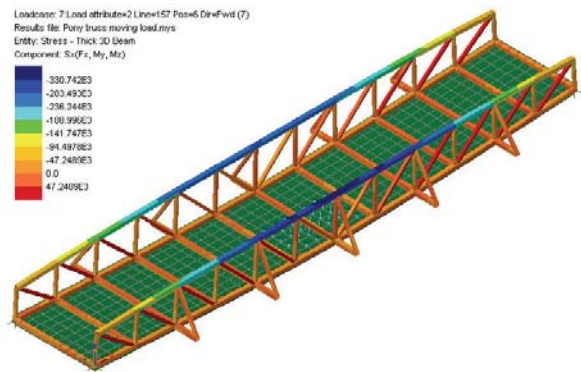
Graphing

Use the step-by-step graph wizard to select results data to be drawn on a graph. Arbitrary line sections may also be taken through any surface model or on a slice cut through a three dimensional solid model.
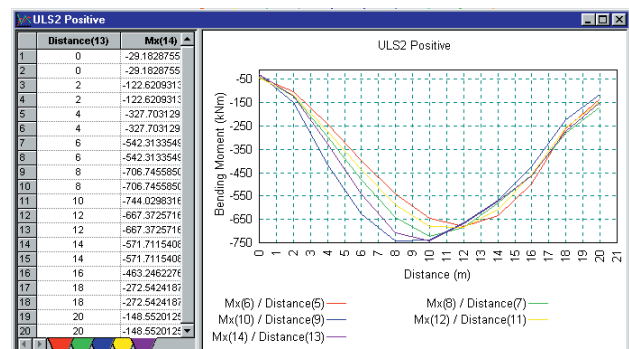
Construction tables

Produce camber, displacement history, and incremental displacement results tables for selected model locations to assist with staged construction work.

Printed results

Tabulate results values for individual results components and entities using the Print Results wizard. Transfer the data to other applications using standard Windows copy and paste operations. Print model and results views directly, or save as high resolution BMP, JPG, or WMF files, or copy and paste direct into other applications.

Report generation

Create one-click reports for selected members, and select general modelling, loadcase and results data on an element, feature type, group, and loadcase basis for inclusion in a main report. Screenshots, saved images, graphs and one-click reports can also be included. Each time a report is created, up-to-date modelling and results data is used to ensure compatibility at all times. Export report data to Excel spreadsheets, Word and other formats.
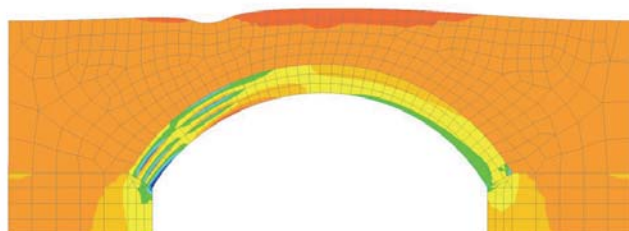
Software customisation

LUSAS software is highly customisable. The LUSAS Programmable Interface (LPI) provides the means to create user-defined menu items, dialogs and toolbars and customise modelling and results processing tasks to your specific requirements.

LUSAS Programable Interface (LPI)

The LPI is a powerful tool for customising and automating LUSAS operations. By using VBScript (or any ActiveX compliant scripting language, such as Jscript, Perl, Python, C++, C# etc.) to access LUSAS facilities and functionality, you can:

- Create user-defined menu items, dialogs and toolbars
- Interrogate all aspects of a LUSAS model
- Customise modelling operations
- Automate repetitive tasks
- Import CAD geometry and properties
- Create parameterised models
- Make direct links to Word and Excel for import or export of data
- Calculate reinforcement quantities
- Perform simple / codified design checks, and when used with automated iterative analysis structural member sizes and configurations can be optimised
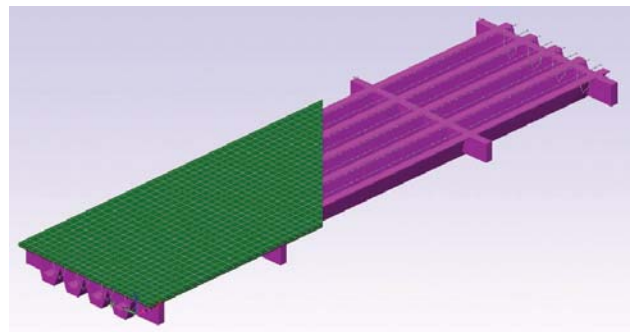

Use the recording facility in LUSAS to generate VB scripts for customising. A dialog editor is provided. The use of Visual Basic Runtime means that any VB script can be run in LUSAS.

Advanced scripting users can automate the creation of whole bridge spans for beam and slab decks incorporating prestress, design checks and output reports in MS Word.

Case study

VB scripting assisted in the model building and analysis of seismic resistant viaduct structures and station guideways for Contract C270 on the Taiwan High Speed Rail Project. For this project, a 38km long viaduct required the creation of 70 separate models. A Visual Basic Script read geometric data, such as column dimensions, span lengths etc from an Excel database and built 3D beam models automatically in LUSAS for global seismic analysis and track-structure interaction assessment. Models were created quicker and with more confidence than by manual methods. Subsequent response spectrum analysis with LUSAS determined forces in columns; a track-structure interaction analysis derived relative movements and stresses within the rails under earthquake loading; and a nonlinear soil-structure analysis determined stresses in piles and pilecaps - all resulting in an economical design within a demanding project time-scale.
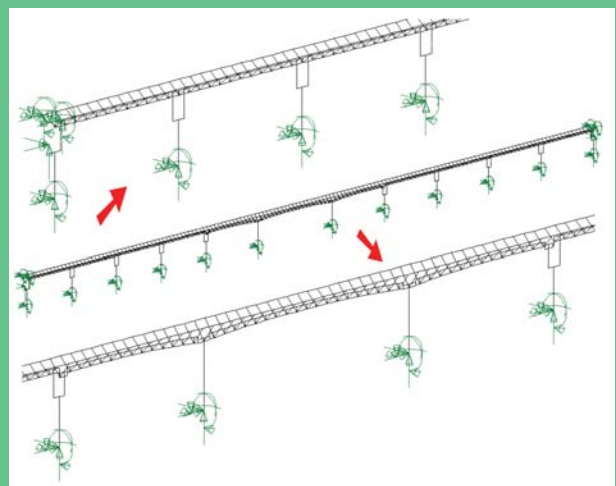
As used to assist with the design of this landmark asymmetric, cable-stayed, pedestrian swing bridge, that spans the Manchester Ship Canal at the MediaCity UK development.

Software options

Extend the analysis capabilities of particular LUSAS Bridge software products by purchasing any of the following software options.

Fast Solvers
A range of additional solvers including: a Fast Multifrontal Direct Solver, a Fast Multifrontal Block Lanczos Eigensolver, a complex eigensolver and a Fast Parallel Direct Solver and Fast Parallel Iterative Solver. Provided by default for all new sales.

Vehicle Load Optimisation
Automatically generates the most adverse live load patterns for multiple lanes of vehicle (road) traffic, or tracks carrying train (rail) loading, in accordance with a variety of international design codes. Provided by default for all new sales.

Steel Frame Design
Provides full details of the calculations made, referencing all relevant clauses and equations from a design code. Gives a step-by-step calculation transparency normally only found in simple frame analysis software. View results as Utilisation ratios on the model for a selected design code and loadcase. Full details of the design checks undertaken can be written to a model report.

RC Frame Design
Provides design checking of regular and arbitrary shaped reinforced concrete members subject to bending and axial force. View results as Utilisation ratios on the model for a selected design code and loadcase. Produces a tabular summary of design check results, and allows drilling-down into detailed results and creation of interaction diagrams for selected members and locations.

Composite Deck Design
The Composite Deck Design software option enables design checking of members / sections along composite bridge decks to AASHTO LRFD 8th Edition, or EN1994. For both, colour coded values easily indicate results that pass or fail.

IMDPlus
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, or moving mass or moving sprung masses.

Nonlinear Analysis
Provides powerful techniques for solving problems having either: geometric nonlinearity (large deformations, finite rotations and large strains); material nonlinearity (concrete, steel, rubber and geotechnical material models) or contact
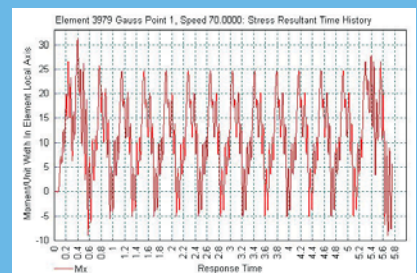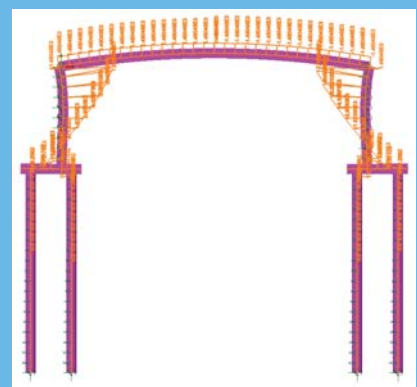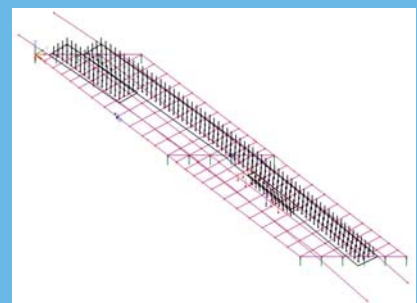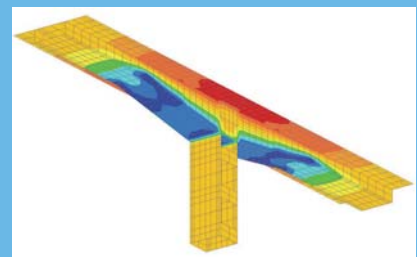
nonlinearity (point and surface). The nonlinear analysis option can be used to solve a multitude of problems having large deformations, high levels of material nonlinearity and complex boundary conditions. It can also be combined with the LUSAS Dynamic and Thermal / Field software options to solve problems 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, with the temperatures and degree of hydration used by a structural analysis to determine a range of time and age-dependent effects.

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 and Eurocode EN 1991-2:2003 Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges.

Structural Composites Analysis

LUSAS Bridge plus can also be extended by purchasing the LUSAS Composite software product. This provides the means to carry out analysis, failure prediction and advanced delamination failure modelling on all types of structural composites engineering problem.

option summary

Fast Solvers
- Multifrontal Direct / Block Lanczos Solvers
- Parallel Direct and Iterative Solvers

Vehicle Load Optimisation
- Live load optimisation to design codes
- Identify most onerous loading patterns

Steel Frame Design
- Design code checking of steel members
- Full details of all calculations made

RC Frame Design
- Design checking of concrete members
- Tabular summaries, detailed results.

Steel / Composite Deck Design
- Steel/composite bridge deck design to AASHTO LRFD 8th Ed. or EN1994

IMDplus
- Fast multiple loading event evaluation
- Seismic response analysis
- Moving load, mass, and sprung mass

Nonlinear
- Geometric and 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
- Evaluate time-dependent effects

Rail Track Analysis
- Track / bridge interaction analysis to the International Union of Railways Code UIC 774-3 and Eurocode 1

Structural Composites Analysis
- LUSAS Composite software product

Software, support and consultancy services

Software availability

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 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