注：详见“开始-LUSAS 19.0-Online Help”或 安装目录"C:\Program Files (x86)\LUSAS190\Programs (x86)\Online_Help\EnglishUS\lusasm.chm" （把左侧目录框拉到最上面）

New Facilities and Improvements in Version 19.0

- Steel / Composite Bridge Wizard introduced for quick and easy modelling of slab-on-beam composite I-girder bridges.
- Composite Bridge Deck design introduced for AASHTO LRFD 8th Edition.
- Steel Frame design now extended to include AISC-360 and GB50017.
- Reinforced Concrete frame design now extended to include AASHTO 8th Edition, AS5100.5-2017, IRC:112-2011 and CSA S6-14.
- Vehicle load optimisation now extended to include IRC:6-2017.
- Geotechnical modelling capabilities now extended to include additional Ko models, Phi-c reduction, drained and undrained conditions, and a Hoek-Brown material model.
- Bridge deck (grillage) attributes introduced for slab, and girder with top slab modelling of grillages.
- Bridge deck temperature and shrinkage profile loading.
- General variation of temperature or strain through-section.
- Generate influences from beam / shell resultants and inspection locations.
- Model view "orientation cube" introduced.
- Branched analyses introduced.
- Access to Fast and Frontal Solvers provided.
- Direct Method Influence analysis improvements.
- Rail Track Analysis enhancements.
- Slice resultants improvements.
- Results averaging speed-up.
- New and updated worked examples.

New facilities and improvements in more detail:

Steel/Composite Bridge Modelling

- Steel composite bridge wizard

Composite Bridge Deck Design

- New Composite bridge deck design software option. It supports:
- **AASHTO 8th Ed. (USA)**

Steel Frame Design

- Steel frame design software option now supports:
- **AISC-360 (USA)**
- **GB50017 (China)**

Reinforced Concrete Frame Design

- RC frame design software option now supports:
- **AASHTO 8th Ed. (USA)**
- **AS5100.5-2017 (Australia)**
- **IRC:112-2011 (India)**
- **CSA S6-14 (Canada)**

Reinforced Concrete Slab Design

- RC slab design now supports:
- **GB50010-2010 (China)**

Vehicle Load Optimisation

- Vehicle load optimisation software option now supports:
- **IRC:6-2017 (India)**

Geotechnical

- Additional K_0 models
- Phi-c reduction
- Drained and undrained conditions
- Hoek-Brown material model

General modelling, analysis and results improvements

- Bridge deck grillage attributes introduced
- Bridge deck temperature and shrinkage profile loading
- General variation of temperature/strain through-section
- Generate influences from beam/shell resultants and inspection locations
- Model view "orientation cube" introduced
- Branched analyses introduced
- Access to Fast and Frontal Solvers provided
- Direct Method Influence analysis improvements
- Rail Track Analysis enhancements
- Slice resultants improvements
- Results averaging speed-up

General

- User change requests
- Documentation

New and updated worked examples

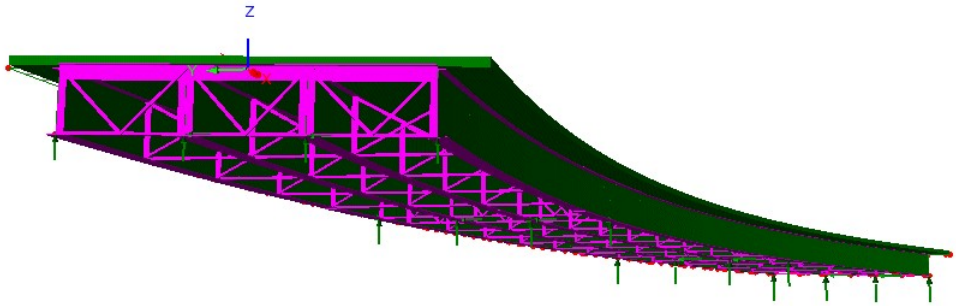
- Steel Composite Bridge Wizard
- Staged construction modelling of a 3-span bridge deck
- Composite bridge deck design to AASHTO 8th edition
- Slope stability modelling showing Phi-c reduction
- Simple grillage analysis
- Grillage load optimisation

Steel / Composite Bridge Modelling Wizard

The Steel Composite Bridge Wizard generates the model geometry and corresponding mesh, geometric, material, support and local coordinate attributes for models of slab-on-beam composite I-girder bridges where the slab and web are modelled with shell elements and the top and bottom flanges, web stiffeners and bracing are modelled using beam elements.

Models can be defined that accommodate:

- Straight or curved decks of constant radius.
- An arbitrary skew, where a skew can additionally be set per support and interpolated across the spans.
- Any number of spans and supports.
- Square and skew bracing.
- Transverse stiffeners.
- Design utilities for design checking against supported design codes.



Example of a curved multi-span steel composite bridge deck with bracing created by the wizard

For more information see Steel Composite Bridge Wizard.

Composite Bridge Deck Design

The Composite Bridge Deck Design software option can be used with new or existing bridge models for software licences that support this facility. It is for use with 2D Grillage/Plate and 3D element model types. When used with LUSAS Bridge LT only 3D beam and 2D grillage models are permitted.

The Composite Bridge Deck Design option provides a consistent approach to design, regardless of the analysis approach adopted, using slice resultants to calculate design forces. This allows an analysis model to be created without having to define design details initially. It allows for the complexity of the analysis model to be increased without changing the design data, and also permits a number of changes to be made to the design information to see what the effect of a particular change would be, without having to change or solve the analysis model each time.

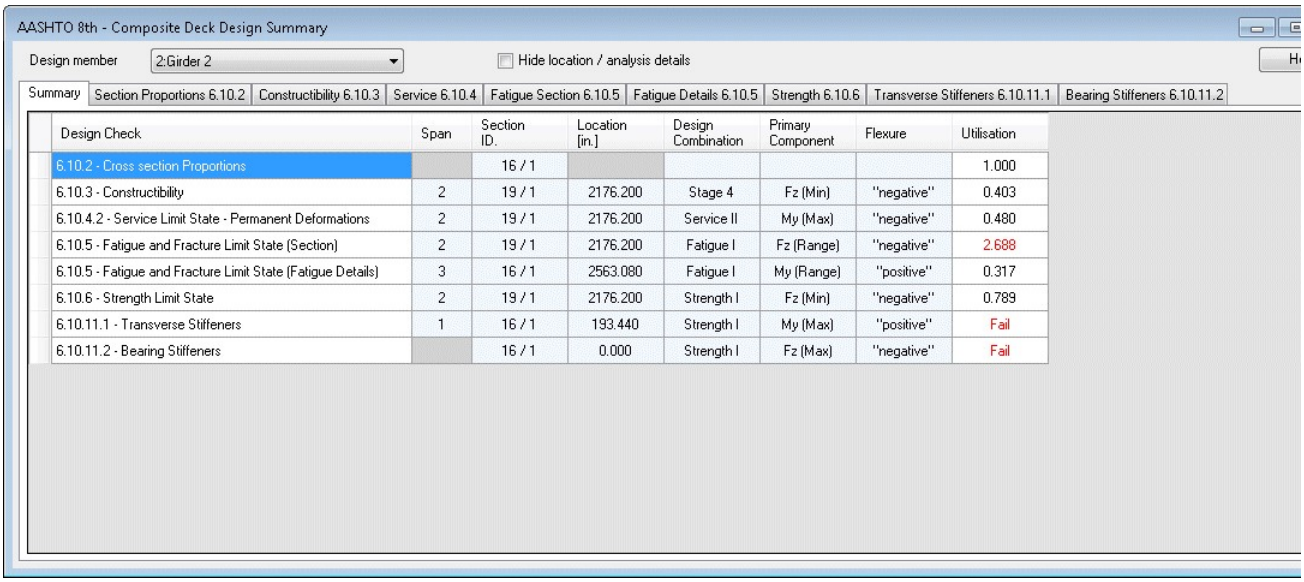
The following steps are required to carry out a composite bridge deck design check:

1. **Create a model of the bridge deck** either manually, or by using the grillage wizard, or the steel composite bridge wizard, and solve it to obtain results.
2. **Define a composite bridge deck design member** for each girder (simple spans) or series of girders (continuous spans) of interest in the model.
3. **Specify the design code to be used** by selecting the **Design> Composite Deck Design** menu item.
4. **Define a results utility** This identifies the design members for which calculations are required and brings together the loadcases / combinations appropriate to the various limit state checks.
5. **View the results** in tabular format, and optionally add selected results to a model report.

Design codes supported

The following design code is currently supported:

- **AASHTO LRFD 8th Edition. (USA)** - AASHTO LRFD Bridge Design Specifications 8th edition, American Association of State Highway and Transportation Officials 2017.



Design Check	Span	Section ID.	Location [in.]	Design Combination	Primary Component	Flexure	Utilisation
6.10.2 - Cross section Proportions		16 / 1					1.000
6.10.3 - Constructibility	2	19 / 1	2176.200	Stage 4	Fz (Min)	"negative"	0.403
6.10.4.2 - Service Limit State - Permanent Deformations	2	19 / 1	2176.200	Service II	My (Max)	"negative"	0.480
6.10.5 - Fatigue and Fracture Limit State (Section)	2	19 / 1	2176.200	Fatigue I	Fz (Range)	"negative"	2.688
6.10.5 - Fatigue and Fracture Limit State (Fatigue Details)	3	16 / 1	2563.080	Fatigue I	My (Range)	"positive"	0.317
6.10.6 - Strength Limit State	2	19 / 1	2176.200	Strength I	Fz (Min)	"negative"	0.789
6.10.11.1 - Transverse Stiffeners	1	16 / 1	193.440	Strength I	My (Max)	"positive"	Fail
6.10.11.2 - Bearing Stiffeners		16 / 1	0.000	Strength I	Fz (Max)	"negative"	Fail

For more information see Composite Bridge Deck Design.

Steel Frame Design improvements

Steel frame design to AISC-360 (USA)

The steel frame design software option now supports:

- **ANSI/AISC 360-16** - Specification for Structural Steel Buildings, American Institute of Steel Construction, Chicago, July 2016

For more information see Steel Frame Design and Steel Frame Design Attribute Settings for ANSI / AISC-360 (2016)

Steel frame design to GB50017 (China)

The steel frame design software option now supports GB50017-2017 Standard for design of steel structures, China Architecture & Building Press, China.

- **GB50017-2017** - Standard for design of steel structures, China Architecture & Building Press, China.

For more information see Steel Frame Design and Steel Frame Design Attribute Settings for GB 50017-2017

Reinforced Concrete Frame Design improvements

The RC Frame Design software option now supports:

- **AASHTO 8th Ed. (USA)**
- **AS5100.5-2017 (Australia)**
- **CSA S6-14 (Canada)**
- **IRC:112-2011 (India)**

For more information see Reinforced Concrete Frame Design and RC Frame Design Attributes

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Reinforced Concrete Slab improvements

The reinforced concrete slab design facility now supports:

- **GB 50010-2010** - Code for design of concrete structures, China Architecture & Building Press, Beijing.

For more information see RC Slab Design : Design Code Settings and Parameters

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Vehicle load optimisation enhancements

The Vehicle Load Optimisation facility now supports:

- **India IRC:6-2017**- Standard Specifications and Code of Practice for Road Bridges - Section : II - Loads and Stresses (7th Revision) Indian Roads Congress, New Delhi.

For more information see Vehicle Load Optimisation Wizard and India IRC:6-2017 - Optional Code Settings

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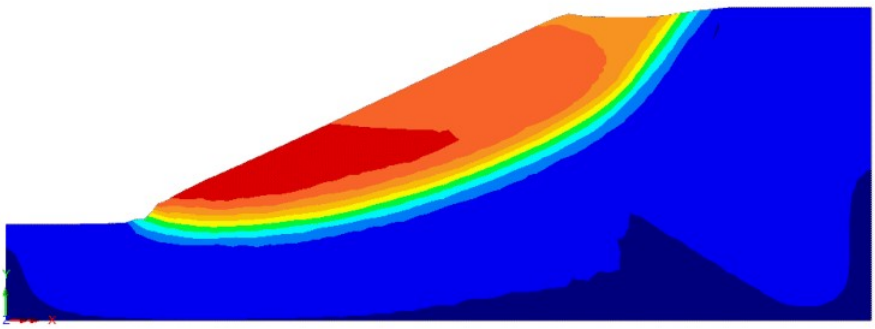
Geotechnical

Additional K_0 models

Two additional K_0 initialisation options, 'Wroth' and 'OCR sin(phi)', have been added to the Modified Cam Clay material model to allow initial stresses in soil to be calculated.

Phi-c reduction

Phi-c reduction attributes can now be defined and assigned to a model to assess soil stability and safety factors for soil represented by Mohr-Coulomb or Hoek-Brown material models. Attributes can be assigned to all or just some of the relevant features in a model, allowing the safety of a particular slope (for example) in a large analysis to be evaluated without other parts of the model being affected. Assignment is made to a particular loadcase or analysis stage, which defines the applicable loading, boundary conditions and activation status.



By its very nature, a phi-c reduction analysis will always run until solution failure, so it is best used in branched analyses where it can be used to study safety factors at several stages of construction without terminating the solution.

For more information see Phi-c Reduction

Drained and undrained conditions

Drained and Undrained attributes can be defined from the **Attributes > Pore Water Pressures**... menu item. They are used to define regions of a model where the soil is drained or undrained.

Drained and undrained attributes can be assigned to features representing soil that are meshed with two phase elements and modelled with two-phase materials in both 2D or 3D models. The use of such attributes is a conceptual shortcut from the beginning to the end of a consolidation analysis, representing the extreme undrained and drained conditions.

For more material see Drained and Undrained.

Hoek-Brown material model

The Hoek-Brown model is now supported. This is an elastic-perfectly-plastic constitutive model suitable for the modelling of rock failure. It is an empirical model, and its parameters are based on both laboratory test data, and visual observation of the rock. The model can be used with standard continuum elements as well as the two-phase elements.

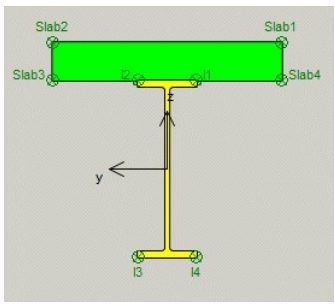
For more information see Hoek-Brown Material Model.

General modelling, material and results enhancements

Bridge Deck (Grillage) attributes introduced

Bridge Deck (Grillage) geometric attributes have been introduced to define geometric properties of specific types of bridge decks that are analysed with reference to, or derived from grillage formulae published by Hambly and others.

When assigned to a model along with a new Bridge Deck (Grillage) material attribute, which contains separate material definitions for the slab, girders, slab and reinforcement (for cracked sections) that are defined in the relevant Bridge Deck (Grillage) geometric attribute, users can more easily analyse the different phases of construction of these types of bridge decks with one model by the use of the multiple analysis facility. In short, one set of grillage geometric attributes is suitable for the life of a bridge, as the sections do not change, whereas several material attributes may be needed to represent the in-construction, short term, and long term cases.



For more information see Bridge Deck (Grillage) Geometric Attributes and Bridge Deck (Grillage) Material and Grillage Analysis.

Bridge deck temperature and shrinkage profile loading

Bridge deck temperature profile loading can be defined for the following design codes.

- **AASHTO 8th**
- **AS 5100.2:2017**
- **EN1991-1-5:2003 Approach 1**

- **EN1991-1-5:2003 Approach 2**

Bridge deck shrinkage profile loading currently supports:

- **AASHTO 8th**

For more information see Bridge deck temperature profile loading to design codes and Bridge deck shrinkage profile loading to design codes

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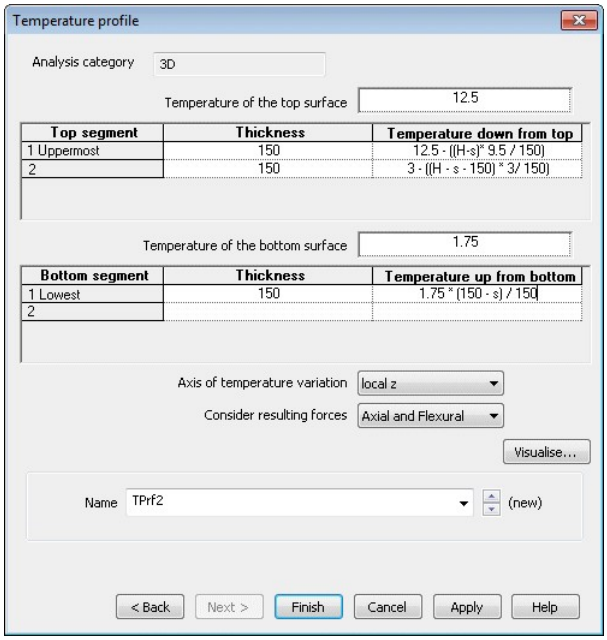
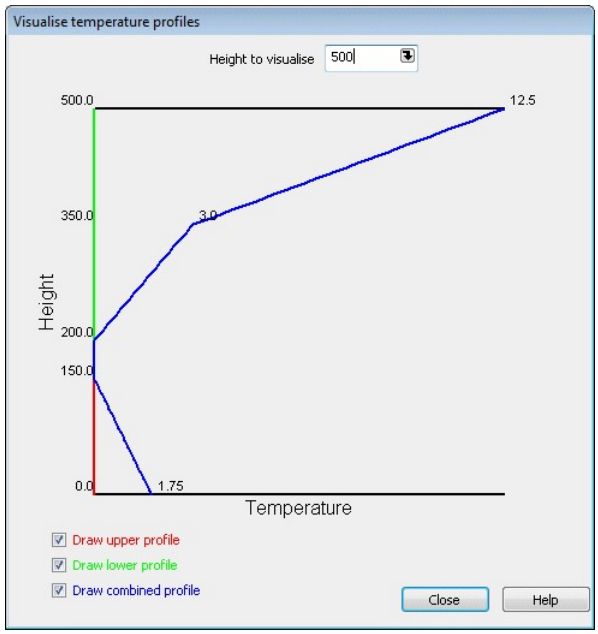
General variation of temperature or strain through-section

For general use, a temperature/strain profile loading can be defined by stating the temperature of the top of the section followed by defining a series of segment thicknesses and corresponding values for the specific height at which the expression is being evaluated. Segment thicknesses and temperature/strain may be stated as a single value, or as expressions, making it possible to replicate expressions in bridge industry Codes of Practice and define code-specific profiles that are not currently supported elsewhere in LUSAS.

Defined profiles can be visualised for a stated visualisation height. The same profile may be assigned to multiple geometric sections of differing heights.





For more information see Temperature profile / Strain profile (TMPE)

Generate influences from beam/shell resultants and inspection locations

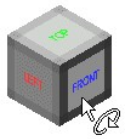
Direct Method Influences can now be generated from beam/shell slice resultant locations and at inspection locations. Direct Method Influence attributes can be assigned to pre-defined Inspection locations, or to Beam/Shell Slices using the 'Assign to' context menu item for the DMI attribute, and then selecting the inspection points or beam/shell slices to which the assignment should be made on the Influence Assignment dialog that subsequently appears.

The ability to assign DMI attributes to Beam/Shell Slices now makes it possible to use the Vehicle Load optimisation facility on bridge decks idealised using mixed beam and shell elements.

For more information see Direct Method Influence Attributes and Obtaining Beam Stress Slice Resultants from Beam and Shell Models.

Model view "Orientation cube" introduced

An orientation cube can now be optionally displayed in each model view window. This provides visual feedback on the orientation of a model, and rotates and updates as the model is rotated or orientated. The top of the cube is aligned to the defined vertical axis for the model.



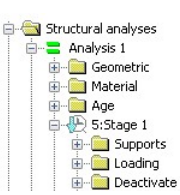
The orientation cube has labelled faces with default names of Left, Right, Bottom, Top, Back and Front, and edges and corners that highlight when a cursor is moved over them. Selecting a face, edge or corner of the cube will orientate the model to be viewed from the selected direction. The model can also be dynamically rotated by clicking and dragging to rotate the orientation cube.

Home, Dynamic Rotation, Resize, and Perspective buttons can be optionally added beneath the axis cube for easy selection.

For more information see View Properties.

Branched analysis introduced

Analysis branches may be added to the Analyses Treeview by selecting the **New > Branch** context menu item for any loadcase in the Analyses Treeview that has (or inherits) a nonlinear or transient control. They allow the creation and solution of one or more sub-analyses to investigate the response of the model at a particular loadcase or "stage".



Examples of use include:

- Carrying out a linear moving load analysis of construction equipment during each stage of the construction of a segmental bridge deck,

- Performing an eigenvalue natural frequency analysis or a buckling analysis during construction.
- Performing a phi-c reduction analysis to derive safety factors for a geotechnical model from each stage in an excavation process.
- Performing an earthquake analysis where gravity is applied in a static nonlinear step, then the earthquake is run as a transient branch. Several sample earthquakes may be run in each branch.

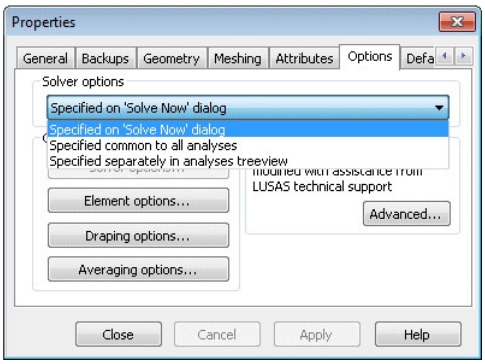
Any number of sub-analyses may be defined for a single parent loadcase.

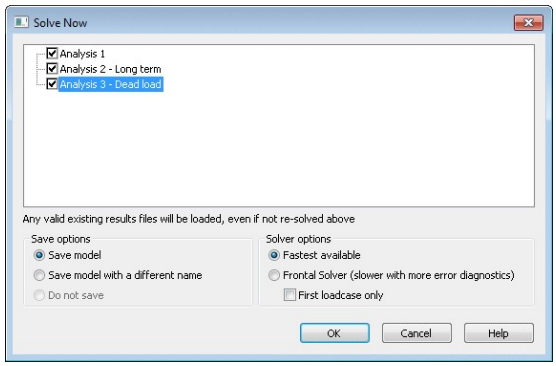
For more information see Branched Analyses.

Access to Fastest available and Frontal Solvers provided

The Fast Multi-frontal solver is now made available by default to new clients with the Fast Solver software option.

Two Solver-related radio buttons previously included at the bottom of the 'Model properties' dialog have been replaced with a droplist control on the dialog that additionally allows specifying solution options on the 'Solve Now' dialog. These now allow for solving by the fastest available and appropriate solver for the task in hand, or the frontal solver, which provides more error diagnostics should issues arise. An option to only solve for the first loadcase (for quick model attribute assignment checking purposes) is also included.





For more information see Model Properties and Solve now dialog help.

Direct method Influence analysis improvements

Direct Method Influence analysis is now faster because the Solver results file is now generated at the same time as the stress recovery stage, saving significant processing time.

Larger Direct Method Influence analyses can now be carried out with either a finer grid or a finer mesh without manually setting any additional parameters. The analysis is split into batches that make maximum utilisation of the memory available but which ensure that no matter how large the DMI analysis, it will solve successfully.

Rail Track Analysis enhancements

The LUSAS Rail Track Analysis software option now includes the following new features / enhancements:

- Bearings can now be modelled offset (inboard) from the ends of the decks.
- Multiple Train Loading Groups can be analysed within the same analysis.
- Avoidance of stubby elements in the modelling.
- Improved pier modelling.
- Train loads are allowed to be outside the extents of the model. This allows long trains to be passed over structures without having to have excessively large embankments to model the correct arrival and departure of the trainset from the structure.
- Use it for EuroCode nomenclature of Traction loads (instead of Acceleration).
- Significant speed up of train/rail load definition and assignment.
- Section axes for deck and pier now included in the Geometric Properties worksheet.
- Improved results / chart titles in the tabulated output.

For more information see Rail Track Analysis User Manual.

Slice resultants improvements

Once defined, slice sections are now visualised immediately on the model without the need for a solve to have taken place first.

For more information see Obtaining Beam Stress Slice Resultants from Beam and Shell Models.

Results averaging speed-up

Averaging of element results across discontinuities has been made more efficient, reducing the time it takes to display averaged results in this situation.

General

User change requests

In addition to the range of new facilities and improvements listed, many user change requests have also been implemented. The originators of all requested changes to the software (some of which are included in the above list of enhancements) that have been incorporated in this release will be notified individually.

Documentation

All online and printed documentation has been updated for this new release. Manuals are provided in PDF format as part of any LUSAS installation, and are also available for download from the LUSAS website.

New and Updated Worked Examples

The following new and updated examples illustrate some of the new facilities provided in this release.

- **Steel Composite Bridge Wizard** - shows how to use the steel composite bridge wizard to build a 3-span bridge.
- **Staged construction modelling of a 3-span bridge deck** - models the construction and loading phases of a steel composite bridge deck.
- **Composite bridge deck design to AASHTO 8th edition** - shows use of the new composite bridge deck design software option.
- **Slope stability modelling showing Phi-c reduction** - shows use of branched analysis and new Phi-c attribute.
- **Simple grillage analysis** - shows use of new bridge deck grillage attributes.
- **Grillage load optimisation** - shows use of new bridge deck grillage attributes on a model optimised vehicle loading.

See Online help > Worked Examples > For LUSAS Bridge and LUSAS Civil & Structural for details.

Other worked examples

All existing worked examples have been updated to match changes made to the software.

Individual worked examples in PDF format are provided as part of the LUSAS software download file or release DVD, and are also available from the online help. Examples are also available from the LUSAS User Area.

Other

Potential issues opening PDF files referenced in CHM files

On some PCs, and for certain operating systems, the installation of security updates as released by Microsoft can affect the opening of PDF files from the table of contents panel within the CHM file-based help. Any links to PDF files from within help topic pages may similarly be affected.

If problems are found when attempting to open these files from within the online CHM file supplied please note the following:

- Selected manuals are supplied in PDF format on the installation kit and these are normally installed into the <LUSAS Installation Folder>/Programs/PDF_Manuals folder.
- Workarounds/solutions may be provided by Microsoft during the availability and support of this particular LUSAS software release.

Previous new facilities and improvements in this release

None, this is the first release of Version 19.