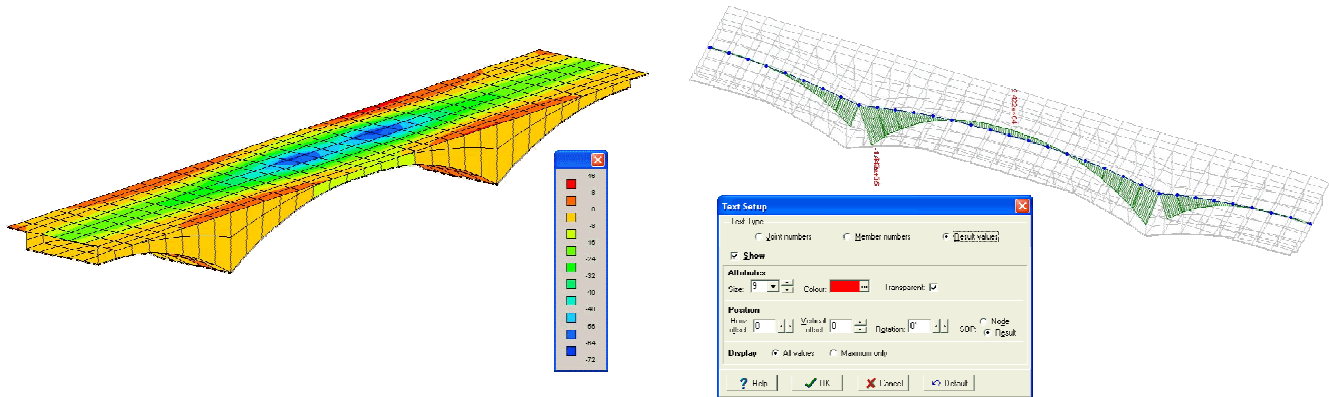


Bridge Loading and Analysis Modules for AASHTO LRFD: A.02_{US}, A.04_{US}, A.06_{US} and A.08_{US}



This is a set of four modules for analysing bridge structures:

- A.02_{US} – Basic analysis of grillages and space frames**
- A.04_{US} – Advanced analysis of general structures including finite element capability**
- A.06_{US} – Analysis of line beam structures with optimised moving variable action envelope**
- A.08_{US} – Variable action optimisation in accordance with AASHTO LRFD and Standard Specifications (for use with A.04)**

These modules analyze bridge structures in order to determine the moments and shears they should be designed to resist.

The analytical models for determining these range from simple line beams, through grillages and space frames, to finite element analysis with 3 and 4 node shell elements.

The live load optimization routines are based on influence surface technology, and are fully compliant with the current loading codes.

The unique benefit of these modules lies in the productivity realized by integrating with the beam modules. Because the geometric and material properties of the beam are known to the system, the dead load effects are easily calculated using line beam analysis (since there is little transverse distribution of load at this stage). The structure is usually defined in terms of longitudinal members corresponding to pre-defined beams, and the deck slab may be either part of the grillage, or a separate finite element mesh. This means that the engineer does not have to calculate member properties at all, and this saves considerable time and removes much scope for errors.

To create an envelope of (say) worst moments for a beam, the engineer merely indicates a beam, and requests the live load optimizer to create the worst loads and to envelope the worst results. After the analysis the envelope is transferred to the beam module for code checking. The time saved in this very simple, yet powerful, integrated approach is enormous.

Although so much of the data input is automated in the interests of productivity, it is still possible to control the whole process. For example, a complex model may be created in a CAD system and imported into Sam, the member properties assigned by hand, and loads placed by hand too. If it is required to place a particular load in a critical location for a particular point in the structure, this too is possible using an influence surface.

Module Specifications A.02_{US} – Basic analysis of grillages and space frames

- 2D and 3D framework analysis
- No imposed limits on model size, load cases, combinations and envelopes, subject to available computer memory and hard disk space
- Element library includes:
 - 2-noded beam members
- Generation of Design Lines (Centrelines of structure and bridged obstruction)
 - Arcs
 - Straight Lines
 - Transitions
- Generation of Carriageways and Footways
 - Defined by offsets to Design Lines
 - Single / dual carriageways
 - Variable width carriageways and footways
 - Notional lanes generated automatically in accordance with associated design code specifications, or user defined
 - User specified notional lane loaded width locations
- Definable Construction Lines for setting out mesh boundaries
 - Offset from Design lines
 - Horizontal and vertical
 - At any angle to design line at specified chainage.
- Generation of Span-end Lines
 - Dynamic object snap; grid, nearest, endpoint, intersection
- Generation of beam member grillage meshes
 - Fully configurable mesh for any shape bounded by four sides. Mesh may be:
 - Skew
 - Orthogonal to span
 - Orthogonal to lines of support
 - Orthogonal to Design Line (Curved or straight)
 - Splay or Splay Orthogonal to Design Line
 - Additional individual beams
- Generation of Sub-models
 - Selection of anchor position as any coordinate or node in the structure
 - Orientation vectors to define sub-model plane
 - Setting out lines
 - Construction lines
 - Beam member generation
 - Single members
 - String of members
 - Split members
 - Merge 2D sub-models to 3D sub-models
 - Reinforcement sets
 - Copy sub-model to a different plane
- Special beam member definition:
 - Truss members
 - Tension only members
 - Compression only members
 - Cable members (i.e. tension only + truss)
- Advanced beam member options:
 - End releases (6 degrees of freedom)
 - Sprung, fractional and limited releases
 - Member limits (e.g. for plastic analysis)
 - Member eccentricities
- Inactive members
- Generation of Supports
 - Fixed, free and sprung support conditions
 - 6 degrees of freedom in global or local axes
 - Lift-off supports
 - Supports with elastic limits
 - Supports with plastic limits
- Import and/or Export of structure data including
 - ASCII list of
 - Joint coordinates
 - Beam member incidences
 - Design lines
 - Deck member definition and carriageway alignment tools
 - Support for importing structure geometry in Drawing Interchange File (DXF) format, from CAD packages
- Calculation of Beam and Section Properties
 - Automatic section properties from direct association with section and beam modules (licences of these modules are not required)
 - Draw parametric sections:
 - Rectangle, Circle, Annulus, Voided Slab, H, I, L, T, U, X, Z
 - Continuous slab, defined by thickness
- User defined section properties
- Specification of Beam Shear Area and Torsion Constant, and Beam Twist
- Graphical assignment of section property data to beam members
- Graphical specification of post-tensioning cables
- Calculation of post-tensioning losses
- Calculation of load effects due to post-tensioning
- Creation of nodal loads
- Creation of initial support displacements
- Creation of bridge deck patch loads
- Creation of beam member loads
 - Longitudinal beam loads
 - Transverse beam loads
 - Beam element loads
 - Temperature primary moments
 - Temperature change
 - Element temperature loads
 - Beam element distortion
- Definition of Highway Loads – AASHTO LRFD 2
 - Design Truck
 - Design Tandem
 - Lane Load
 - Fatigue Truck
 - Owner Specified Vehicle / Permit Vehicle
 - Double Design Truck
 - Double Tandem
- Definition of Highway Loads – AASHTO Standard Specifications
 - H / HS Truck, Lane load & Concentrated load
 - Alternate Military Vehicle
 - Owner Specified Vehicle / Permit Vehicle
- Customizable vehicle load library
- Definition of Truck Convoy
- Generation of influence surface for any joint or beam
 - Support reaction and joint displacement
 - Bending, shear and axial load effects
- Comprehensive tools for reporting model input data and output results both graphically and in tabular format
- Automatic transfer of analysis results to the beam design modules for code-checking, or saved as plain text files for post processing
- Export of analysis results to spreadsheet
- Slab reinforcement moment calculations
 - Graphical specification of multiple reinforcement layers; major and minor steel directions, moment resistance ratios for assessment
 - Wood and Armer method for design
 - Denton and Burgoyne method for assessment
- Composite Results
 - Graphical definition of 2D or 3D composite member including beams and finite elements, with associated composite axis
 - Automatic generation of composite members and axes for integration with beam design modules
 - Automatic calculation of composite moments and forces along composite axis
 - Generation of influence surfaces for composite results
- Staged Construction Analysis:
 - Graphical selection of beam members, finite elements and supports for each stage
 - Assignment of construction stage loadings
 - Individual stage load effects and visual simulation of cumulative load effects from previous stages

Bridge Loading and Analysis Modules for Eurocodes: A.02_{US}, A.04_{US}, A.06_{US} and A.08_{US} (continued)

Module Specifications A.04_{US} – Advanced 3D framework and finite element analysis

- 2D and 3D framework and finite element analysis
- No imposed limits on model size, load cases, combinations and envelopes, subject to available computer memory and hard disk space
- Element library includes:
 - 2-noded beam members
 - 3 or 4-noded thin plate shell finite elements
 - Combined use of full element library in a single model
- Generation of Design Lines (Centrelines of structure and bridged obstruction)
 - Arcs
 - Straight Lines
 - Transitions
- Generation of Carriageways and Footways
 - Defined by offsets to Design Lines
 - Single / dual carriageways
 - Variable width carriageways and footways
 - Notional lanes generated automatically in accordance with associated design code specifications, or user defined
 - User specified notional lane loaded width locations
- Definable Construction Lines for setting out mesh boundaries
 - Offset from Design lines
 - Horizontal and vertical
 - At any angle to design line at specified chainage.
- Generation of Span-end Lines
 - Dynamic object snap; grid, nearest, endpoint, intersection
- Generation of beam member grillage and thin shell finite element meshes
 - Fully configurable mesh for any shape bounded by four sides. Mesh may be:
 - Skew
 - Orthogonal to span
 - Orthogonal to lines of support
 - Orthogonal to Design Line (Curved or straight)
 - Splay or Splay Orthogonal to Design Line
 - Refined finite element sub-regions (e.g. for use near supports)
 - Additional individual beams
- Generation of Sub-models
 - Selection of anchor position as any coordinate or node in the structure
 - Orientation vectors to define sub-model plane
 - Setting out lines
 - Construction lines
 - Beam member generation
 - Single members
 - String of members
 - Split members
 - Finite element meshes
 - Merge 2D sub-models to 3D sub-models
 - Reinforcement sets
 - Copy sub-model to a different plane
- Special beam member definition:
 - Truss members
 - Tension only members
 - Compression only members
 - Cable members (i.e. tension only + truss)
- Advanced beam member options:
 - End releases (6 degrees of freedom)
 - Sprung, fractional and limited releases
 - Member limits (e.g. for plastic analysis)
 - Member eccentricities
- Special finite element definition:
 - Membrane action only
 - Bending action only
- Inactive members
- Generation of Supports
 - Fixed, free and sprung support conditions
 - 6 degrees of freedom in global or local axes
 - Lift-off supports
 - Supports with elastic limits
 - Supports with plastic limits
- Import and/or Export of structure data including
 - ASCII list of
 - Joint coordinates
 - Beam member and finite element incidences
 - Design lines
 - Deck member definition and carriageway alignment tools
 - Support for importing structure geometry in Drawing Interchange File (DXF) format, from CAD packages
- Calculation of Beam and Section Properties
 - Automatic section properties from direct association with section and beam modules (licences of these modules are not required)
 - Draw parametric sections:
 - Rectangle, Circle, Annulus, Voided Slab, H, I, L, T, U, X, Z
 - Continuous slab, defined by thickness
 - User defined section properties
- Specification of Beam Shear Area and Torsion Constant, and Beam Twist
- Calculation of Finite Element Properties
 - Element thickness
 - Isotropic or orthotropic material
- Advanced finite element properties
 - Modified elastic / shear modulus
 - Local axes alignment
 - Conforming sides and fictitious stiffness
 - Element elasticity matrices
- Graphical assignment of section property data to beam members and finite elements
- Graphical specification of post-tensioning cables
- Calculation of post-tensioning losses
- Calculation of load effects due to post-tensioning
- Creation of nodal loads
- Creation of initial support displacements
- Creation of bridge deck patch loads
- Creation of beam member loads
 - Longitudinal beam loads
 - Transverse beam loads
 - Beam element loads
 - Temperature primary moments
 - Temperature change
 - Element temperature loads
 - Beam element distortion
- Creation of finite element loads
 - External loads: force or moment per unit area or volume
 - Internal loads: membrane stress or strain, or bending stress or strain
 - Temperature loads
 - Hydrostatic loads
- Definition of Highway Loads – AASHTO LRFD 2
 - Design Truck
 - Design Tandem
 - Lane Load
 - Fatigue Truck
 - Owner Specified Vehicle / Permit Vehicle
 - Double Design Truck
 - Double Tandem
- Definition of Highway Loads – AASHTO Standard Specifications
 - H / HS Truck, Lane load & Concentrated load
 - Alternate Military Vehicle
 - Owner Specified Vehicle / Permit Vehicle
- Customizable vehicle load library
- Definition of Truck Convoy
- Generation of influence surface for any joint, beam or finite element detail
 - Support reaction and joint displacement
 - Bending, shear and axial load effects
- Comprehensive tools for reporting model input data and output results both graphically and in tabular format
- Automatic transfer of analysis results to the beam design modules for code-checking, or saved as plain text files for post processing
- Export of analysis results to spreadsheet
- Slab reinforcement moment calculations
 - Graphical specification of multiple reinforcement layers; major and minor steel directions, moment resistance ratios for assessment
 - Wood and Armer method for design
 - Denton and Burgoyne method for assessment
- Composite Results
 - Graphical definition of 2D or 3D composite member including beams and finite elements, with associated composite axis
 - Automatic generation of composite members and axes for integration with beam design modules
 - Automatic calculation of composite moments and forces along composite axis
 - Generation of influence surfaces for composite results
- Staged Construction Analysis:
 - Graphical selection of beam members, finite elements and supports for each stage
 - Assignment of construction stage loadings
 - Individual stage load effects and visual simulation of cumulative load effects from previous stages
- Dynamics for normal modes
 - Automated generation of mass
 - Animated mode shapes

Module Specifications A.06_{US} – Line beam analysis with optimised moving load envelope

- Max. 50 spans
- No imposed limits on load cases, combinations and envelopes, subject to available computer memory and hard disk space
- Element library includes:
 - 2-noded beam members
- Graphical generation of line beam layout
- Generation of Supports
 - Fixed, free and sprung support conditions
 - 2 degrees of freedom
- Calculation of Beam and Section Properties
 - Automatic section properties from direct association with section and beam modules (licences of these modules are not required)
 - Draw parametric sections:
 - Rectangle, Circle, Annulus, Voided Slab, H, I, L, T, U, X, Z
 - User defined section properties
- Graphical assignment of section property data to line beam members
- Creation of joint and beam member loads
 - Uniformly distributed loads
 - Linearly varying loads
 - Temperature loads
 - Support displacements
- Definition of Highway Loads – AASHTO LRFD 2
 - Design Truck
 - Design Tandem
 - Lane Load
 - Fatigue Truck
 - Owner Specified Vehicle / Permit Vehicle
 - Double Design Truck
 - Double Tandem
- Definition of Highway Loads – AASHTO Standard Specifications
 - H / HS Truck, Lane load & Concentrated load
 - Alternate Military Vehicle
 - Owner Specified Vehicle / Permit Vehicle
- Influence lines for automatic generation of moving variable action envelope to EN 1991-2 specifications for bending and shear effects
- Automatic calculation of total permanent load effects, including stage construction analysis
- Automatic calculation of action effects due to shrinkage and differential temperature
- Comprehensive tools for reporting model input data and output results both graphically and in tabular format
- Calculation of transverse distribution factors as per method of AASHTO LRFD
- Automatic transfer of analysis results to the beam design modules for code-checking, or saved as plain text files for post processing

Module Specifications A.08_{US} – Automatic load optimisation

- Graphical selection of multiple influence load effects for any joint, beam or finite element detail
- Visual representation of multiple influence surfaces indicating adverse and relieving areas
- A range of customizable features including:
 - Loaded influence area
 - Roadway configuration
 - Selection of load combination type and limit state
 - Traffic flow direction
- Automatic production of critical live load patterns in accordance with AASHTO LRFD 2 or AASHTO Standard Specifications. Includes all the vehicles available in module A.04, and also optimizes for:
 - variations of axle spacing (where applicable)
 - transverse positioning of vehicles
 - transverse positioning of lane loaded widths
 - dynamic load allowances,
 - Multiple presence factors, etc.
- Visual display of resulting critical load patterns
- Generation of enveloped effects Detailed presentation of load configurations and intensities, load and combination factors, lane rank and other factors