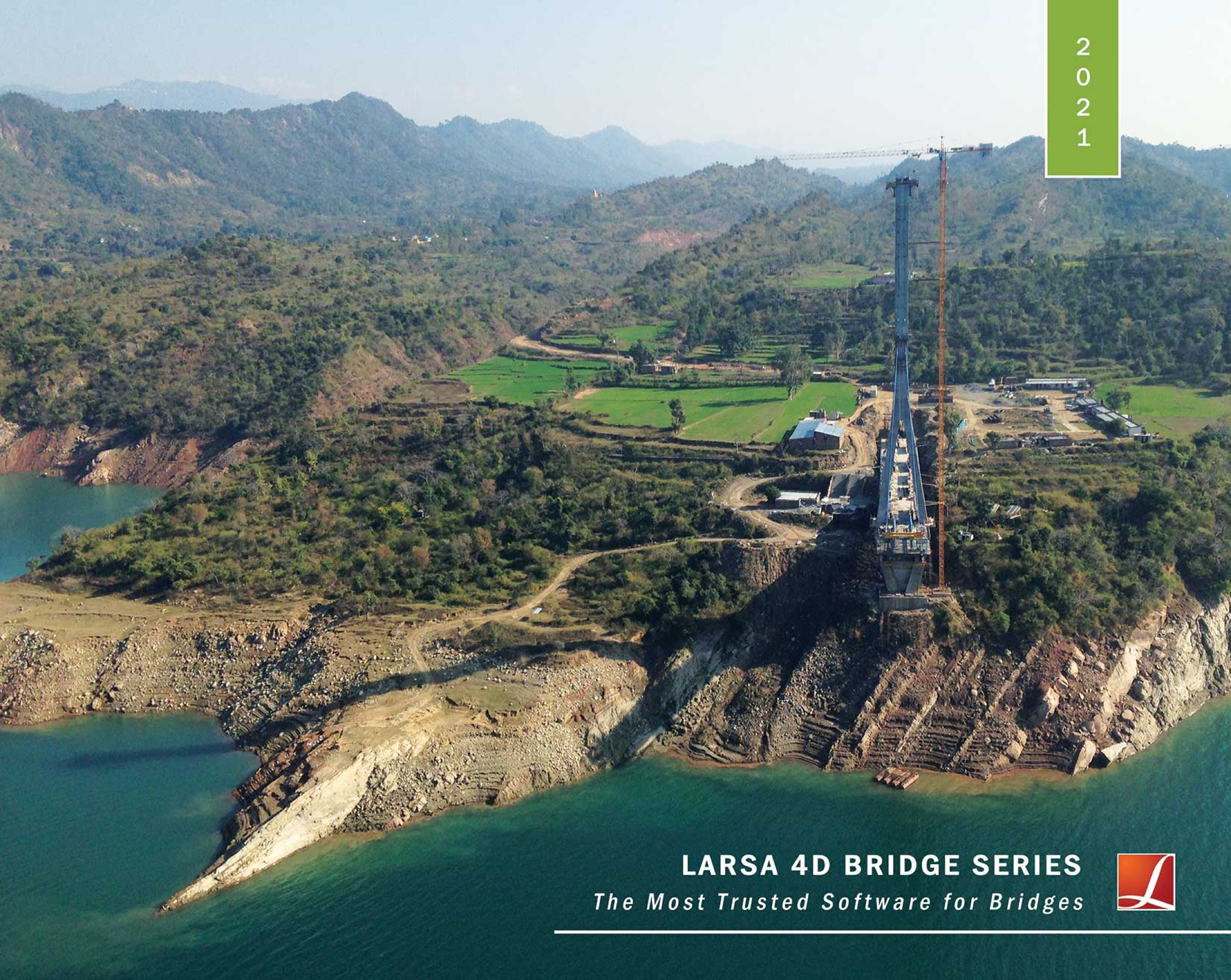
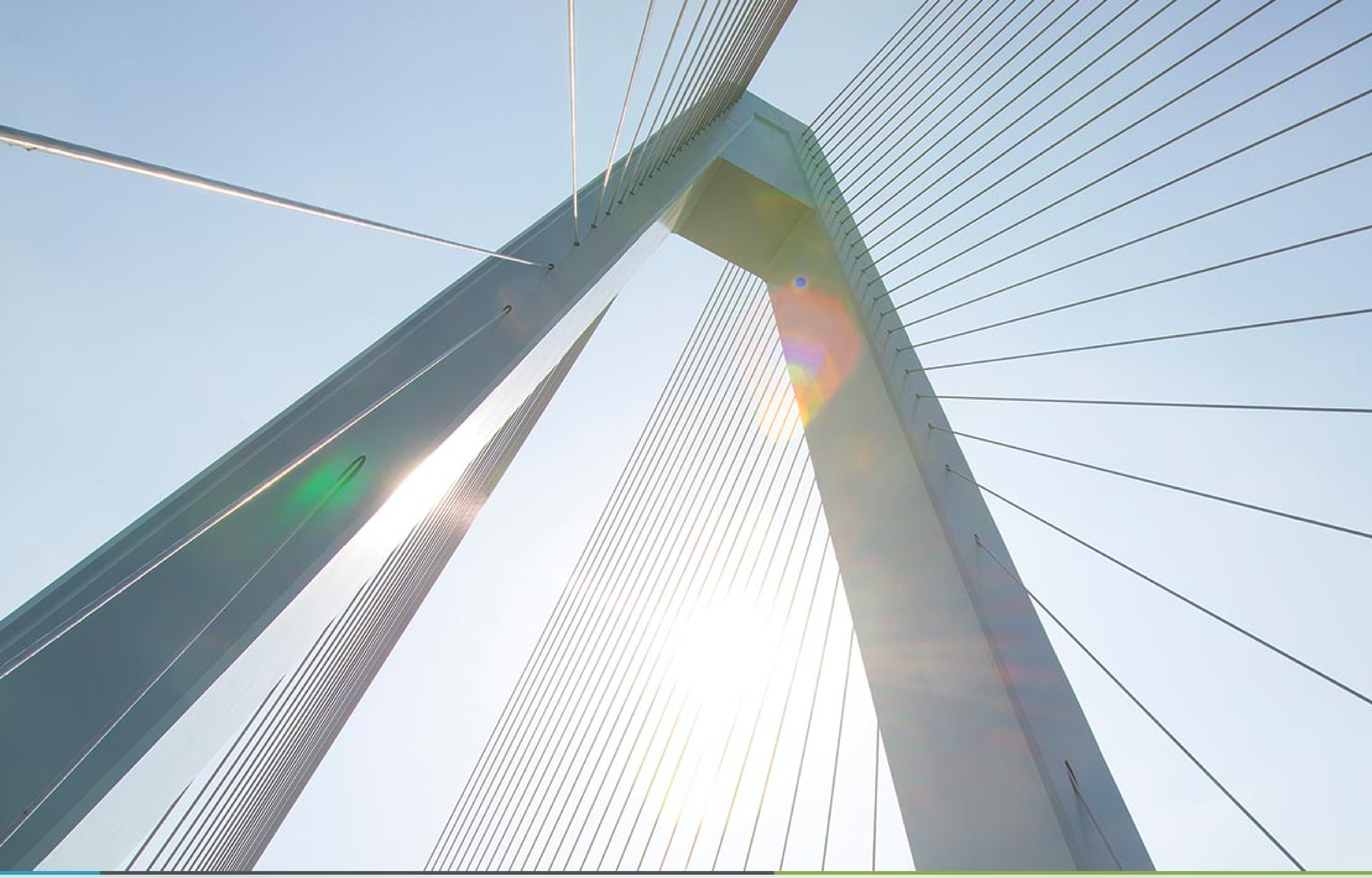


2021

LARSA 4D BRIDGE SERIES

The Most Trusted Software for Bridges



Advanced software for the design and analysis of bridges and structures

About LARSA, Inc.

LARSA, Inc. develops advanced software for the analysis and design of bridges and structures based on the finite element method. By coupling structural analysis and design with the latest computing technology, LARSA 4D has become the most reliable software of its kind for segmental, cable-stayed, suspension, steel girder and other bridge forms, as well as other structures requiring advanced Staged Construction Analysis, geometric and material nonlinearity, or complex three-dimensional geometry. Since it was released in 2002 LARSA 4D BRIDGE SERIES is recognized as the premier software for bridge engineers with the innovative tools necessary to support the life of a bridge project from design to construction. Complemented with unique and innovative client support, LARSA 4D makes engineers feel comfortable as our developers and support personnel work closely with each client to develop the tools clients need to make their work more efficient and effective.

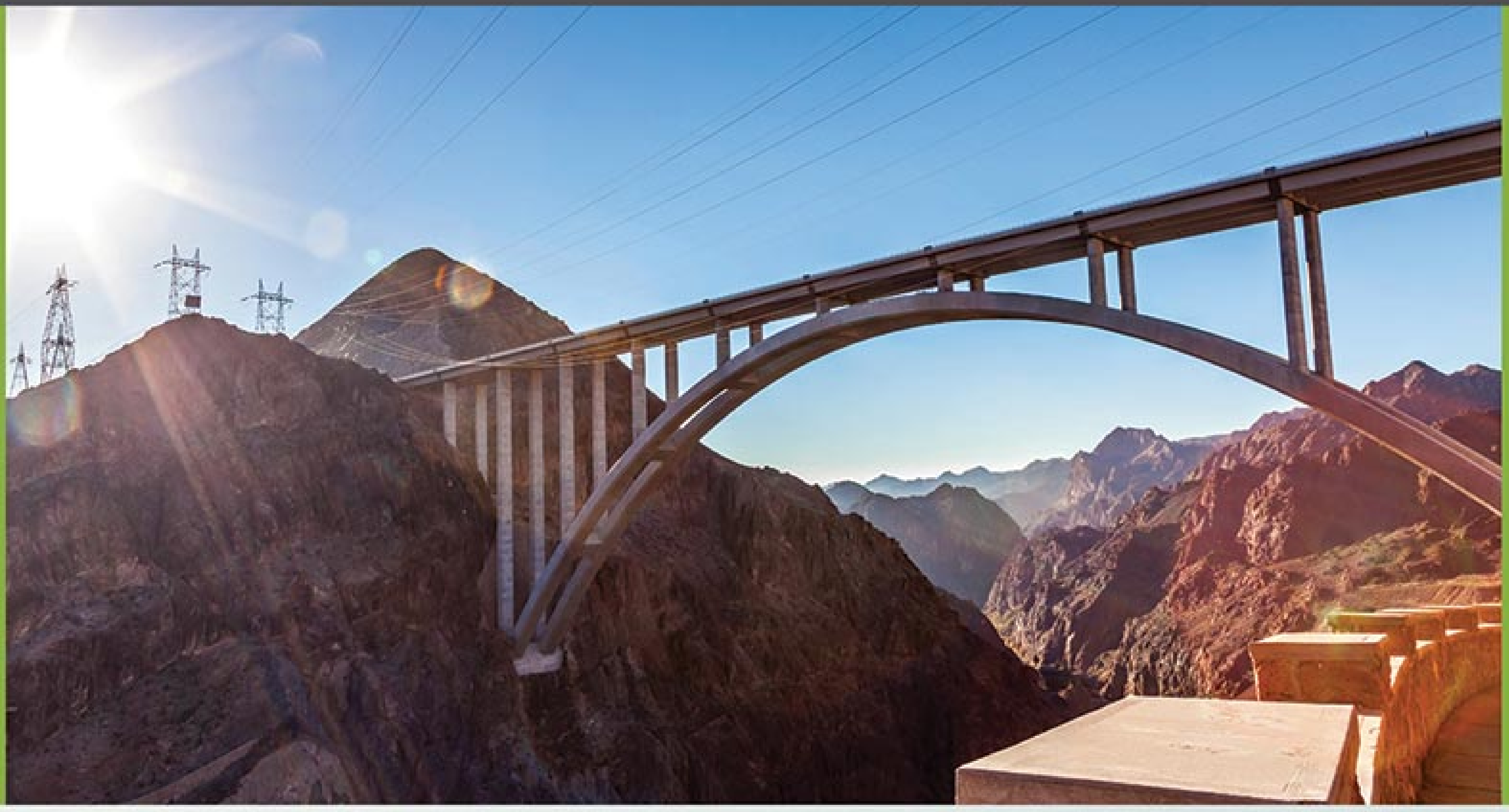
LARSA, Inc. is privately owned and based in New York, with all its software development and client support services conducted in-house.

LARSA, Inc. | Melville, New York | 1-800-LARSA-01 | info@larsa4d.com | www.larsa4d.com

CONTENTS

THE COMPLETE SOFTWARE FOR BRIDGES

Sophisticated, intuitive, versatile. LARSA 4D BRIDGE SERIES is developed by engineers for engineers and is informed by three-decades of experience working closely with our clients. 4D BRIDGE SERIES fully integrates modeling, analysis, and design across one powerful and intuitive interface to streamline analytical tasks and improve decision making. Experience refined analysis in a single information-rich environment that easily defines complex geometries, nonlinear behavior, and seismic behavior with unrivaled accuracy.



ANALYSIS & DESIGN

Design and analyze all types of bridges including steel girder, precast, cast-in-place, segmental, cable-stayed, suspension, tied arch, spliced-girder, railroad, and pedestrian bridges. With a single LARSA 4D bridge model, perform refined staged construction modeling, nonlinear time history, seismic analysis, live load analysis and more.

CONSTRUCTION

Pioneers of time-based "4D" analysis techniques, LARSA 4D's Staged Construction Analysis engine delivers unmatched capabilities informed by decades of experience supporting the needs of bridge engineers. Model incrementally launched bridges over time with construction activities and time-dependent material effects.

CODE CHECK & LOAD RATING

Analyze your LARSA 4D bridge model and perform AASHTO compliant Code Check and Permit and Legal Load Rating for all types of steel girder and pre-stressed concrete bridges. Check for strength, serviceability, fatigue, constructability, cross-frames and substringers, and live load deflection.

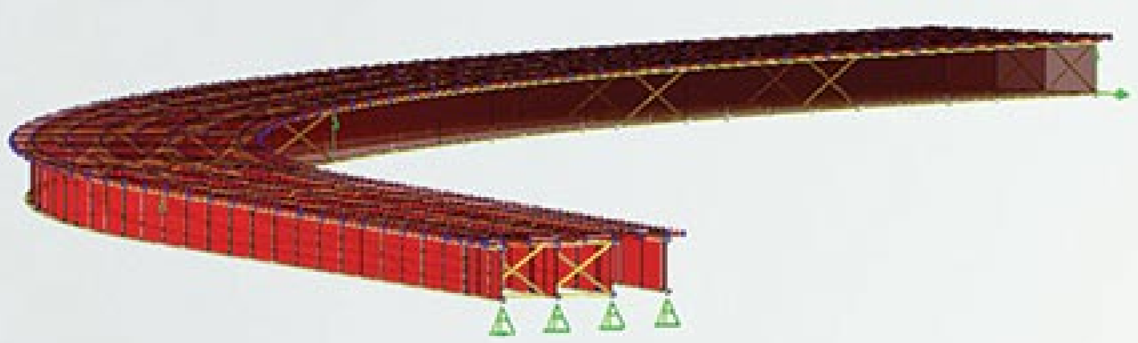
LARSA's 4D BRIDGE SERIES packages are optimized for production and come preloaded with our Section Composer Tool, the LARSA 4D Steel Bridge Module, and unrivaled Staged Construction Analysis.

LARSA 4D STEEL BRIDGE MODULE: Trusted Code Check, Load Rating, and refined modeling solutions for steel girder bridges

LARSA 4D STEEL BRIDGE MODULE

The complete solution for curved and skewed girder bridges featuring irregular spacing, variable deck width, and specialized loading conditions

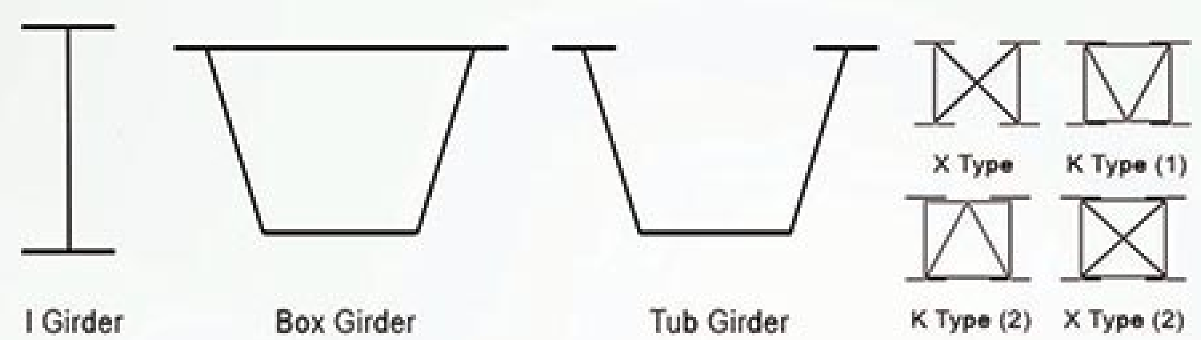
Innovation in Design



The Steel Bridge Module is a model generation and AASHTO Code Check and Load Rating tool built with LARSA's "4D" analysis capabilities. As a parametric modeling tool it uses guided input to generate I, box, and tub girder bridges.

As a design tool the model may be revised during Code Check and Load Rating processes, and through its integration with LARSA 4D the user is able to add new elements (such as diaphragms), revise the model (such as changing girder and deck dimensions), and create special loading conditions.

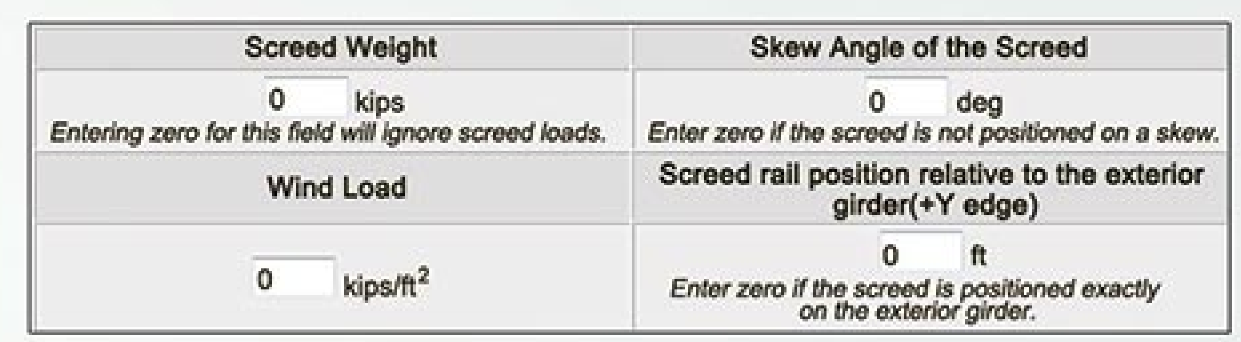
Intuitive Modeling



Basic parameters such as span length, number of girders, cross-frame locations, and deck dimensions are specified to create refined 3D FE bridge models. The module uses single or multiple finite elements to model girder cross-sections. Curved and flared girder layouts, super elevation, vertical curve, variable deck width and concentric girders with uneven spacing are supported.

Combined with LARSA 4D's Bridge Path Coordinate Systems, the module provides a unique way to model horizontal and vertical bridge layouts.

Integrated Loading



As the module automatically creates load cases for dead, live and wind loads, stages for the deck pouring sequence and screed movement, staged construction operates behind the scenes modeling construction in the following sequence:

- DC1: Construct girders/cross-frames, apply self weight then deck weight, apply temporary loads.
- WS: Apply wind loads in all directions.
- DC2: Construct the deck, permanent dead loads.
- LL: Perform influence surface live load analysis.
- DW: Apply additional loads.

LARSA 4D's Analytical Object Modeler brings an intuitive, BIM-ready alternative to the traditional bridge design process

LARSA 4D Section Composer

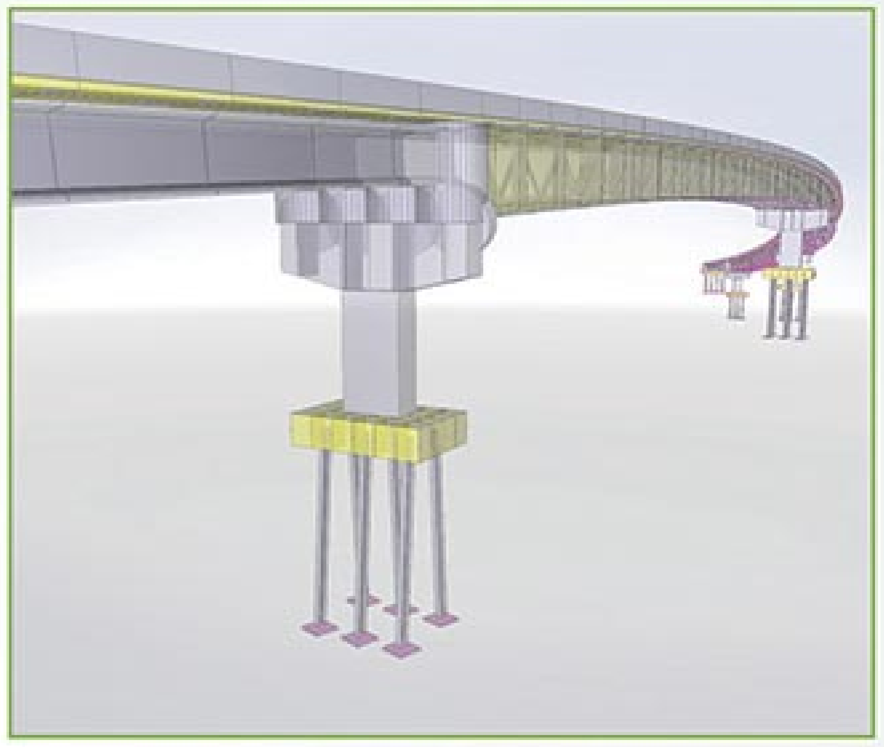
All LARSA 4D BRIDGE SERIES packages are preloaded with LARSA 4D's Section Composer tool, which is an advanced graphical companion tool for modeling cross-sectional properties that computes section properties for nonprismatic and composite sections based on standard, parametric, and custom shape sections.

Defined using parametric equations for width, depth, and thickness, sections can be reused and resized without having to re-compute control point coordinates.

To simplify accurate modeling of bridges whose sections vary along the length of girders or piers, nonprismatic variation uses intuitive formulations which allow linear, parabolic, sinusoidal and other types of functions to be defined for girder or pier definitions.

To learn more about LARSA 4D's Section Composer turn to Page 17.

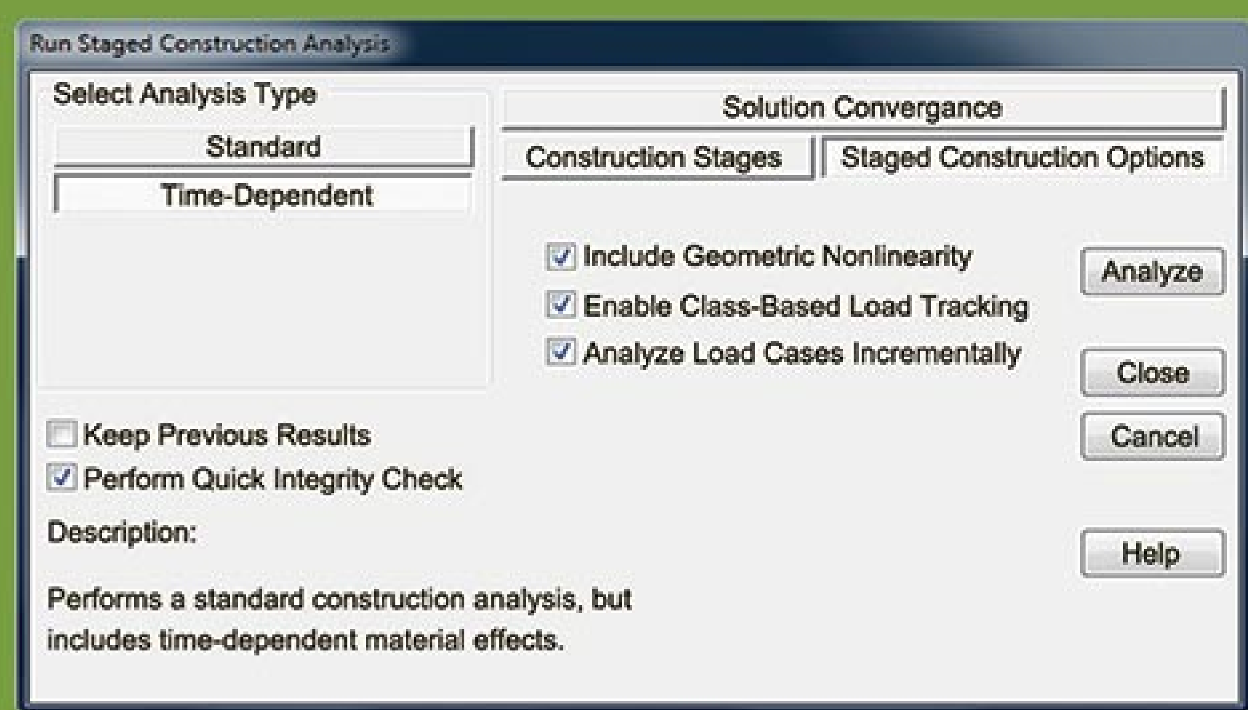
LARSA 4D Analytical Object Modeler (AOM)



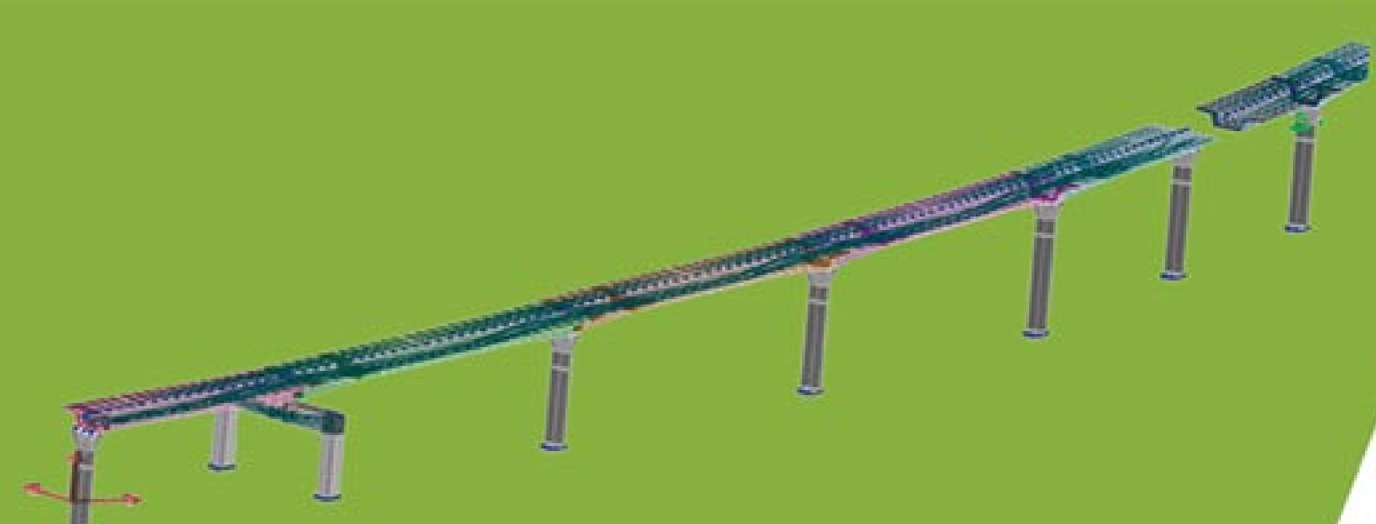
Next level products for LARSA 4D - The LARSA 4D Analytical Object Modeler unites structural object modeling (modeling of girders, decks, piles, etc.) with the rigorous techniques of finite element modeling (modeling beams, shells, etc.). For the seamless interchange of information, the objects used by LARSA 4D's Analytical Object Modeler are designed to exchange information with other BIM-ready software packages as they become available.

Further advantages of this new system include greater automation to bypass repetitive aspects of the traditional design process, and each object can be revised and extended by the engineer to perform design modifications which are propagated in the analytical model. LARSA's first AOM products include new tools for the design and rating of prestressed concrete bridges, and soil-structure interaction to define soil, soil properties, piles, and pile groups to generate p-y curves. Both tools are based on LARSA 4D's nonlinear staged construction analysis, allowing integration for every stage of construction and load combination.

Pioneers of "4D" time-based analysis techniques, LARSA 4D's Staged Construction Analysis stands out among its peers

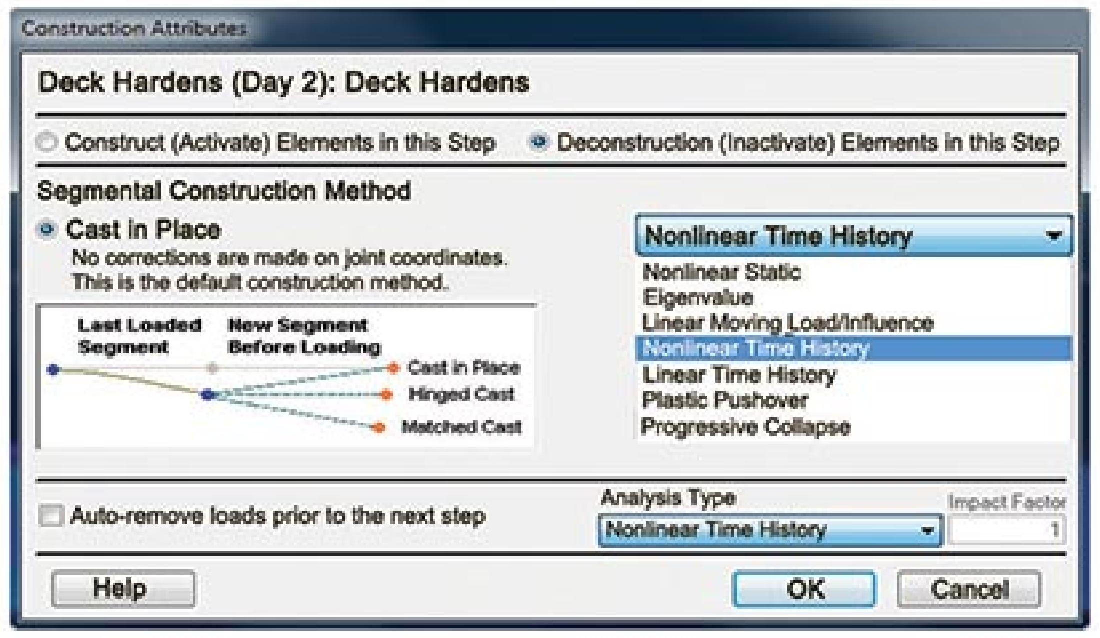


At the core of LARSA 4D's BRIDGE SERIES, staged construction models the changes to a structure over time with construction activities and time-dependent material effects such as concrete creep and shrinkage and tendon relaxation. Supporting the demanding needs of modern bridge engineering, LARSA 4D's Staged Construction Analysis provides unrivaled capabilities, such as performing a nonlinear time history or eigenvalue analysis at any stage within a construction sequence.



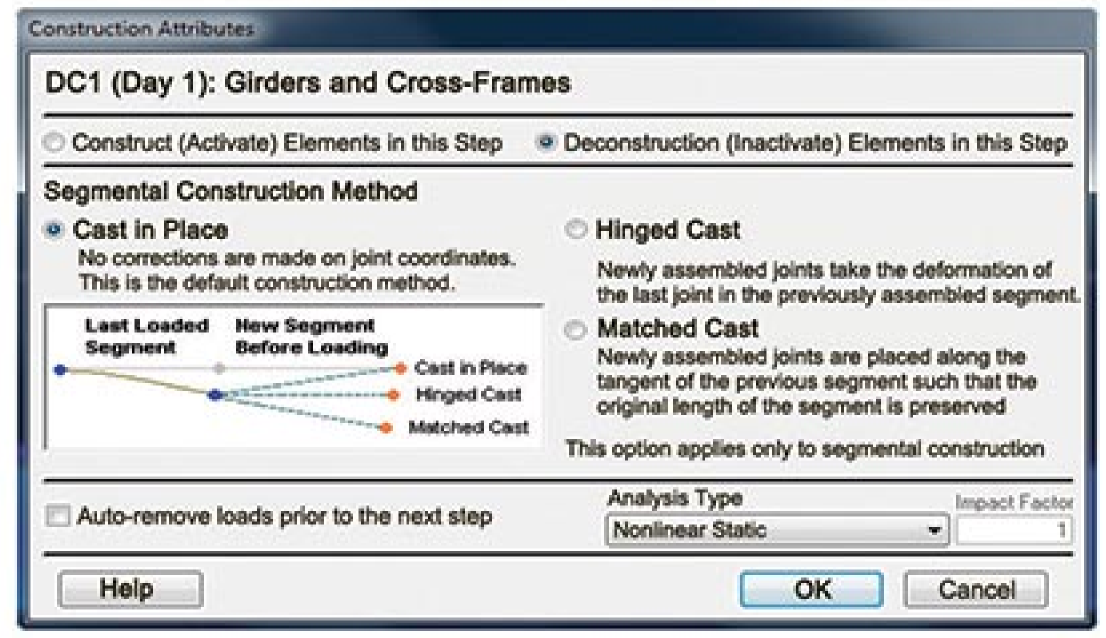
LARSA 4D Load Class Tracking

Essential for the design and Code Check of AASHTO compliant structures, load class tracking allows each construction activity to be associated with a load class such as “dead load,” “live load,” or “prestress,” so that the cumulative effects of load classes can be reported separately for code-based load combinations. In LARSA 4D, load class tracking of construction activities such as support changes and element removal provide an accurate portrayal of nonlinear force redistribution in the structure.



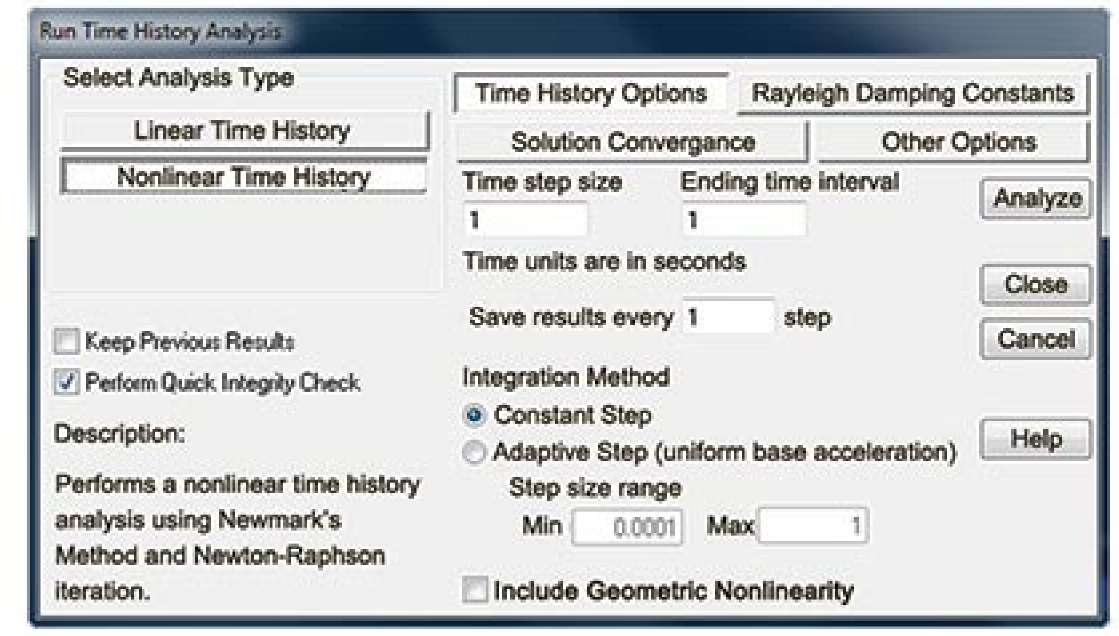
Analysis Scenarios within Staged Construction

Nonlinear time history, eigenvalue, pushover, collapse, moving load, and influence surface analyses can be included within any stage of a construction analysis, in which results are based on the stressed state of the bridge at any point during the construction sequence.



Construction and Deconstruction

LARSA 4D’s powerful Staged Construction Analysis engine with geometric and material nonlinearity captures the unique behaviors of erection and deconstruction in real-time, as defined through the steps-and-stages of the project's construction sequence.



LARSA 4D Analysis Options

Staged Construction Analysis in LARSA 4D includes options that take into account advanced features for time-dependent material effects, as well as geometric and material nonlinearity within the same analysis run to capture results with unprecedented accuracy.

Segmental Construction

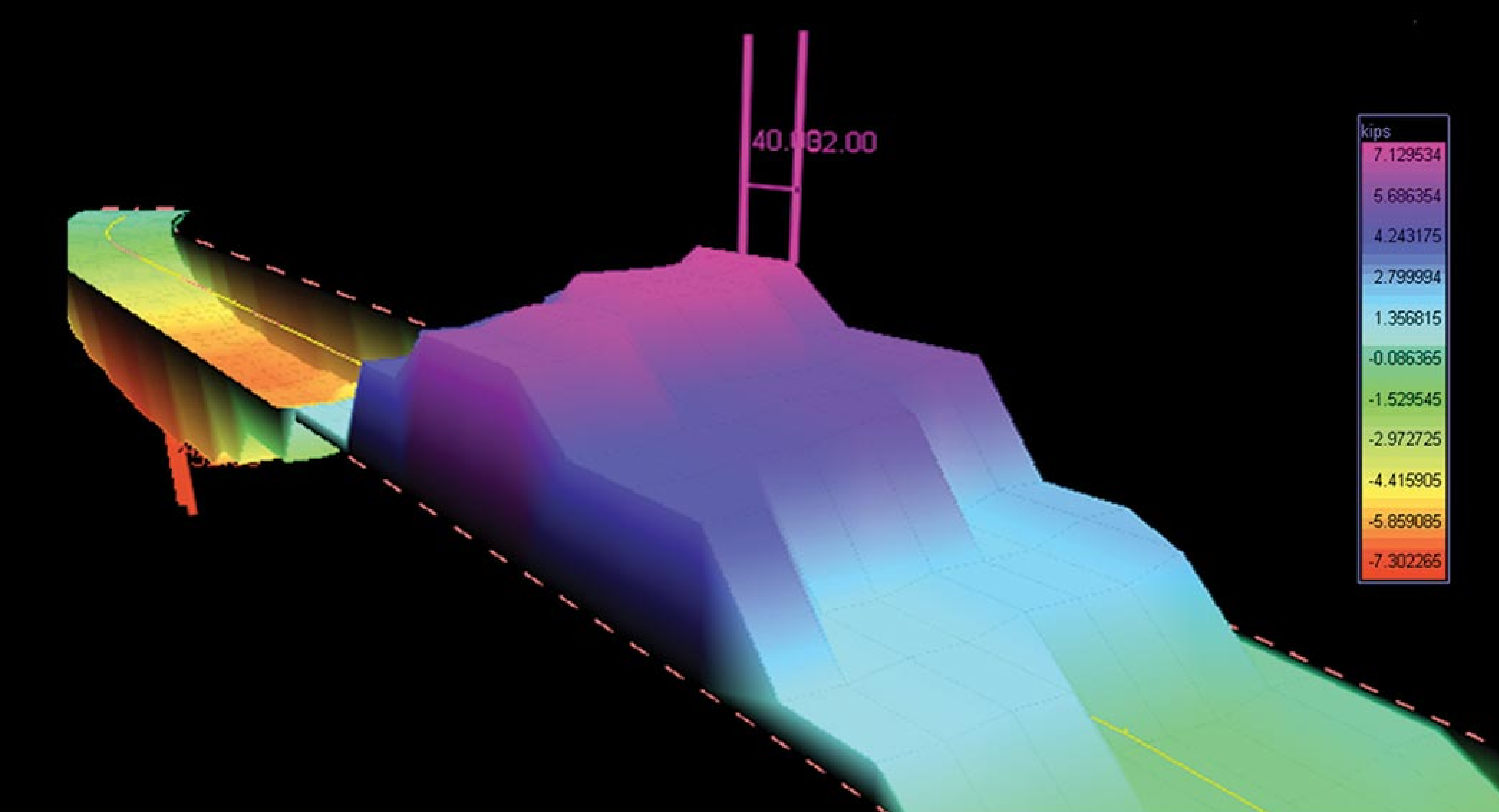
Segmental construction options for Staged Construction Analysis are used for modeling balanced cantilever and other construction methods. Hinged cast, matched cast, and displacement initialization options automatically adjust bridge geometry as new segments are cast, accounting for the displacement of previous segments.

Using the hinged cast option the casting location of new segments matches the vertical deformation of the previously cast segment. The matched cast option adjusts the casting location of new segments so that they remain at the same angle with the previous segment.

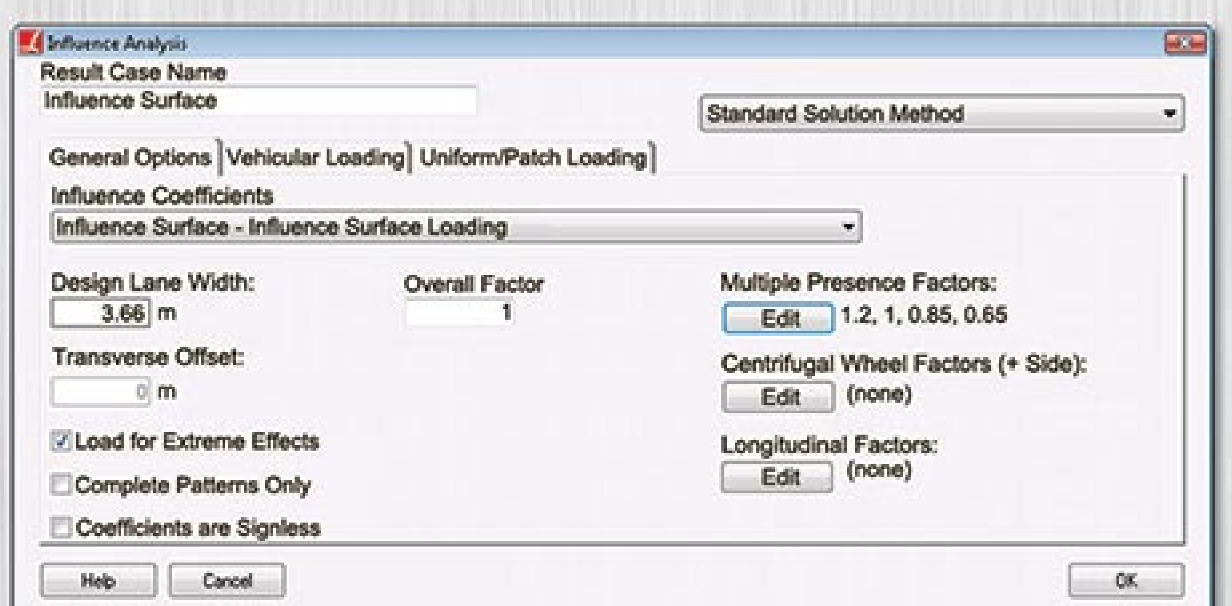
Construction Activities

LARSA 4D’s staged construction is unrivaled in its to ability realistically model all construction activities, providing a refined representation of the entire construction sequence.

Supporting all types of bridges, construction activities in LARSA 4D include construction and deconstruction of members, plates, springs and foundations, in addition to loading, temporary and traveler loads, support changes, displacement initialization and hoist for incremental launching.



Live load analysis in LARSA 4D is based on powerful influence surface algorithms which automatically find the worst-case live load scenarios by positioning vehicles and uniform lane loads to maximize the effect

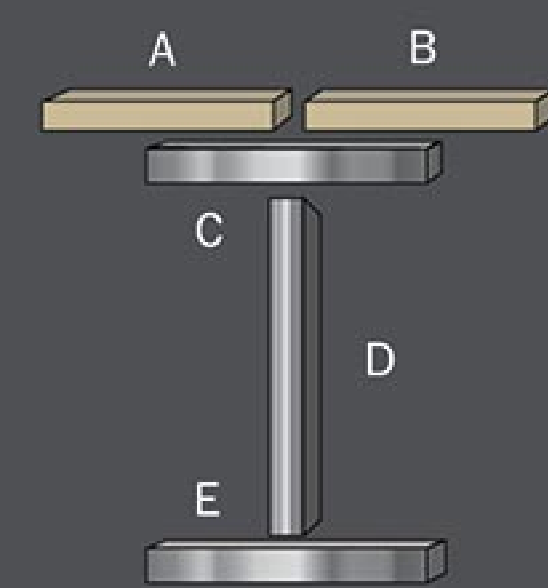


Influence surface analysis is the latest methodology for live load analysis, which extends the notion of an influence line onto a 2D surface on plate-deck models. In LARSA 4D, both influence lines and influence surfaces are available to compute the worst case loading configurations on bridge decks, including bridges with curved and skewed roadways and nonparallel curb lines.

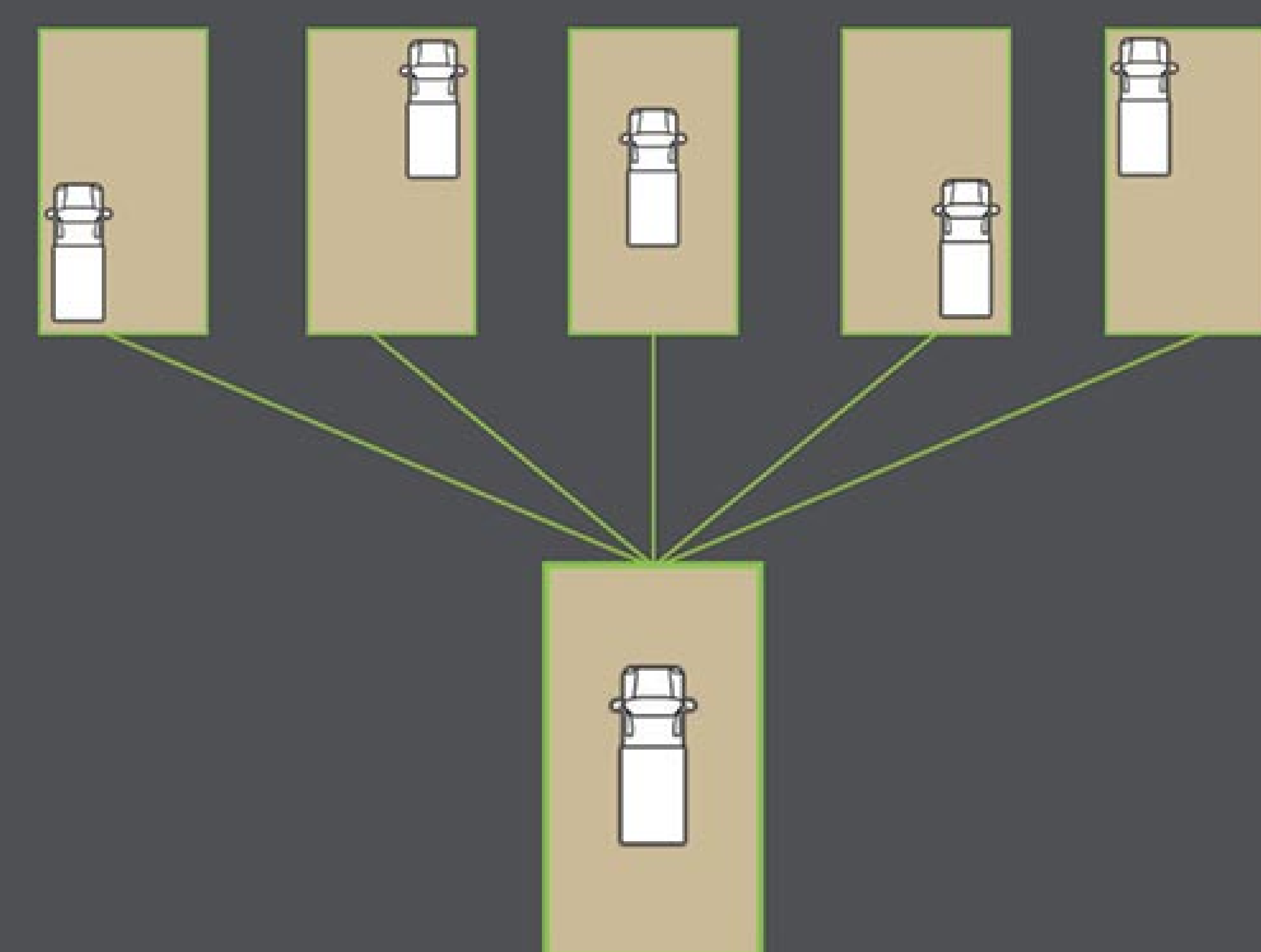
The influence surface algorithms integrated in LARSA 4D automatically determine the transverse location of the design lanes, along with live load placement in the longitudinal direction of the design lane to maximize extreme effects. Both axle-based and wheel-based vehicle definitions that model the length and width of the vehicle can be used.

Compound Element Forces for Live Load Analysis

Compound element forces are the resultant forces at the centroid of a composite section that consists of multiple finite elements. In load cases such as dead load, these resultant forces are computed using transformations of the element forces.



In live load an influence surface needs to be generated for the compound element force. In LARSA 4D influence surfaces for these compound elements are generated on the fly.



By computing influence surfaces on the fly for composite sections, not only is LARSA 4D faster and more accurate than other softwares, but it also allows users to utilize a single model to perform live load, staged construction, nonlinear time history and other analyses without having to create multiple project files with varying degrees of refinement.

Unique Features for Live Load Analysis

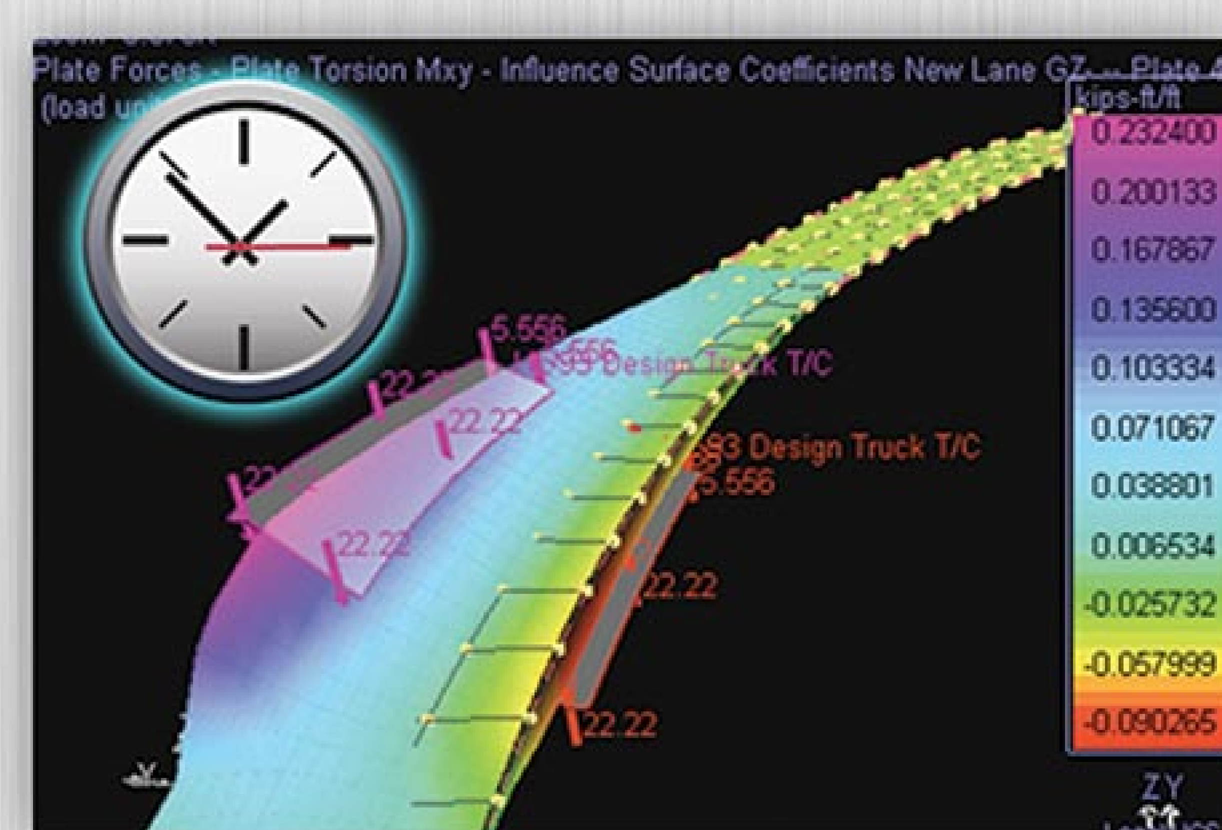
Unique to LARSA 4D's live load analysis, centrifugal force factors can be specified which automatically adjust wheel magnitudes. Multiple factors can be specified to apply different factors on the different segments within a single influence surface, and design lanes can include uniform lane loading without vehicle loading to promote flexibility in creating design and rating code-based load combinations.

Supported Codes

LARSA 4D provides tools that can be tailored and customized for any design live load code. Vehicle load patterns for AASHTO LRFD, AASHTO LFD, BS5400, and Indian Roads Congress come preloaded in LARSA 4D's vehicle library, and custom vehicle load patterns can be entered.

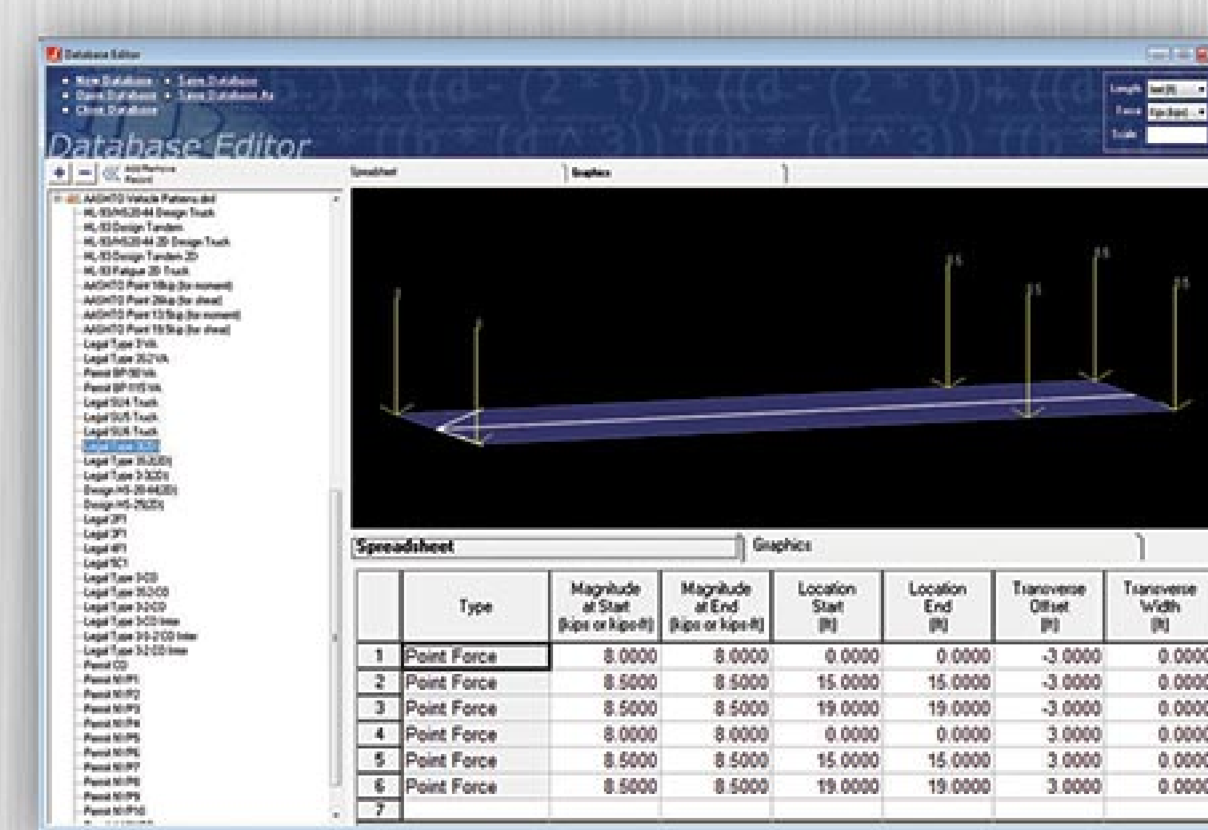
Rolling Stock Analysis

LARSA 4D automatically creates time history excitation curves based on customizable vehicle speeds to perform nonlinear and linear time history analyses which captures the dynamic effects of vehicles or railcars traveling on bridges.



Flexible Post Analysis Capabilities

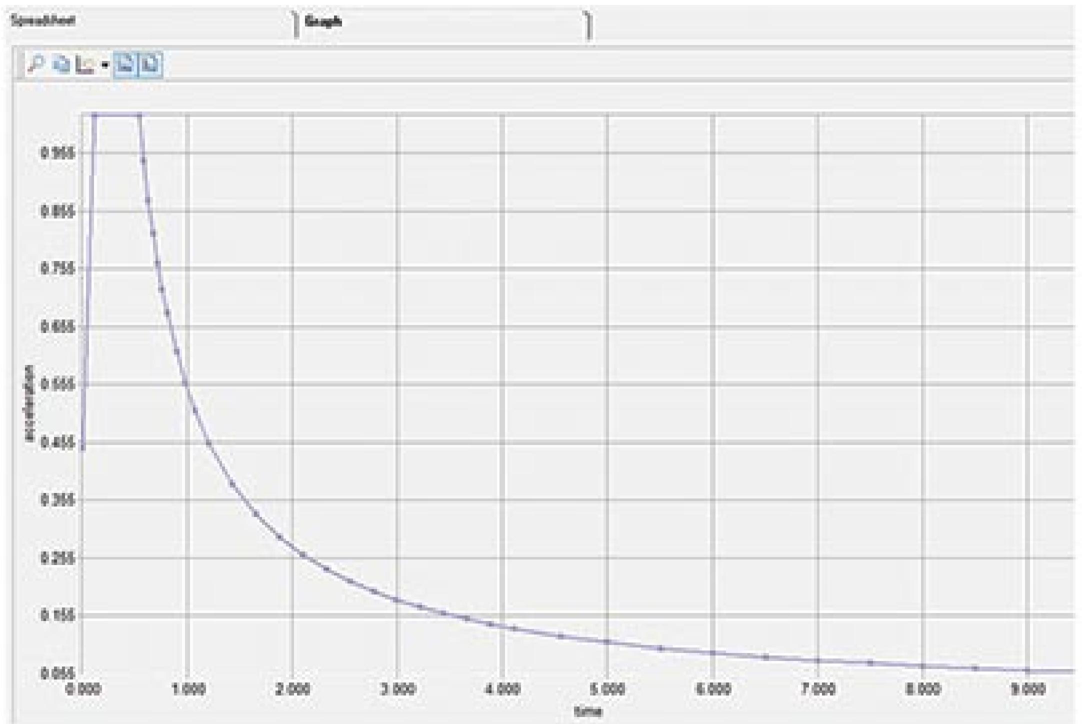
After an influence surface based analysis is performed, new vehicle definitions can be assigned to capture results without needing to run a new analysis, which provides fast-track Load Rating for bridge structures.



Flexible Vehicle Library

LARSA 4D allows users to define their own custom vehicles, or you can select one from the predefined vehicle library with Permit and Legal vehicle definitions to perform Code Check and Load Rating after a live load analysis has been performed.

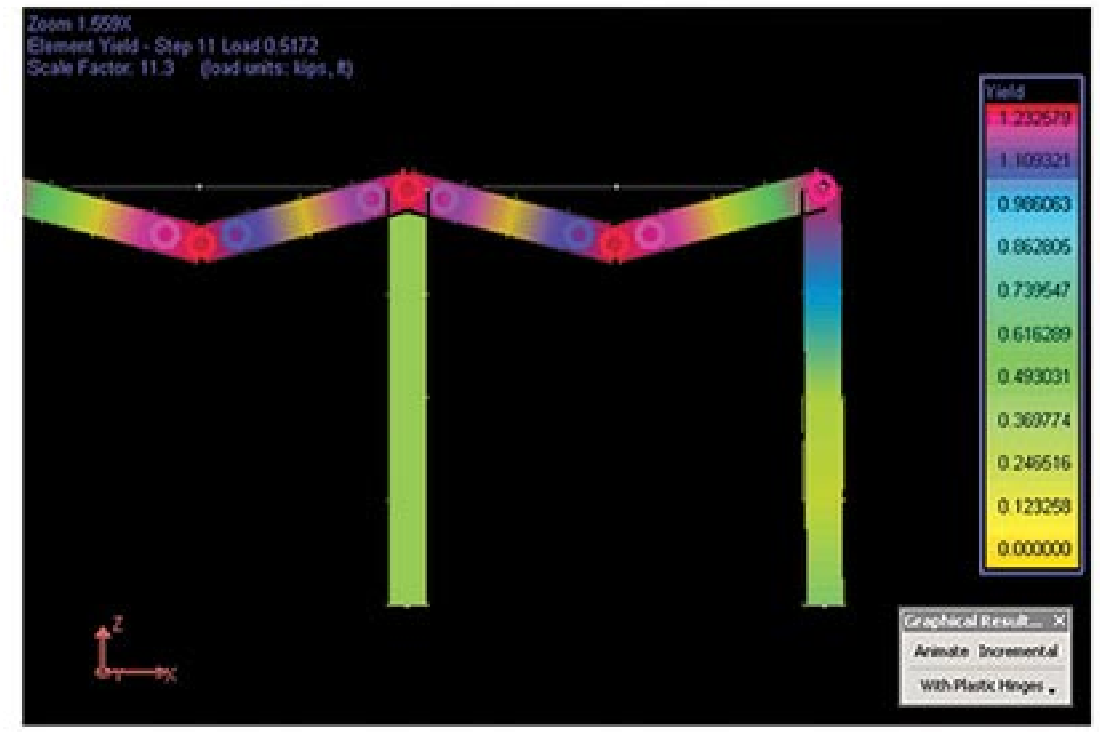
Eigenvalue Analysis & Response Spectra



Eigenvalue analysis is an important precursor to any dynamic analysis because knowledge of the structure's natural frequencies and modes helps to characterize its dynamic response and determine the number of modes to be used in a response spectra analysis (RSA).

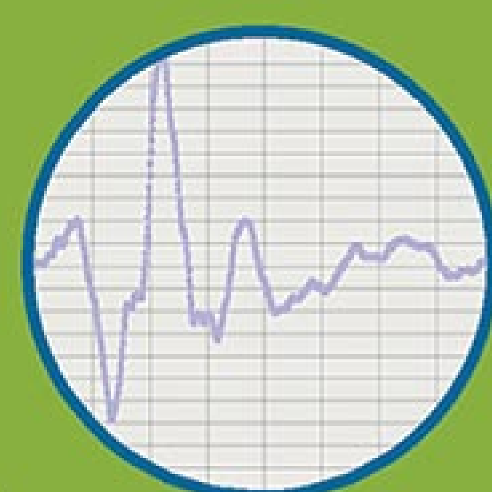
When eigenvalue analysis is performed within LARSA 4D's Staged Construction Analysis, modal results are based on the deformed and stressed state of the structure at any point during construction. RSA in LARSA 4D provides options for modal and spatial combination methods, user-defined RSA curves, ground motion directions, and modal damping.

Progressive Collapse & Nonlinear Pushover Analysis



Progressive collapse and pushover are nonlinear analyses that are performed using models with inelastic elements. These models will typically include hysteretic springs, yield-surface based beam elements, and moment curvature based hinge or beam elements.

Progressive collapse is used to analyze inelastic load redistribution that occurs as a result of the loss of one or more members from a structure, such as cable-snapping. In pushover analysis the structure is subjected to a load of a fixed profile but progressively increasing scale, which uses arc length control with auto-stepping.



Nonlinear Time History Analysis

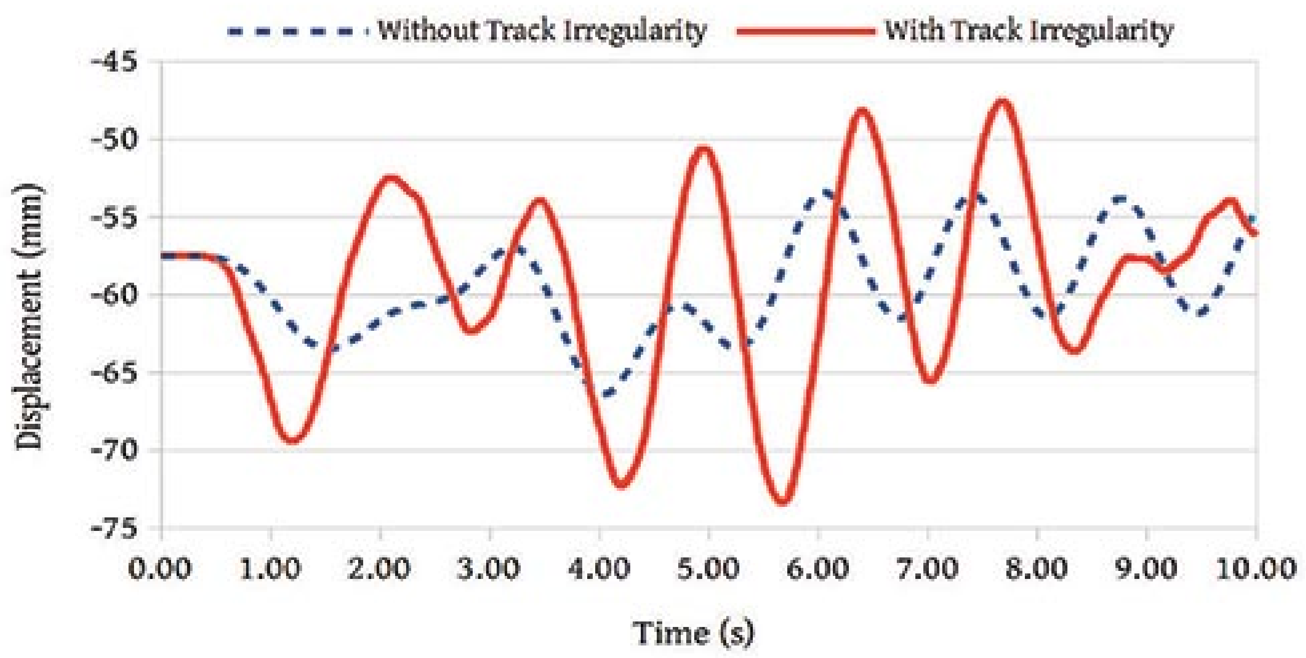
Nonlinear time history analysis uses a combination of the Newmark-Beta time integration algorithm and the full Newton-Raphson method using iterations within each integration time-step. Graphical tools for plotting displacements, force and other time history results easily provide many output options. Excitations can be in the form of force, multi-support displacement, or uniform base acceleration.

Standard Analysis Types

LARSA 4D supports a variety of analysis types integrated in a single application. Each package in LARSA's 4D BRIDGE SERIES includes the following standard analysis types:

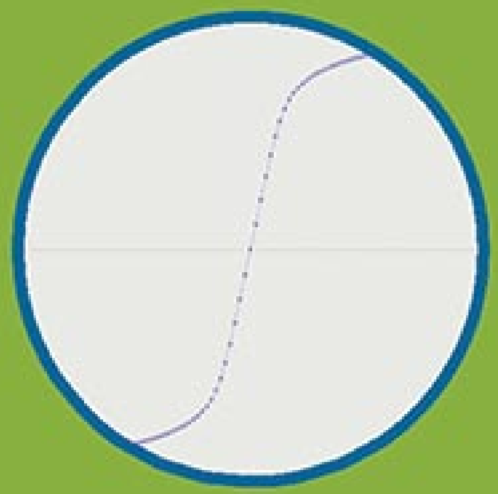
Staged Construction Analysis, Influence Line & Surface Analysis; Linear Static Analysis; Basic Moving Load Analysis; Linear Static Analysis with P-Delta Effects; Eigenvalue Analysis; Response Spectra Analysis; Nonlinear Static Analysis; Linear Time History Analysis and more.

Vehicle Track Structure Interaction Analysis for High-Speed Rail Bridges



The design of high-speed rail structures involves unique analysis requirements. At high speeds, resonance and coupling of the vehicle with the natural frequencies of the structure exacerbate structural demands. When analyzing these structures numerically a conventional rolling stock analysis is insufficient. LARSA 4D's approach to this problem couples independent bridge and train models through kinematic constraints, namely that the displacement of each wheel of the train is equal to the displacement of the bridge at the location of the wheel.

Vehicle Track Structure Interaction (VTSI) Analysis in LARSA 4D is an extension of the time history analysis. In place of time history excitation curves, the user instead provides input for a) the stiffness, mass, and damping of vehicles, b) their speed, and c) the geometry of a track, possibly including irregularity in its profile, and its connectivity to the superstructure. VTSI projects contain both the bridge and the vehicle (one or more train cars) in the same project file. Bogies, suspension, and car bodies of the vehicle are explicitly represented with joints and structural elements in the same manner as bridges are modeled.



Moment-Curvature Analysis

Moment curvature analysis is used to determine the inelastic properties of a reinforced concrete cross-section, which can be any arbitrary shape defined in LARSA 4D's Section Composer tool. Once defined, a "family" of moment-curvature curves is created to define element behavior over a user-specified range of axial force values. These properties are usually assigned to either a hysteretic beam element or analytical hinge element in the LARSA 4D bridge model to perform a nonlinear pushover or nonlinear time history analysis.

32-Bit & 64-Bit Analysis

LARSA 4D includes both 32-bit and 64-bit analysis engines.

By accessing increased physical memory, LARSA 4D's 64-bit analysis engine is ideal for performing analysis on large models, as well as an effective way to boost the performance of LARSA 4D's engine.

Load Types

LARSA 4D supports many load types such as automatic self-weight, beam loads (point, uniform, partial, distributed), plate loads (uniform, point), joint loads, support displacements, thermal loads; nonlinear temperature gradients, pre-stressing and post-tensions for cables.

Flexural Strength Analysis

Moment capacity is an essential tool for determining the moment (flexural) capacity of post-tensioned sections for segmental bridges.

Tendon forces change due to long-term material time-effects such as relaxation, creep, shrinkage, elastic shortening, and super imposed loads. Moment capacity in LARSA 4D automatically extracts tendon forces at any step of a construction sequence or stage of a bridge's life cycle to accurately determine the flexural capacity for a section.

Biaxial Force Moment Interaction Analysis

Biaxial force moment interaction analysis is a feature for the design and investigation (per AASHTO and EUROCODE) for composite steel encased concrete cross-sections with arbitrary shapes and reinforced concrete sections with tendons subject to axial and biaxial flexural loads.

Composite sections can be modeled for any arbitrary shape including round, rectangular, or irregular to support multi-cell and standard concrete box girder bridges, as well as Precast-I and U-Girder bridges. Biaxial force moment interaction analysis is commonly used for: abutments (pile caps and stem-walls), piers (multi-column, hammerhead, and integral), cap shapes (straight, tapered, inverted-T, and integral), and columns (circular, rectangular, hexagonal, octagonal, and parabolic).

All LARSA 4D BRIDGE SERIES packages provide intelligent tools for the Code Check and Load Rating of steel girder bridges based on the latest AASHTO LRFD and LRFR Design Codes

LARSA 4D Code Check

Specify the locations on which the code check procedure will be performed.

Code Check locations

Load Class	Result Case
Dead Load (DC1)	DC1
Superimposed Dead Load (DC2)	DC2
Dead Load on Wearing Surfaces (DCW)	DCW

After the analysis process, LARSA 4D's Steel Bridge Module walks the user through Code Check based on the latest publication of the AASHTO LRFD code covering cross-section proportion limits, constructability, service limit state, strength limit state, stiffeners, and fatigue. For steel I-Girder, Tub-Girder and Box-Girder bridges LARSA 4D's Code Check process recognizes bridge components modeled as beam elements or as a combination of beam and plate elements.

LARSA 4D provides Code Check reports which can be viewed in a "Summary" mode, or results can be viewed in "Detail" mode. Detailed Code Check reports show the line-by-line computations that follow the design code with equation numbers referencing back to the Code.

LARSA 4D Load Rating

Rating for Flexure (Negative)	Rating factor for Mn	RF_Mn_Min = (flexureFactor * Mn + sign (1/3 * Mv_DL_tens) + sign * Mu_DL) / Mu_LL + (1/3 * Mv_LL_tens)) = 249.0958 ; where flexureFactor=1.000, Mn=7.743kips-ft, sign=1.000, Mv_DL_tens=23.76, Mu_DL=1.696, Mu_LL=366.9, Mv_LL_tens=38.82
Rating for Shear (Negative)	Rating factor for shear	Rf_Vn_Min = (shearFactor * Vn + sign * Vu_DL) / Vu_LL = 18.5126 : where shearFactor=1.000, Vn=184.3kips, sign=1.000, VuDL=63.26kips, VuLL=13.37kips
Rating for Flexure (Positive)	Rating factor for Mn	RF_Mn_Max = (flexureFactor * Mn + sign (1/3 * Mv_DL_tens) + sign * Mu_DL) / (Mu_LL + 1/3 *Mv_LL_tens)) = 31.9762 : where flexureFactor=1.000, Mn=7.743kips-ft, sign=1.000, MV_DL_tens=23.376,Mu_DL=1.696, Mu_LL=2.850, Mv_LL_tens=6.573
Rating for Shear (Positive)	Rating factor for shear	Rf_Vn_Max = (shearFactor * Vn + sign * Vu_DL) / Vu_LL = 1.122: where shearFactor=1.000, Vn=184.3kips, sign=1.000, VuDL=63.26kips, VuLL=107.8kips
	Click to see the verbose report	

Increasing complexity in the design and Load Rating of steel girder bridges is driving demand for refined modeling solutions that require sophisticated procedures. LARSA 4D's Load Rating is based on our influence surface solver, which provides accurate results by taking into account the distribution of loads across girders, transverse placement of design lanes, and wheel loads instead of axle loads.

Extensively used, LARSA 4D's Load Rating is based on the latest version of AASHTO LRFR and provides the flexibility to use any Legal, Permit or 2D custom defined vehicle and considers strength, service, and fatigue limit states. Similar to Code Check, summary and detailed reports are available. Detailed reports simulate the manual computation reporting the step-by-step formulations used at each load rating location.

Time-Dependent Material Effects

Time-dependent material effects within Staged Construction Analysis are extensively developed to support the design and construction of concrete spliced-girder and concrete segmental bridges. Using time-dependent material properties, rating factors for bridges can be computed at future points in time, or even as a function of time. Time-dependent material effects include short-term and long-term losses such as creep and shrinkage for concrete, time effects on the modulus of elasticity of concrete, tendon relaxation, and tendon post-tensioning losses due to creep, shrinkage and superimposed loads.

Time-dependent material effects comply with AASHTO LRFD, CEB-FIP ’78 and ’90, AS3600 Australian Codes, and EN 1992-1-1:2004 Eurocode 2. With the flexibility to modify code coefficients users can adjust creep and shrinkage, or enter custom time-dependent curves for tendon relaxation and the modulus of elasticity for concrete.

Concrete Segmental Bridges

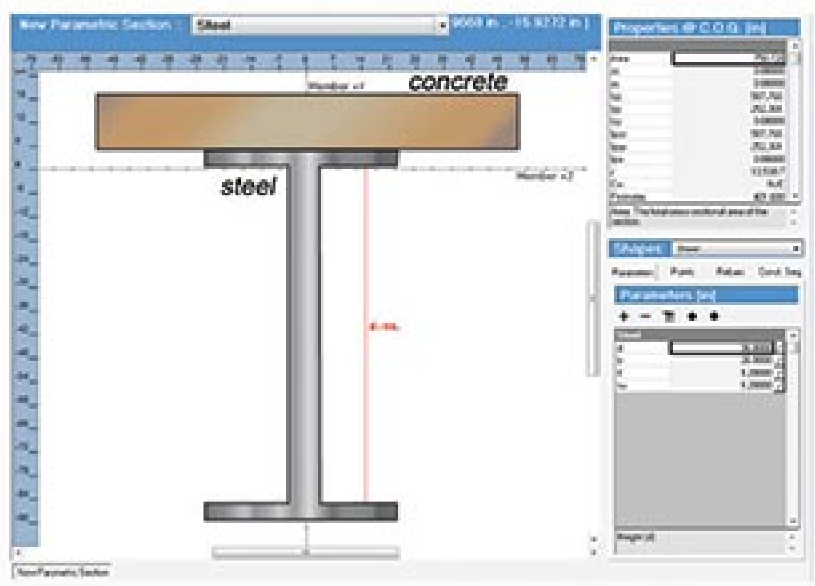
LARSA 4D addresses the unique challenges associated with the design and construction of concrete segmental bridges. LARSA 4D’s time-dependent material effects are integrated into Staged Construction Analysis to determine structural behaviors such as deformations, stresses, and unique material properties that are subject to change based on variations in loading and support conditions, and variations during and after construction. Used extensively for segmentally constructed bridges in the United States, LARSA 4D has become the most trusted software of its kind when time-dependent staged analysis is required.

Concrete Spliced-Girder Bridges

LARSA 4D supports continuous, straight, and curved concrete spliced girder bridges using I-Girder and U-Girder sections with cast-in-place splices and continuity tendons. Any arbitrary, nonprismatic, or custom defined section can be defined in LARSA 4D’s Section Composer, and material time effects are taken into account for creep, shrinkage, time effects on elastic modulus, and relaxation. Spliced girder models can include cast-in-place or precast decks, and can be based on single composite beam sections or composite modeling using plate elements for the deck. Influence based live load analysis can be included within the same model.

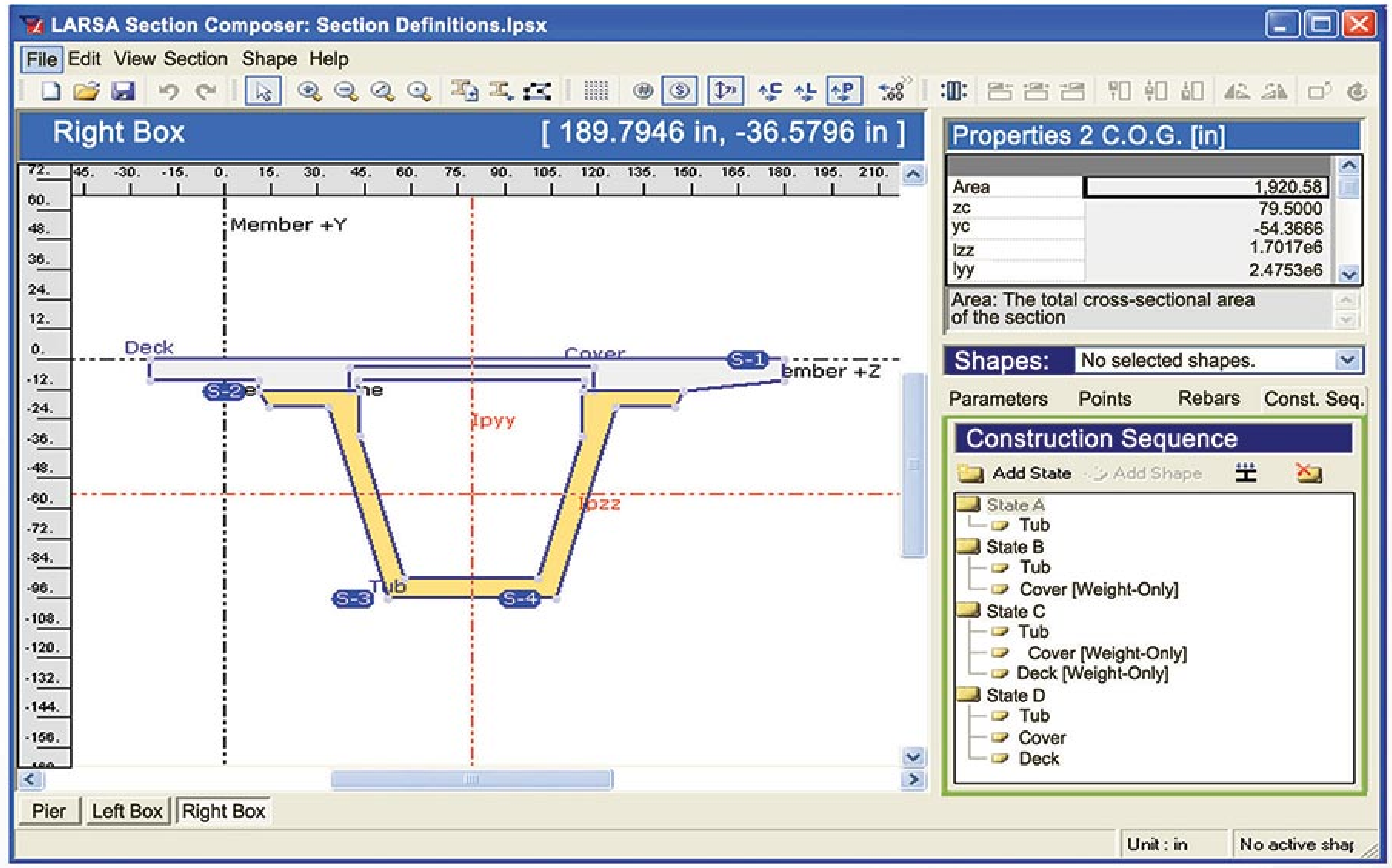
Composite Construction

To support modern practices LARSA 4D models composite beams that are built up from layers of more than one material, or from layers that are constructed at different times in a construction sequence with varying time-dependent material properties. Examples of layered cross-sections include steel beams with concrete slabs, concrete columns formed by an inner pour and an outer pour, or beams augmented with reinforcing elements.



In LARSA 4D composite beams have a hybrid behavior and are treated as simple line elements for the purpose of finite-element analysis, with layer properties transformed to the composite-section centroid. However, in other regards the composite member is treated as being made of independent elements. Thus, stresses and strains are tracked and reported for each layer, non-linear thermal gradients affect layers independently, and inhomogeneity of layers creates eigenstrain and self-equilibrating stress, such as under nonlinear thermal loading.

Using LARSA 4D's Section Composer tool, composite built-up sections can be readily modeled. A shape in Section Composer can be included in a state with weight and stiffness, weight only as a simple method to model concrete before it sets, or stiffness only if the weight of a composite part has been modeled independently of self-weight. When using Section Composer composite section "States" determine which shapes or parts of the section are active at any given time in a construction sequence.



Using LARSA 4D's Section Composer tool built-up sections can be readily modeled. Section Composer automatically computes all cross-section properties in varying "states" of section construction and supports sections that are composed of single or multiple materials.

Composite Construction Activities

In LARSA 4D there are two options available to add composite construction activities within a staged construction analysis. These are:

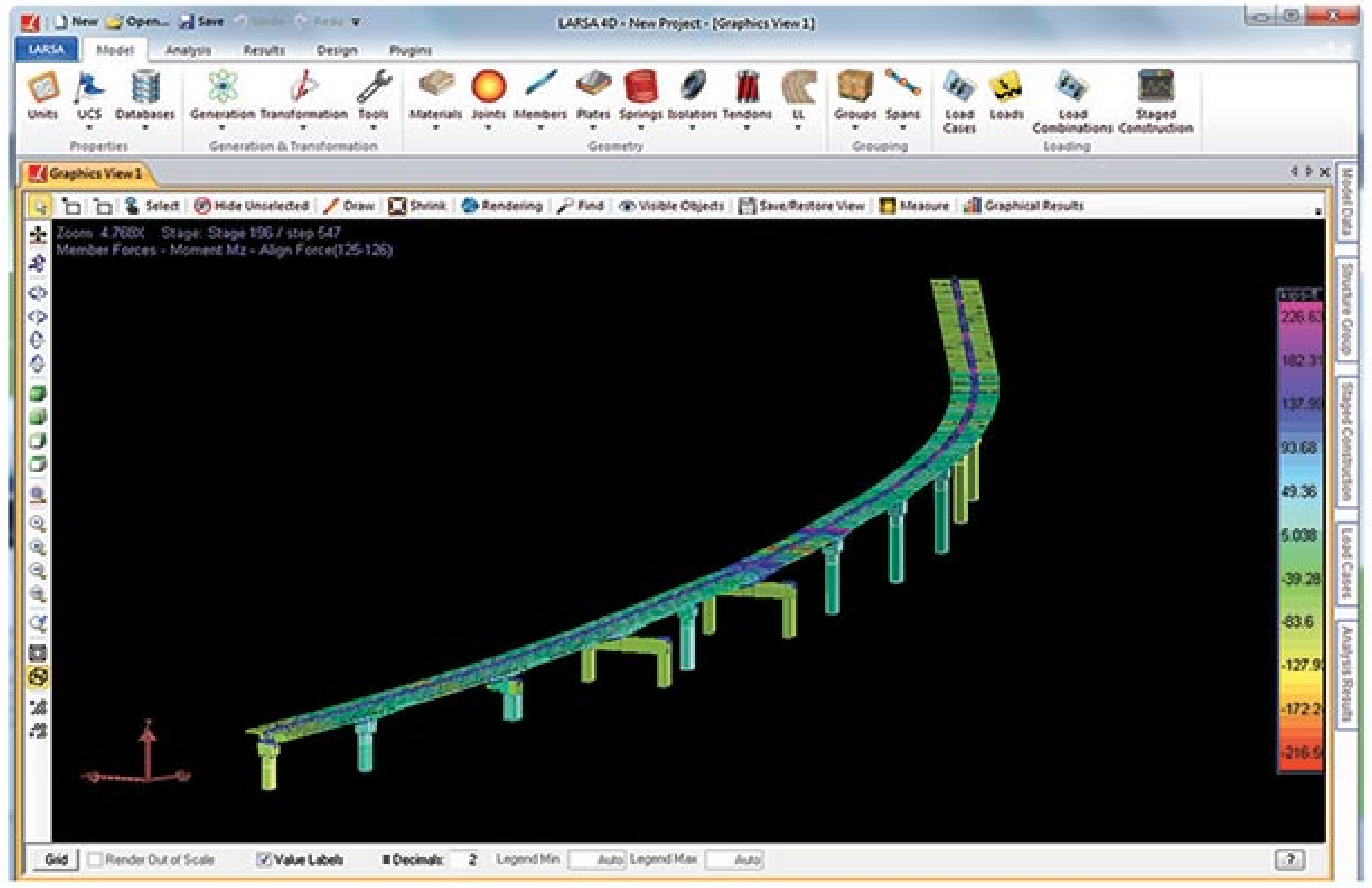
Cast Concrete

"Cast Concrete" activities in time-dependent staged analysis set the casting day for groups of concrete composite parts in a bridge model. Different casting days can be set for parts of the same cross-section, and the differential effects for concrete creep and shrinkage will be included.

Composite Activity

A "Composite Activity" changes the cross-section make-up of a group of members in the model by adding (casting) or removing parts of the section of the members. When parts are removed, the internal forces in the removed part are automatically applied onto the remaining structure.

Viewing Results in LARSA 4D



Analysis results in LARSA 4D can be viewed both graphically and numerically. Graphical results include the deformed model, reactions, member forces, stresses, and plastic yields. Results can be shown for the cumulative effect or for the incremental effect of a single load class in Staged Construction Analysis.

Spreadsheets are also available showing detailed results, which have further options, such as computing displacements and forces in alternative coordinate

Result cases can be enveloped in one click in LARSA 4D's Analysis Results Explorer. As with graphical results, incremental effects and cumulative forces for individual load cases can be reported numerically within a Staged Construction Analysis.

Graphs

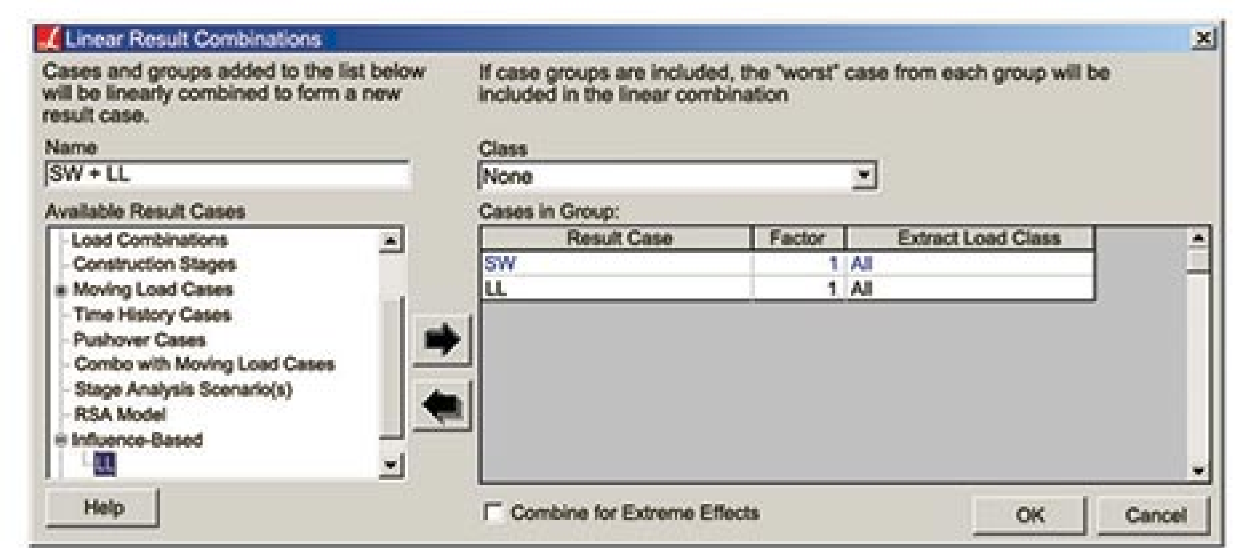
Graphs can be quickly plotted for any result data. In LARSA 4D the x-axis automatically chooses time, load position, or other units appropriate for the data set plotted, and y-axis results can be plotted relative to the value at another location. Result-versus-result graphs can also be created, such as for force-displacement graphs.

Compound Element Forces

Compound Element Forces report the total forces of multiple elements about their common centroid, used when building-up girders from smaller elements.

Special Result Types

Analyzed Member Loads, a commonly used special result type, reports the member loads used in the analysis including generated loads such as for self-weight and live load analysis, which provide an important verification tool.



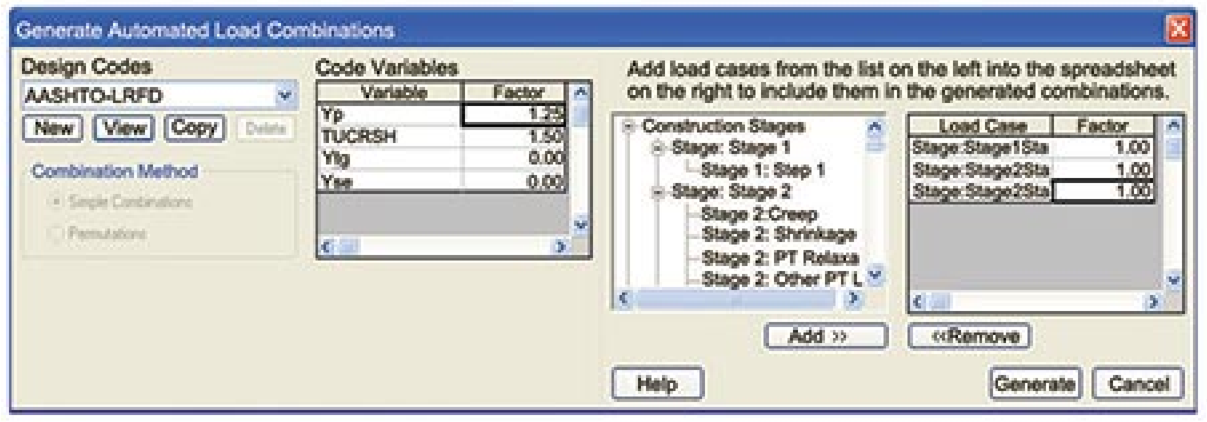
Linear Result Combinations

Linear result combinations create factored load combinations after an analysis by adding together results of solved cases. Linear combinations become result cases, with which all of the usual result tools can be used including graphics, spreadsheets, and graphs. When used with influence based cases, live loads can be combined with other load classes.

Extreme Effect Groups

LARSA 4D's extreme effect groups are like saved envelopes, which allows the user to extract the "worst case" loading scenario from a set of defined result cases, or from a particular group of cases with the same class that had the most negative (when a minimum is being reported) or positive (when a maximum is being reported) value. When used in conjunction with linear result combinations, worst case scenarios from multiple extreme effect groups are combined automatically, eliminating the need to create independent linear result combinations for each result case within the group.

In LARSA 4D extreme effect groups are calculated on-the-fly and do not require the user to reanalyze their bridge model. Like Linear Result Combinations, extreme effect groups act like regular result cases.



Automatic Load Class & Load Combination Wizard

Classification of loads is essential for code-based load combinations. Load cases are assigned classes, such as dead or live load, so that the automated Load Combination Wizard can create combinations based on a chosen design code. LARSA 4D's Load Combination Wizard supports AASHTO LFD, Service Load, LRFD, AISC LRFD, CISC, IRC and user-defined combinations.

Extensibility & Post-Processing Results

Whenever you're faced with a repetitive task, let your computer do the work for you. LARSA 4D macros, through the program's extensive API and object model, can automate any program process to save time, including data import/export, modeling, analysis, and design.

Macros can be written in Microsoft Excel to interface with the spreadsheet application, or using any COM-enabled programming language. Microsoft Office VBA is the most common because of its availability and ease of use, although Visual Basic, C, and Fortran can also be used. While some programming experience is generally needed to write macros, our technical support staff gladly writes macros to help our clients. LARSA 4D's macro API or "object model" was built into the program from the very start, and hundreds of classes and methods in the public API create infinite possibilities for macro writers, including:

Load joint coordinates and other geometry from Excel worksheets, or any other custom data import.

Creating an entire LARSA 4D model with a macro to facilitate parametric analysis.

Copying and transforming parts of the bridge model according to custom rules.

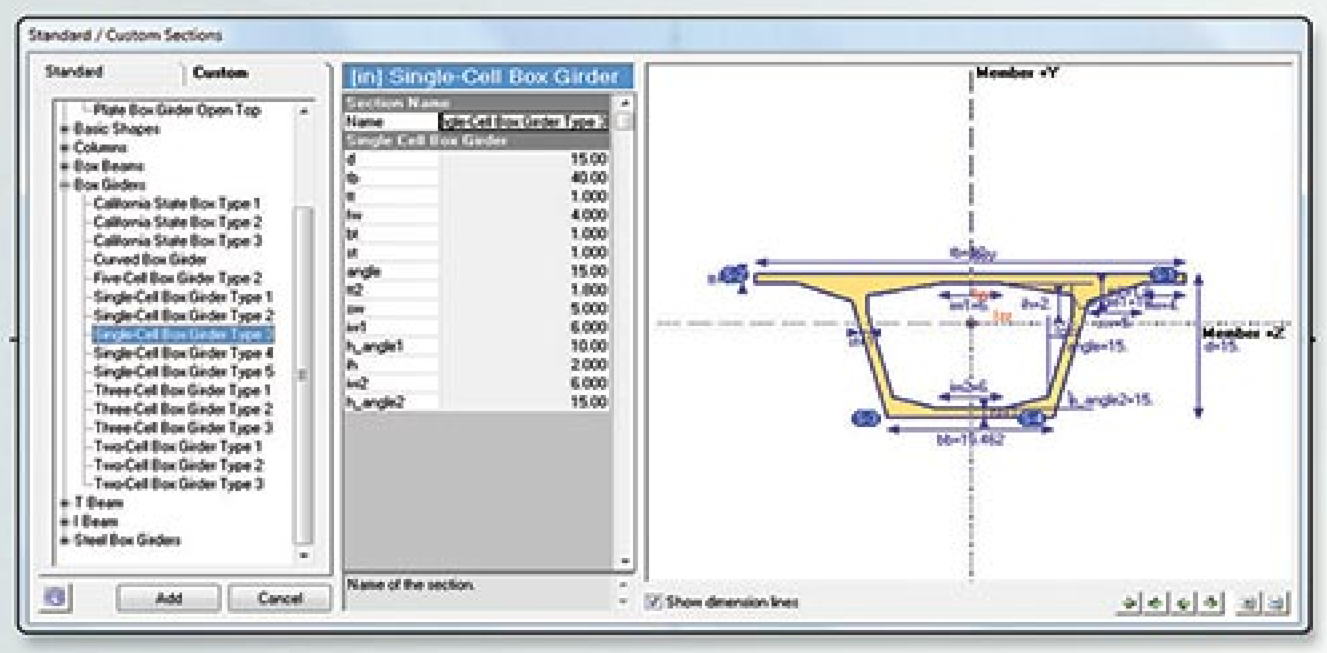
LARSA 4D Section Composer

LARSA 4D's Section Composer is a graphical companion tool for modeling arbitrary sections for use in LARSA 4D BRIDGE SERIES. Section Composer supports standard, parametric, nonprismatic, and custom shape sections, and it computes all section properties in real time.

Flexibility & Properties

Section Composer can be used to model cross-sections with holes, composite parts, and built-up parts with any shape. Properties including area, moment of inertia, radius of gyration, and torsion constant are all computed by Section Composer for any shape.

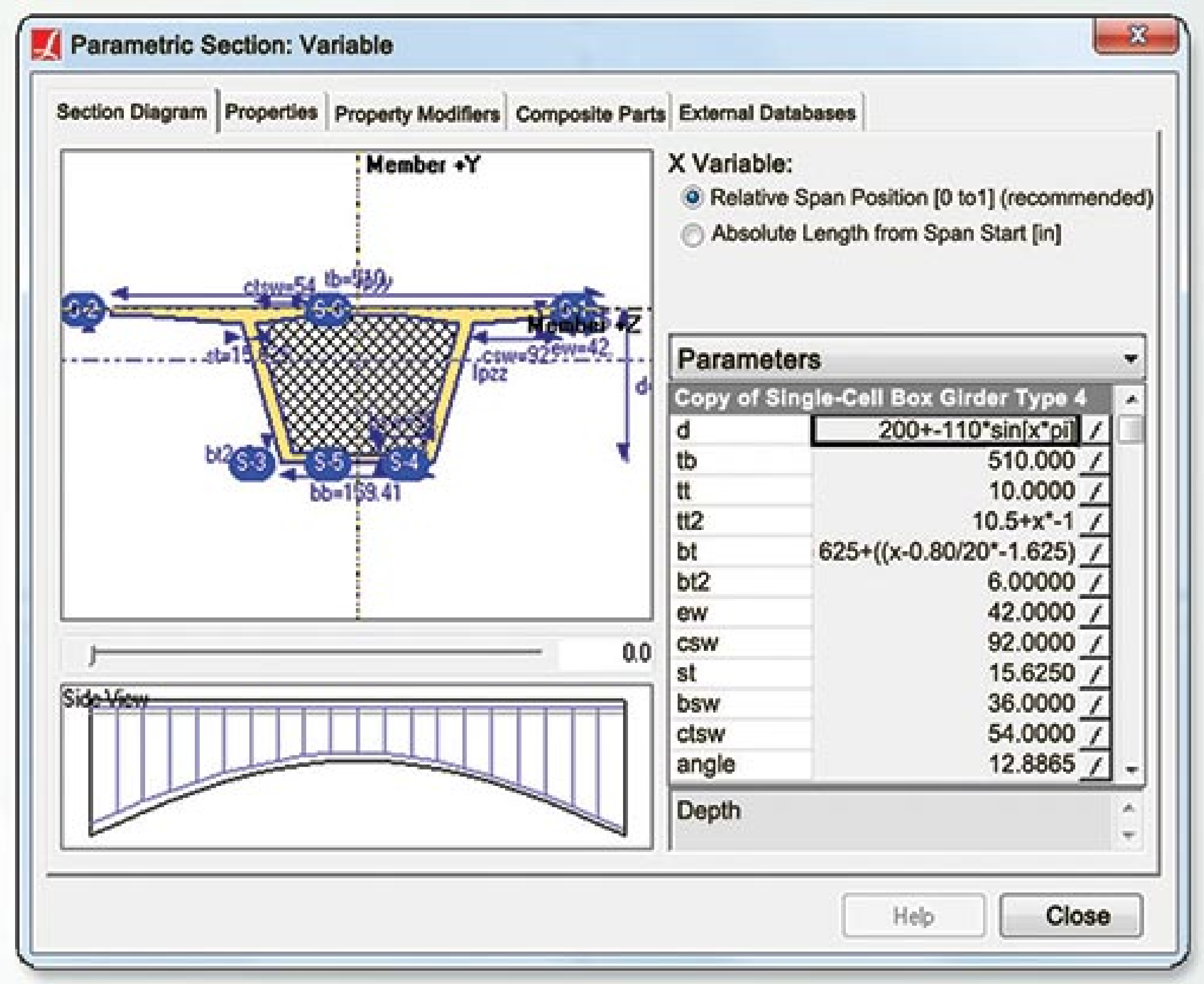
Parametric Definitions



Sections in LARSA 4D's Section Composer are parametrically defined, meaning points are normally entered as equations of a few parameters, such as width, depth, and thickness. Sections defined this way can be reused and resized as needed without re-computing the coordinates of control points. By simply changing a parameter, coordinates are immediately updated.

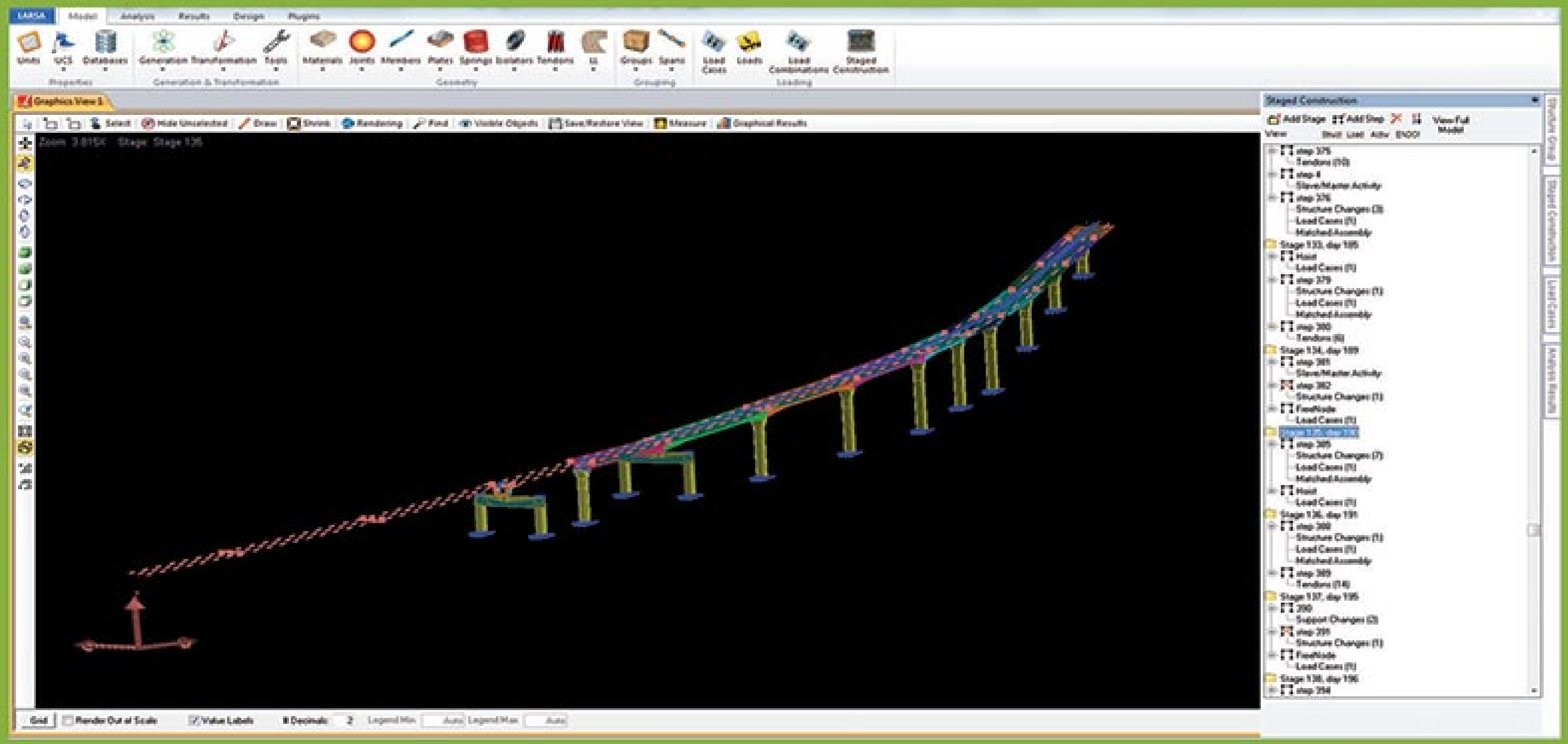
Each point in a shape's perimeter is defined using mathematical equations. Equations in terms of section parameters, such as for creating the points on a rectangle (d,b), (-d,b), (-d,-b), (d,-b), make it possible to alter section dimensions without modifying each point, and to apply nonprismatic variation according to any user-enterable formula, such as d + x/100 for a variation that starts at d and increases on a linear 1:100 slope.

Nonprismatic Variation



Accurate modeling of bridges requires the use of nonprismatic sections, meaning the section's dimensions vary along the length of the member. The Section Composer tool makes it easy to define nonprismatic variation in sections by applying a formula to a parametric section definition.

In LARSA 4D formulas define the value of a parameter as a function of the position along the length of a span. This can include linear, parabolic, sinusoidal, and other types of functions which can be attached to parameters, such as depth, to control nonprismatic variation.



LARSA 4D User Interface

LARSA 4D's user interface is intelligently designed for quick learning and intuitive workflow. Users can access the power of LARSA 4D's Steel Bridge Module, Concrete Bridge Module, and Section Composer to create refined finite element models in LARSA 4D.

In a single interface all project data is displayed and edited through spreadsheets, graphics, and explorer window panes. When model information is revised in other areas of the program, LARSA 4D's interface automatically updates and refreshes the pertinent information across all areas.

Structure Groups

Breaking down a structure into smaller units saves time by allowing quick access to a part of a structure. Structure groups allow you to quickly select and unselect portions of a structure, for using the Model Data Explorer, or for viewing results in particular portions of the structure. Structure groups are also used in Staged Construction Analysis and as design groups in the Steel Bridge Module. For presentation output structure groups can be assigned colors, so that the parts of the structure are easily recognized.

Explorers

Navigating through a 50,000-element project is difficult. While invaluable, spreadsheets often present too much data at once. Presenting a solution to this problem LARSA 4D uses Explorers which summarize large quantities of data into manageable units for quick editing.

Project Reports

Reports for LARSA 4D projects can be printed or saved to file and may include input spreadsheets, output spreadsheets, graphics, and charts. Export file formats include Microsoft Excel, Web Page (HTML), Adobe Acrobat (PDF), and Text-only. Animations of the structure and of results diagrams can be exported as AVI animations.

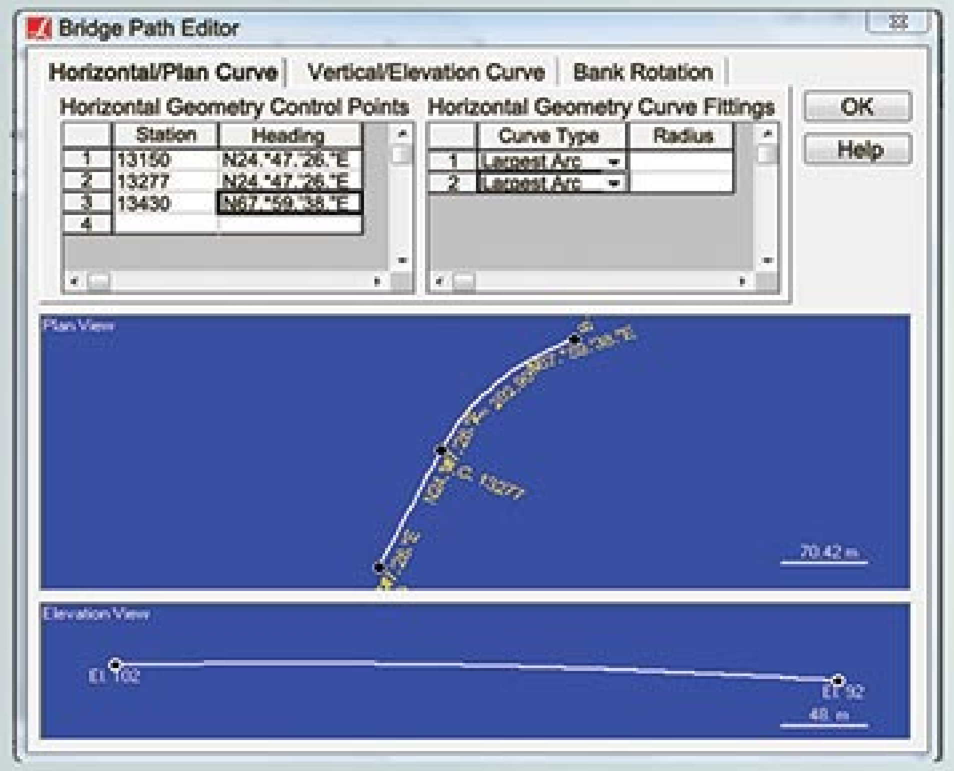
Spreadsheets

Spreadsheet cells display information clearly, using textual names rather than numeric IDs where possible. Column headers always display input units where needed. Spreadsheets automatically refresh when data has been changed in other areas of the program. All model data can be edited in LARSA 4D's spreadsheets.

Integrity Check & Undo/Redo

Integrity checks find common modeling errors and provides shortcuts to correct problems. LARSA 4D supports infinite-level undo and redo of all data-modifying operations.

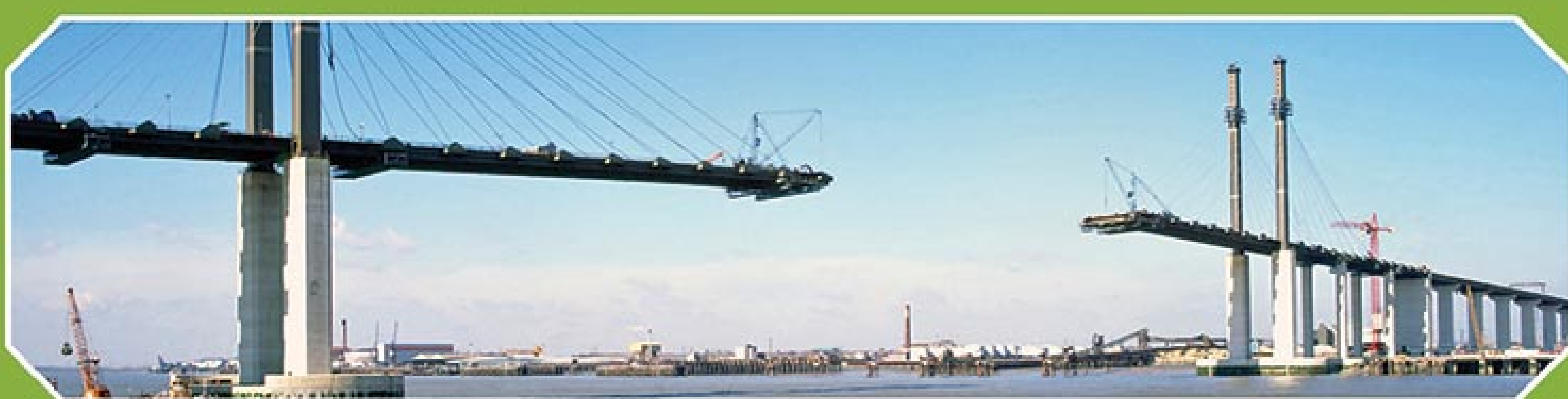
BRIDGE PATH COORDINATE SYSTEMS, FORM FINDING & TENDON GEOMETRY

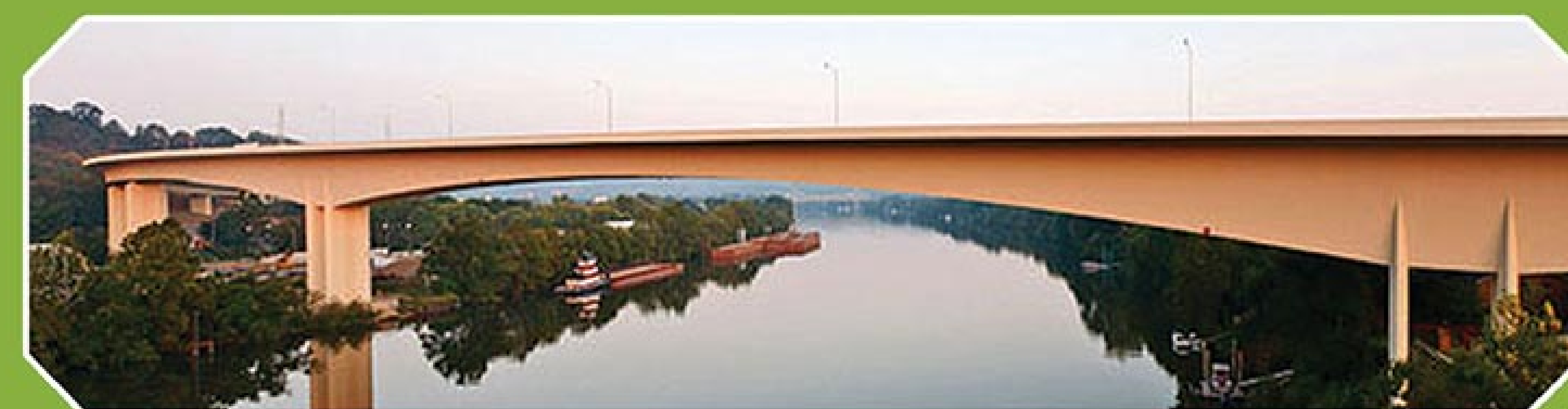


LARSA 4D Bridge Path Coordinate Systems

Developed specifically for bridge engineers, LARSA 4D's Bridge Path Coordinate Systems (BPCS) simplify the modeling of curved bridges. A BPCS is a warped rectangular coordinate system whose axes are station, elevation, and transverse offset. The horizontal geometry of the BPCS is defined with stations and headings which can often be read off of bridge design documents. BPCS's allow the user to work in familiar coordinates despite any curvature of the structure by warping the usual x-axis into a curve that follows the alignment of the bridge.

Elevation and super-elevation can be specified in addition to headings. Multiple BPCS bridge paths can be used in the same model to define girders, spiral on-and-off-ramps, and ground-level footings. These coordinate systems can also be used to specify joint coordinates and directions of supports, including for bearings and springs, and for the reporting of forces and other results.





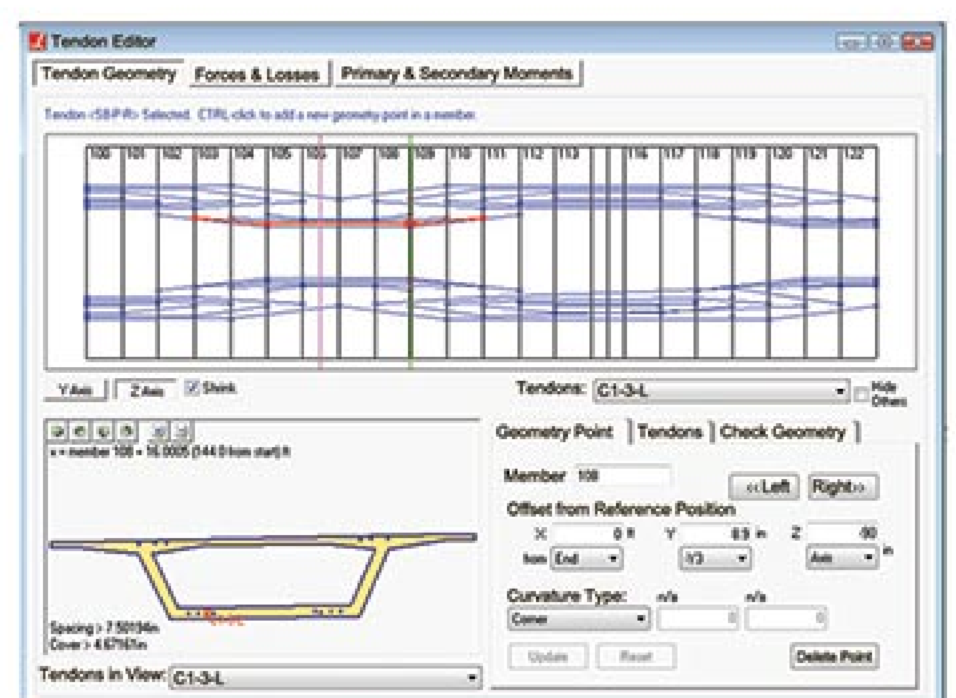
Form Finding & Cable Tension Optimization

A common problem in the analysis of cable-supported bridges is the determination of initial cable tension forces, which when combined with loading, construction sequence, and time-dependent material effects give the structure its final desired geometry and internal forces. LARSA 4D provides two solutions for form finding:

The first method determines cable tension forces in a model in which the structure is constructed in a single step, called Cable Tension Optimization. This procedure is an iterative method that adjusts cable pretension forces until the model has near zero deformation under loading.

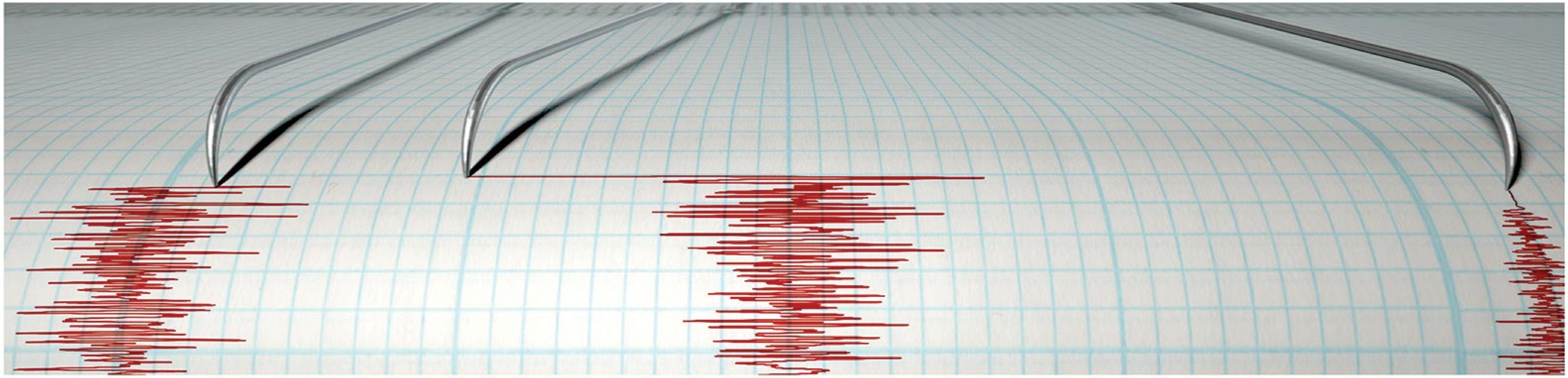
The second method is a generalization into multiple dimensions of the Newton-Raphson method and is used for models with complex construction sequences. In this method, a unit-tug — i.e. one extra unit of jacking force — is applied to each cable and its effect on each of the joints at the bases of the cables is determined. Then a factor is applied to the tugs to zero-out the joint displacements.

Tendon Geometry



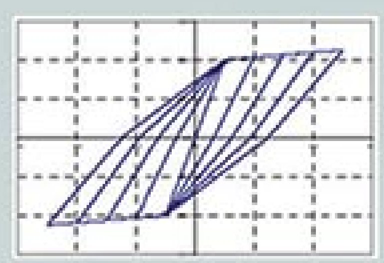
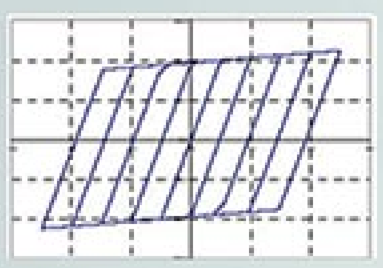
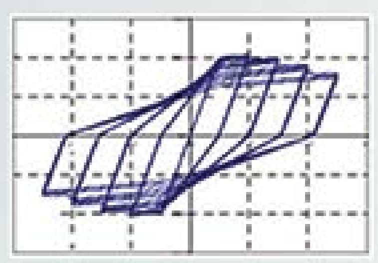
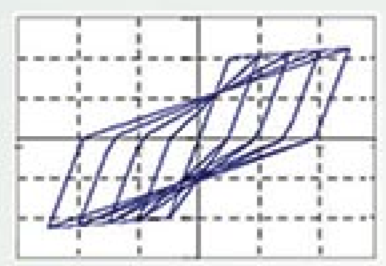
LARSA 4D's Tendon Composer tool simplifies the entry of geometry for pre-stressed and post-tensioned tendons.

In LARSA 4D the path of tendons between control points are modelled as straight lines or second/third-order curves through the 3D geometry of the bridge model. Tendons are presented in both 2D view from all planes and a 3D view that is updated in real-time so that tendon geometry can be visually verified. As the user defines tendon geometry LARSA 4D immediately reports the cover distance and tendon spacing, anchor set and friction losses, and elongation due to jacking.



LARSA 4D's element library includes linear and nonlinear elements and advanced seismic and inelastic elements with nonlinearity

Nonlinear Elements (Material Nonlinearity)

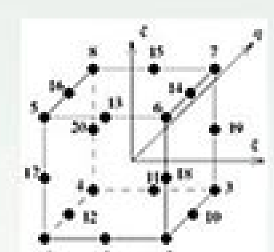
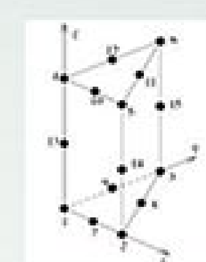
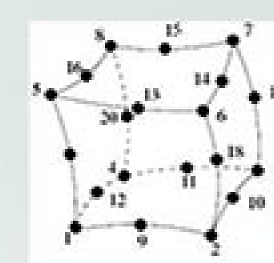
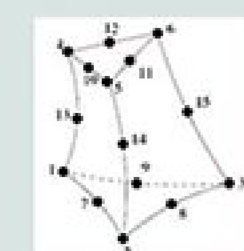





LARSA 4D's inelastic and seismic element library is based on the works of Professor A.M. Reinhorn at the National Center for Earthquake Engineering and Research and Professor M. Sivaselvan at the University of Buffalo. The inelastic analysis tools developed through this collaboration provide LARSA 4D users with new and leading capabilities for seismic and collapse analysis.

Hysteretic elements support many types of nonlinear and inelastic behaviors based on smooth yield surface and polygonal hysteretic models. LARSA 4D's inelastic element library includes the following:

- Analytical Hinge
- Inelastic Connection Beam
- Yield Surface Beam
- Moment-Curvature Beam
- Hysteretic Inelastic Spring
- Triaxial Hysteretic Spring
- Friction Pendulum
- Sliding Friction Bearing
- Viscous Dashpot

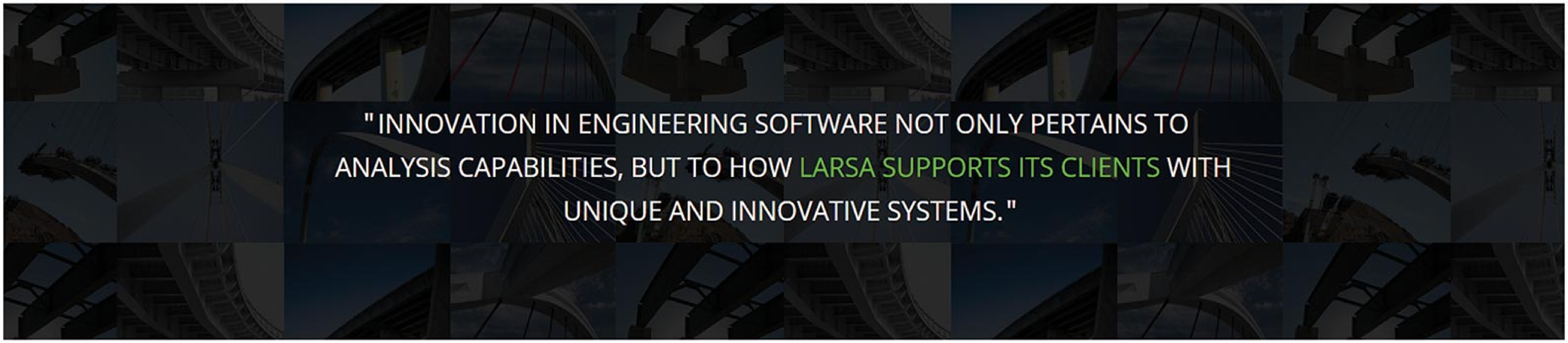
Elastic and Solid Elements

LARSA 4D's finite element library provides accurate modeling for bridges and other structures requiring geometric and material nonlinearity. The finite element library includes linear and nonlinear elements, advanced seismic inelastic elements, line, surface and volume element forms.

LARSA 4D's Elastic Element Library includes the following elements:

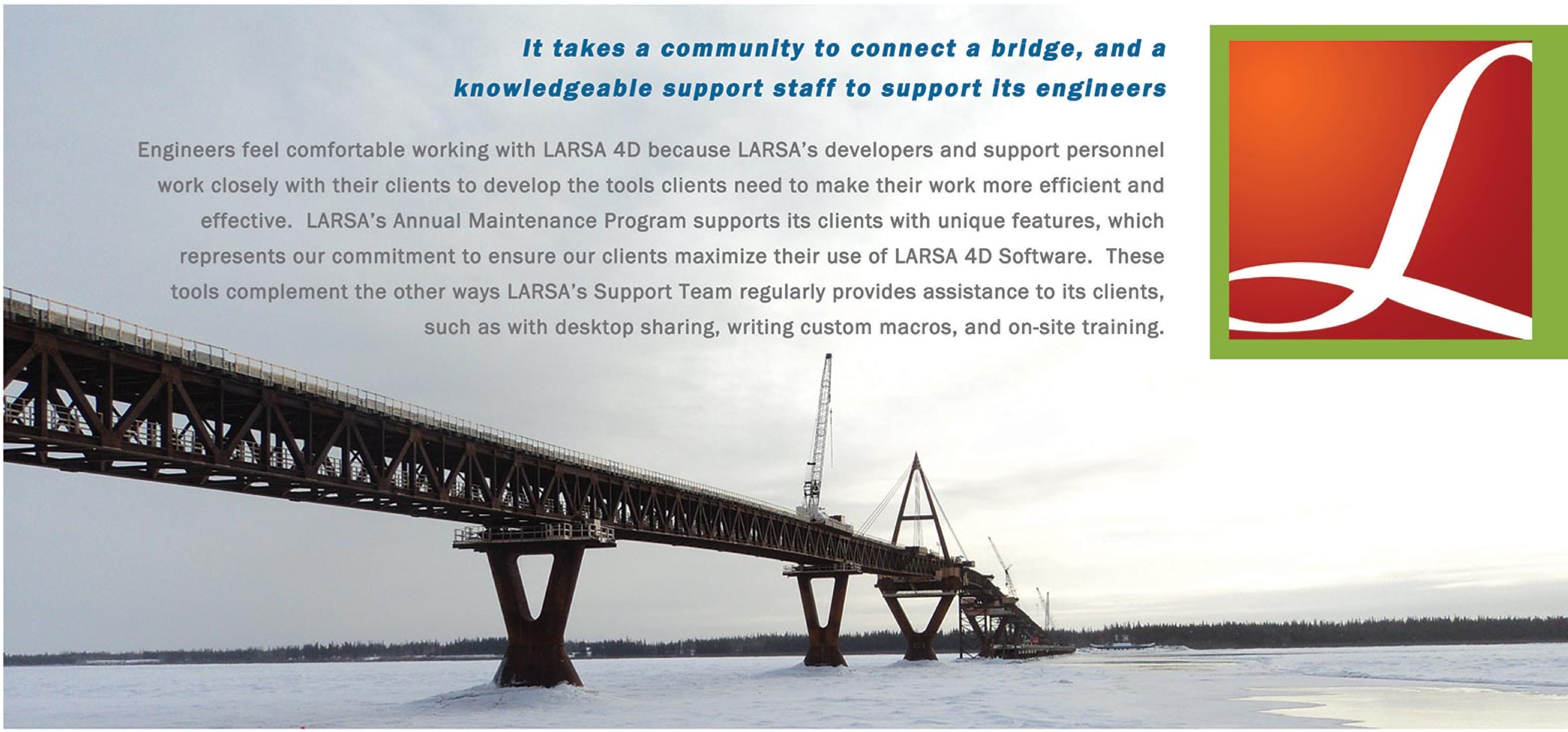
- Truss/Beam
- Cable
- Super Cable
- Compression/Tension-Only Truss
- Nonlinear Grounded Spring
- Nonlinear 2-Node Spring
- Coupled 6x6 Foundation Spring
- Hook and Gap Element
- Triangle Shell Element
- Quadrilateral Shell Element
- Thin & Thick Plate Behavior
- 8-Node and 20-Node Brick
- 6-Node and 15-Node Wedge



"INNOVATION IN ENGINEERING SOFTWARE NOT ONLY PERTAINS TO ANALYSIS CAPABILITIES, BUT TO HOW LARSA SUPPORTS ITS CLIENTS WITH UNIQUE AND INNOVATIVE SYSTEMS."

It takes a community to connect a bridge, and a knowledgeable support staff to support its engineers

Engineers feel comfortable working with LARSA 4D because LARSA's developers and support personnel work closely with their clients to develop the tools clients need to make their work more efficient and effective. LARSA's Annual Maintenance Program supports its clients with unique features, which represents our commitment to ensure our clients maximize their use of LARSA 4D Software. These tools complement the other ways LARSA's Support Team regularly provides assistance to its clients, such as with desktop sharing, writing custom macros, and on-site training.



Innovations in Digital Support

Better, stronger, faster. Let us not forget that there is more to innovation in engineering software than the speed of a solver and the numerical accuracy of its elements. Innovation applies to a company's support services. With recent releases of LARSA 4D, LARSA, Inc. has shortened the distance between the LARSA 4D user and the LARSA 4D Support Team to provide rapid response to our clients.

Unlimited Client Training

LARSA, Inc. is authorized to issue Professional Development Hours to licensed Professional Engineers. Client training is conducted by an experienced member of the LARSA 4D team. We offer web-based training on as "as needed" basis, along with complimentary "on-site" training for clients that possess 10 or more seats of LARSA 4D.

Home-based Licensing

All LARSA 4D clients are granted special licenses to all of their engineers for the duration of the maintenance period so that engineers may install and use the same full version of the LARSA 4D license package (the same license package as is issued to the client) on their home computers, for "after-hours" and educational use.

Features On Demand

Similar to an app on your smartphone, Features on Demand allows LARSA's support engineers to provide new features directly to waiting clients without having to go through the normal software release cycle and without having to uninstall and reinstall to an updated version of the program. Once a feature is completed, it's placed on LARSA's website where the client can download it at their convenience.

Customization

When faced with a repetitive task, let your computer do the work for you. LARSA 4D macros, through the program's extensive API and object model, can automate any program process to save time, including data import/export, modeling, and results analysis While some experience is generally needed to write macros from scratch, our technical support staff gladly writes macros to help our clients.

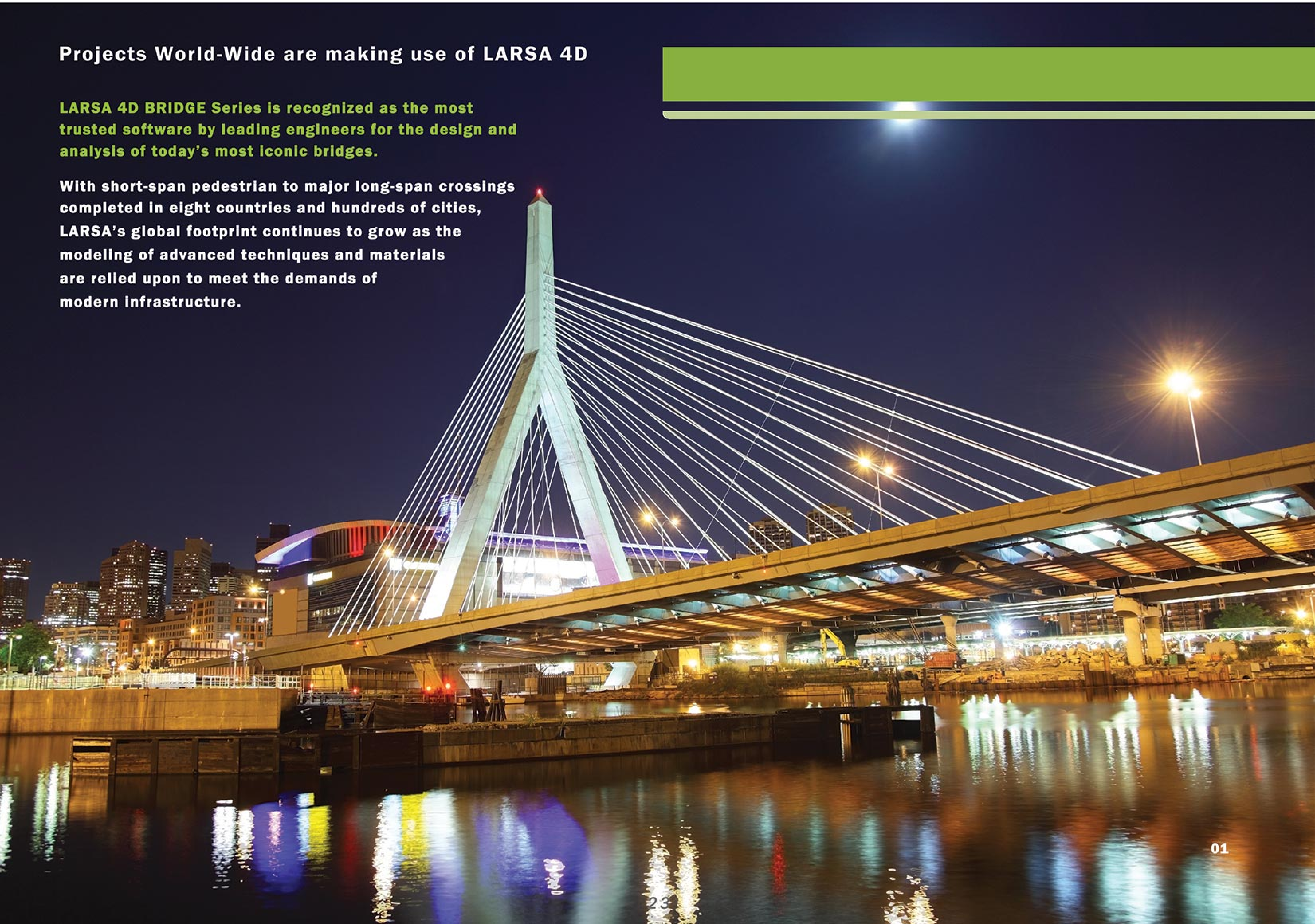
LARSA LIVE

LARSA Live is a new deployment technology that allows clients to utilize custom features or new versions of the software without needing to uninstall LARSA 4D or make any changes to their computer system. This is particularly useful when an ongoing project requires staying at a particular version number, but the capabilities in the newer version would be beneficial for a current or upcoming project.

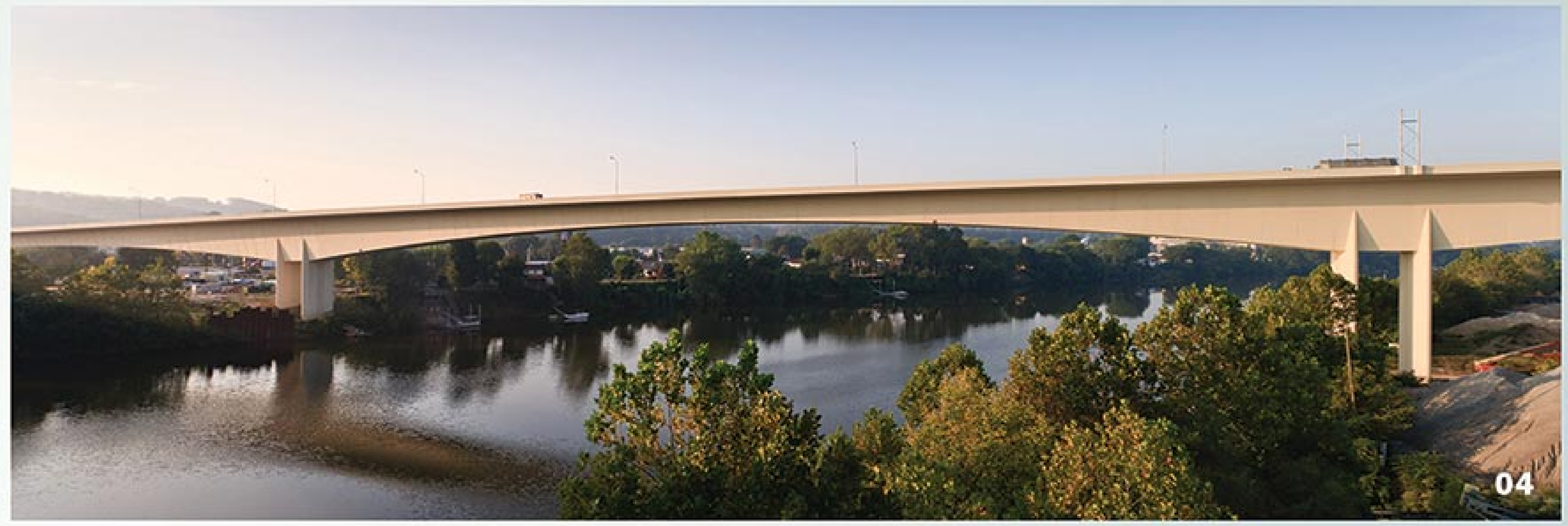
Projects World-Wide are making use of LARSA 4D

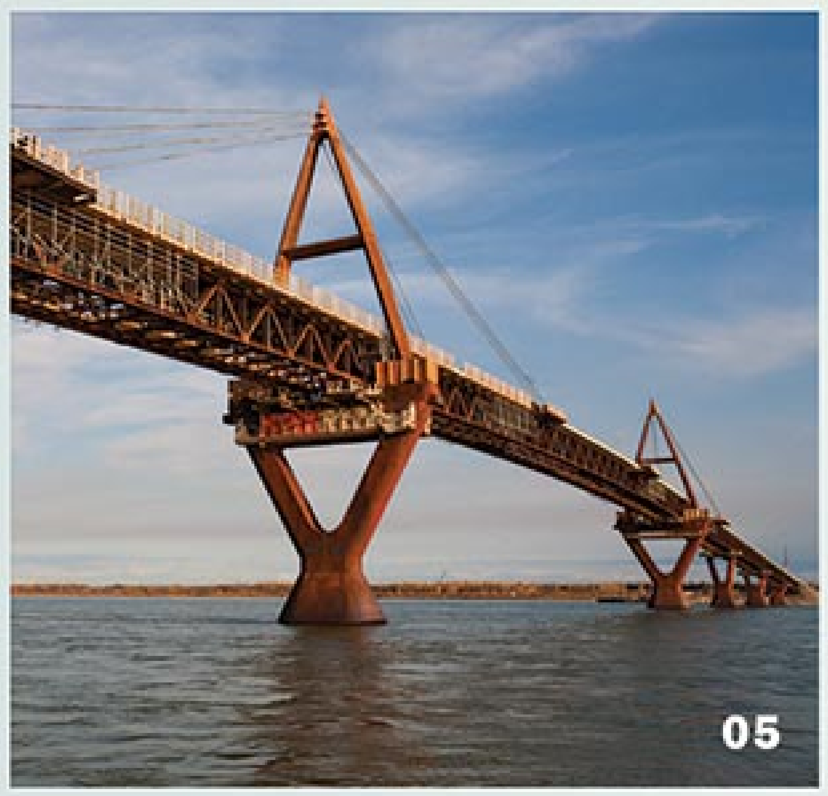
LARSA 4D BRIDGE Series is recognized as the most trusted software by leading engineers for the design and analysis of today's most iconic bridges.

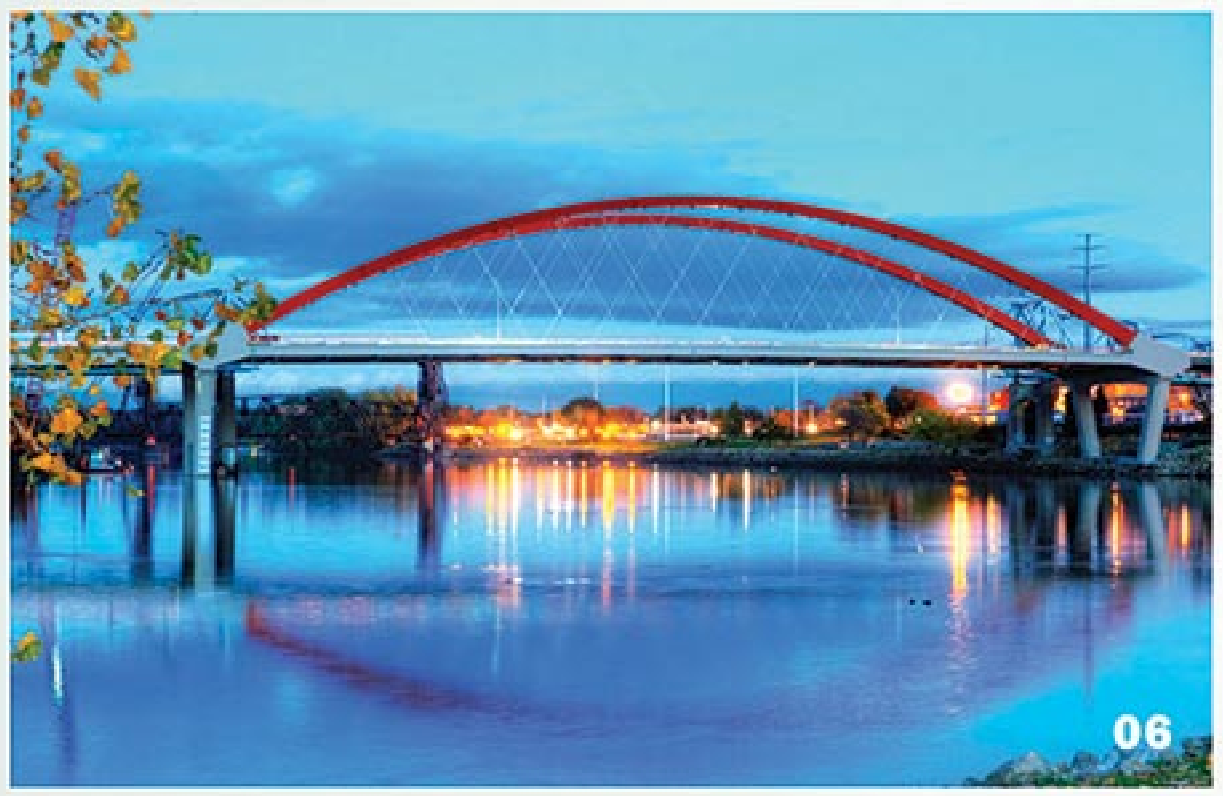
With short-span pedestrian to major long-span crossings completed in eight countries and hundreds of cities, LARSA's global footprint continues to grow as the modeling of advanced techniques and materials are relied upon to meet the demands of modern infrastructure.



LARSA 4D Portfolio







LARSA 4D continues to lead the field of bridge engineering software with robust staged construction integrated with nonlinear analysis, influence-based live loading, seismic analysis and other complex design needs. FIGG Engineering, HDR, and many other corporate clients have shaped the development of LARSA 4D BRIDGE SERIES. That may be why LARSA 4D BRIDGE SERIES is the company standard at FIGG, HDR, SYSTRA International Bridge Technologies, WSP | Parsons Brinckerhoff, Parsons Transportation Group, T.Y. Lin International, and many other leading firms around the world.

LARSA 4D BRIDGE SERIES PACKAGES

LARSA 4D BRIDGE SERIES is available in three packages to accommodate all of your bridge engineering needs and internal software budgets. Whether you're tasked with a short-span girder bridge or the next record-setting long-span crossing, LARSA 4D is there for you with the power of our expertise, the power of our portfolio, and the power of our team.

4D BRIDGE pLT

4D BRIDGE pLT is designed for engineers working with curved and skewed steel girder bridges. Featuring LARSA 4D's Steel Bridge Module, Staged Construction Analysis, influence surface based live load analysis and more, 4D BRIDGE pLT delivers high-end features without the high-end price tag commonly associated with advanced finite element analysis software.

4D BRIDGE

LARSA 4D BRIDGE is suited for advanced analysis of bridges including cable-supported bridges. This package includes all features in 4D BRIDGE pLT plus LARSA 4D's nonlinear element library and analysis options for pushover/buckling and nonlinear time history. The element library includes yield-surface and moment curvature based beams and inelastic springs.

4D BRIDGE PLUS

LARSA 4D BRIDGE PLUS is the premier tool for the analysis and design of segmental, cable-supported, skewed, and all other advanced bridge types. This package includes everything in LARSA 4D BRIDGE, plus pre- and post-tensioning for tendons, material time effects such as creep, shrinkage, and relaxation, and LARSA 4D's new Concrete Bridge Module.

LARSA 4D LICENSING

All LARSA 4D licenses are issued using LARSA's Cloud-based Enterprise Licensing System, which allows users to utilize our applications with minimal licensing set-up and maintenance. With cloud-based technologies eliminating traditional "local-area" and "wide-area" network definitions, each LARSA 4D license can be installed at an unlimited number of workstations at multiple office/site locations to support company-wide access.

LARSA 4D BRIDGE SERIES: SPECIFICATIONS

	4D BRIDGE pLT	4D BRIDGE	4D BRIDGE PLUS
INTEGRATED LARSA 4D MODULES			
LARSA 4D Section Composer	✓	✓	✓
LARSA 4D Steel Bridge Module	✓	✓	✓
BRIDGE FEATURES			
Bridge Path Coordinate Systems	✓	✓	✓
Influence Line Based Live Load	✓	✓	✓
Influence Surface Based Live Load	✓	✓	✓
ANALYSIS TYPES			
Linear Static	✓	✓	✓
Nonlinear Static	✓	✓	✓
Eigenvalue & Response Spectra	✓	✓	✓
Linear Time History	✓	✓	✓
Nonlinear Pushover/Buckling		✓	✓
Nonlinear Time History		✓	✓
Rolling Stock		✓	✓
Vehicle Track Structure Interaction			✓
STAGED CONSTRUCTION & ACTIVITIES			
Element Construction	✓	✓	✓
Element Deconstruction		✓	✓
Support, Constraint, Apply/Remove Loads	✓	✓	✓
Analysis Scenarios	✓	✓	✓
Material Time Effects			✓
Tendon Stress/Slacken			✓
Hoist for Incremental Launching			✓
Balanced Cantilever, Cast-in-Place, Precast			✓
Composite Layered Construction			✓
LARSA 4D LINEAR & NONLINEAR ELEMENTS			
Linear Elastic Element Library	✓	✓	✓
Cable & Super Cable		✓	✓
Compression/Tension-Only Truss		✓	✓
Nonlinear Elastic Spring		✓	✓
Hysteretic Inelastic Spring		✓	✓
Moment Curvature Beam		✓	✓
Nonlinear Hysteretic Beam		✓	✓
Hysteretic Inelastic Connection Beam		✓	✓
Friction Bearing: Pendulum & Sliding		✓	✓
Viscous Dashpot		✓	✓

Need more Information about LARSA 4D?

Visit us online at: www.LARSA4D.com

or contact us at: 1-800-LARSA-01 info@larsa4d.com

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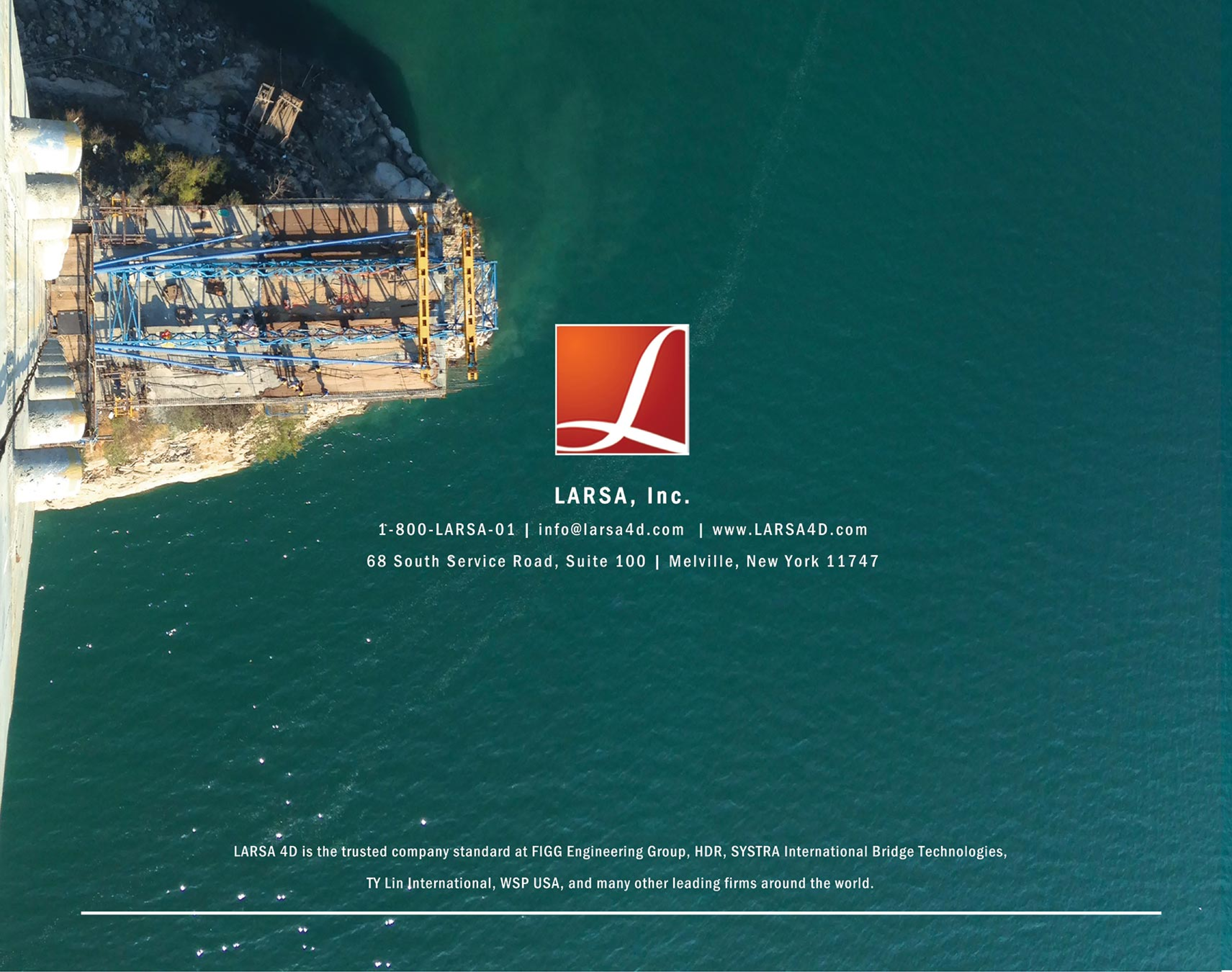

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