

LET **LARSA4D** TAKE YOUR
PROJECTS INTO THE NEXT DIMENSION

version 7.01

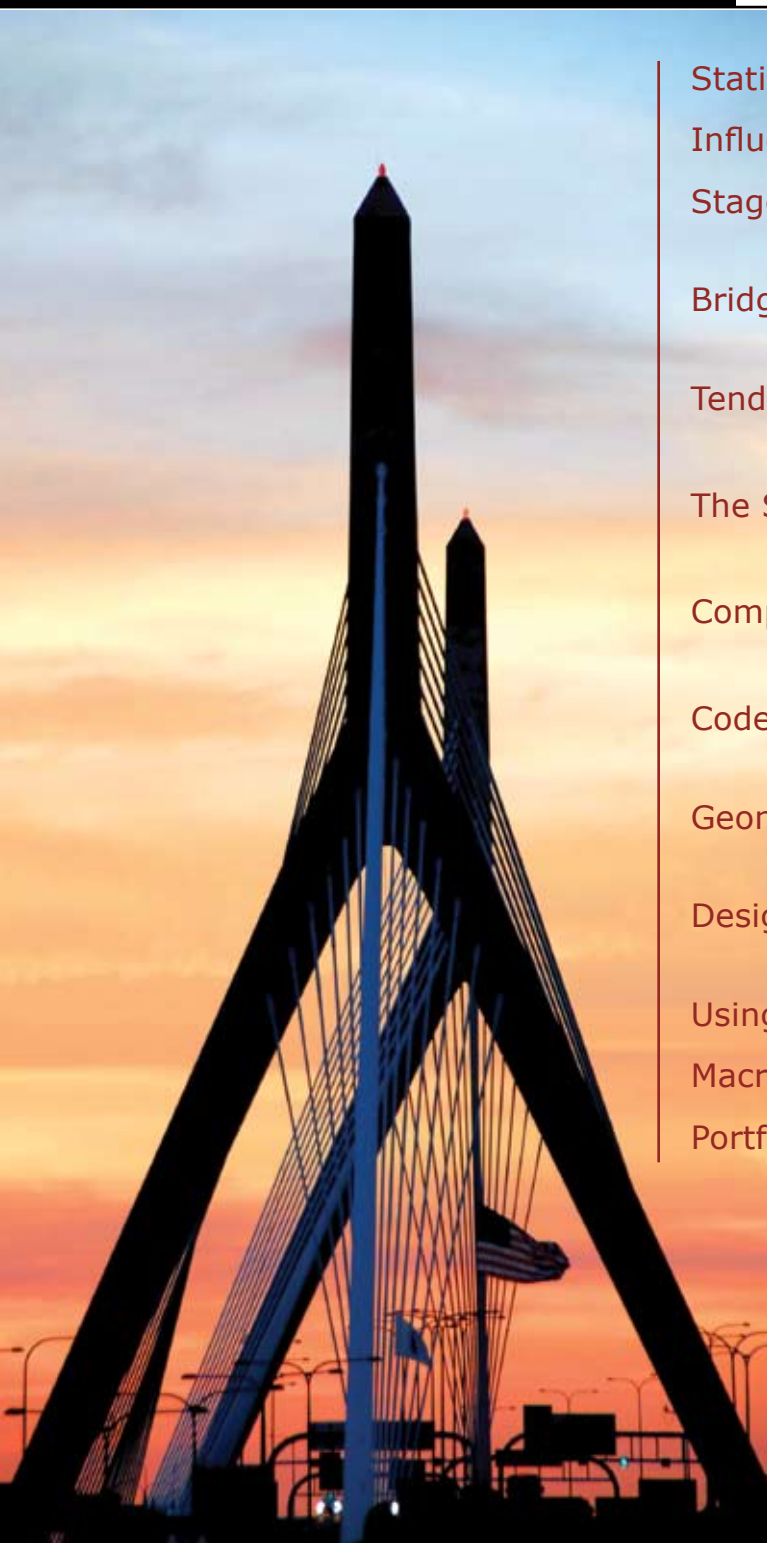


LARSA4D

• BRIDGES • ANALYSIS • DESIGN • CONSTRUCTION •



the complete software for bridge engineering



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Cover: Veterans' Glass
City Skyway over the
Maumee River;
Toledo, Ohio; Figg
Engineering Group



Why the 4th Dimension?

LARSA 4D is based on a rock-solid 3D analysis engine with new and unique features including staged construction analysis, progressive collapse, and influence line and surface live load analysis. All of these features are integrated into a single application, making LARSA 4D a perfect fit for your bridge and building projects.

Time is the focus of LARSA 4D because complex structures and segmental bridges are built in discrete stages. LARSA 4D features a Construction Stages Explorer which organizes the changes to the structure over time. In one analysis, the state of the structure after each construction activity is computed, and live load and earthquake scenarios can be run at multiple points during construction. Bridge projects need tools such as LARSA 4D that can model tendons with long-term losses and parametric nonprismatic sections.

LARSA 4D's user interface is easy to learn and quick to use. Its spreadsheets and graphics are better and faster than ever before. LARSA 4D also has infinite-level undo/redo,

macro integration with Microsoft Excel, and integrity checks, making it easy for users to correct those inevitable mistakes. Modeling tools include meshing, extrusion, parametric templates, and CAD-like drawing tools.

Projects world-wide are making use of LARSA 4D. LARSA software is the company standard at FIGG, HDR, International Bridge Technologies, Parsons Brinckerhoff, Parsons Transportation Group, TYLIN International, and is a standard in many offices of leading firms including Halcrow and TGP in the UK, SYSTRA in France, and Yüksel Proje in Turkey. Throughout the United States, bridge projects are making use of LARSA 4D's influence-based support for the AASHTO LRFD code and building projects are making use of progressive collapse analysis and hysteretic springs.

The LARSA team is continually developing and improving our software, staying one step ahead of our users' engineering needs. When you're ready to make the jump to the fifth dimension, we'll be waiting on the other side.

About the Company

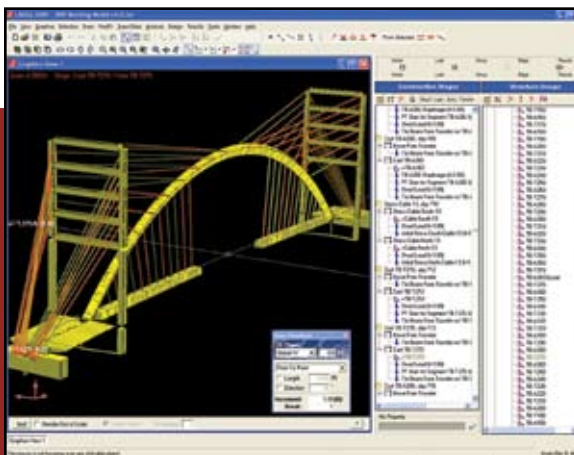
LARSA was originally developed 25 years ago to perform nonlinear static analyses on structures with large displacements, such as suspension and cable-stayed bridges and guyed towers. Using tangent stiffness and the full Newton-Raphson method with iterations, LARSA produced results with unprecedented accuracy.

LARSA has come a long way since it was first available decades ago, but the focus has stayed the same: pushing the envelope of structural analysis. In 1986, LARSA expanded its engine to include seismic analysis and design, and at the same time its first graphical user interface was released for DOS. LARSA continued to lead the industry in the 1990s as

the first to release a Microsoft Windows user interface, in 1994, and later the first to offer plastic pushover analysis and a leader in the use of sparse solver technology.

The next millennium is here, and LARSA is still leading the industry. LARSA 4D is the culmination of all of the experience we have gained in the last two decades. See how LARSA can take you to the next dimension with advanced features including staged construction analysis.

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



LARSA 4D's analysis types range from basic static and dynamic models to more advanced methods including stressed eigenvalue, nonlinear time history, pushover and collapse.

Linear Elastic Static & P-Delta Analyses

The linear elastic static analysis is a first order analysis that excludes nonlinearity. This analysis can compute the response of the structure to static loads. P-Delta analysis is a very basic form of a nonlinear static analysis based on Newton-Raphson and tangent stiffness.

Nonlinear Static Analysis

Geometric and material nonlinearities can be considered for more accurate design. Geometric nonlinearity includes both the change in geometry and the effects of geometric stiffening such as that encountered when a cable or a thin member is stressed in tension.

Moving Load Analysis

Moving Load Analysis simulates the movement of a vehicle or multiple vehicles passing over a structure on a possibly curved user-defined path through members or plates. Users can define their own vehicles or use one of the many standard patterns provided.

The advanced analysis types found only in LARSA 4D take bridge and building projects to the next dimension.

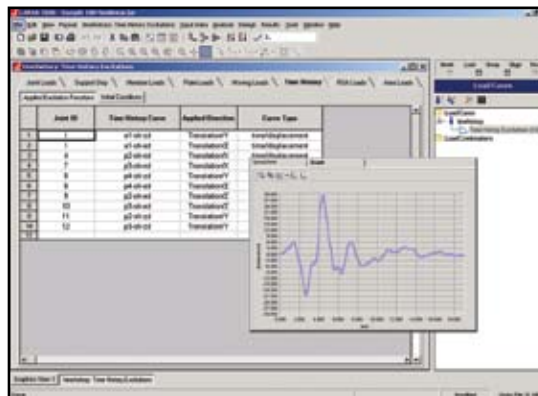
Stressed Eigenvalue Analysis

The stressed eigenvalue analysis is an extension to the basic eigenvalue analysis. The stiffness matrix includes the effects of static loads (stress stiffening) and the deformed geometry of the structure, unlike the basic eigenvalue analysis.

Nonlinear Time History Analysis

The nonlinear time history analysis is an extension to its linear counterpart, computing the response of a structure to time-dependent loads taking into account geometric and material nonlinearity. This analysis is invaluable for cable-stayed and suspension bridge projects, in which nonlinearity plays a vital role.

The analysis is carried out by using a combination of the Newmark-Beta time integration algorithm and either full or modified Newton-Raphson method, using iterations within each integration time-step.



The setup for a nonlinear time history analysis

Linear Time History Analysis

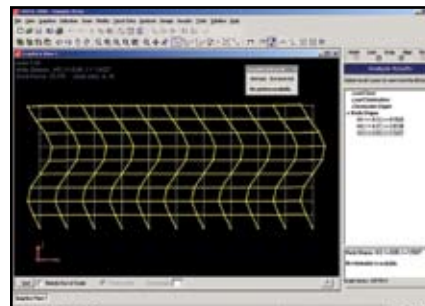
This analysis computes the response of the structure to time-dependent loads which are specified as excitation records in the form of force, displacement, or acceleration and can be applied to one or more joints.

Eigenvalue Analysis

The eigenvalue analysis is performed to extract the natural frequencies and mode shapes of a structure and is important as a predecessor to any dynamic analysis because natural frequencies and modes can help characterize a structure's dynamic response. With new sparse solver technology, eigenvalue analysis is 5-10x faster than before.

Response Spectra Analysis

This analysis can be used to determine the response of a structure to shock loading conditions for seismic analysis. RSA cases can use modal combinations of various methods.



The third mode of a framework reported by eigenvalue analysis

Pushover and Progressive Collapse

Plastic pushover analysis is a simplified form of progressive collapse. Plastic pushover performs a nonlinear inelastic analysis on a load case, continuously loading the structure until a stopping criterion is met. The criterion is a maximum displacement at a particular joint in a particular direction.

The progressive collapse analysis uses arc length and auto-stepping for post-buckling strength, and is made more powerful by LARSA's inelastic element library.

Other Analysis Types

Staged Construction Analysis and Influence-based Analysis are discussed separately in this brochure.

Influence lines & surfaces find the worst-case live load scenarios by positioning vehicles and uniform lane loads to maximize the effect.

With an assumption of linearity, by running a unit load over the deck of a bridge the effects of any set of vehicles, even with variable axle spacing, can be computed without needing to re-run an analysis. This is called influence-based analysis.

Using this method, the engineer need not decide ahead of time which points on the structure he wants influence results for. Once the fast Influence Analysis is run, the most extreme conditions for any point on the structure are computed in real-time as they are needed.

Influence Lines

Influence lines are used when the bridge is modeled as line girders or as a deck surface modeled as plates. Vehicle and lane loads are applied directly to the girder following a linear path. Distribution of load across girders or lanes is accomplished by lane loading factors.

Influence Surfaces

Influence surfaces extend the notion of an influence line onto a 2D surface and are used for plate-deck models. Both standard and new two-dimensional vehicle definitions that model both the length and width of the vehicle can be used. With influence surfaces, the locations of lanes that maximize extreme effects are automatically found.

Influence-based result case

Vehicle Variation

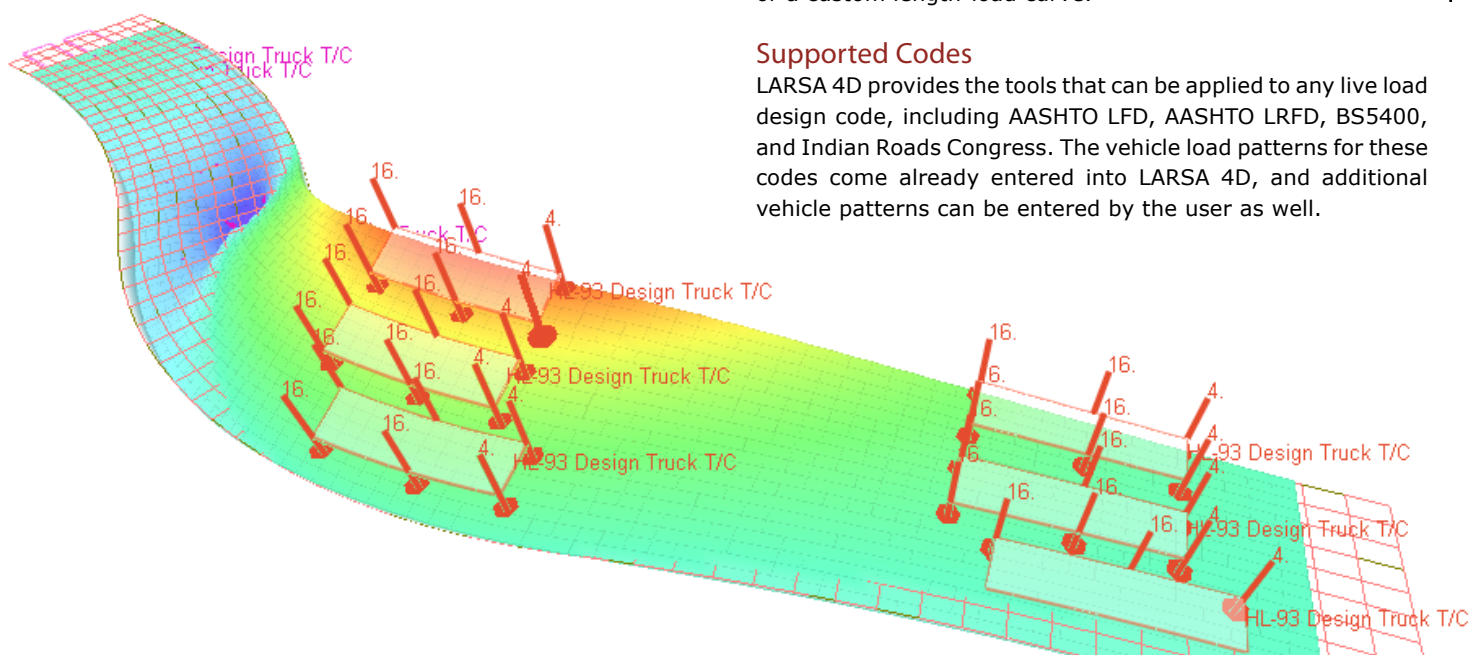
Influence line and surface analysis reports the most extreme effects generated by any permutation of vehicle parameters. LARSA 4D supports varying axle spacing, multiple vehicle applications simultaneously with varying distance between the vehicles, minimum vehicle spacing longitudinally and transversely, and multiple presence factors. With influence surfaces, vehicles can be constrained so that only one or two trucks can be placed on each design lane.

Lane Load Variation

UDL/patch lane loading is applied only where it contributes to the extreme force effects. UDL magnitude can be constant or variable based on the loaded length according to UK BS5400 or a custom length-load curve.

Supported Codes

LARSA 4D provides the tools that can be applied to any live load design code, including AASHTO LFD, AASHTO LRFD, BS5400, and Indian Roads Congress. The vehicle load patterns for these codes come already entered into LARSA 4D, and additional vehicle patterns can be entered by the user as well.



Staged Construction Analysis provides an integrated environment in which to model the changing state of a structure over time, including structural changes, load applications, concrete & composite activities, and time-dependent material effects.

Staged Construction Analysis

Staged Construction Analysis is necessary for any construction project, especially for segmental bridges. Within one project file, all of the analyses needed for each stage of construction can be solved in one run.

Used with segmental concrete bridges, LARSA 4D's staged construction analysis stands out among its peers. The tools available in LARSA 4D simplify the complicated process of designing post-tensioned concrete box girder bridges.

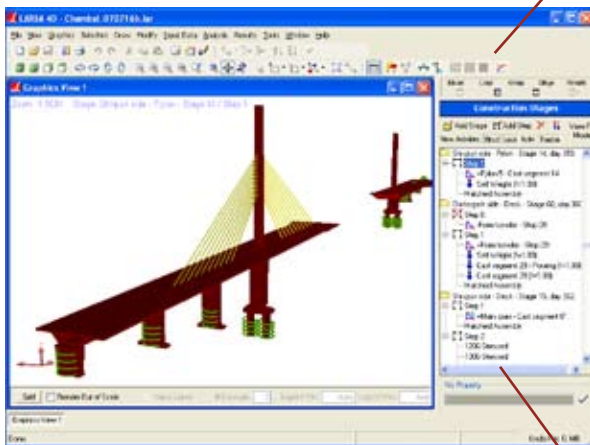
Construction Activities

Automatic construction activities available in LARSA include:

- Construction and deconstruction of members, plates, springs, and foundation elements
- Loading, temporary/traveler loads
- Support and constraint changes
- Displacement initializations
- Hoist for incremental launching
- Hinged cast, matched cast for segmental construction
- Tendon stressing and slackening
- Post-tensioning stay cables

(and coming in 2008)

- Casting concrete elements, including composite parts
- Adding and removing composite parts



The Construction Stages Explorer shows the sequence of activities involved in the construction of the bridge model.

Deconstruction, support removal, and composite shape changes involving the removal of composite parts automatically apply support reactions and element-internal forces back onto the model.

Analysis Options

Staged construction can include the effects of geometric and material nonlinearity, as well as time-dependent material effects, within the same analysis run.

Cumulative & Incremental Results

Each activity can be associated with a load class so that the cumulative effects of individual load classes can be reported separately for code-based load combinations. Extracting the effect of post-tensioning and creep, for instance, is essential for many design codes. The Code Combination Wizard will automatically combine the class-based effects according to predefined or user code combination rules.

Incremental effects are also available, allowing the user to see the changes to the structure since the previous stage.

Construction Activities

- Construct elements
- Apply Loads
- Deconstruct elements
- Segmental Construction Joint Initialization
- Stress Tendons

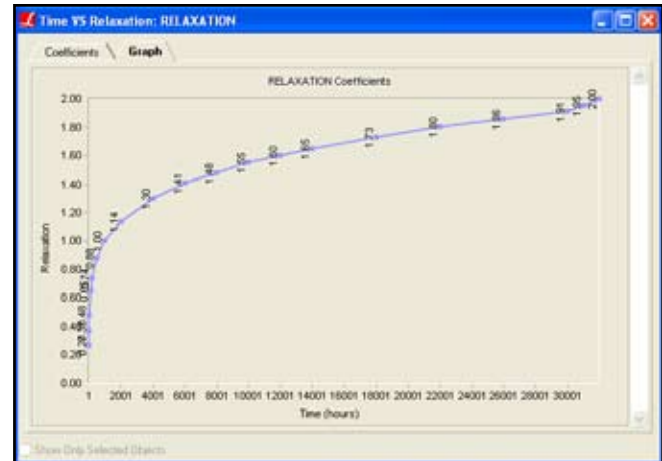
Time-Dependent Material Properties

Not only does the geometry of a structure change over time, but material properties do as well. Time-dependent material properties are an integral part of LARSA's staged construction analysis.

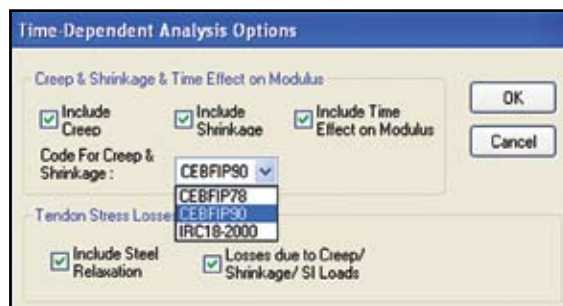
Time-dependent material properties include:

- Concrete creep
- Shrinkage
- Steel relaxation
- Time effect on elastic modulus
- Tendon post-tensioning losses from creep, shrinkage, and superimposed loads
- According to CEB-FIP '78 and '90 codes, and others

Users can also enter custom time dependent curves for particular material properties and codes.



Time vs. relaxation curves entered by the user are applied to tendons in the model



Time-dependent material effects options

Analysis Scenarios

A normal Staged Construction Analysis is a nonlinear static analysis performed after each change to the structure, keeping track of the displacements, forces, and stressess from step to step.

At any stage during construction, additional analyses can be performed. These analyses continue based on the deformed state of the structure at that stage. Possible analysis types include:

- Stressed Eigenvalue
- Nonlinear Time History
- Pushover
- Progressive Collapse
- Moving Load, Influence Analysis

Seismic activities may occur during construction. Stressed eigenvalue analysis can be performed at any stage using the stiffness of the loaded deformed structure, yielding the modes of the structure in its partially constructed state. LARSA 4D's stressed eigenvalue analysis performed after the

final construction stage will be considerably more accurate than a stressed eigenvalue analysis performed without construction stages. Stressed eigenvalue analysis within staged construction will more realistically account for locked-in stresses.

Progressive collapse scenarios can be performed at any stage simulating the loss of a pier or the snapping of a cable. An impact factor can be specified to account for dynamic effects.

Pushover scenarios can be performed at any stage by specifying the load pattern and target displacement. LARSA 4D will incrementally apply the load pattern, utilizing the arc-length method for snap-through and buckling.

Related Product Features

See later in this brochure for more information on the following:

Pre- and post-tensioning tendons can be stressed at any stage during construction. The effects on post-tensioning of long-term material property changes and superimposed loads is included.

Deformed geometry control for segmental bridges includes options for matched cast, hingest cast, and cast in place.

AASHTO LRFD code check performed at any stage of construction, and creating factored combinations of effects at different points in construction.

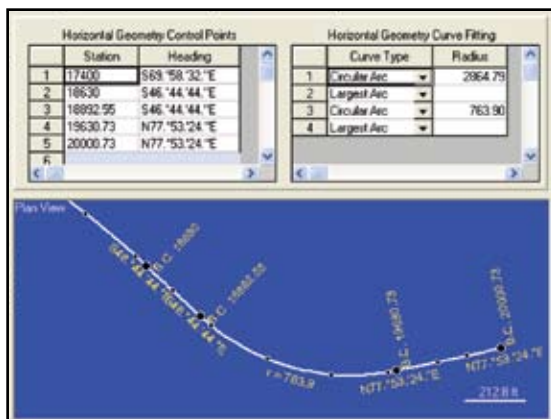
Coming in 2008, **composite section construction** adds activities for casting parts of members at different times.

Advanced tools for modeling segmental, cable, and curved bridges reduce the user's dependence on other one-task software tools. Everything you need is in LARSA 4D.

Bridge Path User Coordinate Systems

The bridge path user coordinate system is a tool of convenience for modeling, allowing the user to work in very simple coordinates despite any curvature of the structure. This is accomplished by warping the usual x-axis into a curve that follows the curved centerline of the bridge.

The warped "station (x) axis" is defined in two planes. Geometry control points at stations along the bridge define the path in the plan view. Circular and spiral curve fitting can be applied between control points to establish the curve of



With bridge path coordinate systems, the horizontal geometry of the bridge is defined with stations and headings. Geometry is entered with station, offset, and elevation coordinates, rather than X, Y, Z.

the path. The elevation or vertical path is defined by a series of elevation control points.

Multiple bridge paths in the same project can be used to define girders, spiral on- and off-ramps, and ground-level footings.

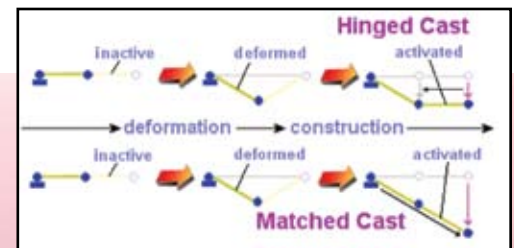
Model Optimization

The new Model Optimization tool determines how to prestress cables when they are installed so that the deformed geometry of the model, such as a cable or deck profile, matches a desired target. The tool uses iterative Newton's method in multiple dimensions with rank-reduction, and with Staged Construction Analysis takes into account the construction sequence, nonlinearity, and long-term time effects.

Segmental Construction Methods

The segmental construction options for Staged Construction Analysis are used for modeling balanced cantilever bridges. The hinged cast, matched cast, and displacement initialization options automatically adjust bridge geometry as new segments are cast to match the displacements of previous segments.

The hinged cast option adjusts the casting location of new segments to match 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.



Tappan Zee Bridge; New York/New Jersey, USA
LARSA is the software standard for the current project to evaluate the bridge at Arup, Lichtenstein and Wagh (USA)

Tendons, used for pre- and post-tensioning, with the Staged Construction Analysis, model short and long term effects.

Tendon Geometry: Location and Curvature

Tendon paths are determined through control points at which a location and curvature type are specified. The path of tendons between control points are automatically computed as straight lines or second/third-order curves, depending on the curvature type. Curvature is defined using angle of inclination from the members that it passes through, or using a radius of curvature.

The positions of control points are given as relative to the members they are in, based on section extents or from the member reference line, which can be strategically chosen as separate from the centroid to make positioning tendons easier, especially in nonprismatic sections.

Tendons are presented in both 2D views from all planes and a 3D view that is updated in real time so that tendon geometry can be visually verified. Members are displayed with their actual shapes and dimensions.

Short-Term Losses

Short-term stress losses due to wobble and curvature friction and anchorage slip are immediately calculated while entering tendon geometry.

Long-Term Losses

Long-term stress losses include relaxation, elastic shortening, and losses due to creep, shrinkage, and superimposed loads. Custom relaxation curves can be entered by the user. Long-term losses are computed during the Staged Construction Analysis and results are marked with load classes to support code-based load combinations.



Forces in the tendon reported before anchor set, after anchor set, and after long-term effects including relaxation

Geometry Definition Checks

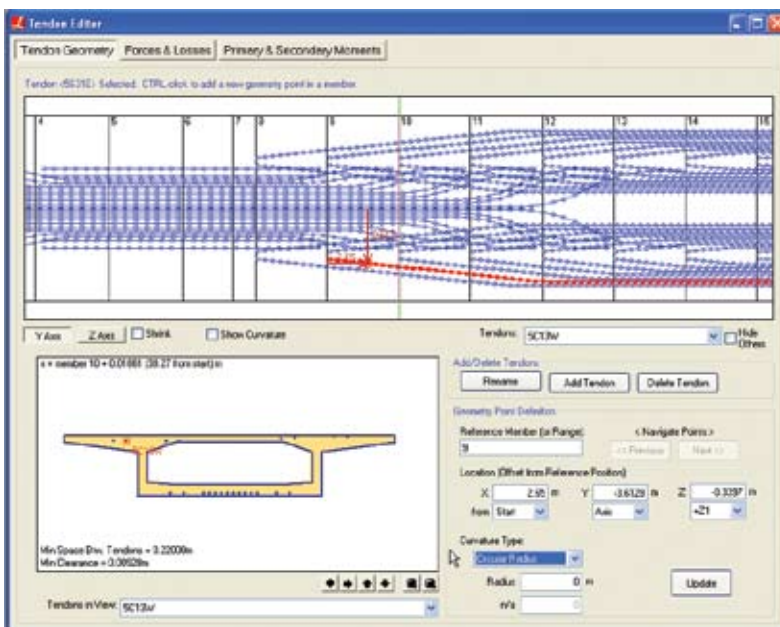
As the user is defining the geometry, LARSA 4D reports immediately:

- Cover
- Space between tendons
- Anchor set and friction losses
- Elongation due to jacking

With Staged Construction Analysis

Tendon stressing is applied during the construction of a structure with the use of Staged Construction Analysis (see earlier in this brochure). Tendon force reports and graphs are available at any stage and these are used to track the effect of tendons. Primary and secondary moments, and forces throughout the containing members, are available for each step in construction.

With time-dependent material effects in Staged Construction Analysis, relaxation and other material changes are accounted for.

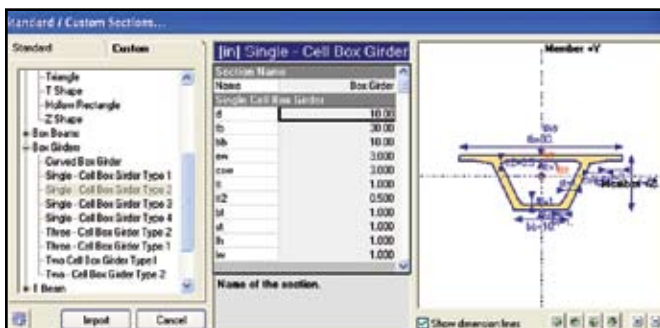


Tendons viewed on two 2D planes

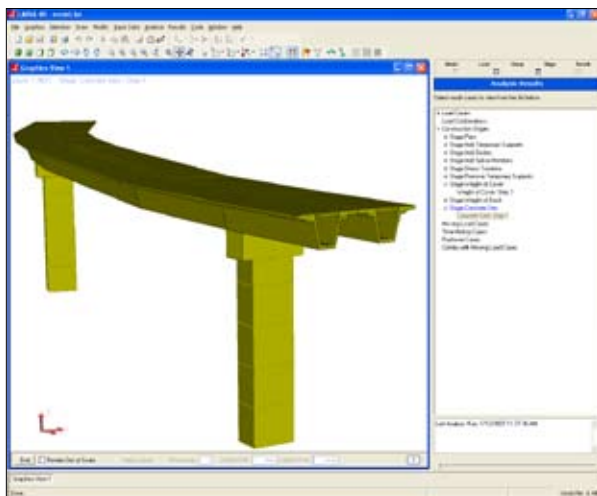
The Section Composer is an advanced tool for modeling cross-sectional properties using parametric section definitions. Parametric sections improve efficiency by allowing reuse and resizing without computing coordinates.

The LARSA Section Composer is a graphical companion tool for modeling arbitrary sections for use in LARSA 4D. The Section Composer supports nonprismatic and composite sections based on standard, parametric, and custom shapes, and it is able to compute section properties in real time.

The Section Composer is fully integrated with LARSA 4D. Sections created in the Section Composer are used directly in LARSA 4D like any other section. When graphical rendering is turned on, the true shape of member sections are shown in the LARSA 4D graphics window.



When importing a parametric section, the user enters the values of parameters such as b, d, tf, etc. Dimension lines on the preview image indicate the meaning of the parameters.



LARSA 4D using a section defined in the Section Composer

Parametric Section Library

LARSA 4D and the Section Composer feature a parametric section library comprised of the most common cross-sectional definitions. Both basic shapes, like I, C, and angles, and complex shapes including many types of box girders can be added to a project simply by specifying the values of dimensions like width, depth, and thickness.

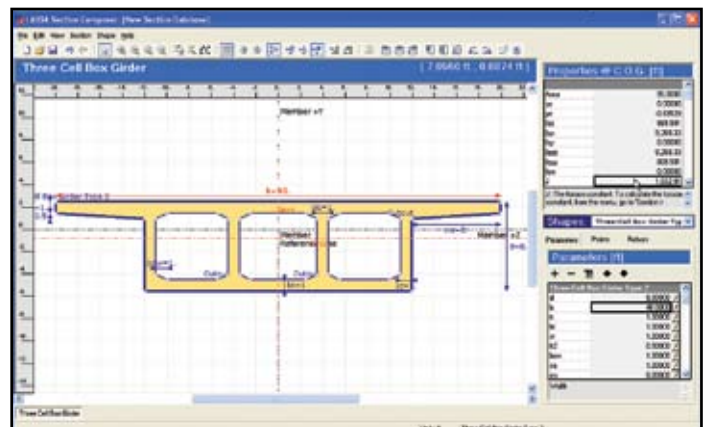
Automatic Computation of Properties

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

Parametric Definitions

Sections in the Section Composer are defined parametrically, meaning points are normally entered as equations of a few parameters, such width (b), depth (d), and thickness (t). The benefit of a parametric definition is twofold. First, sections defined this way can be reused and resized as needed without recomputing the coordinates of control points. By simply changing a parameter, coordinates are immediately updated. Secondly, parametric definitions make it simple to add nonprismatic variation (see the next page).

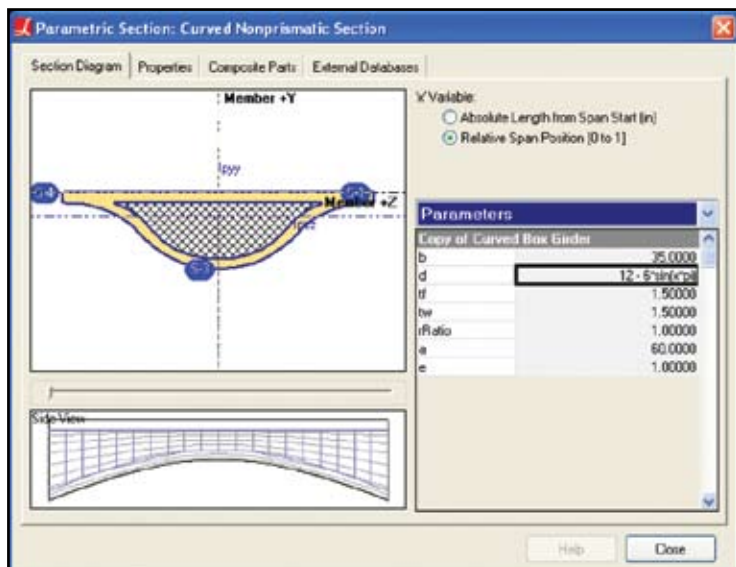
There is no limit to the number of parameters that a user may enter for a section, and equations defining coordinate points can be as simple or as complex as needed for the project.



The Section Composer

Nonprismatic Variation

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



A curved box girder with nonprismatic variation in depth

Formulas give the value of a parameter as a function of the position along the length of a span. Linear, parabolic, sinusoidal, and other types of functions can be attached to parameters, like depth, to control nonprismatic variation.

Using Equations in Section Definitions

Shapes from the template library or created parametrically by the user use mathematical equations to locate each point on its perimeter. 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.

Section Drawing Tools

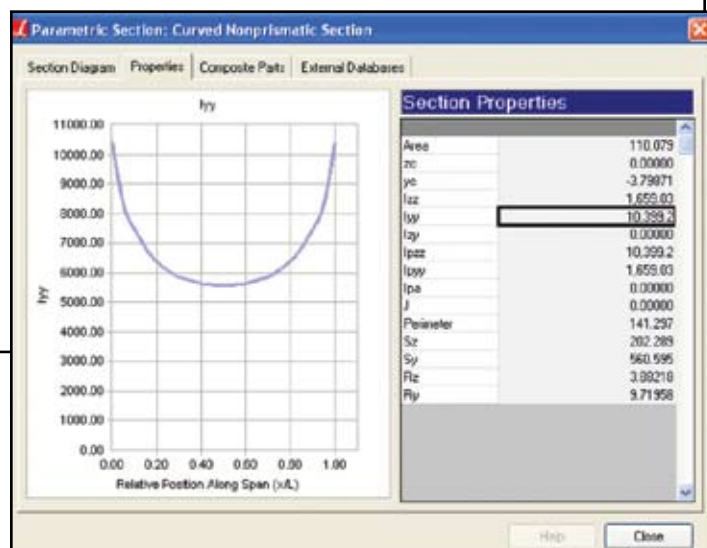
Creating cross-section definitions is aided by graphical tools including align, snap, rotate, and flip. When creating a built-up section or combining basic shapes such as rectangles and I-shapes to define a more complex shape, the align tools are used to line up shapes on their centers or edges.

The Member Reference Axis

LARSA 4D uses a member reference axis to align parametric sections to the members to which they are assigned. When a girder's centroid is moving, this allows the user to model the geometry at the top of the girder, which is unchanging, rather than having to compute the centroid location at each station along the bridge.

The member reference axis is positioned in the Section Composer relative to the section and is aligned in LARSA 4D with the joint-to-joint line of members. By placing the reference axis at the top of a box girder cross-section with nonprismatic variation, the user can keep the tops of members more easily aligned by just drawing a straight line of members in LARSA 4D. The members' centroids will automatically be offsetted internally to match the offsets of the centroids from the reference axis.

Tendon geometry definitions follow the reference axis as well, rather than the member centroids, so that the user can specify their positions relative to a fixed edge.



A graph shows the change in moment of inertia along the length of the member due to nonprismatic variation

The snap tool makes any two edges flush. This is often useful to connect the top of a concrete I or box shape to the bottom of a concrete or steel plate or a deck.

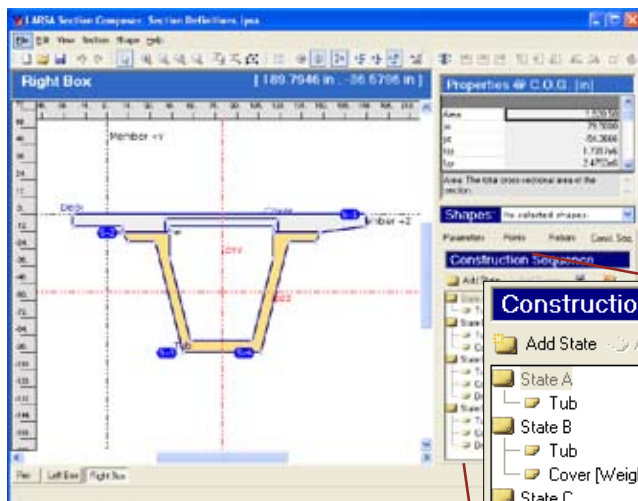
Rotate and flip is useful when developing a library of sections for a project involving a left and right box that are mirror images of each other.

Coming in 2008: Model built-up members with composite parts of a single cross-section definition. Composite sections are easier to model than creating independent elements for each section part, and are more accurate by maintaining continuity.

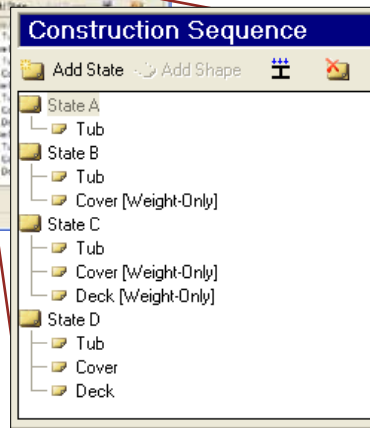
What is composite section construction?

When the components of a single cross-section are assembled at different times, with each part behaving independently with respect to time-dependent material properties, composite section construction must be used to maintain the continuity of behavior of a single cross-section. A composite member is a single continuous line element made up of shapes of different materials or shapes constructed (cast) at different times.

Using the LARSA Section Composer, built-up sections can be readily modeled. These sections may or may not be composed of multiple materials. The Section Composer will compute all of the cross-section properties immediately.



Composite sections are defined in the Section Composer. "States" determine which shapes are active during any given stage.



Composite section "states" determine which shapes are active at any given time. A shape 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 automatic self-weight computation. Weight-only is an alternative to using time-dependent material properties and setting the casting day.

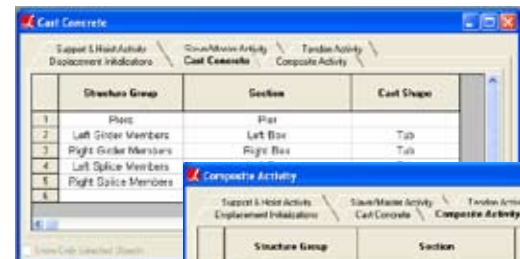
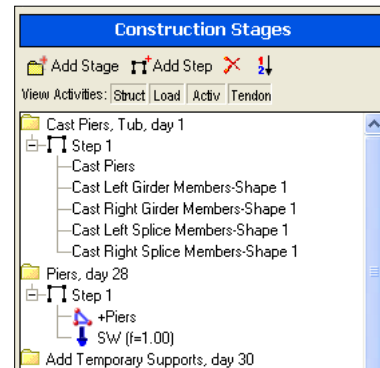
Composite Construction Activities

Composite section construction is an addition to the Staged Construction Analysis. Two new activity types become available:

Cast Concrete: In a time-dependent staged construction analysis, this activity sets the casting day for groups of concrete composite parts in the model. Different casting days can be set for parts of the same cross-section, and the differential

effects of concrete creep and shrinkage within each member element are computed.

Composite Activity: This activity changes the cross-section make-up of a group of member elements in the model by adding (casting) or removing composite parts to members. When composite parts are removed, the internal



forces in the removed part are applied automatically onto the remaining structure.

Composite parts of a cross-section behave independently in the calculation of the time-effect on elastic modulus, which, as with the addition or removal of cross-section parts, can change the location of a member's centroid over time. Cross-sectional properties are automatically updated at each stage.

Load Classes & Load Combination Wizard

Classification of loads is essential for code-based load combinations. Load cases are assigned classes, such as dead or live, so that the Automated Load Combination Wizard can create combinations automatically based on a chosen design code.

The load combination wizard supports AASHTO LFD, AASHTO service load, AASHTO LRFD, AISC LRFD, CISC, IRC, and user-defined combinations.

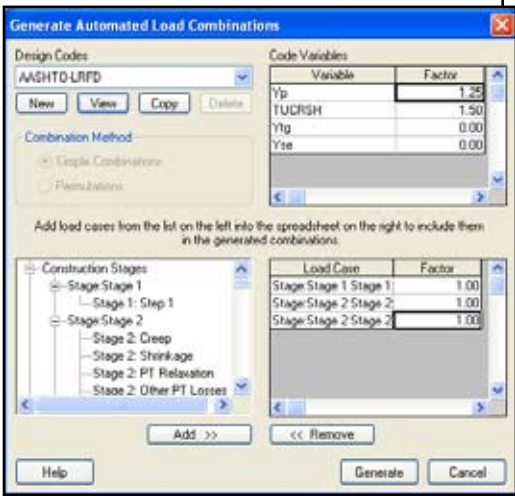
LARSA 4D automatically assigns load classes to time-dependent analysis results, such as creep, shrinkage, and prestressing effects.

Linear Result Combinations

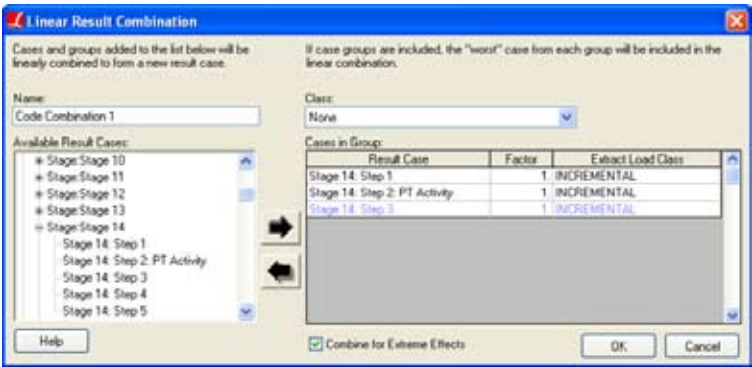
Linear results combinations can be used to create a factored load combination after an analysis has been completed by adding together the results of solved load cases as they are requested. Linear result combinations become regular result cases with which all of the usual results tools can be used, including graphics, spreadsheets, and graphs. When linear results combinations are used with influence based load positioning, the maximum and minimum extreme values for any combination of load cases with vehicle and lane loads can be obtained without any need for large disk storage or extra analysis time.

Extreme Effect Groups

Extreme effect groups allow the user to set up result cases that represent the “worst case” out of a group of cases. They are like saved envelopes. These groups always report the minimum and maximum values from a group of cases, enveloping over a particular result. Extreme effect groups are calculated on-the-fly and do not require a reanalysis. Like Linear Result Combinations, these groups act like regular result cases.



Automatic generation of code-based load combinations



Linear Result Combinations



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

Linear and Nonlinear Elements

- Beam and Truss
- Cable, tension-only with rebirth
- Tension-Only, Compression-Only Truss
- Grounded Spring (translational/rotational)
- 2-Node Spring (translational/rotational)
- Coupled 6x6 Foundation Stiffness
- Compression-Only Foundation Spring
- Hook and Gap Element
- Plate, Shell, and Membrane Elements
- Lumped Mass

Other Features

- User Coordinate Systems can be rectangular, cylindrical, spherical, or special "bridge paths" (described earlier in this brochure)
- Displacement coordinate systems for joints using user coordinate systems
- Supports, springs, and loads specified in global or user coordinate systems
- Member rigid end zones, semi-rigid connections, and end-offsets
- Slaved degrees of freedom
- Nonprismatic tapered sections
- Member reference axis and centroid offsets allow the centroids of nonprismatic sections to vary against a fixed reference line set by the user

Load Types

- Joint loads and joint displacements
- Automatic self-weight for members and plates
- Beam loads: point, trapezoidal, uniform, partial, and distributed, in local, global, and projected directions
- Thermal loading for beams: uniform, linear gradient, and coming in 2008 nonlinear gradients
- Uniform thermal loading for plates
- Floor and area loads
- Prestressing for cable, truss, and beam
- Post-tensioning cable elements with option to lock the cable tension
- Shell, plate, and membrane loads in global, local, or projected directions
- Post-tensioning with tendons

SEISMIC LIBRARY

Seismic Element Library

The isolator and bearing elements are used to model isolation devices, energy dissipation devices and bearings, and they exhibit nonlinear force-deformation relationship with hysteretic behavior. The following types of isolator and bearing elements are included in LARSA 4D. These elements can be used in any nonlinear analysis.

Elastomeric Bearings, Steel Dambers

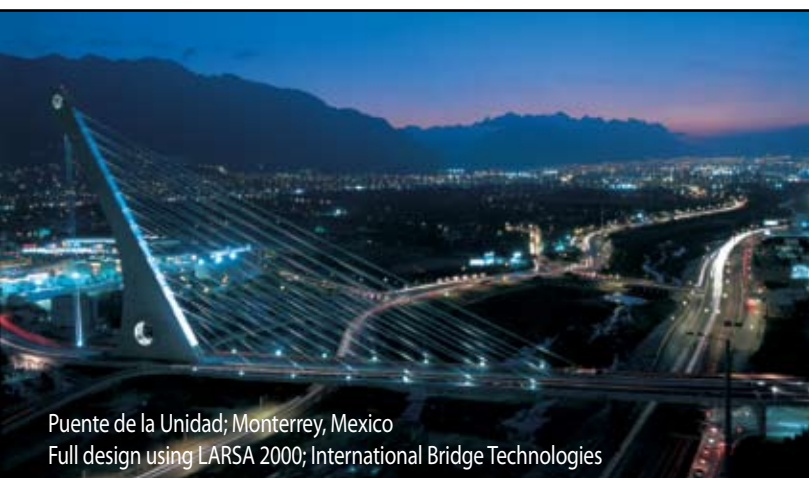
This element models the behavior of low damping rubber bearings, high damping rubber dampings in the range of strain prior to stiffening, and lead-rubber bearings.

Viscous Fluid Dampers

Suitable for modeling the behavior of fluid viscous dampers or other devices displaying viscous behavior. Time history analysis only.

Other Elements

- Lead-core Elastomeric
- Elastomeric with Stiffening
- Sliding Friction Bearings
- Friction Pendulum



Puente de la Unidad; Monterrey, Mexico
Full design using LARSA 2000; International Bridge Technologies

Uniaxial Hysteretic Spring

This element works in translation and rotation or as axial or torsional springs. The hysteretic spring uses a polygonal hysteretic model (PHM), the same material model used in the computer program IDARC2D and in the FEMA program NONLIN. The material model has strength and stiffness degradation capabilities.

Connection Beam Element

This element consists of an elastic beam with built-in yielding springs at the ends. This is uncoupled plasticity with concentrated yielding model. There can be up to four such end-springs – two springs at each end, one for each direction of bending. The properties of these springs can be assigned so as to model the elastic-plastic behavior of the beam itself and/or to model the flexibility and inelastic behavior of the end connections.

Hysteretic Beam Element

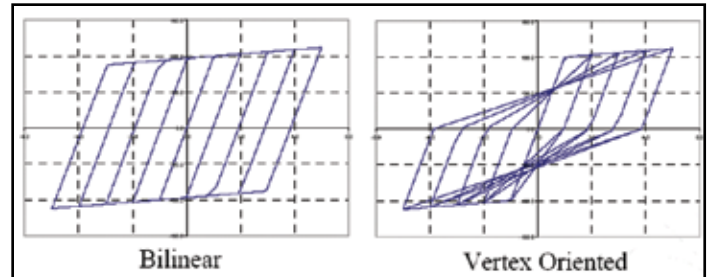
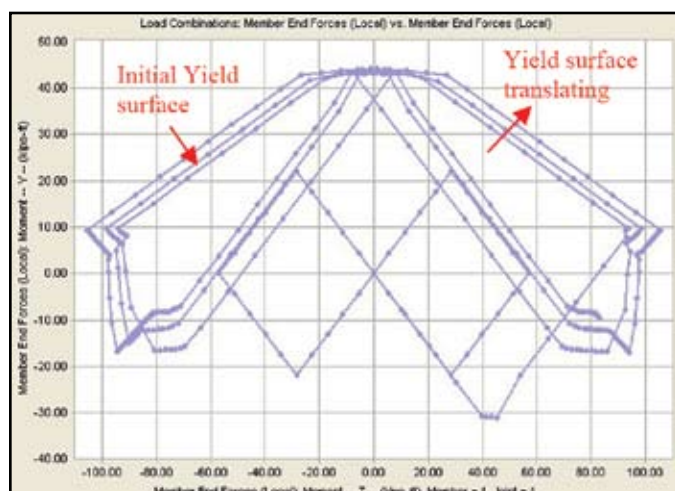
This element models the continuous spread of plasticity along the length of a member and represents the interaction between axial force and strong and weak-axes bending moments using the smooth yield surface equation at a specified number of Gauss points along the length of the member.

Triaxial Hysteretic Spring

This 2D and 3D force interaction spring element is used to couple the local axial force and bending moments by means of a yield surface or an interaction force diagram.

Yield Surface-Based Beam Element

In contrast to the hysteretic beam element the yield surface-based beam element accounts for interaction at the Gauss integration points using the piecewise planar yield surface.



Our Collaborative Effort with MCEER Earthquake Research Group at the University at Buffalo

The nonlinear analysis of structures has become increasingly important in the study of structural response to hazardous loading such as earthquake and blast.

The latest tools available for this type of analysis are often impractical for professional use, generally university research projects that lack convenient user interfaces or overload the user with questions only important to researchers.

LARSA, Inc. is working with the earthquake research group MCEER at the University at Buffalo to bring the latest nonlinear earthquake analysis technologies into mainstream use by integrating their research into the already user-friendly analysis environment that LARSA provides.

With the inelastic analysis tools developed through this collaboration, LARSA 4D takes away the overhead of entering fine-grained details for these advanced analysis options, providing engineers new realistic capabilities for seismic and collapse applications.

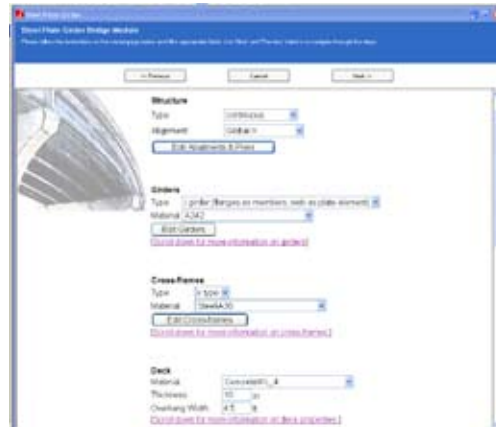
LARSA's inelastic and seismic element library is based on the works of professors M.C. Constantinou, A.M. Reinhorn and P.C. Tsopelas at the National Center for Earthquake Engineering Research and the University at Buffalo, and M. Sivaselvan, formerly at NCEER at Buffalo now at the University of Colorado at Boulder.

The code check and design tools below are based on LARSA's "4D" analysis engine. That means that the effects of curvature, transverse bracing, and time-effects on materials are all accurately considered during the code check and design process.

AASHTO LRFD Bridge Design 2006

Checks are available for:

- Cross-Section Proportion Limits
- Constructability
- Service Limit State
- Strength Limit Check
- Stiffeners (Longitudinal, Transverse, Bearing)
- Tension, Compression Members
- I, Box Section Flexural Members
- Rolled I sections
- Plate girders
- Symmetrical, unsymmetrical



The AASHTO LRFD 2006 tool asks for code parameters in a step-by-step wizard.

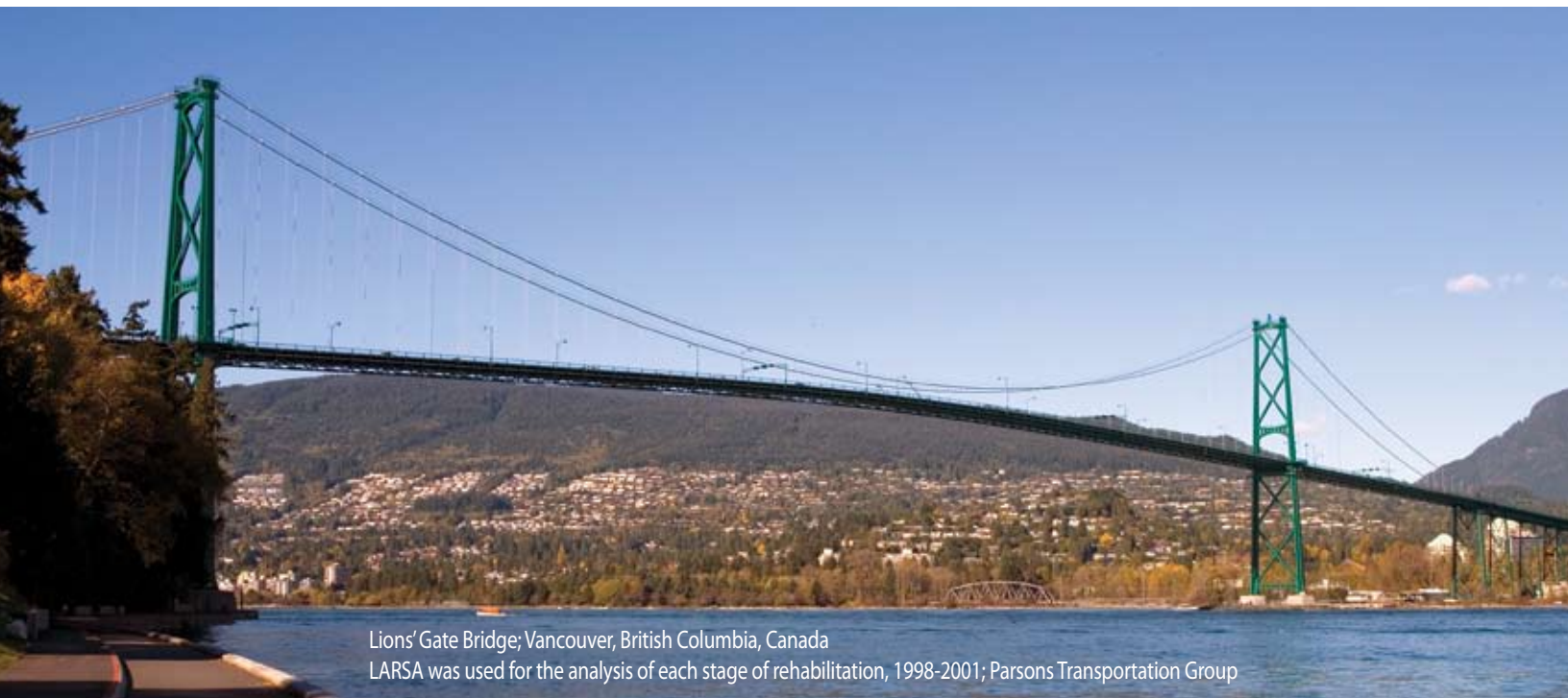
	EndPanel? No
	$\frac{2 \cdot D \cdot tw}{t_w} \leq 2.5$? Yes
The nominal resistance determined in 6.10.9.2 and 6.10.10.1 for unstiffened and stiffened webs, respectively 6.10.9.3.2.2	$V_n = V_p \cdot \left(c + \frac{0.87 \cdot (1 - c)}{\left(1 + \left(\frac{d_o}{D} \right)^2 \right)^{0.5}} \right) = 6380$
Discretely braced comp	

The equations used in the code check, with their computed values, are displayed for the user's reference.

Code check can be performed on an existing LARSA 4D model, or can be used to rapidly generate a new model. The results include:

- Overall structure status
- Detailed results for a particular member
- All equations and values used in the code check are reported
- Exact section of code reported when a member fails the code check

V-Load, M/R methods used when the girder is modeled as a single linear element.



Lions' Gate Bridge; Vancouver, British Columbia, Canada

LARSA was used for the analysis of each stage of rehabilitation, 1998-2001; Parsons Transportation Group

Ultimate Strength Check

The Ultimate Strength Check tool allows users to perform a flexural strength check on prestressed and/or reinforced concrete structures. Currently, the tool has support for the following codes:

- AASHTO LRFD 2006
- BS5400
- EN 1992-1-1:2004

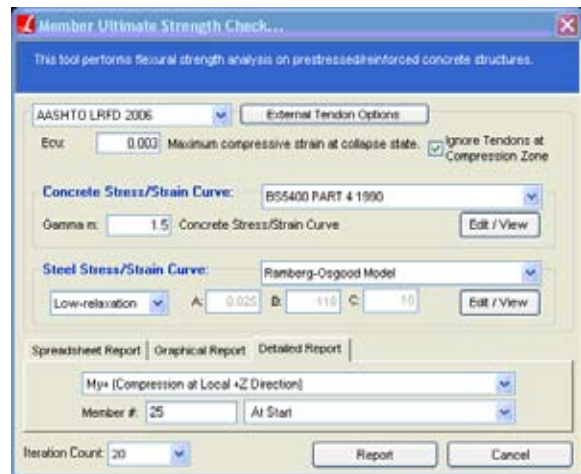
Flexural moment capacity is reported at stations along each member, and results are available in spreadsheets and graphically.

Steel Design

Steel code check & design are available for:

- AASHTO LFD
- AASHTO LRFD
- ASD 89
- Canadian 1991
- LRFD 2001

The tool iteratively finds the neutral axis of cross-sections, considering the forces in pre- and post-tensioning tendons and rebars.



Ultimate Strength Check

Influence Line & Surface Analysis

The influence results tools are designed to be applicable to any number of codes and are suitable for:

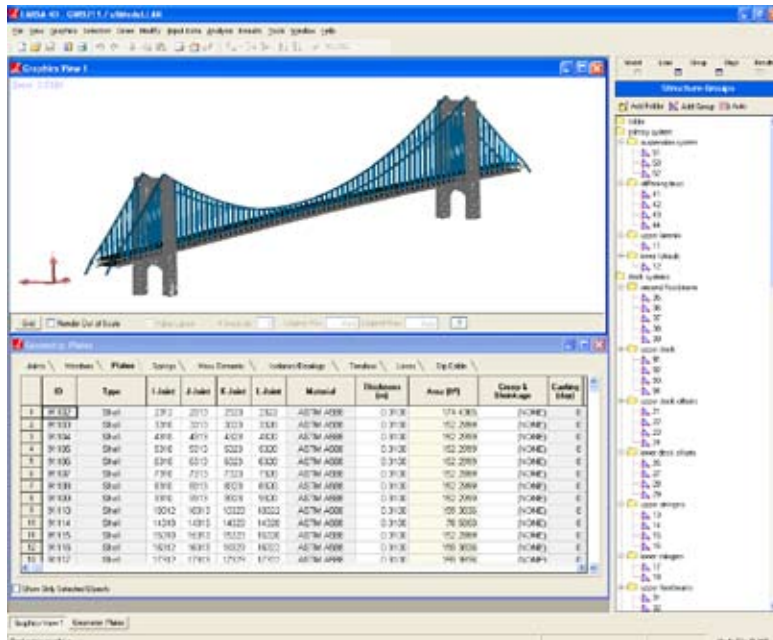
- AASHTO LRFD
- AASHTO LFD
- IRC
- and others



Steel Design



LARSA 4D's user interface is easy to learn and quick to use. All project data is shown and edited through spreadsheets, graphics, and "explorers".



LARSA 4D graphics, plates spreadsheet, and structure groups explorer

Undo/Redo & Integrity Checks

LARSA 4D fully supports infinite-level undo and redo of all data-modifying operations with an undo history limited only by the size of the hard drive. Integrity checks find common modeling errors and provide shortcuts for correcting problems.

Reports

Reports on LARSA 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 to AVI animations.

Structure Groups

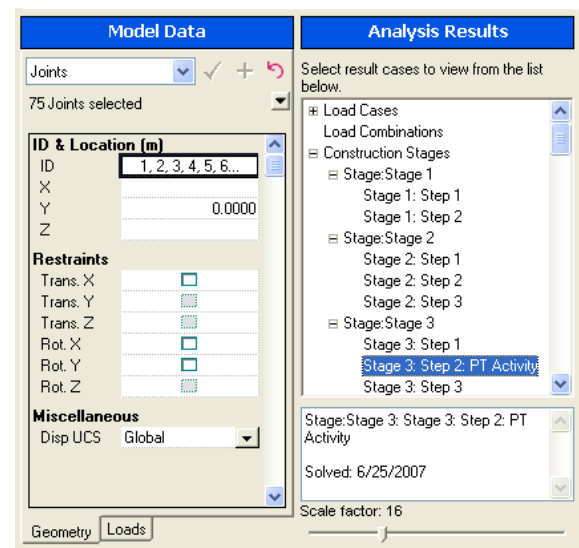
Breaking down a structure into smaller units can save time by allowing quick access to a part of a structure. Structure groups allow you to quickly select and unselect portions of a structure, for using the Model Data Explorer, or for viewing results in particular portions of the structure. Groups are also used in staged construction analysis and as design groups for Steel Design. Structure groups can also be given colors so that parts of the structure are easily recognized, or for presentation output.

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 data can be edited in the spreadsheets.

Explorers

Navigating through a 20,000 beam project is difficult, no matter what software package is used. While invaluable, spreadsheets often present too much data at once. Presenting the solution to this problem, LARSA 4D uses Explorers to summarize large quantities of data into manageable units which can be quickly edited.



The Model Data Explorer and Analysis Results Explorer

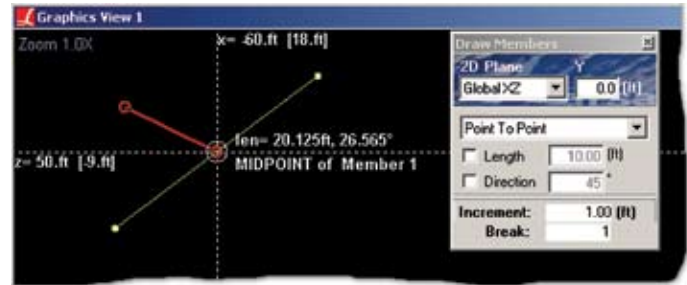
Technical Support

Our technical support team based in New York is dedicated to helping our clients achieve an accurate and efficient LARSA experience. Support is provided over the phone or by email, with questions resolved often within hours.

On-site training is also available.

Advanced Draw

Advanced Draw is the most feature-intense graphical drawing tool in any structural analysis program. It is used to draw joints, members, plates, springs, and isolators. Advanced draw supports snapping to existing geometry, polyline mode, and curved spans. It can draw on grids, including special construction grids. As geometry is drawn, element length and angle information is shown next to the mouse.



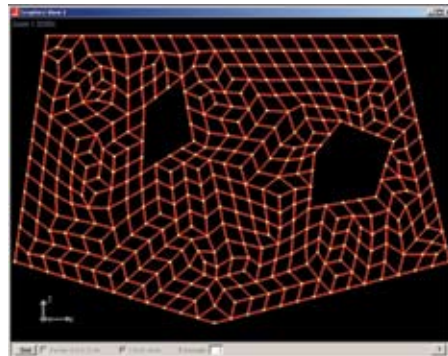
Advanced Draw

Transformation Tools

The transformation tools include translate, rotate, mirror, scale, sag, breaking members and plates, slicing plates, merging joints, and joining members. When breaking members with loads or tendons inside, LARSA knows to reassign the loads and tendons to the pieces.

Meshing

The meshing tool can perform both triangular and quadrilateral meshing of any polygon, including areas with holes. The mesh size can be specified. The polygon and holes are specified by clicking the joints that define the region.



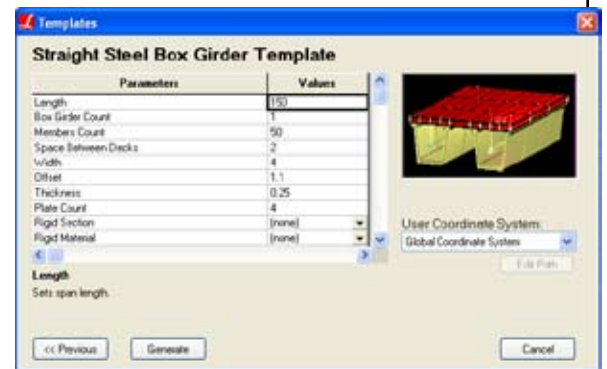
A Mesh

Generation

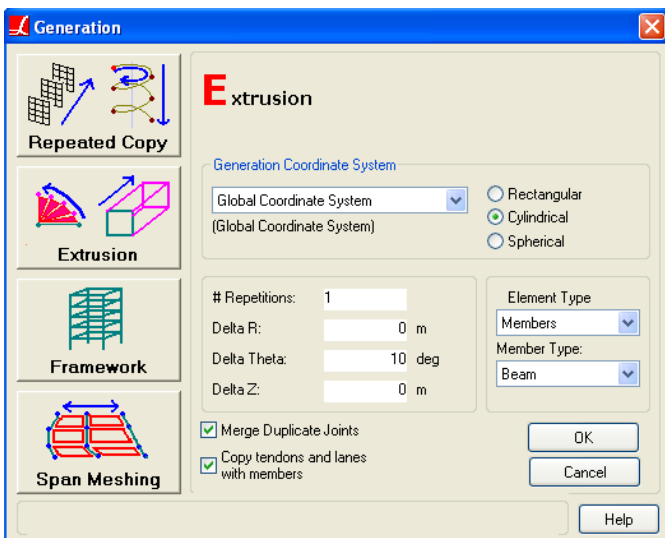
LARSA also has several generation tools, including extrusion, repeated copy, and framework, which can be used to create large structures in a very short time. Extrusion and repeated copy can work in cylindrical, spherical and bridge path coordinate systems, allowing for the fast generation of curvilinear structures.

Templates

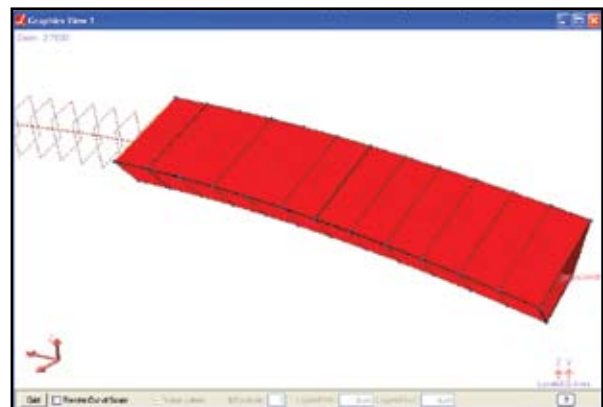
Templates of common structures also come with LARSA, from simple frames to cable-stayed bridges to well foundations. For the bridge templates, the length, width, height, clearance, and number of cables can be quickly entered to produce a bridge model in just a few clicks. Additionally, bridge templates which normally are created along the global x-axis can be generated using a Bridge Path Coordinate System so that it automatically follows curved geometry.



Model Templates



The Generation Tools



Extruding geometry along a Bridge Path Coordinate System is a fast way to create a curved bridge deck.

Analysis Optimizations

LARSA 4D makes use of sparse solver technology and parallel solvers taking advantage of dual-processor or dual-core machines to make static and dynamic analysis runs 5-30x faster than in the past, and less memory-intensive. The Newton-Raphson method in nonlinear analysis and options to control geometric nonlinearity allow the nonlinear analysis to converge quickly.

Viewing Results

Analysis results can be viewed both graphically and numerically. Graphical results include deformed model, reactions, member forces and stresses, plate deformations, forces, and stresses, and plastic yield. Results can be shown for the total cumulative effect or, in Staged Construction Analysis, for the incremental effect of a stage's loading or for the cumulative effect of just a single load class.

Spreadsheets are also available showing detailed results and have further options, such as computing displacements and forces in alternate coordinate systems. Result cases can be enveloped merely by clicking the cases in the Analysis Results Explorer which always sits on the right-hand side of the LARSA 4D screen. As with graphical results, incremental effects and cumulative effects for individual load classes can be reported for Staged Construction Analysis results.

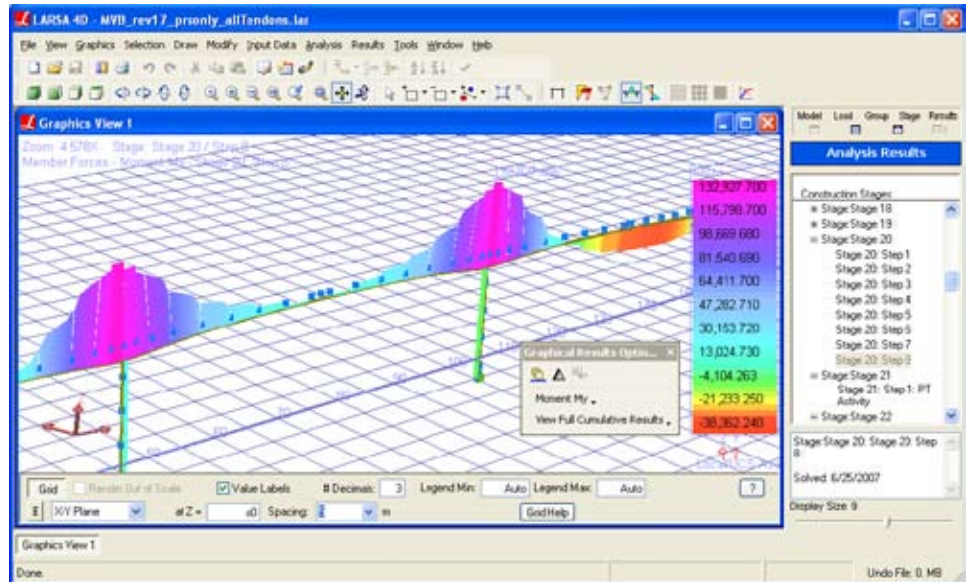
Graphs

Graphs can be quickly plotted for any result data. The x-axis automatically chooses time, load position, or other units as appropriate for the data set plotted. Axis options include standard and logarithmic scale, and y-axis result values can be plotted relative to the value at another location. Result-versus-result graphs can also be created, such as force-displacement graphs.

Special Result Types

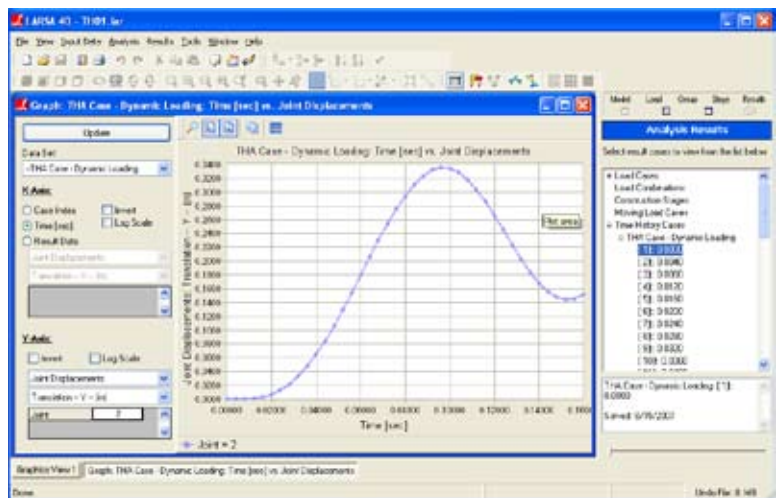
Compound Element Forces report the total forces of multiple elements about their common centroid, used when building-up girders from smaller elements.

Special results like Analyzed Member Loads, which reports the member loads used in the analysis including generated loads such as for self-weight and live load analysis, is an important verification tool.



Graphical results diagrams are available for most result types. The Analysis Results Explorer on the right-hand side of the screen helps in navigating result cases.

LARSA 4D's numeric and graphical results tools make it easy to find extreme values and query loading conditions.



Graphs can be plotted for any result type

Program macros to extend LARSA 4D to suit the particular needs of each of your projects. Macros can automate repetitive tasks and can interface with Microsoft Excel.

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, modeling, and results analysis & export.

Macros can be written within Microsoft Excel, to interface the spreadsheet application with LARSA 4D, or using any COM-enabled programming language. Microsoft Office VBA is the most common because of its availability & ease of use, but it is possible to use Visual Basic, C, and Fortran as well. While some programming experience is generally needed to write macros from scratch, our technical support staff gladly writes macros and helps our clients develop and modify macros.

LARSA 4D's macro API or "object model" was built in to the program from the very start and the hundreds of classes and methods in the public API create infinite possibilities for macro writers. Here are some:

Data Import

- Load joint coordinates and other geometry from an Excel worksheet, or any other custom data format.
- Use Excel to input model parameters, and then write a macro to assemble the repetitive parts of the structure programmatically.
- Create entire models with a macro to facilitate parametric analysis.

Modeling

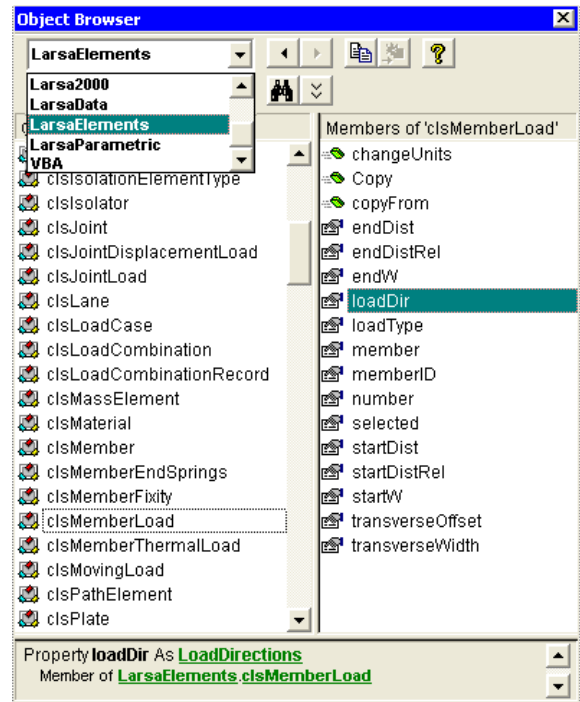
- Copy and transform parts of the structure according to custom rules.
- Edit and convert thousands of existing model objects at once.

Results

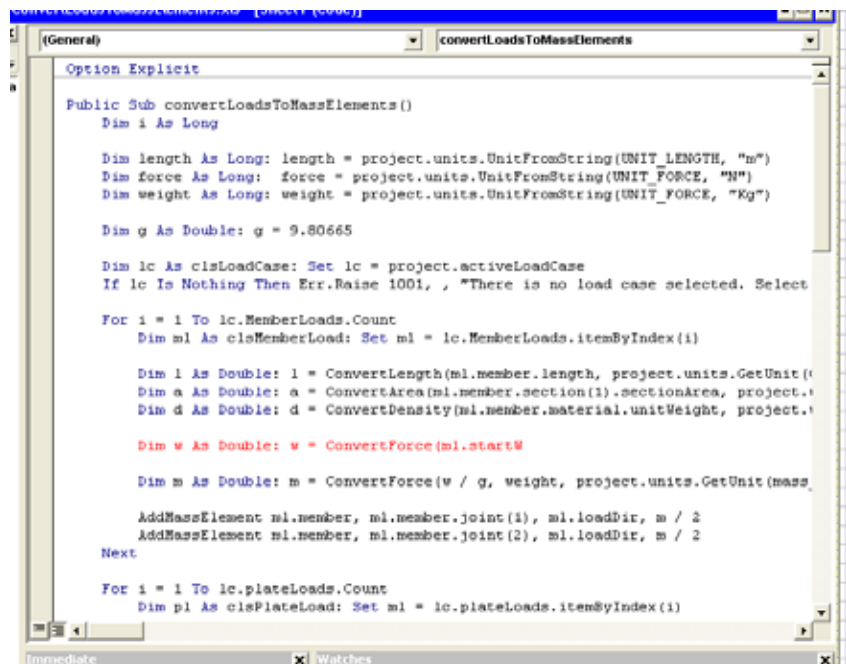
- Post-process analysis results according to project-specific criteria in a macro, without copy-pasting to Excel.
- Export result data to other applications.

Analysis

- Use a macro to perform iterative form-finding by automating the process of running an analysis, extracting results, and updating model geometry or loading. Macros can read all results and can update any aspect of model data.



Part of the Object Model/API available to LARSA 4D macro writers



A macro to automate the creation of mass elements written with VBA in Microsoft Excel

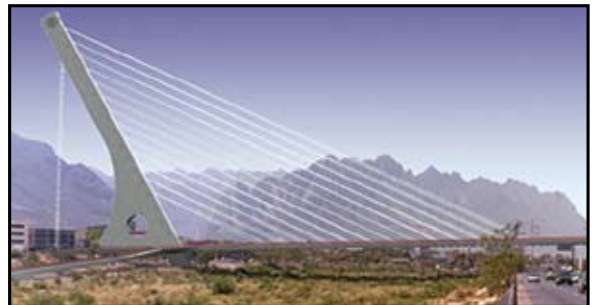
George Washington Bridge | NY/NJ, USA
 Roman Wolchuk Consulting Engineers (USA)
 Status: 2001-2003
 Orthotropic deck studies. An analysis of traffic temperature, wind, and seismic effects.



Indian River Inlet Bridge | Delaware, USA
 Figg Engineering Group (USA)
 Status: Current
 America's longest concrete arch cable-stayed bridge.
 Featured in Structure magazine, October 2003.



Puente de la Unidad | Monterrey, Mexico
 International Bridge Technologies (USA)
 Status: Completed in 2003
 Full design of the bridge using LARSA 2000's segmental construction features.



The New Tacoma Narrows | Washington State, USA
 Parsons Transportation Group (USA)
 Status: Current
 Live load analysis using LARSA 2000.
 Main span 2,800 ft.



Second Vivekananda Bridge | Kolkata, India
 International Bridge Technologies (USA)
 Status: Current
 Extradosed cable-stayed bridge. Eight spans.
 Preliminary and final design using LARSA 4D.



Veterans' Glass City Skyway | Toledo, Ohio, USA
 International Bridge Technologies, construction
 Figg Engineering Group, design
 Status: Under Construction





Pfulger Pedestrian/Bicycle Bridge Texas, USA

In 1999, HDR Engineering chose LARSA as its corporate standard.
 "HDR is running, not walking, into the new millennium and LARSA is part of it."

— Bridge Users Group Chairman, HDR Engineering (USA)



Hoover Dam Bypass Bridge Nevada/Arizona, USA

"We won't use a program that cannot match the needs of field accuracy during erection, and we do not see any program other than LARSA 4D that can match those needs."

— David Goodyear, Senior Vice President, TYLIN International (USA) and HDR (USA)



Docklands Light Railway Extension London, UK

2.9 km long post-tensioned concrete box girder viaduct.

"The LARSA support team has helped Halcrow by implementing a number of new features... The cooperation we have experienced from the team is much appreciated."

— Dr. Innes Flett, Assoc. Director - Bridges, Halcrow Group (UK)



Pedestrian Bridge Iowa/Nebraska, USA

Innovative curved cable-stayed bridge.

Staged construction analysis using LARSA 4D.

Figg Engineering Group (USA)



Lions' Gate Bridge British Columbia, Canada

Suspension bridge, gravity-anchored, deck truss.

Built in 1937. LARSA used for the analysis of each stage of rehabilitation, 1998-2001.

Parsons Transportation Group (USA)



William H. Natcher Bridge Kentucky/Indiana, USA

Cable stayed bridge. Length: 671 m. Main Span: 366 m.

Designed using LARSA, 1988-98.

Parsons Brinckerhoff (USA)



Tappan Zee Bridge New York/New Jersey, USA

Cantilever truss bridge.

LARSA is the software standard for the current project to evaluate the bridge.

Arup, Lichtenstein and Wagh (USA)

	Introductory		Advanced Series		
	4D Lite	4D Basic	4D Structure	4D Bridge	4D Bridge Plus
Elements					
Truss/Beam/Plate/Shell	■	■	■	■	■
Grounded-Springs (compression only)	■	■	■	■	■
Cable		■	■	■	■
6x6 Stiffness Element		■	■	■	■
Analysis					
Linear Static	■	■	■	■	■
Eigenvalue/RSA	■	■	■	■	■
Linear Time History	■	■	■	■	■
Nonlinear Static	■	■	■	■	■
Moving Load Analysis	■	■	■	■	■
Solver					
Fast Skyline	■	■	■	■	■
Sparse Solver			■	■	■
Staged Activities					
Change Supports	■	■	■	■	■
Construct Grounded Springs	■	■	■	■	■
Advanced Elements					
Nonlinear Elastic Springs			■	■	■
Nonlinear Inelastic Springs			■	■	■
Isolators/Bearings			■	■	■
Hysteretic/Connection/ Moment Curvature Beam			■	■	■
Advanced Nonlinear Analysis					
Pushover/Collapse			■	■	■
Nonlinear Time History			■	■	■
Nonlinear Buckling			■	■	■
Bridge Features					
Influence Line			■	■	■
Influence Surface				■	■
Bridge Geometry Control				■	■
3D Tendons				■	■
Staged Construction Features					
Construct/Deconstruct Elements			■	■	■
Analysis Scenarios			■	■	■
Construction Methods				■	■
Tendon Stressing					■
Material Time Effects					■



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