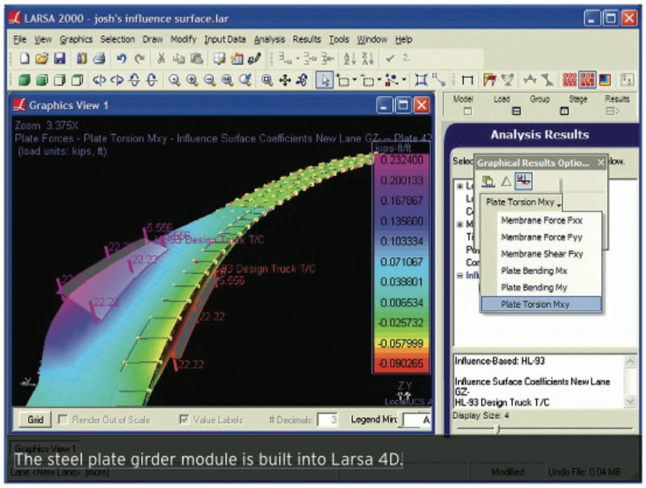
UNLIMITED EDITION

Modelling for the analysis and design of steel plate girder bridges is due to be simplified by the release of an updated module



The steel plate girder module is built into Larsa 4D.

A new update of Larsa 4D's Steel Plate Girder Bridge module, due for release this year, will see its model generation capabilities extended to bridges with very complex geometry, new algorithms for influence surface-based live load analysis improve accuracy and speed, and the module revised to code check for the current AASHTO LRFD code.

The ability to create a 3D finite element model for code-checking is vital for bridges that do not follow a simple template. The steel plate girder bridge module will create models with a variety of special conditions, such as bridges with girder lines that are not parallel or do not follow the bridge alignment, with girders terminating at different stations, and bridges with decks that are not a uniform width. With a wizard-like interface within the Larsa 4D environment, the module generates a complete staged analysis bridge model ready to be analysed and code-checked by Larsa 4D's non-linear staged analysis engine.

This method moves beyond the 2D grillage analysis that is commonly used for steel plate girder bridges. The 2D grillage method of analysis has the advantage of being simple, quick, and effective for bridges that are horizontally straight, or almost straight, with a relatively small skew. There are a number of programs commonly used in the industry to perform an analysis based on the grillage method, but these have limitations. Live-load analysis in these programs is often performed using an influence line, where load distributions across multiple girders are not based on a stiffness analysis, and the substructure often cannot be included. Grillage models do not take into consideration warping of the girder or the shear lag effects, and as the horizontal curvature of the bridge grows and/or a larger skew angle is required, grillage analysis becomes insufficient.

Three-dimensional finite element analysis is usually required for more refined and more accurate representation of these bridges. Finite element analysis has been thought of as complex, and model generation for steel girder bridges has been considered difficult, tedious, and computationally expensive, requiring powerful computer programs. General finite element programs often do not include code-checking, leaving the end-user to create their own tools in order to extract results and carry out the code-checking process.

The steel plate girder bridge module is built into Larsa 4D, in order to take the complexity out of modelling for the analysis and design of steel plate girder bridges, by drawing on the modelling and analysis strengths of Larsa 4D. With the help of this module, engineers are able to create a full 3D finite element model of the bridge by providing alignment, span, girder, deck, and cross frame information. Larsa 4D is 3D finite element software for the analysis and design of bridges and structures which require non-linear, time-dependent, or other advanced analysis. Staged construction analysis, which models the changes to a structure over time including the construction or deconstruction of elements, the application of loading, and time-variable material properties, is the core of the program's analysis. It is capable of capturing the 3D behaviour that a grillage analysis cannot, including the effect of warping and shear lag, and the behaviour of a complex, curved, and/or skewed bridge.

The program's full non-linear staged construction analysis not only takes second-order effects into account, it also provides the ability to capture the effect of the construction itself. Simulating the deck pouring sequence and/or screed movement is a good example where the need for staged construction becomes apparent.

Four girder types are supported by the module: I-girder using beam elements only, I-girder using a combination of beam and plate elements, steel plate box, and steel plate tub. The module can be used to generate the model geometry and roadway lane definitions, load cases for dead, live, and wind loading, staged construction analysis stages and steps, and result combinations and envelopes. The module can also be used to code-check an existing model.

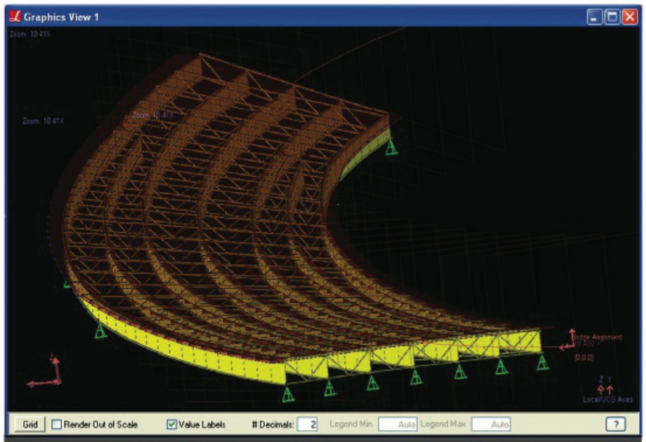
While computationally expensive and complex, influence-surface-based analysis is the most desirable live-load analysis capability that today's analysis software can offer bridge structures. With the influence-surface method, load distribution across multiple girders is accomplished automatically because the 3D finite element model, with finite elements such as plate and shell elements as the deck, determines how forces are transferred throughout the model. Another advantage of the influence-surface method over the influence-line method is the ability to apply 'two-dimensional' load patterns. These load patterns are so named because wheels are arranged over a surface, rather than in a line. It is always recommended to use 2D vehicle load patterns when using influence surfaces; only 2D load patterns model the width of vehicles, which plays a role in the requirements for vehicle placement within lanes.

The updated module makes use of Larsa 4D's influence-surface analysis method for live-load effects. This provides the ability to load the roadway with standard AASHTO trucks, permit trucks, or any other user-defined custom load patterns. The influence surface in Larsa 4D covers the complete deck surface with one or more rows of traffic, not an individual traffic or design lane. Larsa 4D will place as many lanes as will fit on the surface simultaneously maximising the effect according to any multiple presence factors specified.

The new algorithm implemented in 2012 will find the worst-case loading configurations of vehicles and lane load. Improvements include the ability for trucks to be placed at the very edges of design lanes regardless of the transverse grid spacing of the influence-surface coefficients, improved accuracy by solving for the best lane and vehicle positions simultaneously, improved speed especially on multi-core/multi-processor computers, simultaneous optimisation over multiple lane configurations – different truck types and limits on the number of trucks of any type – and the ability to combine the span-by-span requirement of AASHTO LRFD with multiple presence factors.

The influence algorithm effectively simulates all of the vehicle configurations that arise from the different number and location of design – traffic – lanes and vehicles placed, the direction of each vehicle – forward or backward – and the length of variable-axle-position load patterns.

Once the 3D finite element model is created, loaded, and analysed, the steel plate girder bridge module can perform code-checking based on the latest publication of AASHTO LRFD code. The code-check report can be viewed in summary mode, where pass/fail state of a particular location on the structure can be investigated, or the results can be viewed in detail mode where step-by-step computation and checks are reported. Users can produce reports simply by specifying the stations and girder IDs instead of element or joint IDs. Reports show the line-by-line computations that follow the design code, with equation number references to the code. Reports cover the following components of the code: cross-section proportion limits, constructability, service limit state, strength limit state, and stiffeners.



The new module is intended for bridges that do not follow a simple template.

The steel plate girder design module has a task-based user interface where each task is carried out in a step-by-step procedure. Navigation buttons are used to advance or backtrack through the steps. At each step the module may need you to make certain decisions and/or input certain information to complete the task. Most of the input fields are self-explanatory or if not, include a short explanation, and further information specific to each step is also available ■