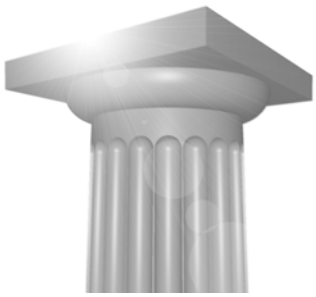
2009 Roads and Bridges Conference

SW-2

Introduction to Prestressed Girder Design with LEAP Bridge V9

Presenter: Steve Willoughby, Bentley Systems, Inc.

Bentley Systems, Incorporated
685 Stockton Drive
Exton, PA 19341
www.bentley.com



Introduction to Prestressed Girder Design

Overview

This workshop is an introduction to the design of prestressed concrete bridge beams with LEAP Bridge. As this type of bridge is a widely accepted alternative to long-span bridges, the solutions to be presented are widely used throughout the United States. Learn more about the flexibility of the layout and design with 2008 LRFD code specifications.

Objectives

After completing this course, you will be able to:

- Use the ABC wizard in LEAP Bridge to quickly layout superstructure and substructure of a bridge.
- Apply LRFD loads to the beams.
- Analyze the superstructure based on user defined loads and limit states.
- Design beam strands and rebar based on analysis of loads.
- Export various views to MicroStation drawings.

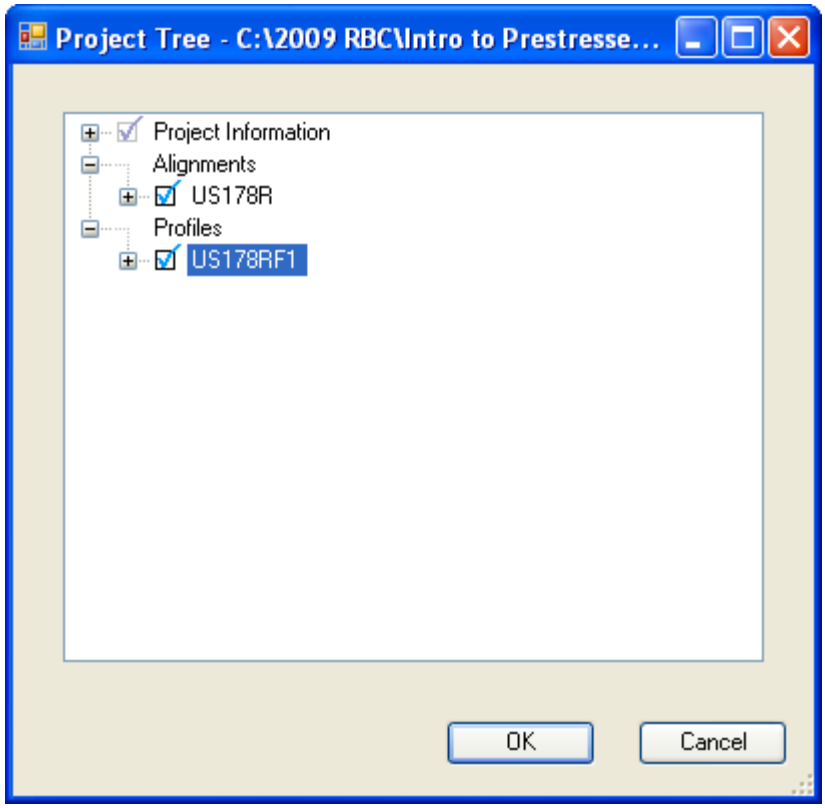
Create Bridge with ABC Wizard

These steps will walk you through using the ABC Wizard in LEAP Bridge to create a 3D model of a bridge including the super and substructure components.

➔ **Exercise: Use ABC Wizard to create an 3-70' span structure**

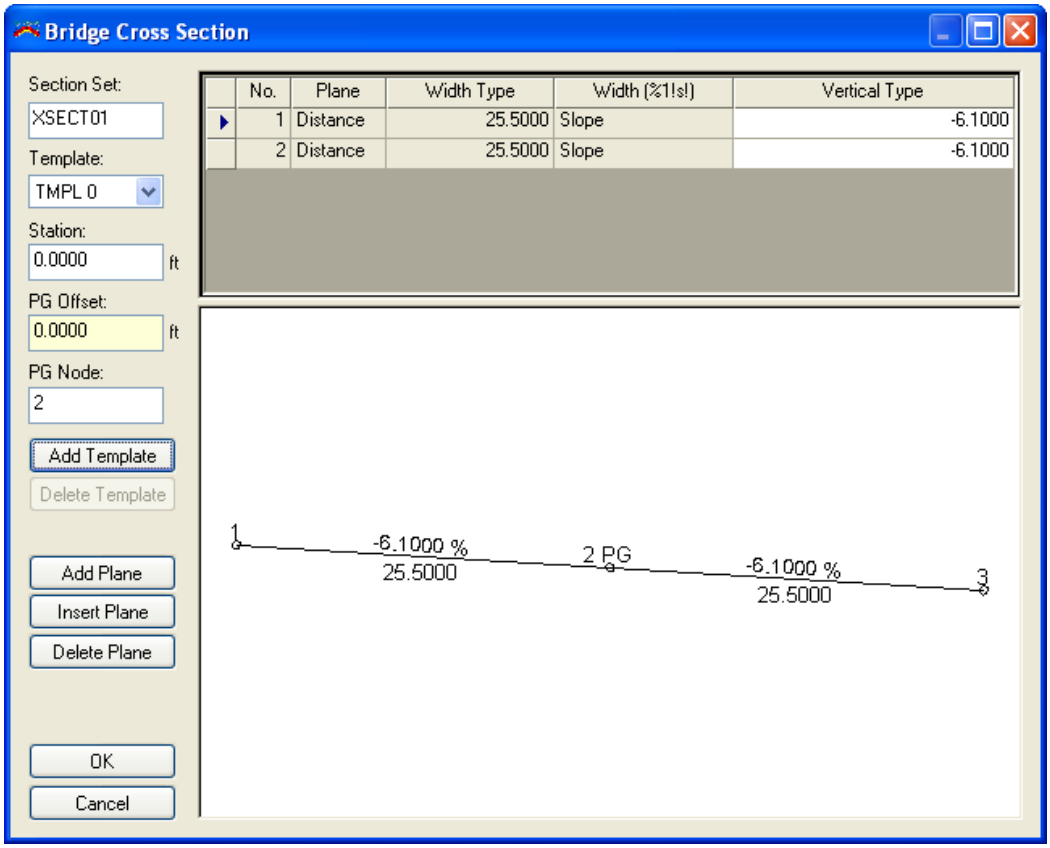
1. Start LEAP Bridge.
2. Start the ABC Wizard.

3. Select **LandXML**. Select *C:\2009 RBC\Intro to Prestressed Girder Design\us178r_chain.xml* from the Browse button. Enable the **Connect to Data source** toggle and select **OK**.
4. Expand the Alignments and Profiles toggles and toggle on the alignment and profile as shown below. Select **OK** to import the geometry.

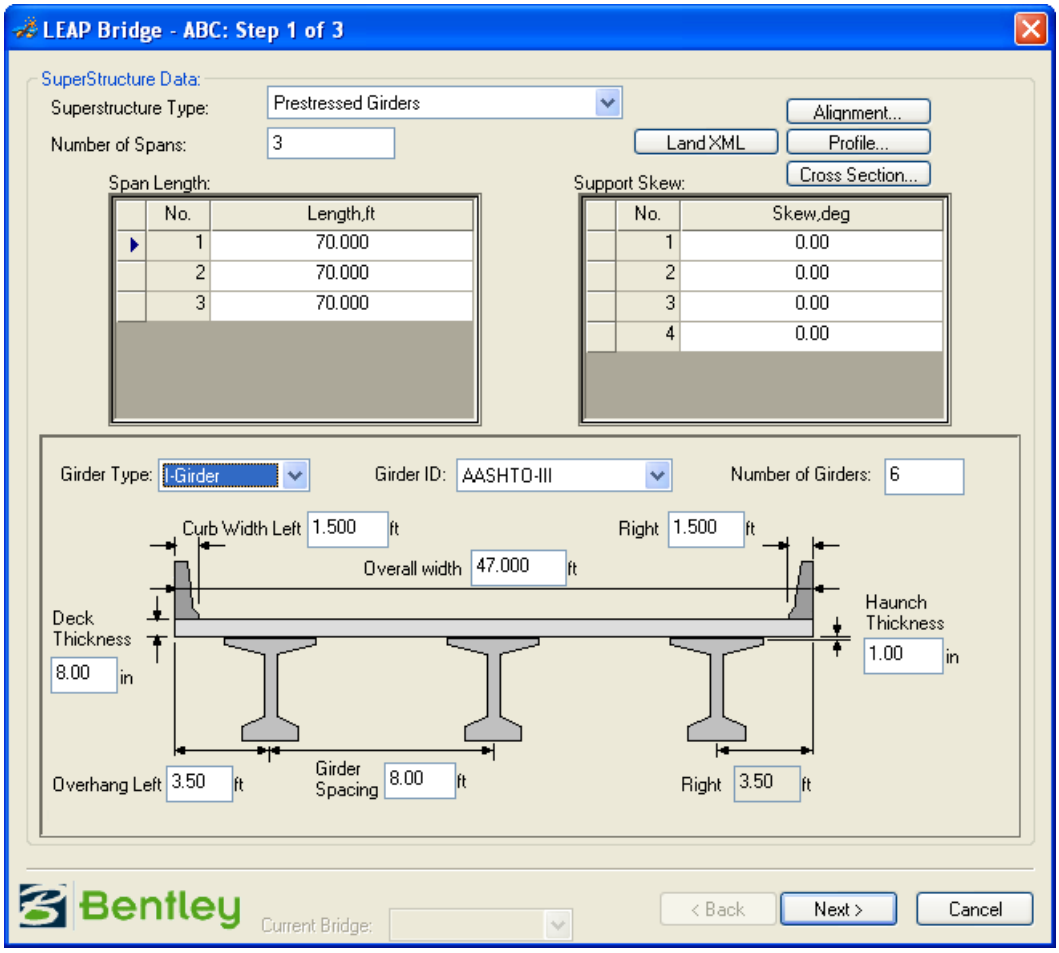


5. The bridge begins at station 379+90. Select **Alignment** and set the **Begin Bridge Station** to *379+90*. Select **OK** to accept this value.

6. The Cross slope of the structure is 6.1%. Select **Cross Section…** from the Step 1 of 3 dialog. Populate the Bridge Cross Section dialog as shown and select **OK** when completed.

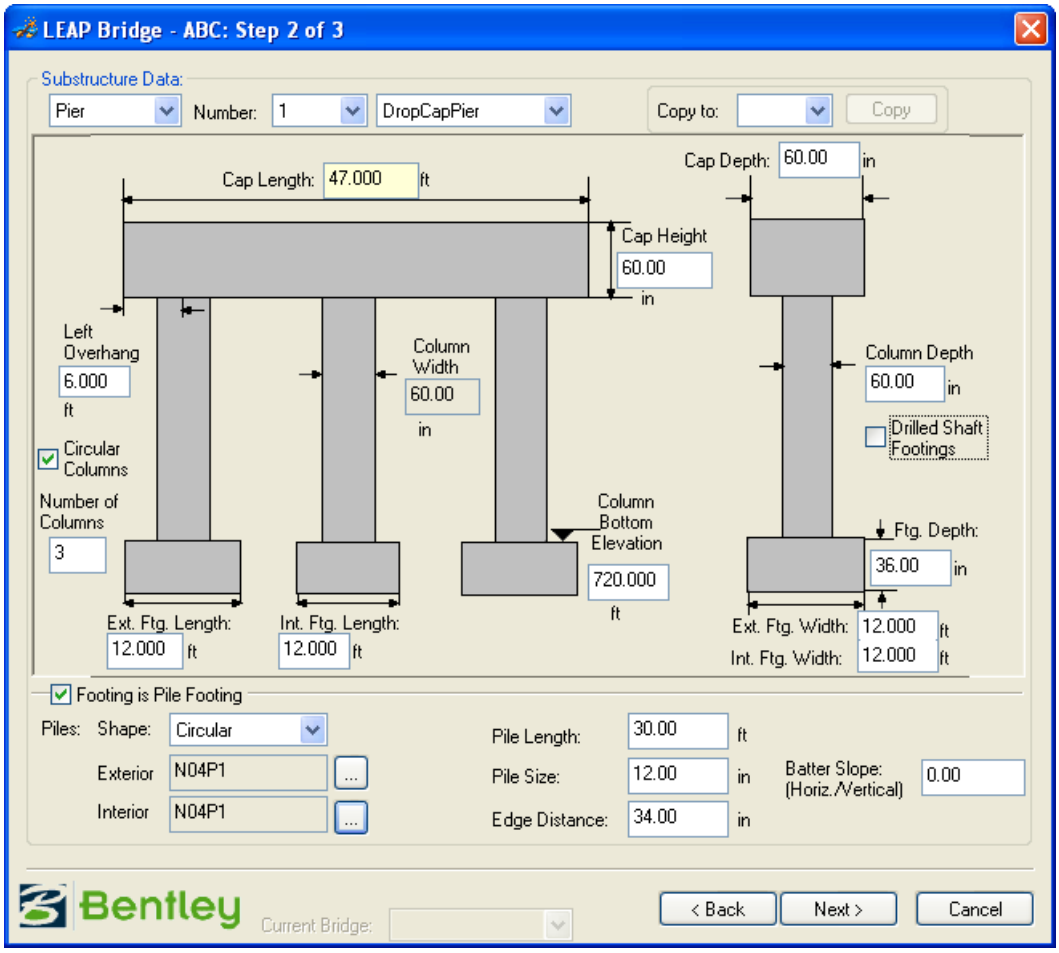


7. Populate the Step 1 of 3 dialog as shown below. Select **Next** when complete.



8. Click **OK** when prompted to the notice that the piers have been synchronized.

9. For Pier 1, complete the dialog as shown.



10. Set the **Copy to:** field to *2* and select **Copy**. Select **Next** to continue.

11. Select **Next** twice. Select Finish to complete the wizard.

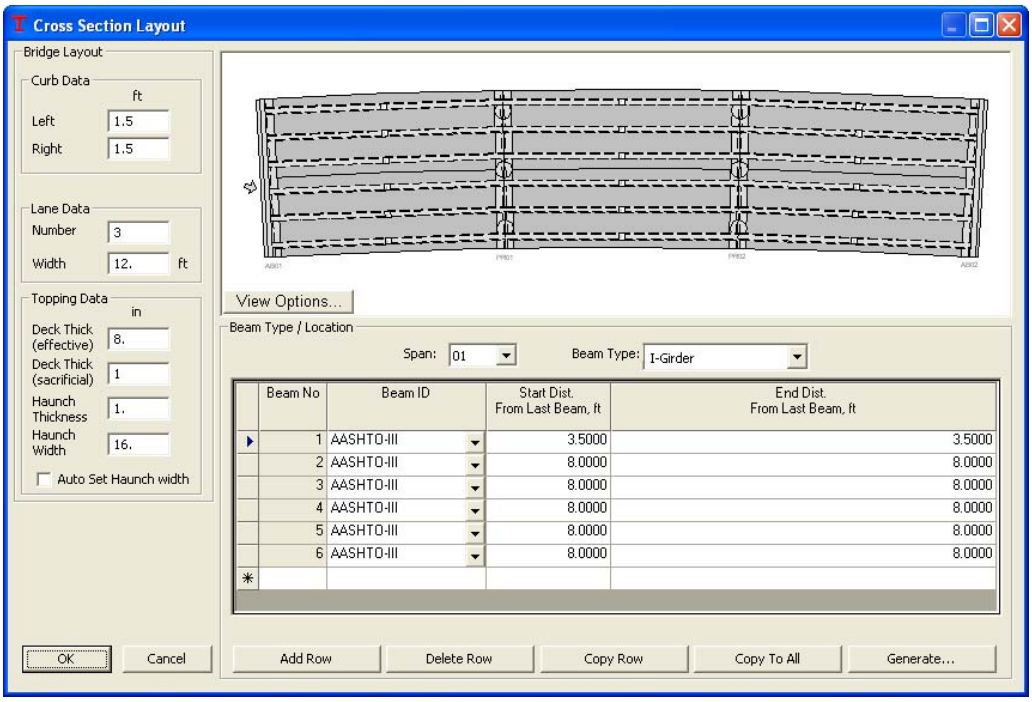
12. Select the **Geometry** tab to view a 3D model of structure.

Apply LRFD Loads to the Structure

The following steps will guide you through the process of applying LRFD dead loads and live loads to the structure.

➔ **Exercise: Apply dead and live loads to the structure**

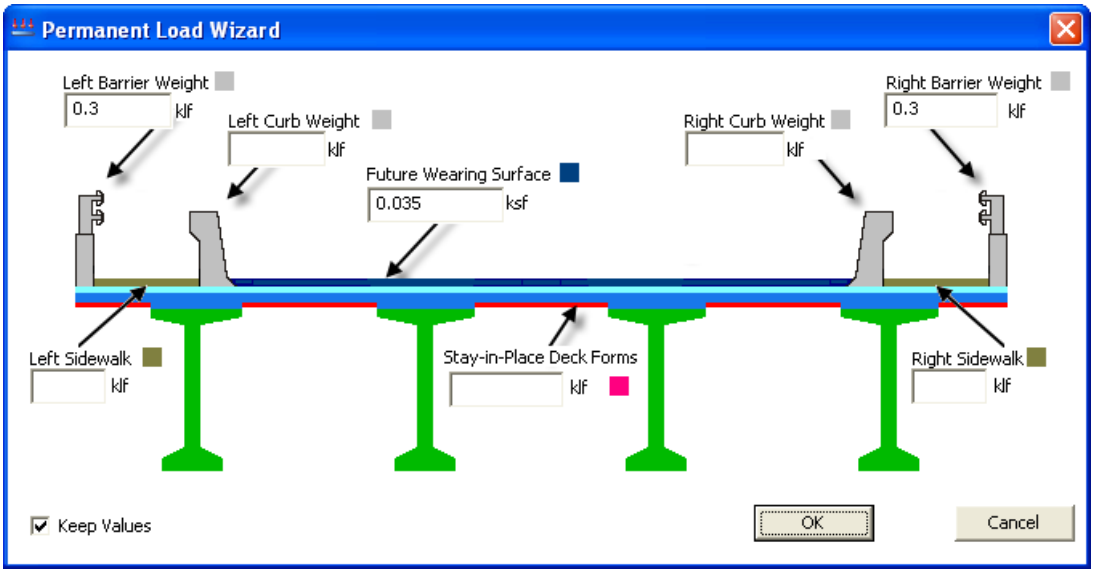
1. From the **SuperStructure** tab in LEAP Bridge, select **CONSPAN**.
2. Select the **Geometry** tab.
3. Select the **Cross Section…** tool.
4. Change the **Deck Thick (sacrificial)** value to **1** inch.



5. Select the **Loads** tab.
6. Select the **Wizard…** button at the upper right.

7. Fill out the Permanent Load Wizard using the following values. Enable the **Keep Values** toggle. Select **OK** when completed.

Load Type	**Magnitude**
Left and Right Barrier	0.3 klf each
Future Wearing Surface	0.035 ksf
Sacrificial Wearing Surface	1 in



This will populate the **Permanent Loads** section of the dialog.

8. Enable the **Include LL Deflection** toggle.

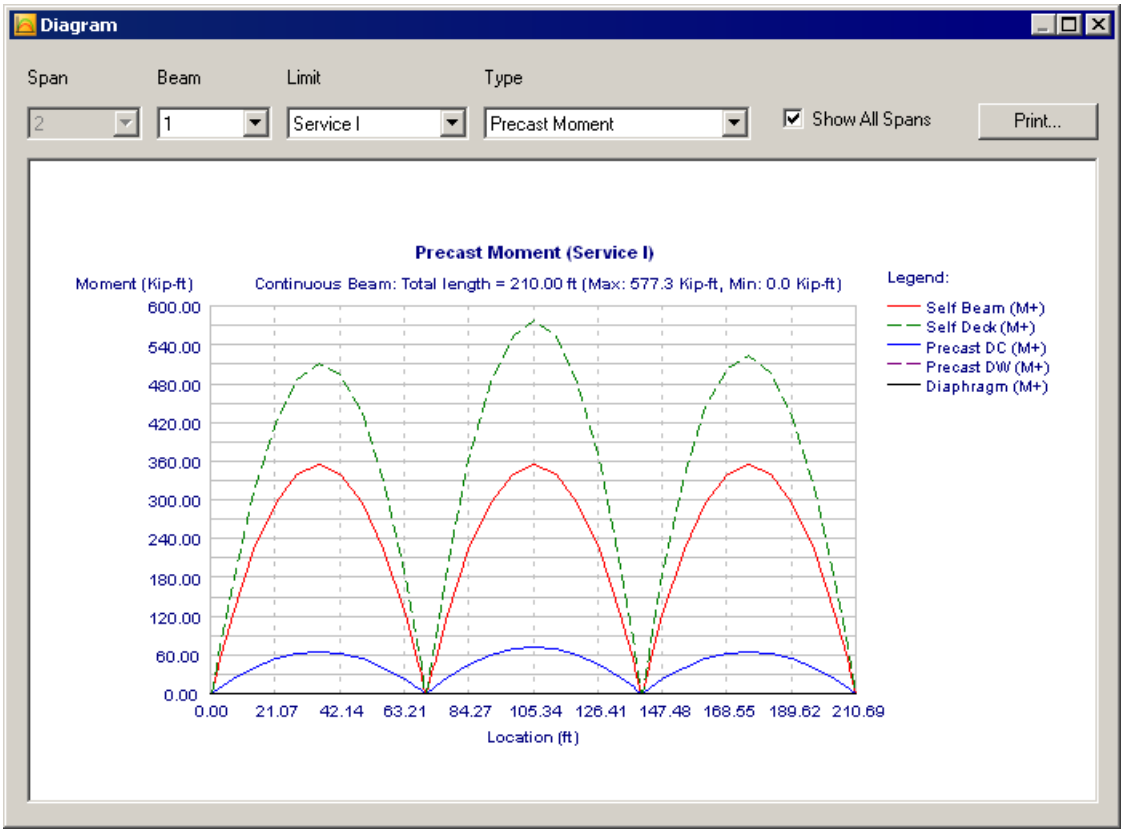
9. Select **File > Save As…** to save a copy of the current data to a CONSPAN file. Place the file in the folder with the other workshop files and name the file *US178-1.csl*.

Analyze the Superstructure

The following steps will guide you through the process of analyzing the superstructure based on the loads supplied in the previous section.

➔ **Exercise: Apply dead and live loads to the structure**

1. Select the **Analysis** tab.
2. Select **Analysis Factors…** to review the current values for load distribution, load factors and modifiers.
3. **OK** the Analysis Factors dialog.
4. Select **Run Analysis...** . Review the analysis values for the various spans, beams and limit states.
5. Select the **Diagram** icon to view the results graphically.



Beam Design

This exercise will walk through the process of designing the reinforcing strands and rebar within a beam.

➔ **Exercise: Design a beam and use as the template for the remaining beams.**

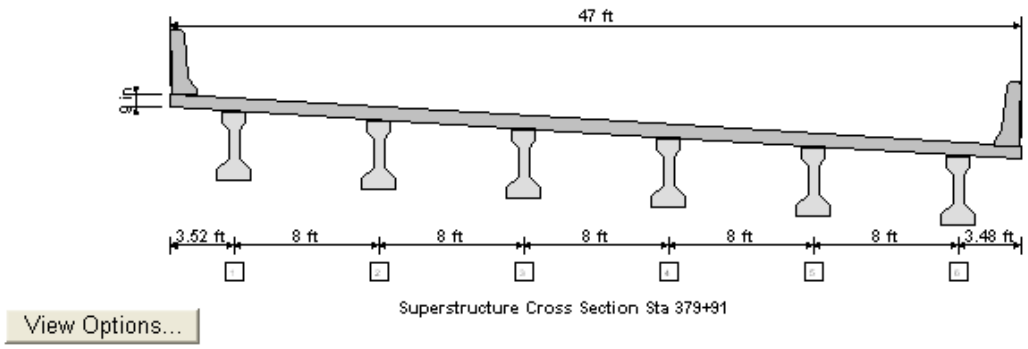
1. Select the **Beam** tab.
2. Set the **Span** to *02* and **Beam** to *1*.
3. Select **Strand Pattern…** to design the strands.
4. Select **Auto Design** to perform an initial design.
5. Review the resulting design status. The only failure is in the deck (Topping-top).
6. Copy this pattern to all other beams in all spans. **OK** the strand pattern dialog.
7. Select **Rebar Pattern…** . In the Auto Design section of the dialog, set the **Size** to *US #4[M13]* and the **Legs** value to *4*. Select **Auto Design…** .
8. Modify the Start and End distances to round values of feet. Review the **Graph**. Copy the resulting reinforcing too all beams in all spans.

Export Drawings to MicroStation

Lastly, we'll take a look at exporting various views in the LEAP products to MicroStation.

➔ **Exercise: Export views to MicroStation drawings**

1. From CONSPAN, select the **Geometry** tab.
2. Select **Section**. Right click the graphical view of the section and select **Export View…**. Set the **Save as type** to *MicroStation DGN*. Name the file *Section1.dgn* and click **Save**.



3. Close CONSPAN. When asked to update the LEAP Bridge model, select **Yes**. When prompted to generate reports, select **No**.
4. Select the **Geometry** tab in LEAP Bridge. Rotate the model to various angles.
5. Click the **SOLID** button at the lower left of the graphics window to view the model in a transparent state. The tendons and rebar will be visible through the beams.
6. Using the right click menu, export this view to a DXF file called *US178 3d.dxf*.
7. Open MicroStation and review the drawings that have been created.

Appendix A: Program Capabilities

Bentley Systems, Inc. LEAP CONSPAN is the first integrated AASHTO LRFD and Standard (LFD) program for the analysis, design and load rating of single span and multiple span bridges, constructed with simple-span prestressed girders made continuous by reinforcing the cast-in-place top deck with mild steel in regions of negative moment. The following highlights some of CONSPAN's main features:

Design Code and Units

- Dual design codes, AASHTO Standard and LRFD. You can switch between the two specifications at any time during program execution.
- Load Rating according to the *Manual of Condition Evaluation of Bridges*.
- Load Rating according to the *Manual for Condition Evaluation and Load and Resistance Factor Rating LRFR of Highway Bridges*.
- Dual units, U.S. and Metric. You can switch between the two units at any time during program execution.
- State Specification drop-down: Select from Florida or Califoria to apply state specific criteria.

Libraries

- Reduce input time using predefined library of prestressing tendon types, rebars, and beam section types or modify/add custom libraries.
- Specify pre-defined strand patterns and use as manual input or during auto-generation.
- Select AASHTO Standard (LFD) design trucks from a predefined library (HS20 Truck, HS20 Lane, H20 Truck, H20 Lane, Military, etc.) or define unlimited new loads manually.
- Select LRFD design moving loads from a predefined library (Design Truck, Design Tandem, Design Lane, Double Truck, Double Tandem, etc.) or define unlimited new loads manually.

Span Type

- Increased input efficiency by selecting either the Simple-Span or Multi-Span option to enable custom program input and output options.

- Option to analyze a multi-span structure as a series of simple spans (i.e. superimposed dead and live loads are applied on simple beam model rather than continuous beam model).
- Quickly specify project and job descriptions.

Flared Girder Geometry

- Specify flared (splayed) girder geometry. Program considers varying beam lengths in the same span due to skew angle differences, or due to non-parallel arrangement of girders.
- Specify advanced geometric information including alignment information, abutment, pier and deck information.
- Advanced Graphics show layout, cross section of bridge.

Analysis and Design

- Dead Load Wizard: makes input of common loads very simple
- Specify Negative Moment Continuity steel in deck slab. Compare required vs. provided capacities.
- Copy beam strand patterns to other beams in same span or other spans.
- Specify variable span lengths, precast beam lengths, bearing-to-bearing lengths, and skew angles for bridge.
- Specify different beam sizes in the same span and different beam types in each span.
- Retains previously designed strand patterns when changes are made to geometry, materials, or loads information.
- Input loads for DC and DW on precast, composite, or supplemental. Loads can be specified as concentrated, area, or line loads.
- Specify supplemental topping/deck thickness and include superimposed dead loads on supplemental.
- Automatically compute dead loads due to self-weight of girders, deck, haunches, and supplemental.
- Have the capability to allow input of dead loads on composite as linear loads, e.g., to simulate barrier loads.
- Specify an unlimited number of diaphragm loads. Use the copy feature to copy diaphragm loads to all beams and/or all spans.

- Analyze self-weight and dead loads assumed to act on the precast section being designed using simple beam analysis.
- Analyze dead loads on composite sections using continuous analysis.
- Specify pedestrian loads.
- Choose whether or not to include LRFD live load deflection criteria.
- Perform automatic moving load analysis on simple-span or continuous multi-span bridges.
- Select specific Standard (LFD) groups for analysis and design (1, 1/1A, and 1B).
- Select specific LRFD limit states for analysis and design (Service I, Service III, Strength I, and Strength II).
- Use refined methods of analysis (grillage models) to compute live load distribution factors.
- Display distribution factors as contour graphs.
- Customize LRFD factors, including dynamic load allowance, distribution, gamma, and h factors.
- Customize or select limiting stresses for concrete at release and final conditions.
- Customize or select length multipliers for transfer and development lengths.
- Easily customize variables that are automatically calculated by the program, such as live load and dead load distribution factors and dynamic load allowance impact/factors.
- Automatically generate straight and draped strand patterns or manually input the pattern for analysis.
- Specify transformed section properties.
- Customize the maximum number of strands that can be debonded, as the maximum percentage of each row, or the total number of strands in each section.
- Specify end and midspan debonding (shielding) manually or have the program compute it automatically. While using a draped/straight pattern, only the straight strands can be debonded.
- Customize varying percentages of strand pull for various strand groups.
- Specify or have the program compute release and final prestress losses according to the AASHTO LRFD and LFD Specifications.
- Automatically design top flange tension reinforcement at release.
- Check design status at critical points for release and final stresses as well as for ultimate loads and cracking load criteria.
- Perform vertical, anchorage zone, and horizontal shear reinforcement design.

- Auto design required vertical shear reinforcement.
- Report camber and deflection computations at tenth point locations along the beam, including live load deflections.
- Automatically compute deck reinforcement required for continuity.
- Select among three methods whether to include restraint moments, including the PCA Method, Ref. 7.
- Display and print moment, shear, and stress diagrams for either specific load cases and/or load combinations.
- Optionally compute Moment Capacity by Strain Compatibility.
- Program provides option to consider composite loads in Horizontal Shear computations.
- Convert loading from LFD to LRFD on the fly and also apply different DF for different dead loads.
- Consider the span lengths specified in Table C4.6.2.2.1-1 in the computation of LRFD load distribution factors.
- Option to distribute dead load equally to all beams or based on tributary fraction.
- Optionally, input Stirrup reinforcement schedules manually or use auto-design algorithms.
- Store commonly used stirrup schedules in the library file, and reuse across projects.

General

- Use the save setting feature to minimize future input.
- Design standard or custom beam types using convenient section property editor and visual strand pattern templates.
- Use wizards to quickly specify beam layouts.
- Save input data and/or results at any time. Save designs and check them for new loading conditions. Strand pattern is automatically saved unless the beam itself is changed.
- Specify font for viewing/printing output.
- Send data file in an e-mail message from within the program.
- Options to specify the default working folder.
- Option to keep analysis factors input manually.
- Use wizards for generating strand templates.
- Toggle between LFD (Standard) and LRFD modes without losing the strand pattern or dead load information.

- Section Library Transfer Utility, allows for bulk transfer of section from old libraries into new, or from different files, into a consolidated file.
- Link from within the program, from the Help menu, to the User manual in PDF format.
- Automatically check for updates from Web site.
- Detailed and separate reports of all input and output either in text form or in enhanced report format.
- Option to include 2D views (cross-section, elevation) and analysis/design graphs in the enhanced report (HTML) outputs.
- Strand pattern Wizard now allows definition of straight/draped strands in an easy to use, point and click graphical user interface. Get production quality printout showing strand patterns graphically.

Load Rating

- Load Rating according to the *Manual of Condition Evaluation of Bridges*, in standard specifications mode.
- Operating and Inventory Rating
- Load Rating summary and details at all tenth points for Moments (Flexure, positive and negative), Shears and Stresses (concrete and prestressing steel).
- Select multiple trucks from predefined truck library or define your own rating vehicle.
- Load Rating according to the *Manual for Condition Evaluation and Load and Resistance Factor Rating LRFR of Highway Bridges for Design, Legal and Permit Load Rating*.
- Completely customizable input parameters including factors and allowable stresses.
- Run refined analysis to use live load distribution factors to model trucks non-standard gage width (different than 6 feet).

Appendix B: Program Boundaries

The following is a list of CONSPAN's boundaries and conventions.

- Width of bridge must be constant in all spans when flared girder option is not used.
- Flared girder option is only available for I-girders, box-beams and U-beams.
- Beam moment of inertia must be constant within a span, e.g., no change in beam properties along the span.
- Topping (slab) thickness must be the same for all spans and within a span.
- All beams must be the same type but may be different sizes (e.g., you cannot use AASHTO I-beams and box beams in the same span but you can use various sizes of AASHTO I-beams in the same span).
- Maximum number of axles that can be defined for a truck is 20.
- All beams in a specific span should have the same length and should be parallel to one another.
- Pedestrian Load not considered in Load Rating Analysis.