

AASHTOWare BrDR 6.8.3

Prestressed Concrete Design Tool
Getting Started

Introduction

AASHTOWare Bridge Design and Rating (BrDR) version 6.8.3 includes the Prestressed Concrete Design Tool (PS Design Tool). This tool provides the overall framework including libraries of beam shapes, vehicles, appurtenances, materials and the basic capabilities required to analyze and design a single prestressed concrete beam. A future release will add the capability to design all beams in a cross section. The user can describe the overall bridge framing plan that includes multiple prestressed concrete beams. This is the “System” definition in BrDR. The tool will compute live load distribution factors and both dead loads and live loads. The user specifies design parameters, such as a range for the beam depth, and the tool will determine a strand pattern for either harped strands or debonded strands as specified that satisfies the AASHTO LRFD specification. The user will be presented with one or more beam designs that satisfy the specification and can further refine the design using the tool.

Launch PS Design Tool

The PS Design Tool is installed with the BrDR installation. After the BrDR installation is completed successfully, you can start PS Design Tool by double-clicking the PS Design Tool shortcut icon on your desktop or select Start Menu ► All Programs ► AASHTOWare ► PS Design Tool.



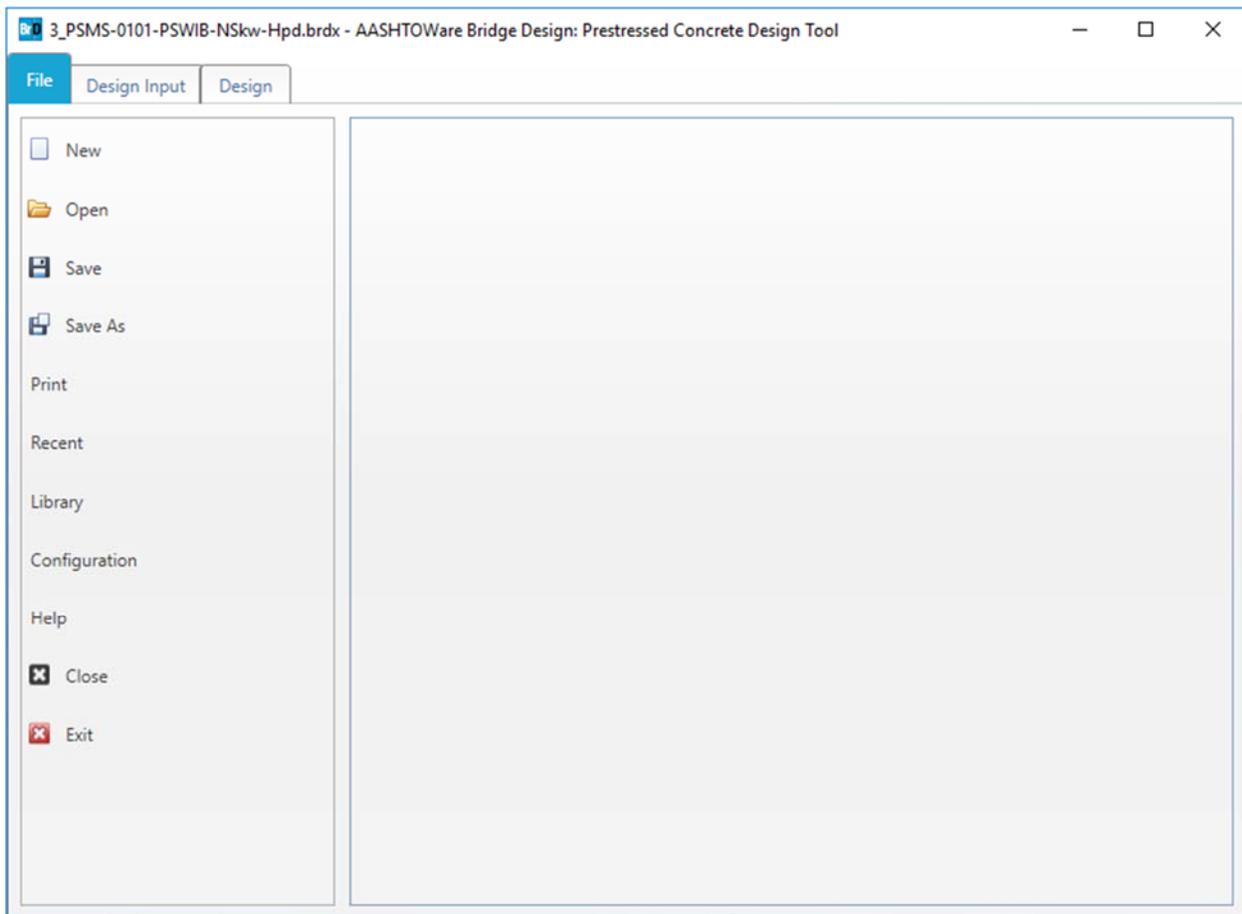
Five PS Design Tool's design project examples are provided with the installation. The design project examples (.brdx) are located in the same folder where the PS Design Tool is installed. The default installation folder is *C:\Program Files\AASHTOWare\BrDR68\PsDesign*. The following table describes the five design project examples.

Design Project Examples					
File name	1_PSSS-0005-PSBB-NSkw-Hpd.brdx	2_PSMS-0116-PSNIB-Skw-Dbd.brdx	3_PSMS-0101-PSWIB-NSkw-Hpd.brdx	4_PSSS-0012-PSTB-Skw-Dbd.brdx	5_PSSS-0001-PSWIB-NSkw-Hpd.brdx
General Description					
Basic beam type	Box beam - adjacent rectangular void	I beam - narrow top flange	I beam - wide top flange	Tee beam - double stems	I beam - wide top flange
Simple or continuous	Simple	Continuous	Continuous	Simple	Simple
Number of spans	1	3	3	1	1
Number of beams	10	4	4	6	4
Girder spacing (ft)	4	12	12	5	7
Skewed	No	Yes	No	Yes	No
Composite	Yes	No	Yes	Yes	N/A
Deck included in beam	No	No	No	No	Yes
Strand layout	Harped	Straight/Debonded	Harped	Straight/Debonded	Harped
Loading					
Live load	HL-93	HL-93	HL-93	HL-93	HL-93
Pedestrian load	No	No	No	No	No

Quick Tour

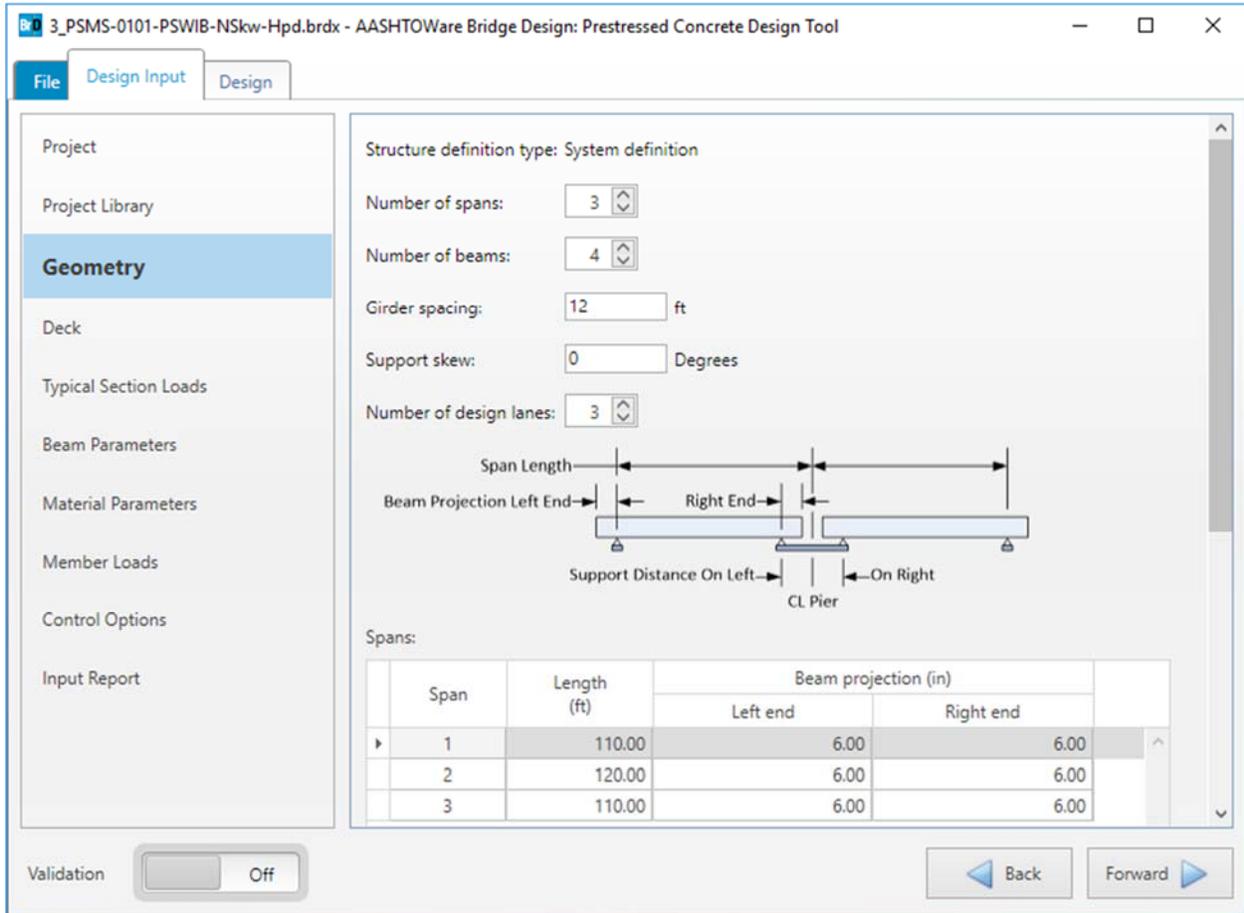
Launch PS Design Tool and select Open on the File tab. Open the 3_PSMS-0101-PSWIB-NSkw-Hpd.brdx file provided with the installation.

The PS Design Tool user interface is composed of the File, Design Input and Design tabs.



The **File tab** is used to create new design projects, open existing design projects and save the current design project. **Print** allows you to send the design project to the printer. **Recent** shows a list the recently opened design projects for easy access. **Library** allows you to manage the appurtenances, materials, prestress beam shapes and vehicles for use in the design projects. **Configuration** allows you to set the configuration of new design project. **Help** provides access to the PS Design Tool Help and technical support information.

Select the Design Input tab.

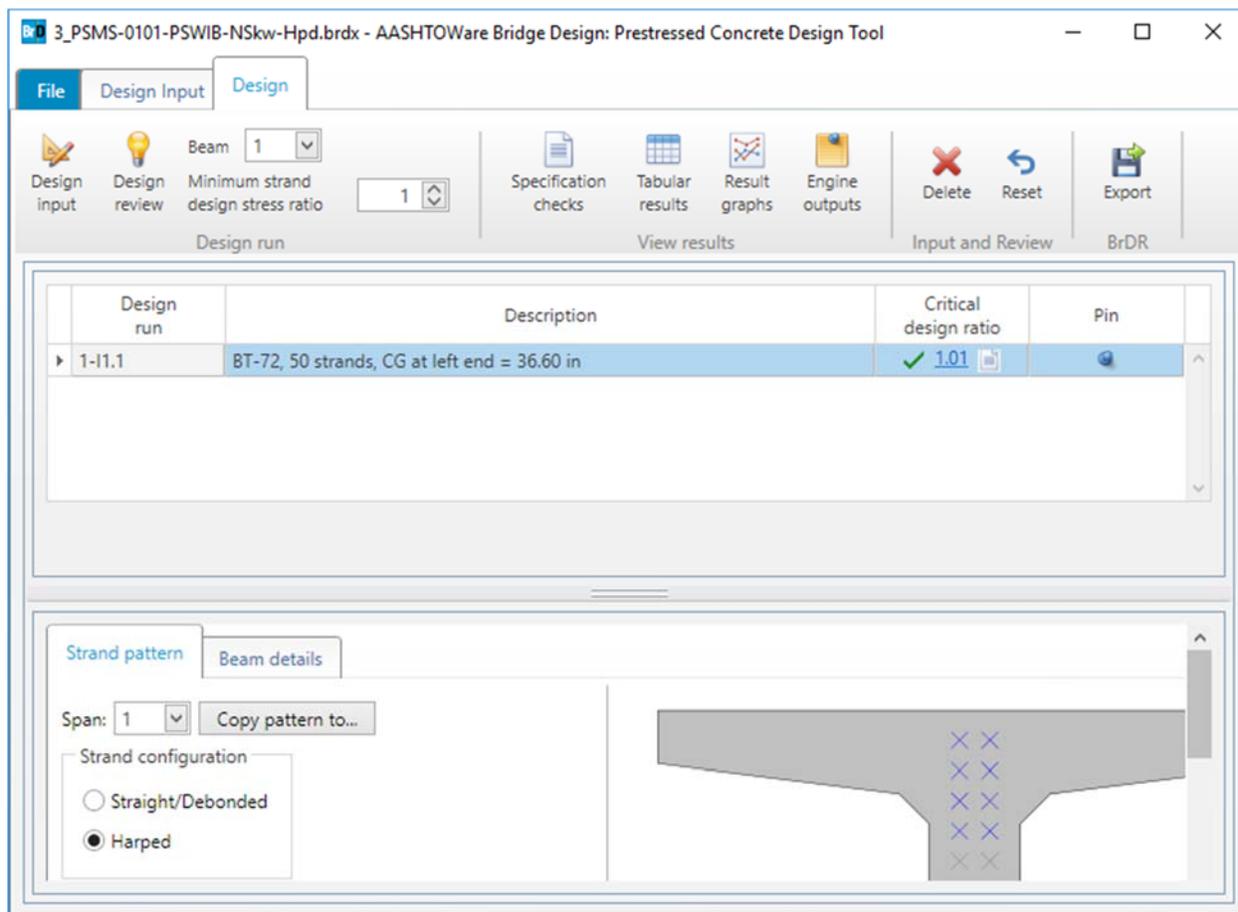


The **Design Input tab** is composed of the Project, Project Library, Geometry, Deck, Typical Section Loads, Beam Parameters, Material Parameters, Member Loads and Control Options input groups and the Input Report. The data entered in these input groups are the design inputs and parameters of the design project. The **Input Report** reports all the design input data.

Select each of the design input groups to review the design input data.

Validation allows you turn on and off the on-the-fly design input validation. **Forward** and **Backward** provides navigation among the input groups.

Select the Design tab and click on the Design input button  to kickoff a design input run.



The **Design tab** is composed of the Design ribbon, Design Run table and Design Review data.

The **Design ribbon's Design run group** is used to kickoff a design run. A design run can be either a design input run or a design review run.

The **Design Run table** presents the beam designs for the design runs. Design run 1-11.1 signifies the beam design is for Beam 1, Design input run 1 and Iteration 1.

Click on the  icon next to the critical design ratio to review the Specification Checks Summary.

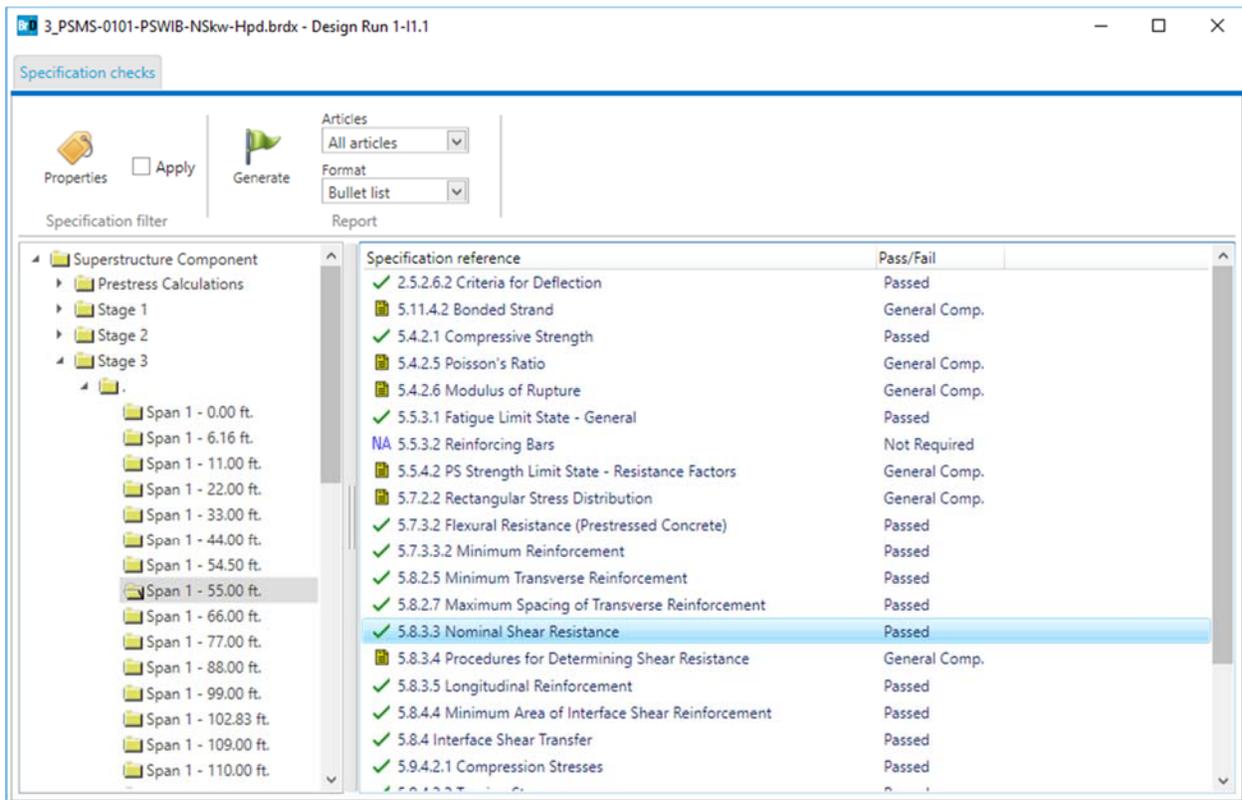
The **Design Review data** represents the beam details and strand pattern of the selected beam design in the Design Run table. Each beam design in the Design Run table represents a set of Design Input data and a set of Design Review data.

Review Design run 1-I1.1 beam details and strand pattern.

Design input run uses the Design Input data to perform design optimization for the selected beam and the specified minimum strand design stress ratio. When a design input run is completed successfully, one or more beam designs will be presented in the Design Run table. **Design review** run uses the Design Input data and Design Review data to perform design review for the selected beam. When a design review run is completed successfully, one beam design will be presented in the Design Run table.

The **Design ribbon's View results group** is used to open the specification checks, tabular results, result graphs and engine outputs on the Results window for the selected beam design in the Design Run table.

Select Design run 1-I1.1 and click on the Specification checks button to open the Specification checks tab on the Results window. Double-click on the specification articles to review the detail specification checks.

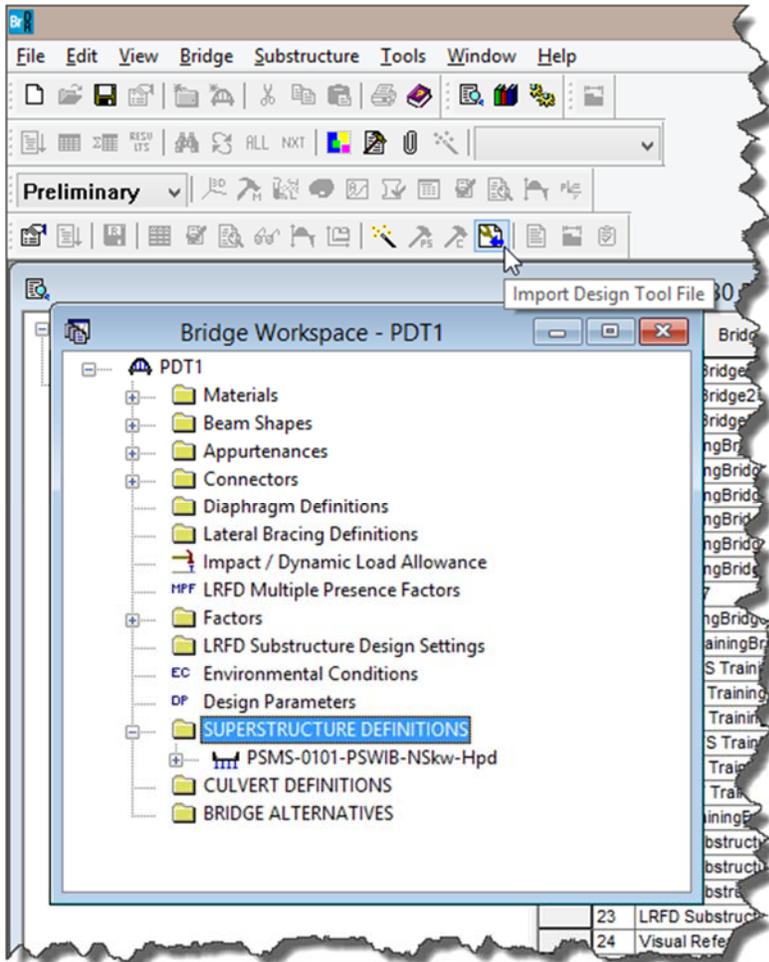


Click on the Tabular results button, Result graphs button and Engine outputs button to open the corresponding tabs on the Results window.

The **Design ribbon's Input and Review group** and **BrDR group** are used to manage the Design Input data and Design review data of the selected beam design in the Design Run table.

Click on the Export button to export the beam design to a Bridge Design Input file (.brdi).

Launch BrDR and select File ► New ► New Bridge to create a new bridge. Enter PDT1 as the Bridge ID and NBI Structure ID. Click OK to close the Bridge Description window. Select SUPERSTRUCTURE DEFINITIONS in the Bridge Workspace and click on the Import Design Tool File button on the Bridge Workspace toolbar. Select Design run 1-I1.1 Import and click on the Import button to import the beam design into BrDR.

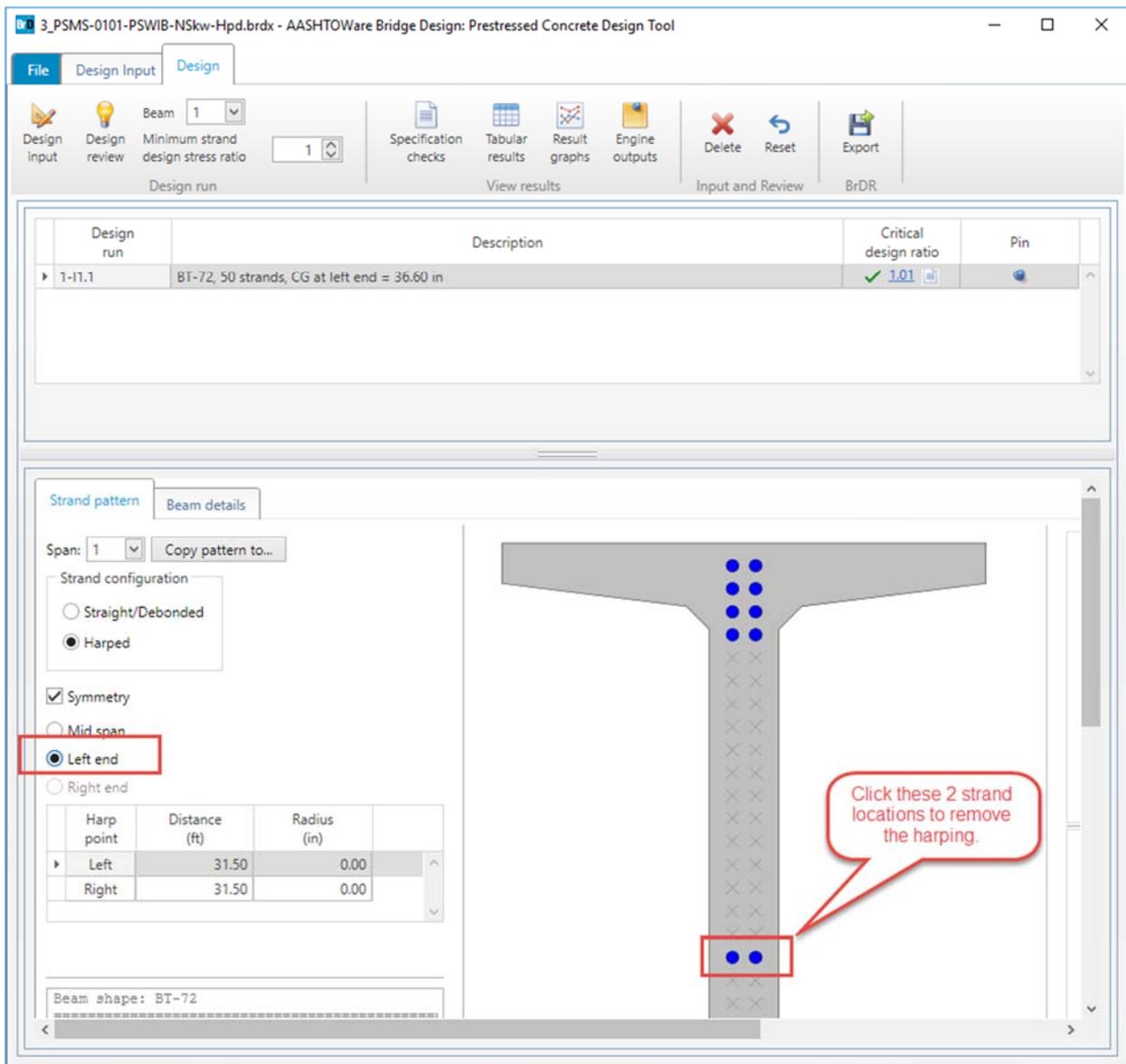


Design Review

After the PS Design Tool has generated a beam design, you can modify the generated design on the **Strand pattern** and **Beam details** tabs and do a Design Review to evaluate your changes.

Modify the designed strand pattern by selecting the Left end strand location and removing the bottom 2 harped strand locations.

Click the Design Review button to launch a Design Review of this beam with the modified data.



PDT1 - Getting Started with Prestressed Concrete Design Tool

The results of the Design Review run are shown below.

The screenshot displays the software interface for the Prestressed Concrete Design Tool. The top menu bar includes 'File', 'Design Input', and 'Design'. Below the menu is a toolbar with icons for 'Design input', 'Design review', 'Minimum strand design stress ratio' (set to 1), 'Specification checks', 'Tabular results', 'Result graphs', 'Engine outputs', 'Delete', 'Reset', and 'Export'. The main workspace is divided into two sections. The upper section contains a table of design runs, and the lower section shows a 'Strand pattern' configuration and a beam diagram.

Design run	Description	Critical design ratio	Pin
1-I1.1	BT-72, 50 strands, CG at left end = 36.60 in	✓ 1.01	📌
▶ 1-R1.1	BT-72, 50 strands, CG at left end = 36.60 in	✗ 0.99	📌

Strand pattern configuration:

- Span: 1
- Strand configuration:
 - Straight/Debonded
 - Harped
- Symmetry
- Mid span
- Left end
- Right end

The beam diagram shows a T-shaped cross-section with 50 strands (represented by 'x' marks) arranged in a harped pattern. The 'Initial stress check' graph plots Stress [ksi] against Location [ft], showing a fluctuating stress profile between 0 and -2 ksi over a 200-foot span.

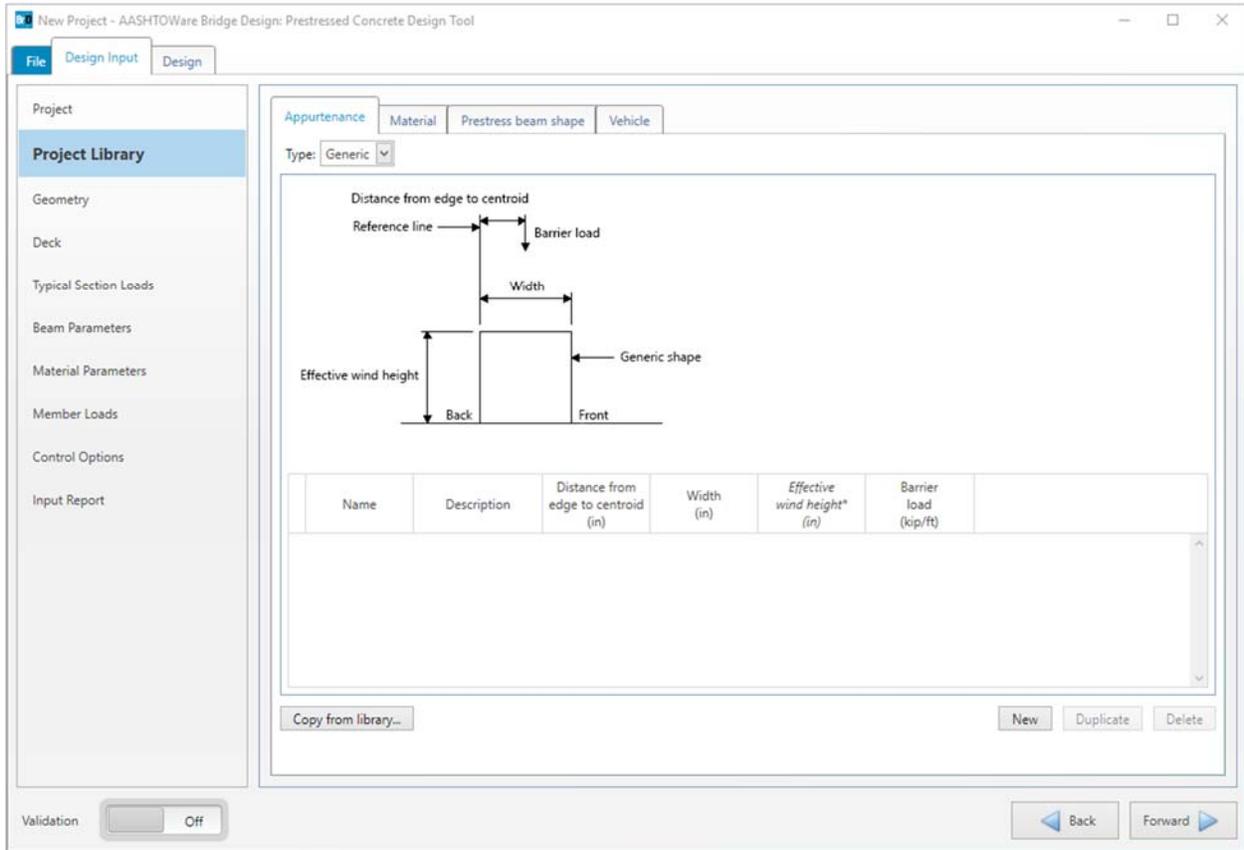
Library

The PS Design Tool comes preloaded with the Library items that are delivered with BrDR. The **Import** button allows you to import library items, such as agency materials, vehicles, etc., that were exported from the BrDR library. Library items can also be entered manually.

Name	Description	Library type	Distance from edge to centroid (in)	X1 (in)	X2 (in)	X3 (in)	Y1 (in)	Y2 (in)	Y3 (in)
Jersey Barrier	Standard New Jers...	Agency Def...		12.0000	2.0000	7.0000	0.0000	19.0000	10.0000

Project Library

The Project Library contains the library items to be used by a particular project. Library items can be copied from the PS Design Tool library or entered manually.



Design Algorithm

The Prestressed Concrete Design Tool estimates the strand layout based on a simple span analysis of the span. Design of beams for structures made continuous for live load is performed by starting with the first span and continuing with the second, then third, etc. For multi-span structures, the design tool will choose the same depth beam for each structure. For example, if a beam passes the first span, but then a subsequent span fails, the design tool will continue incrementing the beam depth until successful designs are found for all spans or no designs are found. The Prestressed Concrete Design Tool only computes the strand layout based on the actual and allowable stresses at discrete locations along the span and considers the longitudinal reinforcement check when considering the adding of strands.

The Prestressed Concrete Design Tool first computes the required number of strands by solving two equations for stresses. The first equation is for the initial tensile stress in the top fiber at the harp point location if harped or at a distance equal to the transfer length from the end of the beam if the strands are straight/debonded. The second equation is for the final tensile stress in the bottom fiber at the point of maximum live load moment in the simple span due to the chosen design vehicle (typically HL-93). These two equations are solved using the allowable stress values and assumed loss values. The calculations are iterated until the assumed loss values equal the actual loss values within a given tolerance. The loss values are computed using the chosen loss method.

The next step the Prestressed Concrete Design Tool performs is to compute the required design eccentricity. The required design eccentricity is estimated by solving several equations for stresses. The minimum eccentricity is computed as the maximum of the following:

- Eccentricity based on final tensile stress in the bottom fiber at the point of maximum live load moment.
- Eccentricity based on final compressive stress in the top fiber at the point of maximum live load moment.
- Eccentricity based on final compressive stress in the top fiber due to dead load and prestress force at the point of maximum live load moment.

A preliminary strand pattern is found to satisfy this minimum eccentricity. If necessary, strands are added to the pattern until a strand pattern that satisfies the minimum eccentricity requirements is found.

The maximum eccentricity is then computed as the minimum of the following:

- Eccentricity based on initial tensile stress in the top fiber at the harp point if harped or at a distance equal to the strand transfer length from the end of the beam if straight/debonded strands are used.
- Eccentricity based on initial compressive stress in the bottom fiber at the harp point if harped or at a distance equal to the strand transfer length from the end of the beam if straight/debonded strands are used.
- Eccentricity based on final compressive stress in the bottom fiber due to dead load and the prestressing force at the harp point if harped or at a distance equal to the strand transfer length from the end of the beam if straight/debonded strands are used.

- When computing the debonding maximum eccentricity at the transfer length, the value for the prestressing force is reduced by the maximum amount of debonding percent input by the user. This assumes that later in the design process that the algorithm will reduce the prestressing force by that amount.

If the strand pattern found to satisfy the minimum eccentricity produces an eccentricity greater than the maximum eccentricity computed above, the strand pattern is adjusted to produce an eccentricity falling between the minimum and maximum eccentricities. This is done by trying to pull some of the bottom strands up higher in the strand grid.

For a harped strand configuration, the required eccentricity at a distance equal to the strand transfer length from the end of the beam is computed as the minimum of the following:

- Eccentricity based on initial tensile stress in the top fiber at a distance equal to the strand transfer length from the end of the beam.
- Eccentricity based on initial compressive stress in the bottom fiber at a distance equal to the strand transfer length from the end of the beam.
- Eccentricity based on final compressive stress in the bottom fiber due to dead load and the prestressing force at a distance equal to the strand transfer length from the end of the beam.

An eccentricity at the end of the beam is then computed using interpolation. A harped strand pattern is then found to produce this required eccentricity at the end of the beam. The harped strand pattern is found by moving strands up in such a way that they are balanced around the center of the beam. The user may input the minimum distance from the beam top to the highest harped strand and the maximum number of strands that may be harped. Only strands that can be harped to the top of the beam will be moved. For example, for box beams, strands that would encroach on the void will not be harped. Only strands in the box beam webs will be moved.

For debonded strand patterns the user input values of maximum bonding percentage, maximum debonded strands percentage per row, and the maximum number of debonding cutoff locations are used to determine the debonding pattern. The following debonding procedure is used:

- After a mid-span strand pattern has been determined, the top tensile stresses are checked by incrementally stepping from the mid span back to the support and checking the initial top tensile and compression stresses at each location. If the check fails, that location is marked and is then considered the last debonding location.
- Debonding locations are then developed by dividing the distance from the end of the beam to the determined final debonding location by the maximum number of debonding locations input by the user. If the distance between debonding locations is less than the transfer length, the number of debonding locations is reduced.
- Starting with the location at the transfer length, a debonding pattern is developed. The user input maximum percent debonding per row is used to establish the number of strands per row can be debonded. The maximum debonded strands percentage is used to determine the overall number of strands that can be debonded.

- Debonding strands are placed first in the bottom most row until all available strands are debonded, after which the algorithm moves to the next row. This process is repeated until a pattern is found to satisfy the initial stresses or the maximum number of debonded strands is reached.
- This process is repeated until a debonding pattern is found for all debonding locations.

For both harped and debonding, if a strand pattern cannot be found at mid span, the last strand pattern tried is returned to the user. For both harped and debonding, if an end strand pattern cannot be found, the last end pattern attempted is returned to the user. The user can work with this pattern in a design review process to try to determine if a pattern will work.

During the checking of all stresses, the losses are computed using the LRFD specification articles specific to the user input loss method.

Once a mid-span and end strand pattern have been determined, the losses and stresses at release and final load are then recalculated with these final strand patterns. The longitudinal steel article is checked and if it fails additional strands are added to the pattern.

The Prestressed Concrete Design Tool will also calculate vertical shear reinforcement ranges based on the vertical shear reinforcement criteria input by the user. Shear ranges are developed by calculating the stirrup spacing required at 10th points and critical locations and determining ranges of stirrup spacing from the design.

Once the strand pattern has been developed and the stirrup ranges have been created, the specification articles are checked for all of the points of interest.