

STRUCTURAL CONCRETE SOFTWARE SYSTEM

# **ADAPT-FLOOR PRO 2019**

## **TENDON MODELING SUPPLEMENTAL MANUAL**










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**INTRODUCTION**

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## 1. INTRODUCTION

This supplemental manual provides descriptions and instruction on ADAPT-Floor Pro's new and improved tendon modeling and tendon display features. These improvements have been introduced to increase productivity and efficiency in tendon modeling, modification, and optimization for new or existing models with post-tensioning.

In addition to linear representation of tendons, Tendons modeled can now be represented in ADAPT-Floor Pro using spline functionality. True tendon shape and curvature, both in- and out-of-plane, are captured analytically and graphically for solution and construction document accuracy. Tendon spline functionality allows users to easily model and adjust tendon swerve and span points. Tendons can be easily edited for control point heights in plan, slab anchorage angles, among other added tendon modeling improvements. The user has tendon display settings control and can revert back to linear representation and modeling of tendons if required.

Further to linear and spline representation of tendons, in ADAPT-Floor Pro 2019 and later versions the user can represent tendons with the new fillet functionality. More information on the fillet tendon representation can be found in the ADAPT-Builder 2019 New Features Supplement.

One of the most exciting new features added to ADAPT-Floor Pro is the addition of the Tendon Optimizer. ADAPT's Tendon Optimizer is a tool that calculates and optimizes the total PT force for pre-compression, load balancing and stress for a group of distributed or banded tendons for an individual span. The Tendon Optimizer increases the productivity of the engineer performing the design as well as aids engineers in developing a truly optimized tendon design based on their tendon layout.

The following chapters will provide an overview of the new improvements to tendon modeling and describe their use. In addition, this manual will cover the use of the Tendon Optimizer. With the addition of these added features the user is able to model, design, and revise designs in a more efficient and effective manner than previously possible in ADAPT-Floor Pro.





## **TENDON MODELING IMPROVEMENTS**

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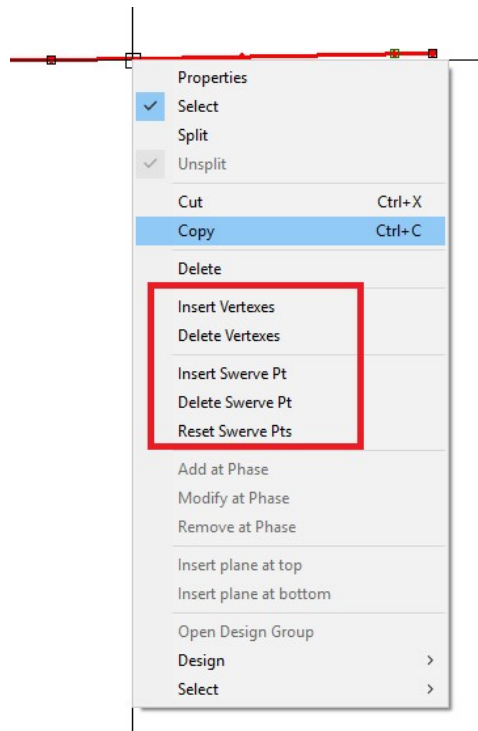
## 2. TENDON MODELING IMPROVEMENTS

### 2.1 Insert Point (Vertex)

Using the Insert Point tool, the user now can add a vertex to a tendon. In previous version of ADAPT-Floor Pro, a span added to a tendon was done by going to the tendon properties and adding either a start or an end span. Using the same insert vertex tool that worked previously for support lines, slab regions, openings or CAD line components, among others, the user can now insert a point along a tendon.

To insert a vertex on a tendon:

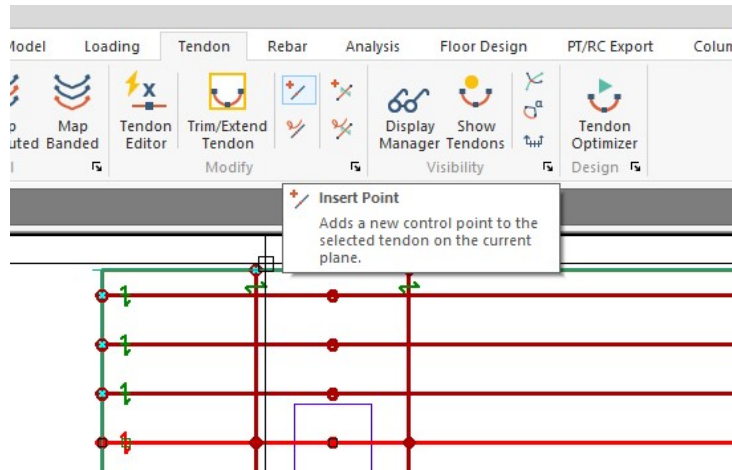
- Select the tendon
- Right-click to get the right-click menu
- Select 'Insert Vertex'



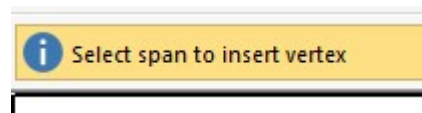
Or,

- Select the tendon

- Go to the ribbon: *Tendon* → *Modify* → *Insert Point*



Either method will put the program into the 'insert vertex' mode. You can see in the User Information Bar that you are prompted to select a span to insert a vertex to.



To insert a vertex on the tendon:

- Click one of the existing vertexes of the tendon. The new vertex will be added at the center of the span toward the terminal end of the tendon, unless you select the terminal end, then it adds the vertex to the center of the last span.

Or,

- Click on the span line between existing vertexes. This will add the new vertex to the selected span.

You can add as many vertices as you like in 'Insert Vertex' mode. Esc or Exit to get out of 'Insert Vertex' mode. You cannot add a vertex to a span that has a swerve point (except the auto swerve points on the ends). The program will ask if you want to delete all the swerve points in the span or cancel the insertion. If you select 'Yes', the swerve points in that span will be removed and the vertex insertion will proceed.

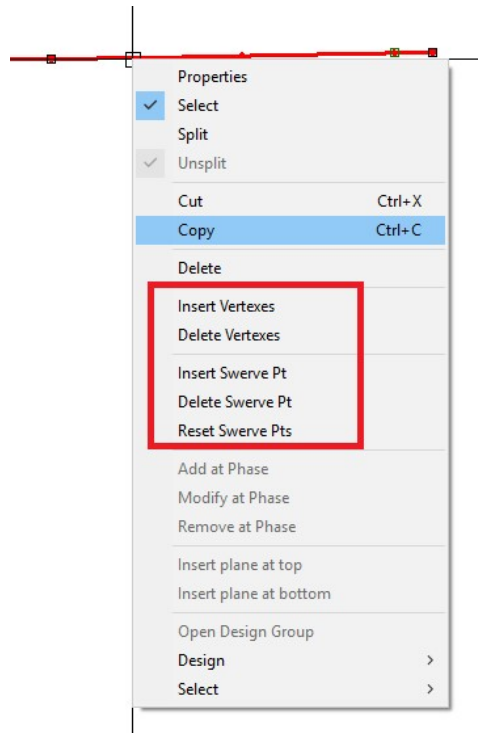
NOTE: The 'Insert/Delete Vertex' right click menu options will appear on the right click menu when other graphical entities are selected.

## 2.2 Remove Point (Vertex)

Similar to the Insert Vertex tool, improvements were made for the ability to remove a vertex on tendons. This effectively removes all spans attached to the vertex and replaces the span with a new 'Typical' span.

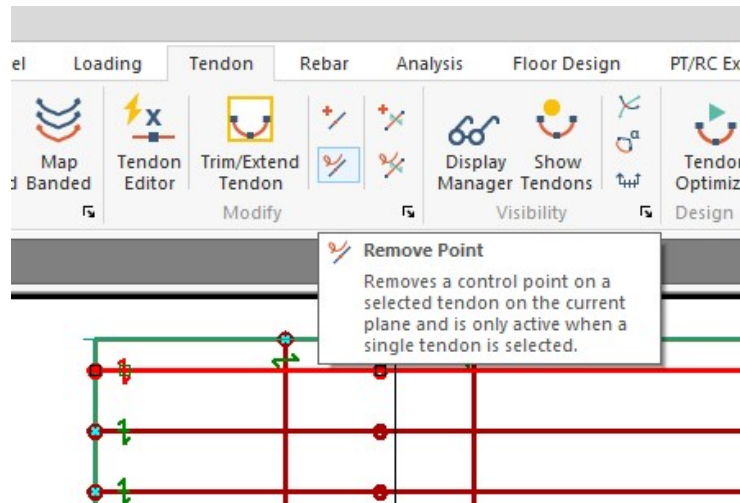
To delete a vertex on a tendon:

- Select the tendon
- Right-click to get the right-click menu
- Select 'Delete Vertex'



Or,

- Select Tendon
- Go to the ribbon: Tendon → Modify → Remove Point



Either method will put the program into the 'delete vertex' mode. You can see in the User Information Bar that you are prompted to select a vertex to delete.



To delete a vertex on the tendon:

- Click one of the existing vertices of the tendon. The vertex will be deleted. You can delete as many vertices as you like in 'Delete Vertex' mode. Esc or Exit to get out of 'Delete Vertex' mode.

NOTE: The 'Insert/Delete Vertex' right click menu options will appear on the right click menu when other graphical entities are selected.

### 2.3 Insert/Delete/Reset Tendon Swerve Points

Swerve points are points that control the shape of the tendon between span end points in the plane of the slab. In effect, they allow for horizontal tendon deviation.

Swerve points are displayed as a green double-arrow symbol. After the swerve points are added, they can be moved when the tendon is selected to change the shape of the tendon in the XY plane, primarily for going around openings and other obstructions, without changing the vertical profile of the tendon. The vertical drape of the tendon between the high points and low points stays the same even when the XY shape of the span is 'swerved'. You can add a maximum of 3 swerve points to a single span.

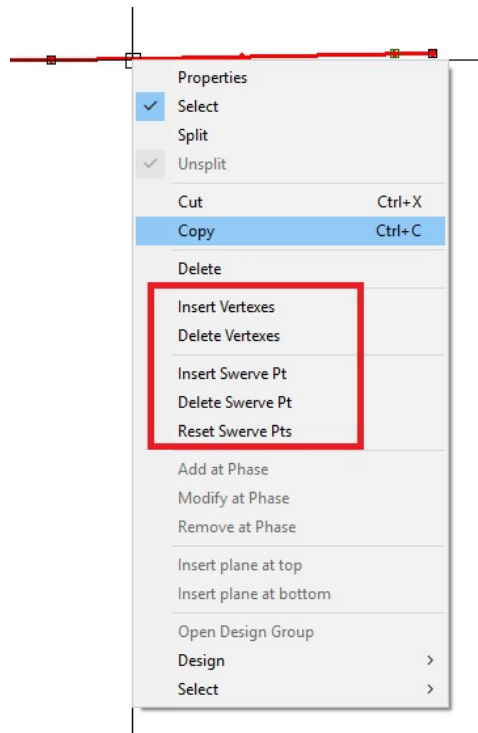


### 2.3.1 Insert Swerve Point



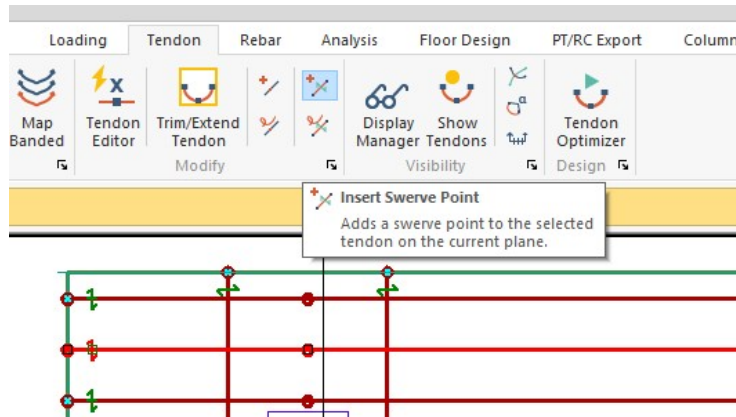
To insert a swerve point on a tendon:

- Select the tendon
- Right-click to get the right-click menu
- Select 'Insert Swerve Point'



Or,

- Select the tendon
- Go to the ribbon: Tendon → Modify → Insert Swerve Point



Either method will put the program into the ‘insert swerve point’ mode. You can see in the Message Bar that you are prompted to select a span to insert a swerve point to.



To insert a swerve point on the tendon:

- Click on the span line between existing vertexes.
- The new swerve point will be added to the span where the span is clicked at.
- You can add as many swerve points to the tendon as you like observing the 3 points per span rule. The user can click Esc or Exit to get out of ‘Insert Swerve Point’ mode.

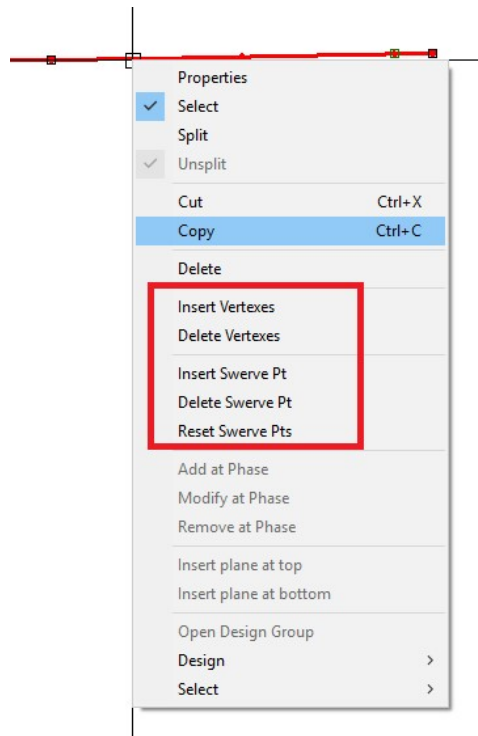
NOTE: The ‘Insert Swerve Point’ right click menu options will appear on the right click menu only when a tendon is selected

### 2.3.2 Remove Swerve Point

To remove a swerve point on a tendon:

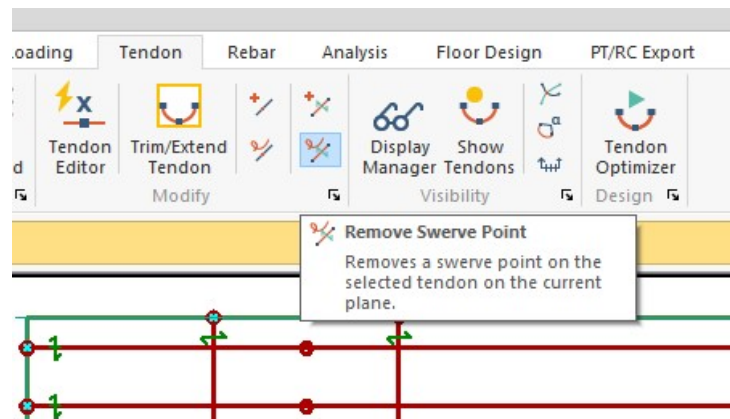
- Select the tendon
- Right-click to get the right-click menu
- Select ‘Remove Swerve Point’





Or,

- Select Tendon
- Go to the ribbon: Tendon → Modify → Remove Swerve Point



Either method will put the program into the 'delete swerve point' mode. You can see in the User Information Bar that you are prompted to select a span to insert a swerve point to.



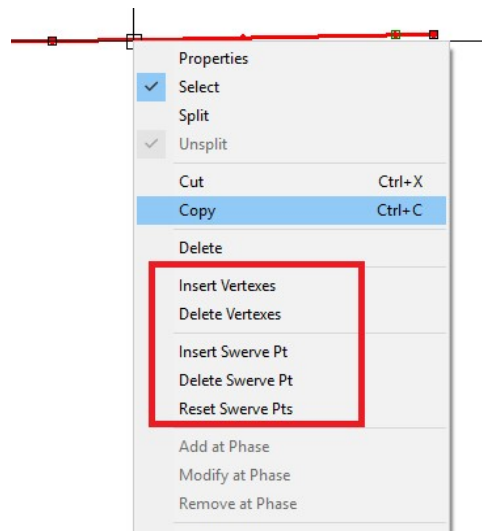
To delete a swerve point on the tendon:

- Click one of the existing swerve points of the tendon. The swerve point will be deleted. You can delete as many swerve points as you like in 'Delete Swerve Point' mode. Esc or Exit to get out of 'Delete Swerve Point' mode.

NOTE: The 'Insert/Delete Vertex' right click menu options will appear on the right click menu when other graphical entities are selected.

### 2.3.3 Reset Swerve Points

“Reset Swerve Points” removes all the swerve points from the tendon except the auto swerve points on the ends. This is used to ‘reset’ the tendon spline representation back to the defined tendon control points.



## 2.4 Tendon Properties – General Tab

### 2.4.1 Stick to Slab Edge Options

There are two blocks of input for tendon end attachments located in the individual tendon properties dialogue window. These inputs are also editable from *Tendon* → *Modify* → *Tendon Editor*. This input section will only be enabled if the tendon mode is set to *Spline* or *Fillet*.

The screenshot shows the 'Tendon 6' dialog box with the 'General' tab selected. The 'Mode' section has 'Spline' selected. The 'First End' and 'Last End' sections are highlighted with a red box. In the 'First End' section, the 'Angle' is set to 90 and 'Auto swerve point' is set to 'Use percentage' with a value of 10.00. The 'Last End' section has the same settings. Other fields include '#: 6', 'Label: Tendon 6', 'Group: Group 1', 'Material: Prestressing 1', 'Area per strand: 0.153 in<sup>2</sup>', 'Tendon/duct height: 0.5 in', and 'Number of strand(s): 1.00'.

Figure 2.4.1-1

**Angle:** The tendon-to-slab edge anchorage angle. The angle is defaulted to 90 degrees (perpendicular). You can change the angle to 60, 45 or 30 degrees or free. The side of slab edge perpendicular line the angle will be drawn will automatically be determined by the program based on which side of the slab perpendicular the interior end of the end span falls. If the tendon end is perpendicular to the slab edge and you change the angle, the program will pick a direction. If it's the wrong direction, go to the Tendon Edit Mode and click that tendon end again to switch direction.

**Auto Swerve Point:** The auto swerve point is added to the end span based on the distance entered in this section of the input. The length can be set as a length or as a percentage of the end span length. This option is only active if the first option is active and selected.

## 2.5 Tendon Properties – Stressing Tab

### 2.5.1 Long-term Stress Losses

When the PT Shop Drawing module is enabled, the program gives new input and functionality for the calculation of long-term losses for unbonded tendons and bonded tendons stressed at the same time. For more information on Long-term stress losses please see the ADAPT-Builder 2019 New Features Supplement manual.

The screenshot displays the 'Stressing' tab in the ADAPT-Builder software. The 'Post-Tensioning Design Option' section has 'Calculate force' selected. The 'Force per strand' is set to 26.700 k. The 'First End' and 'Last End' sections both have 'Live' selected, with 'Seating loss' set to 0.250 in and 'Stress/fpu' set to 0.80. The 'Long-term Stress Losses' section is highlighted with a red box and contains the following options and inputs:

- Long-term Stress Losses**
  - ☒ Estimate long-term loss
    - Long-term Stress Loss Estimate: 10.000 ksi
  - ☐ Calculate long-term loss
    - Type of Strand: ☒ Low-Lax ☐ Stress-Relieved
    - Age of Concrete at Stressing: 5.00 days
    - Concrete's Modulus of Elasticity at Stressing: 1500.000 ksi
    - Relative Ambient Humidity (RH): 80.00 %
    - Volume to Surface Ratio (V/S): 4.00 in
    - Average initial precompression: 0.150 ksi
    - Ultimate Creep Coefficient: 1.60
    - ☒ All tendons stressed at one time

Figure 2.5.1-1

## 2.6 Tendon Properties – Span Tab

### 2.6.1 Harp Shape Control Point Display Location

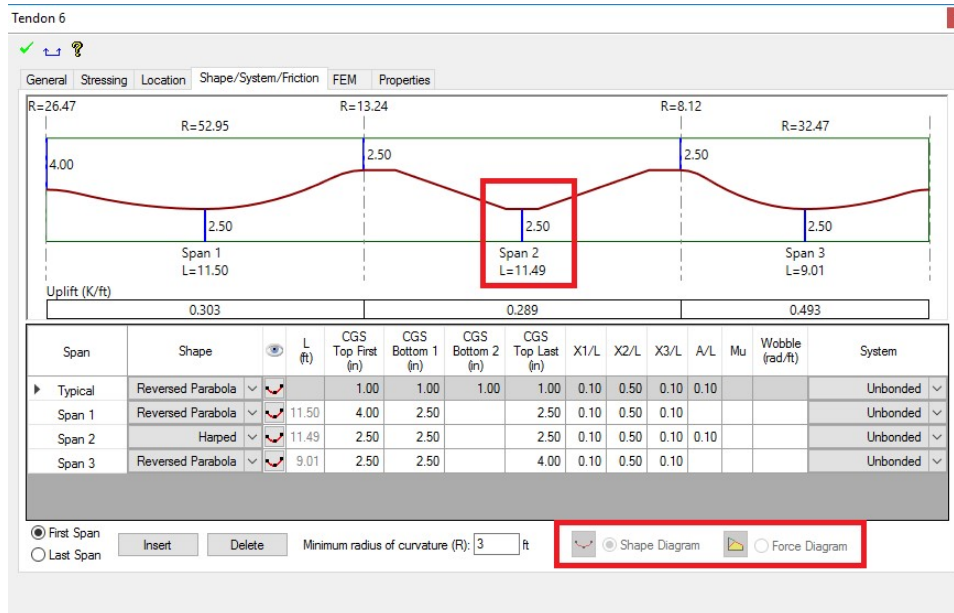


Figure 2.6.1-1

On the harped shape, the blue line that represents X2 was moved to the center of the flat section, representing  $\frac{1}{2}$  the distance of A/L. Previous versions represented this control point at the start of A/L.

### 2.6.2 Shape/Force Diagram Buttons



Figure 2.6.2-1

The icon buttons were replaced with radio buttons and descriptions. The icons remain but to activate them the user would have to click on the radio button in order to see the graph in the window.

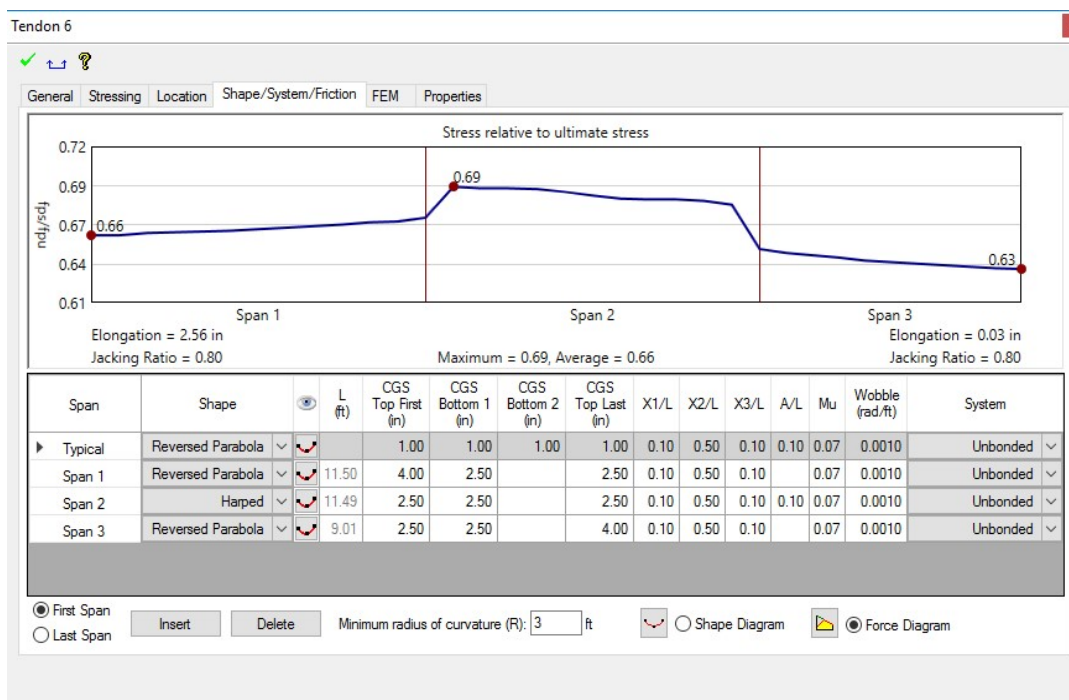


Figure 2.6.2-2

The Force Diagram is only available if “Calculated Force” is selected on the Stressing tab. The Friction and Elongation calculations will be performed when the Force Diagram radio button is selected.

## 2.7 Tendon Properties – Display Tab

The display tab was removed from the tendon properties dialog window. It was no longer necessary after v2017 with the updates to the stressing tab and the tendon display property box.

## 2.8 Tendon Graphic Display

### 2.8.1 Move Handles

The control point handles to move a selected tendon were drawn red in previous ADAPT-Floor Pro versions, the same color as the tendon, making it difficult to see them. The color was changed to ‘White’ on a black background and ‘Black’ on all other background colors to improve visibility.

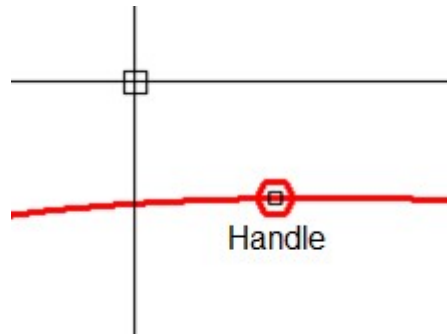


Figure 2.8.1-1

### 2.8.2 Color Coded Control Points

In ADAPT-Builder tendons display color coded control points. The color codes are described below:

- Tendon high points (end of spans) remain red.
- Tendon low points are now drawn dark blue.
- End point of tendons that have been attached to a slab edge are now drawn with a cyan center.
- Swerve points are drawn as a green double-arrow.

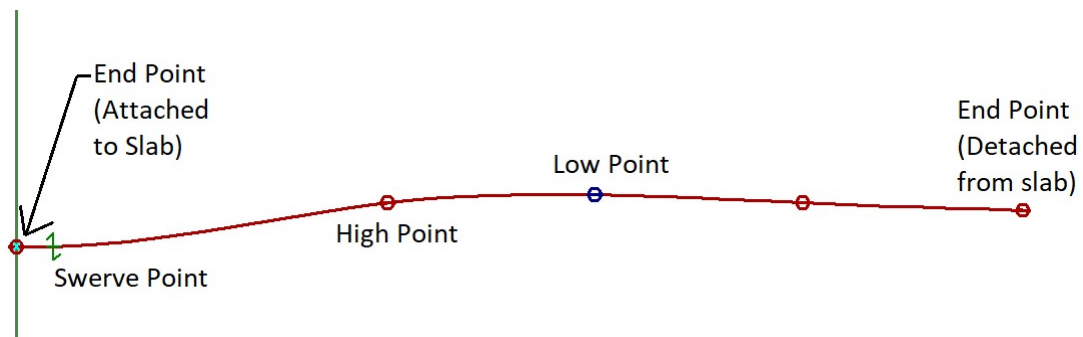


Figure 2.8.2-1

### 2.8.3 3D Control Points

3D control points make it easier to see the control points in side and isometric views (**Fig. 2.8.3-1**). To activate this option, select *Tendon* → *Settings* → *Tendon Settings* (**Fig. 2.8.3-2**) that will turn the display of 3D control points on and off.

NOTE: Performance may be degraded when this option is active on a large file with many tendons on each level.

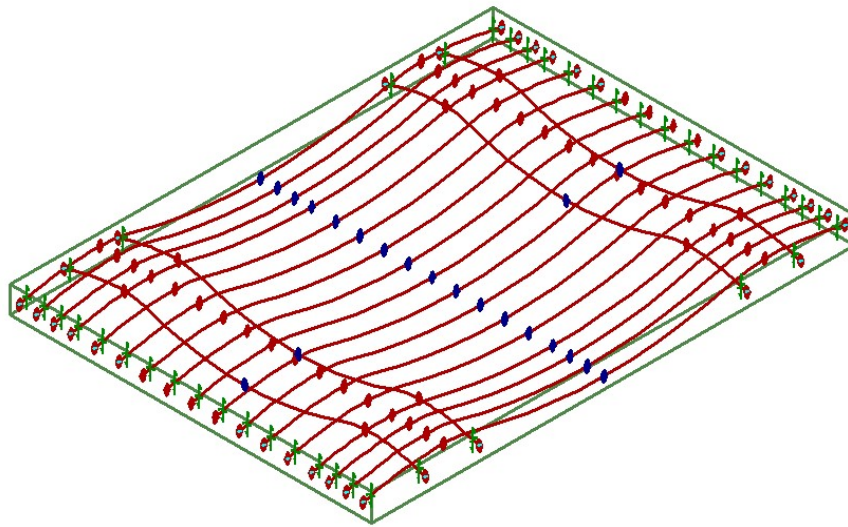


Figure 2.8.3-1

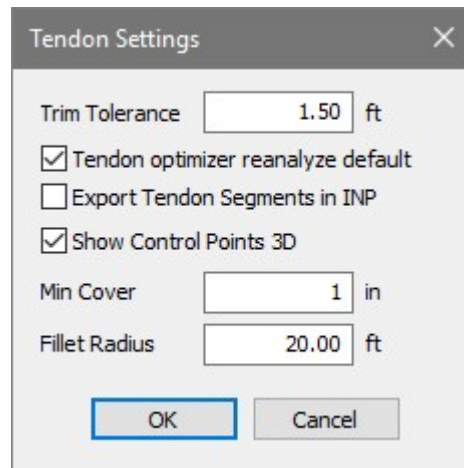
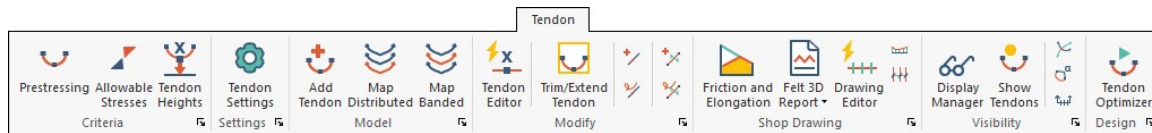


Figure 2.8.3-2



## 2.9 Tendon Ribbon

ADAPT-Builder 2018 introduced a new graphical user interface that is ribbon-based. The tendon ribbon contains all necessary tendon controls and modeling capabilities related to post-tensioning. The latest improvements related to tendon modeling that were introduced in the latest versions are listed below.



### 2.9.1 Tendon Display Options



This tool launches a dialog window that is similar to Tendon Plan Report dialog from *REPORTS* → *Tendon* → *Tendon Plan*. This dialog allows the user to turn on specific data/display items for the tendons without having to go into Tendon Plan Report mode. Clicking the Tendon Eyeglasses button opens the dialog. You can turn on/off various display options. When you click 'OK' the selected display options show up on the screen and the Tendon Eyeglasses button stays clicked. Clicking the Tendon Eyeglasses button again turns off the display of the selected items. Control points and Swerve points are on by default.

**Tendon Display Information**

**Tendon Properties**

☐ Tendon ID

☐ Tendon label

☐ Area

☐ System

☐ Total length (end to end)

☐ Number of strands

☒ Decimal as specified

☐ Rounded Up

☐ Considered or disregarded

☐ Material

**Geometry**

☒ Control points

☐ Control point height

☐ Inflection points

☐ Inflection point height

☒ Swerve points

☐ Shape

☐ Shape Parameters

☐ Radii of curvature - Vert

☐ Tendon out of bounds

☐ Analytic Tendons

**Shop Drawings**

☐ Chair Heights

☐ Concrete length

☐ Length group colors

☐ Bundle symbol

☐ Installation length

☐ Construction Joints

**XY Plane Curvature**

☐ Show Horizontal Curvature Ranges

☐ Show 'OK' range

Spline Slope: < 1:12    1:12 to 1:8    1:8 to 1:3

Fillet Radius: >= 20 ft    < 20 ft    < 10 ft

**Stressing**

☐ Stressing: live, dead ends

☐ Effective force

☐ Total force

☒ Force per strand

☐ Elongation

☐ Calculated force

☒ Average Force

☐ Minimum Force

☐ Maximum Force

OK    Cancel    Reset to Default

Figure 2.9.1-1

These display options are in sync with the Tendon Plan Report dialog and will show whatever settings that are set in the Tendon Eyeglasses dialog and visa-versa. They have been rearranged into more meaningful groups to make it easier to locate and better understand what the options represent.

Some new/modified options were added to the original Tendon Plan Report dialog options:

- **Reset Default Button:** clears all the check boxes except control points and swerve points.
- **XY Plane curvature:** color codes locations on a tendon that exceed curvature ranges so as to indicate locations where special bursting reinforcement is required.

- **Effective Force:** shows effective force values on the tendon, either force per strand or total force. Note this force represents the true force when tendons are entered as decimal input for number of strands. Previous versions would round-up tendon strand quantities to whole numbers.
  - **Total Force:** was on the old report dialog and functioned like a radio button but was a check box. It has been converted to a radio button.
  - **Force per strand:** was on the old report dialog and functioned like a radio button but was a check box. It has been converted to a radio button.
- **Calculated Force:** shows the calculated force values on the tendon as average, maximum or minimum.
  - **Average Force:** The average force calculated for the tendon.
  - **Minimum Force:** The minimum force calculated for the tendon.
  - **Maximum Force:** The maximum force calculated for the tendon.
- **Inflection Points:** shows the inflection points on the tendon for each span in gray.
  - **Inflection Point Heights:** shows the inflection point heights, similar to control point heights. The dimension is measured from the top of slab.
- **Swerve Points:** shows the swerve points on the tendon display.
- **Radius of Curvature – Vert:** option to show the radius of the tendon vertical drape.

### 2.9.2 Display/Hide Radius of Curvature Button

Selecting this button will display the vertical radius calculation results on the display. Clicking the button off will turn off the display of the radius calculations values. This is considered a ‘mode’ and not connected to the display radius in the Tendon Display Options box.

### 2.9.3 Tendon Intersection Detector Button

Selecting this button will display tendon intersections for both the linear representation and the spline representation depending on which mode is selecting in Settings>Tendon Settings. Clicking this button off will turn off the tendon intersections. The intersection is displayed using a magenta X with a circle as shown in the figure below.

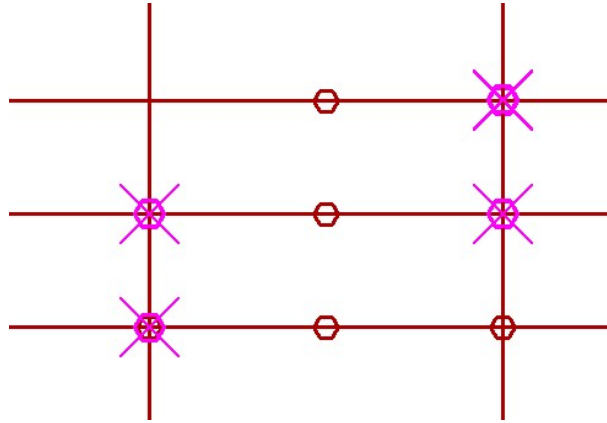


Figure 2.9.3-1

### 2.9.4 Dynamic Tendon Editor

Selecting the *Tendon Editor* button will display a floating dialog window that allows the user to graphically edit properties of tendons: CGS, # Strands, Anchor Angles and Spline Override. The dialog will remain open while in tendon edit mode. You can exit the edit mode by clicking the 'Exit Tendon Editor' button on the floating dialog, pressing the 'ESC' key or right-click Exit.

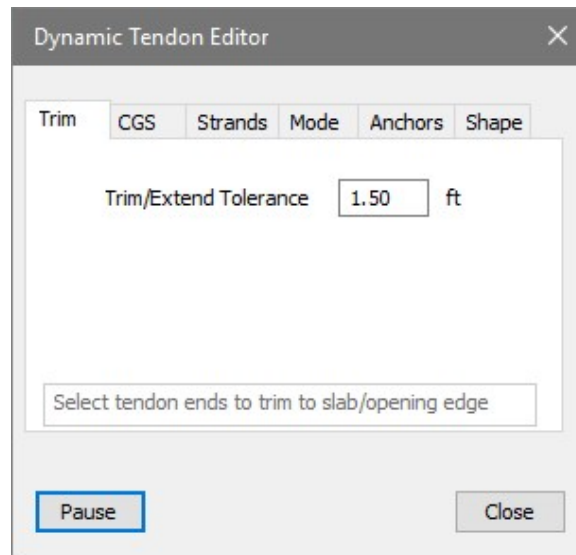


Figure 2.9.4-1

### 2.9.4.1 Selection Features

You can select control points individually, add to the selection with the ctrl key, remove a selection by selecting it again, or use the drag box for multiple selection. If you have selected items and then click anywhere that's not a handle, the selection is cleared. Selections can be across multiple tendons. This applies to all three tabs.

### 2.9.4.2 Trim Tab

The Dynamic Tendon Editor by default opens to the Trim tab. In this tab you can set the Trim/Extend Tolerance. This sets the distance from slab edge that the program will trim or extend tendons to the slab edge within. If the tendon end point is within this distance the program will extend the tendon using the Trim/Extend tendon icon of the Tendon ribbon. If the tendon end point is not within this distance the tendons will be left unchanged.

### 2.9.4.3 CGS Tab

When the CGS tab is selected, the display changes to show the CGS heights from top or bottom so the input

is reflective of the Tendon Property Dialog – Span tab. Each control point has a selection handle and only control points can be selected.

With the ‘Auto Apply on Selection’ check box off, make your selections and click the ‘Apply’ button to change the CGS values.

With the ‘Auto Apply on Selection’ check box on, selecting a control point will change the CGS immediately.

The CGS value is initialized to one inch (1”) or 25 mm depending on the current system of units. Once modified by the user, the box will store the last value entered.

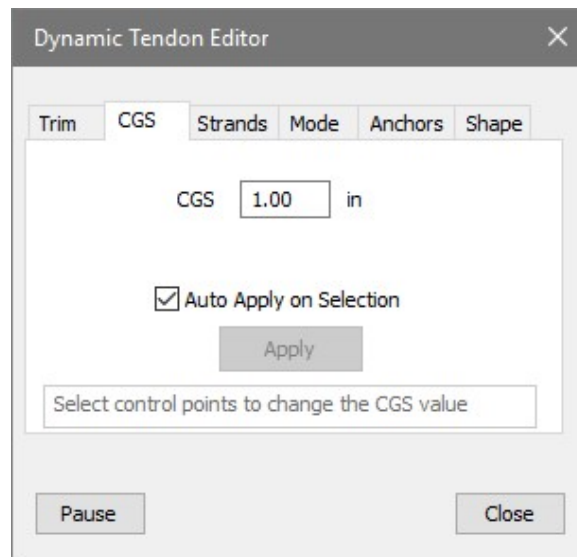


Figure 2.9.4.3-1

#### 2.9.4.4 Strands Tab

With the Strand tab selected, when the Number of Strands radio button is selected, the display changes to display the # of strands label on the tendons and the # of strands symbol on the tendons. Selecting a tendon line will select the tendon for editing.

When the Effective Force radio button is selected, the display changes to display the effective force label on the tendons. Selecting a tendon line will select the tendon for editing.

With the 'Auto Apply on Selection' check box off, make your selections and click the 'Apply' button to change the # of strands value.

With the 'Auto Apply on Selection' check box on, selecting a control point will change the # of strands immediately.

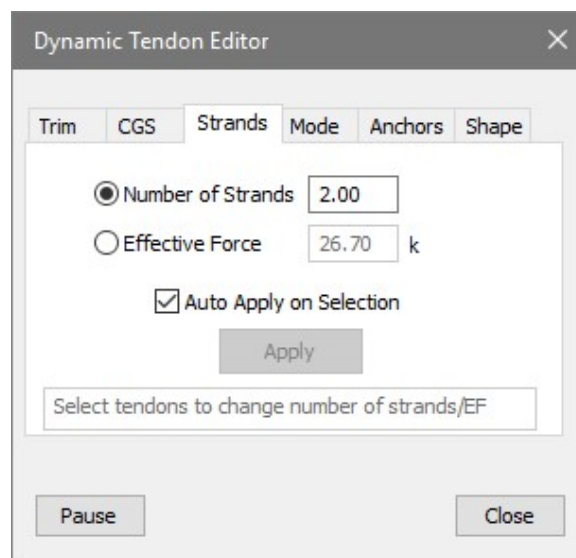


Figure 2.9.4.4-1

### 2.9.4.5 Mode Tab

When the Mode tab is selected, the user can set the radio button and when a tendon is selected the mode of that tendon will change to the selected mode.

If the show fillet details is selected the program will display the circle in which the curvature in the tendons follows.

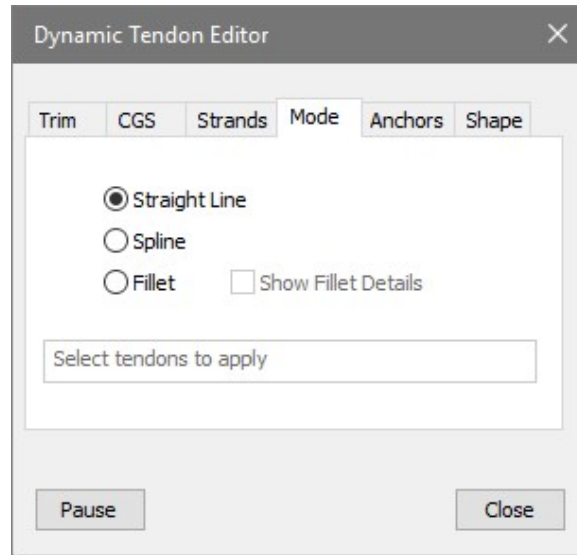


Figure 2.9.4.5-1

#### 2.9.4.6 Anchor Tab

If the model includes tendons that are set to Spline or Fillet mode, tendons will have an automatic swerve point added to force the tendon to be perpendicular to the slab edge. Some anchor systems allow for the tendon to hit lock to the slab edge at a different angle. This tab lets the user change the angle of an attached tendon end to 30, 45, 60 degrees, back to 90 degree, or release the forced angle by selecting 'free'. 'Free results in the auto swerve point falling on the line between the end point of the tendon and the end of the span.

When setting an angle of less than 90 degrees, the program will automatically set it to side of the perpendicular line that the other span end is on. If the line perpendicular to the slab edge is very close to the same as the linear span line, the program will pick one side of the perpendicular or the other. If you want the angle on the opposite side of the perpendicular to slab, click the end point again and the program will switch sides. If the angle is set to an angle less than 90 degrees, moving the first control point from the end of the tendon to the opposite side of the line perpendicular to the slab edge, it will switch the side the angle is on automatically.



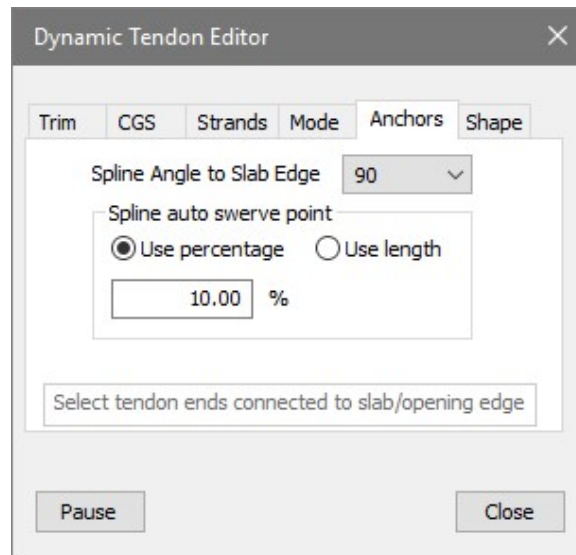


Figure 2.9.4.6-1

### 2.9.4.7 Shape Tab

When the Shape tab is selected, the user can set the End Span Shape using the drop-down dialog box. Set the drop-down box to the end-span shape you would like to implement to the tendon, then drag select the yellow control point at the end span you wish to change the end-span shape of.

With the 'Auto Apply on Selection' check box off, make your selections and click the 'Apply' button to change the end-span shape.

With the 'Auto Apply on Selection' check box on, selecting a control point will change the end-span shape immediately.

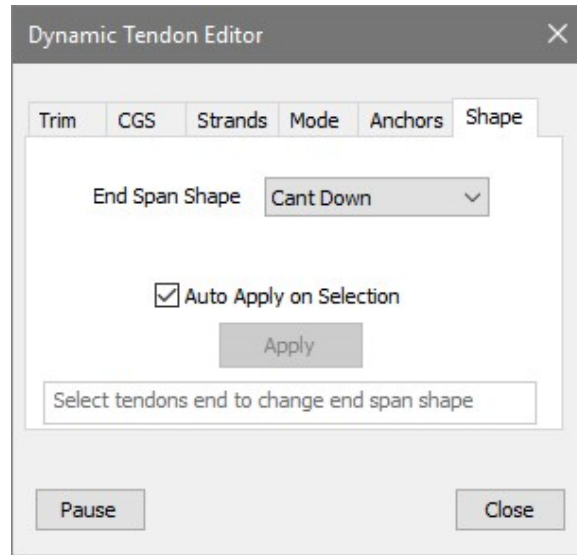


Figure 2.9.4.7-1

## 2.10 Spline Mode

Spline mode is a new way to view and work with tendons. It is a tendon mode that represents tendons as a curved shape reflective of their true shape as placed in the field. Spline mode gives tendons a more realistic appearance and more accurately reflect the tendon's in-plane curvature. All functions related to tendons when in spline mode work with the spline curve so lengths, swerves around openings, tendon intersections, and such will be represented with more accuracy.

By default, tendons are Straight Line tendons when modeled in ADAPT-Floor Pro. The user can modify the model to *Spline* mode through the *General* tab of the tendon properties. The tendon modes can also be modified using through the *Dynamic Tendon Editor* → *Mode* tab.

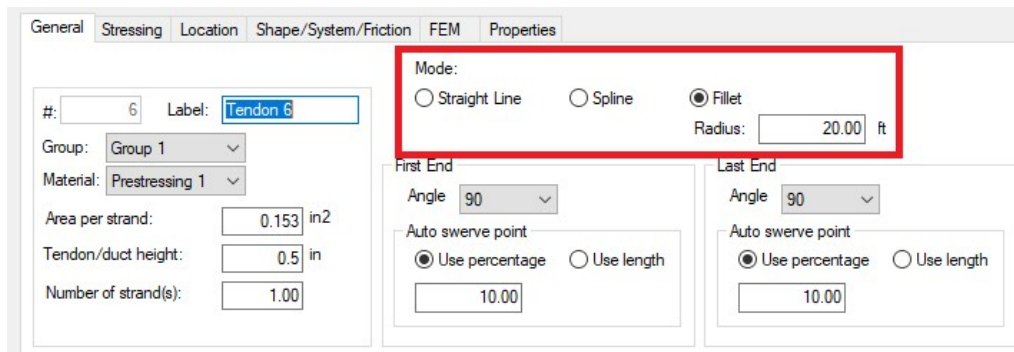


Figure 2.10-1

Changing the setting and closing the dialog will automatically redraw the tendons on the screen in the selected mode, spline or linear.

In spline and fillet tendon modeling mode, the xy shape of the tendon can be controlled with end span points and swerve points. As you create or move points in edit mode, you'll see the shape of the spline change and represented by a green spline so the user can anticipate the final shape. There is a possibility, in spline mode, to move points out-of-bounds which will make the spine invalid. End points and swerve points cannot cross over another end point or swerve point. They have to stay between their adjacent points. If the points go out-of-bounds, the tendon will revert to Straight Line mode.

### 2.10.1 FEM Mesh with Spline Mode

The FEM mesh used to analyze a slab uses the spline shape to calculate intersections between the mesh cells and the tendon. This allows for more accuracy in the analytical representation and ultimate PT solution when splines are used with an appropriately size mesh.

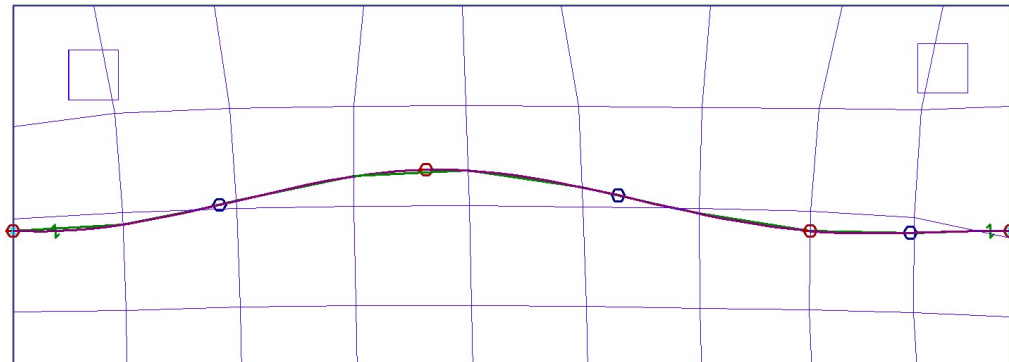


Figure 2.10.1-1

In Fig. 2.10.1-1, the reddish line is the spline line. The green line is the idealized line used for the FEM model.

### 2.10.2 Auto Swerve Points

Auto swerve points are controlled through General tab of the Tendon properties window (individual edit) or through the use of the Dynamic Tendon Editor (group edit).

(a) Tendon Properties – General Tab

(b) Dynamic Tendon Editor – Anchors Tab

Figure 2.10.2-1

Tendons terminating at a slab or opening edge generally require a certain length prior to the termination that is straight to avoid unnecessary curvature. By placing a swerve point near the end of the span, the spline results in straight segments near the tendon anchorage zones. This avoids unnecessary time spent manually drawing very short tendons spans at each tendon end.

If the ‘Automatic swerve pts on ends’ check box is on, whenever a tendon is created, a swerve point will automatically be added to the end of the first and last span near the terminal ends if the tendon end is attached to a slab or opening edge. There are settings on the Tendon Settings dialog that control the distance the auto swerve points are added to the tendon. You can either use a percentage of the tendon length or a given distance. Select the radio button to

choose which measure to use and enter the measurement in the box.

### 2.11 Tendon Trim Tolerance

The tendon trim tolerance was set in an INI file that was not easily accessible in previous versions. The trim tolerance has been moved to the **Tendon Settings** dialog found under *Settings* → *Tendon Settings* as shown in the figure below.

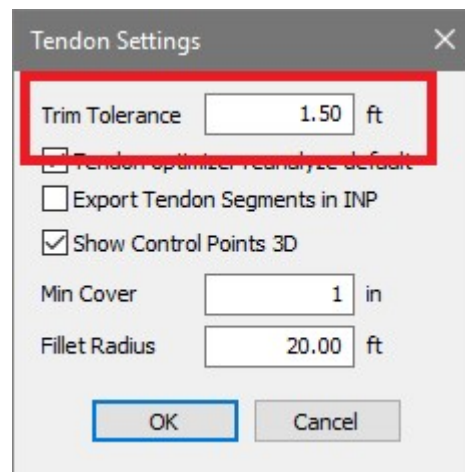


Figure 2.11.4-1

The tolerance only applies to the actual tendon trim action through the trim/extend toolbar button. Tendon tolerance for auto trim is as described above.

### 2.12 Beam Depth on Edge Fix

In previous versions, a transverse beam at a control point would adversely affect the tendon CGS value where the value would be relative to the beam depth, not the slab depth. In the current version any beam that is more than +/-10 deg from parallel to the tendon span will be ignored when calculating the tendon CGS. Beams that are within +/- 10 deg of parallel will be included in the CGS calculation.

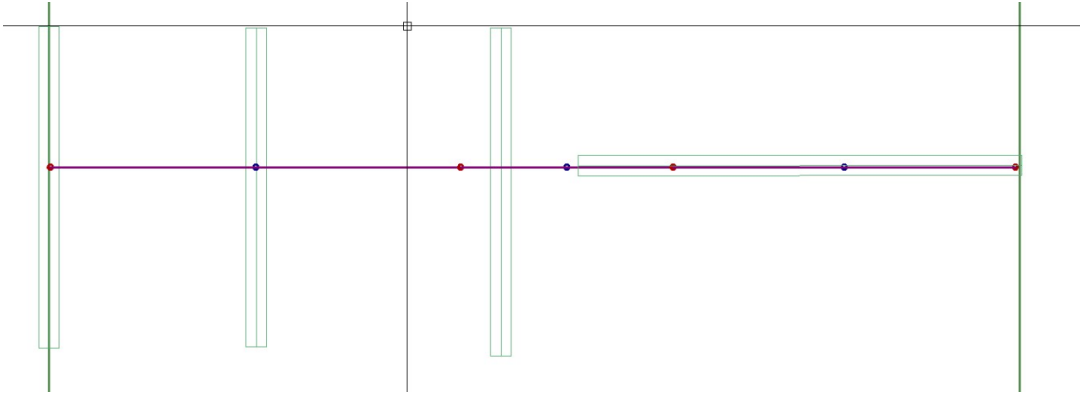


Figure 2.12-1

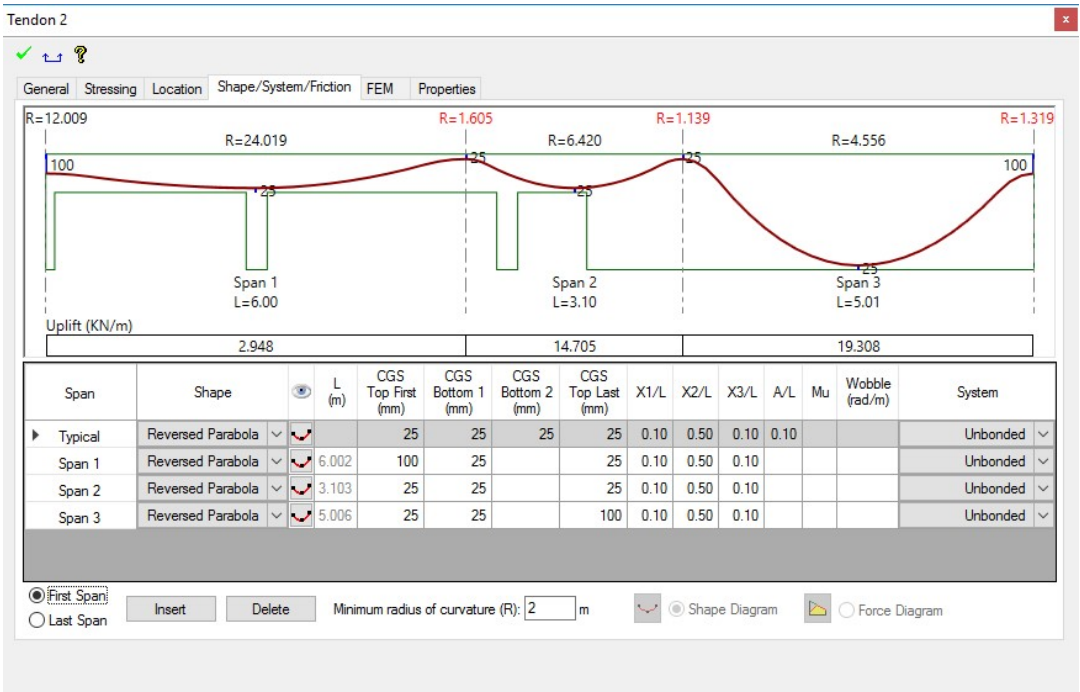


Figure 2.12-2

## **TENDON OPTIMIZER**

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### 3. TENDON OPTIMIZER

#### 3.1 Overview

ADAPT-Floor Pro's Tendon Optimizer is a tool that calculates and optimizes the total PT force for pre-compression, load balancing and allowable tension and compressive stresses for a group of distributed or banded tendons for an individual span. Selecting a group of distributed or banded tendons defines a tributary area and section lines are created at the center of the tributary area as well as near the ends of the tributary area. For banded tendons, the tributary width can be manually entered and the tributary area will be defined. For optimization of banded tendons, the requirement of over-riding the auto-calculated tributary will nearly always be required to accurately represent the full tributary that the banded tendons are intended for.

In order to use the Tendon Optimizer, the model must be meshed and analyzed once. Prior to selecting the tendons to be optimized the user must select the Tendon Optimizer tool  from the Tendon Toolbar. After that any group of adjacent tendons may be selected and viewed in the Optimizer.

Once the tributary area is defined, the program calculates the total effective force, pre-compression along the center section, total strands, average CGS, load balance for the tributary area, and stresses along the three virtual section lines. Note that these section lines are not part of user-defined design strips and are used only for the optimization procedure. If all of these values fall within the user defined ranges no optimization is required. If any of the values fall outside the user defined ranges, then the program attempts to find an effective force that puts all the values into the allowable range. User-defined ranges are set in the "Settings" dialogue window of the Optimizer. The optimized numbers are shown on the screen. If the optimizer cannot find a solution, the user can manually change one of the top three values and recalculate the solution. Once a solution is found, press the Apply button to update the number of strands and CGS values for the selected tendons.

Tendon Optimizer has 4 tabs: Optimizer, Details, Settings and Calcs. The **Optimizer** tab shows the basic data related to optimization in tabular and graphical format. The **Details** tab shows detailed tabular data related to the optimization (**Figure 3.1-1**). The **Settings** tab allows the user to set allowable ranges for pre-compression and load balance, tributary width

override and positioning of end section lines, format for the stress values. The **Calcs** tab shows the intermediate calculations used in the optimization process (Figure 3.1-2).

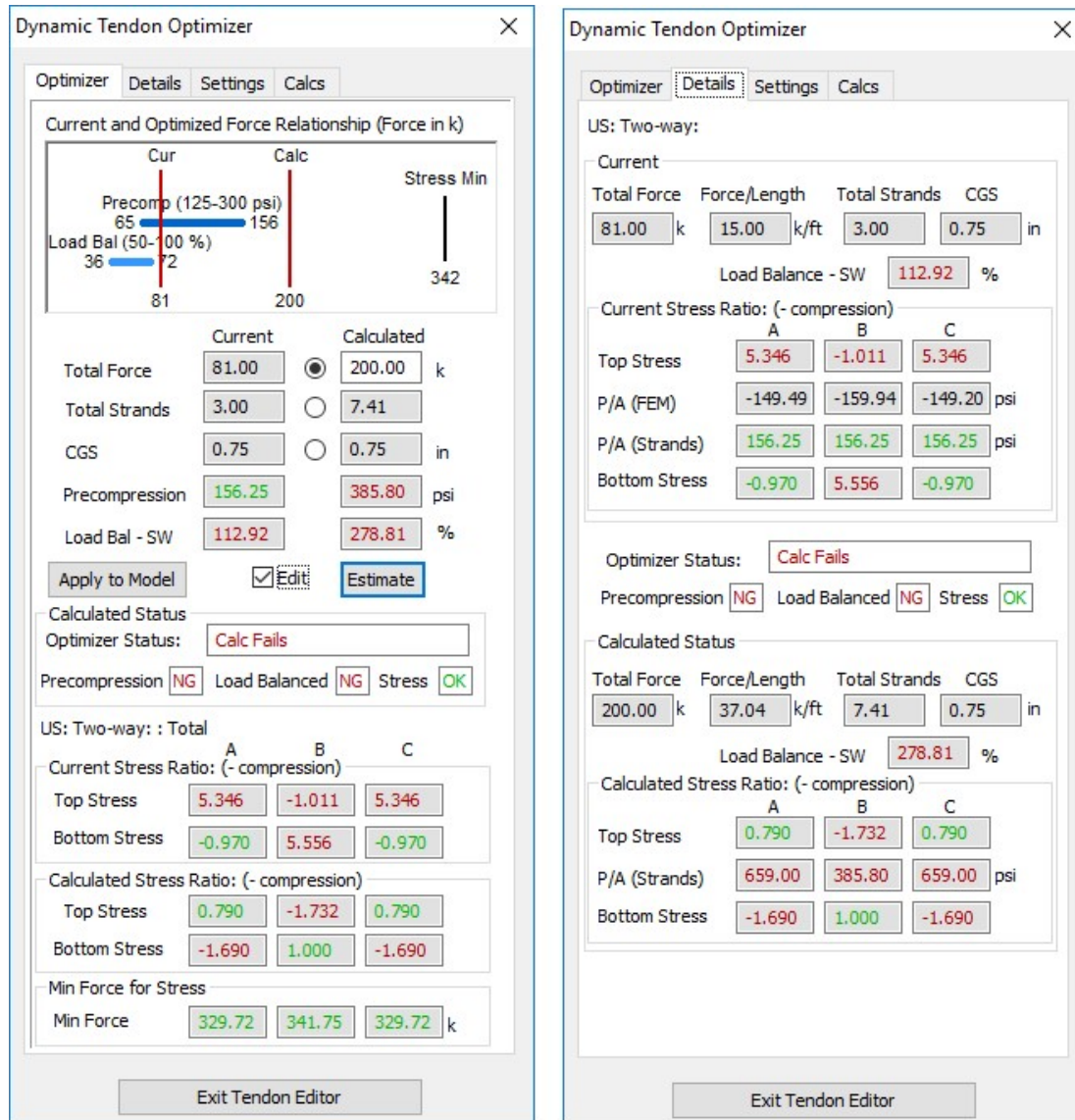


Figure 3.1-1

**Dynamic Tendon Optimizer - Settings Tab**

**Trib Width Settings**

Tributary Width: 5.40 ft      End Section Cut % of Span: 5.00 %      [Update]

**Display Settings**

Load to Balance: ☒ SW      ☐ SW+DL

Stress Value Format: ☒ Ratio      ☐ Factored      ☐ Actual

**Desired Ranges**

	Min	Max	
Precompression	125.00	300.00	psi
Load Balance	50.00	100.00	%

Load Combination: Service(Total Load) ▼

Criteria: Two-way slab criteria ▼

**Stress Allowables**

US: Two-way: : Total

Top Tension	Bot Tension	Compression
379.47	379.47	2400.02

Optimization Parameters: ☒ Precomp      ☒ Load Balance      ☒ Stress

☐ Use whole number of strands per tendon

[Exit Tendon Editor]

**Dynamic Tendon Optimizer - Calcs Tab**

Unit System: American

**Tributary Area Properties**

Selected Tendons: 3  
 Total Uplift: 14.6 k  
 Total Strands: 3.00  
 Total Effective Force: 81.00 k  
 Average Thickness: 8.000 in  
 Average Length: 24.000 ft  
 Average High CGS: 1 in  
 Average Low CGS: 1 in  
 Self-Weight: 13.0 ksi  
 Self-Weight + DL: 129.6 ksi  
 Section Width A: 5.400 ft  
 Section Width B: 5.400 ft  
 Section Width C: 5.400 ft

**Selected Values**

Selected Total Force: 81.00 k  
 Selected Force/Length: 15.00 k/ft  
 Selected Total Strands: 3.00

Selected Min Range CGS: 1.000 in  
 Selected Max Range CSG: 4.000 in  
 Selected Avg CGS: 0.750 in NG

**Selected Load Balance (%) Calcs**

Load Balance Min Range: 50.00  
 Load Balance Max Range: 100.00  
 Selected Load Balance: 112.92 NG

**Selected Precomp (psi) Calcs**

Precomp Min Range: 125.00  
 Precomp Max Range: 300.00  
 Selected Precomp A: 156.25 OK  
 Selected Precomp B: 156.25 OK  
 Selected Precomp C: 156.25 OK

[Exit Tendon Editor]

Figure 3.1-2

### 3.2 Opening Tendon Optimizer

The Tendon Optimizer can only be used once a model has been meshed and analyzed. The button to open the Tendon Optimizer dialog will be enabled once tendons are added to the model. But once the dialog is open, the model is checked to see if it has been analyzed and the Optimizer will display an error message and close if the model has not been analyzed.

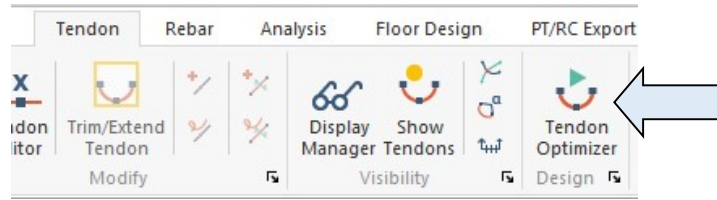


Figure 3.2-1

### 3.3 Tributary Area

#### 3.3.1 Tendon Selection

Upon opening the Tendon Optimizer dialog, the model graphics will change to show yellow handles on each tendon span. If two or more tendons are selected, all tendons in the group must be adjacent to one another. Tendons that are not approximately parallel will be automatically removed from the selection. The selected handles will be shown with circles around the handles, the control points for the selected spans will be shown. The number of strands, total force per tendon and the CGS will also be shown next to the control point.

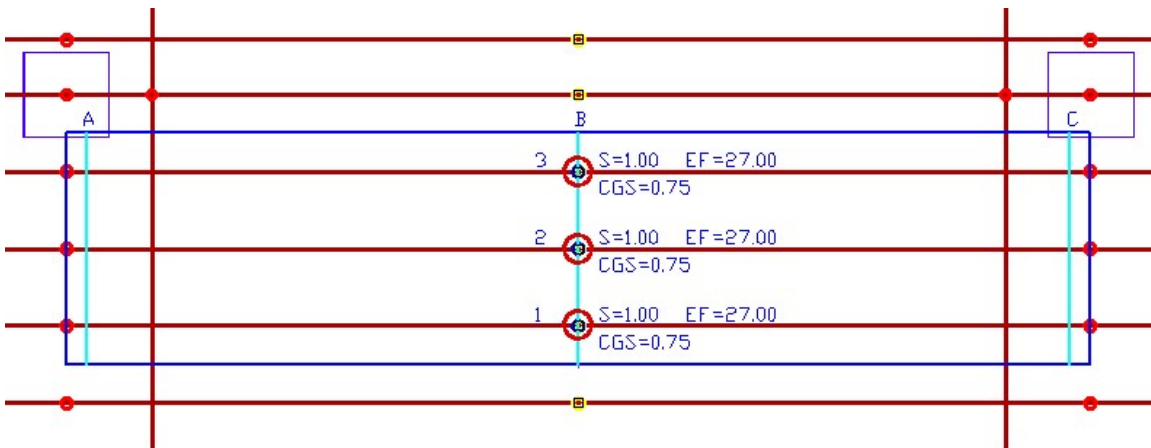


Figure 3.3.1-1

A tributary area will be generated based on the span end points for the tendons on the extreme edges of the selected group. The tributary area will extend half the distance between the outside tendon and the adjacent tendon beyond tendons on the outside edges of the group (**Figure 3.3.1-1**). If the tendons are curved, the tributary area will grow to encompass the effective area of the curved tendons (**Figure 3.3.1-2**).

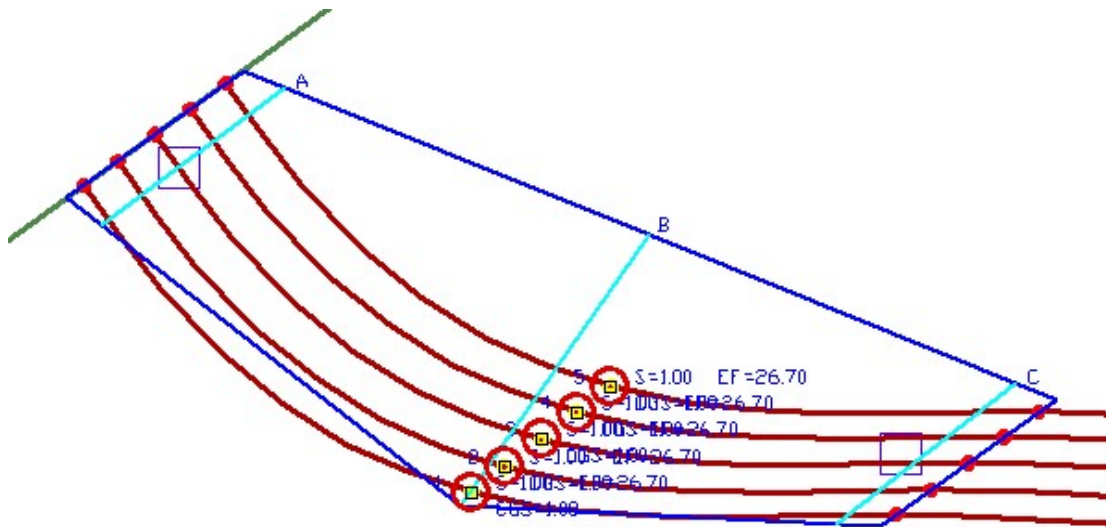


Figure 3.3.1-2

If a single (banded) tendon is selected, the program will prompt for a tributary width to be entered manually (**Figure 3.3.1-3**). This value will be used to create the tributary area (**Figure 3.3.1-4**).

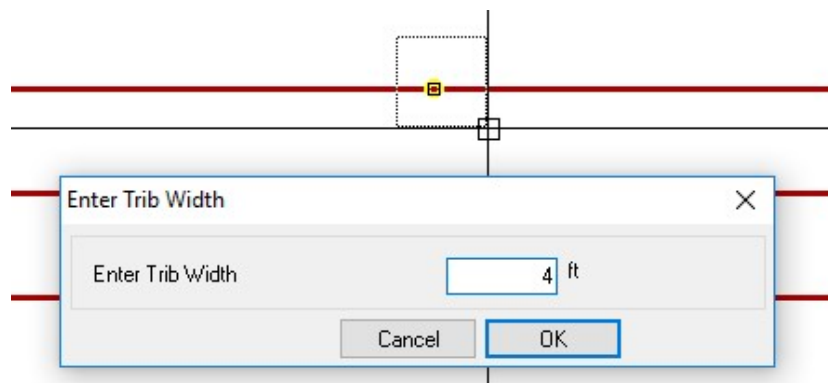


Figure 3.3.1-3

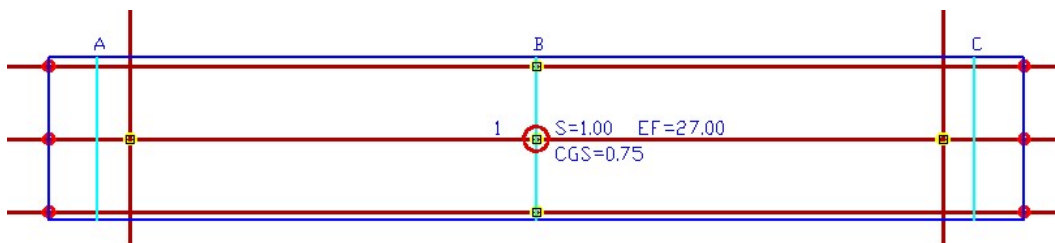


Figure 3.3.1-4

The tributary width can be modified on the Settings tab. Enter the new tributary width and click the Update button and the tributary width will be regenerated and all of the calculations will be done for the new tributary width (**Figure 3.1-2**).

The tributary area has three section lines drawn, one at the center of the tributary area and one near each end of the tributary area (**Figure 3.3.1-1**).

The distance the section lines fall on the ends is controlled by a setting on the settings tab. Enter the percentage of the span to use to calculate the distance from the end line to draw the section line. Clicking the update button will regenerate the end section lines and recalculate (**Figure 3.1-2**). Note that this percentage where the end sections are cut may not reflect the same location for sections generated automatically for design strips. If you are comparing results between the Optimizer and the design section results, ensure that the sections are being cut at similar locations for comparable results (e.g. stresses, precompression, etc.)

### 3.3.2 Consistent/Inconsistent Selections

In propagating an optimized solution to the model, if the effective force and the cross-sectional area of all the tendons selected in the group are the same, the selected tendon group is consistent. This allows the changes in values to be applied across all tendons equally as well as to a single tendon or by adding new tendons.

If the effective force and cross-sectional area of any of the tendons selected in the group are different, the selected tendon group is inconsistent. This limits the apply options to making changes to a single tendon or adding new tendons.

## 3.4 Optimizer Tab

The Optimizer tab is where the essential data and controls for optimizing the total force in the tendons to meet the preset criteria. It is broken up into 5 sections: **A: Diagram, B: Input/Output, C: Status, D: Load Case/Criteria, E: Critical Stresses.**



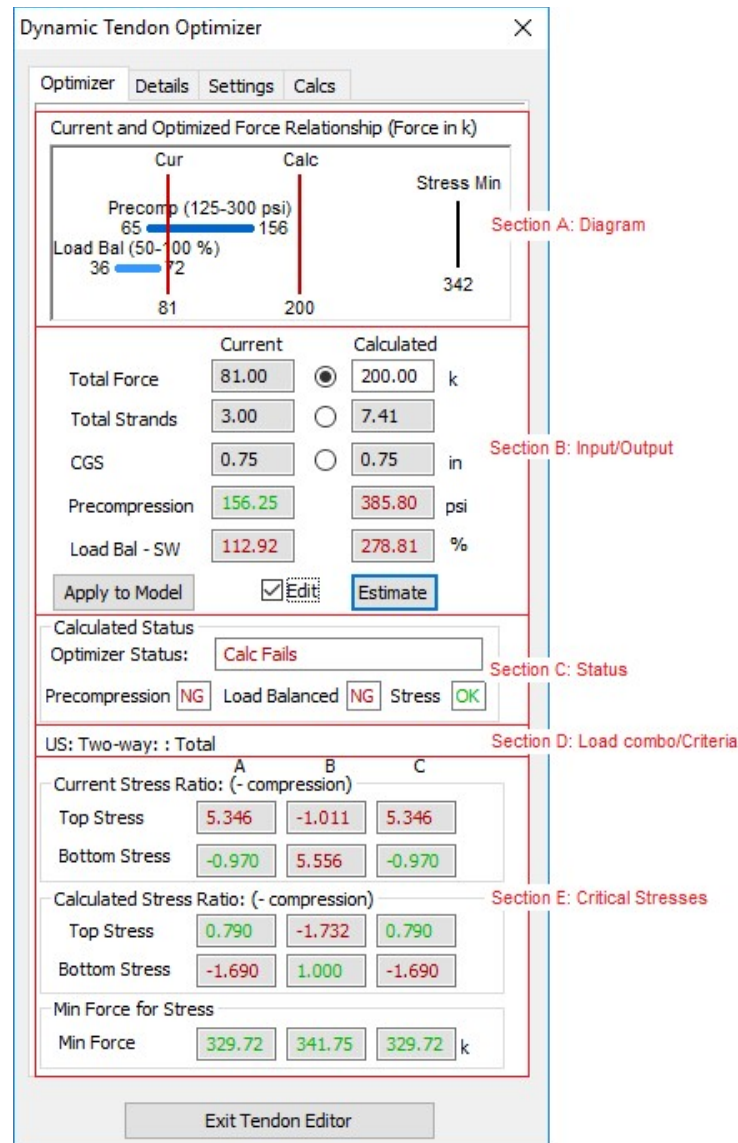


Figure 3.4-1

### 3.4.1 Section A: Diagram

The diagram graphically shows the relationships between the total forces required to meet the various criteria. The horizontal axis of the diagram represents total force in appropriate force units. There are horizontal bars that represent the pre-compression and load balance ranges. The minimum and maximum stress values for the pre-compression range and the minimum and maximum percentages for the load balance range are shown above the appropriate bar. The total force required to produce the min/max range for pre-compression and load balance is calculated and

plotted as the start and end of each of the bars. The force value is shown at the end of the bar, in line with the bar.

The vertical lines represent the current total force based on the tendon spans that are selected, the estimated or calculated total force that is generated by the optimization algorithm or by manual user input, and the total force required to meet the minimum stress required if tension stress governs the analysis.

Load balance and pre-compression requirement ranges are set on the Settings tab (**Figure 3.1-2**) or on the Results Display Settings dialog (red eyeglasses) (**Figure 3.4.1-1**). The minimum stress requirement is based on the tension top and tendon bottom stress allowables for the given building code, load case and criteria. These allowables are shown on the Settings Tab (**Figure 3.1-2**) but can only be set from the main menu Criteria>Allowable Stresses option.



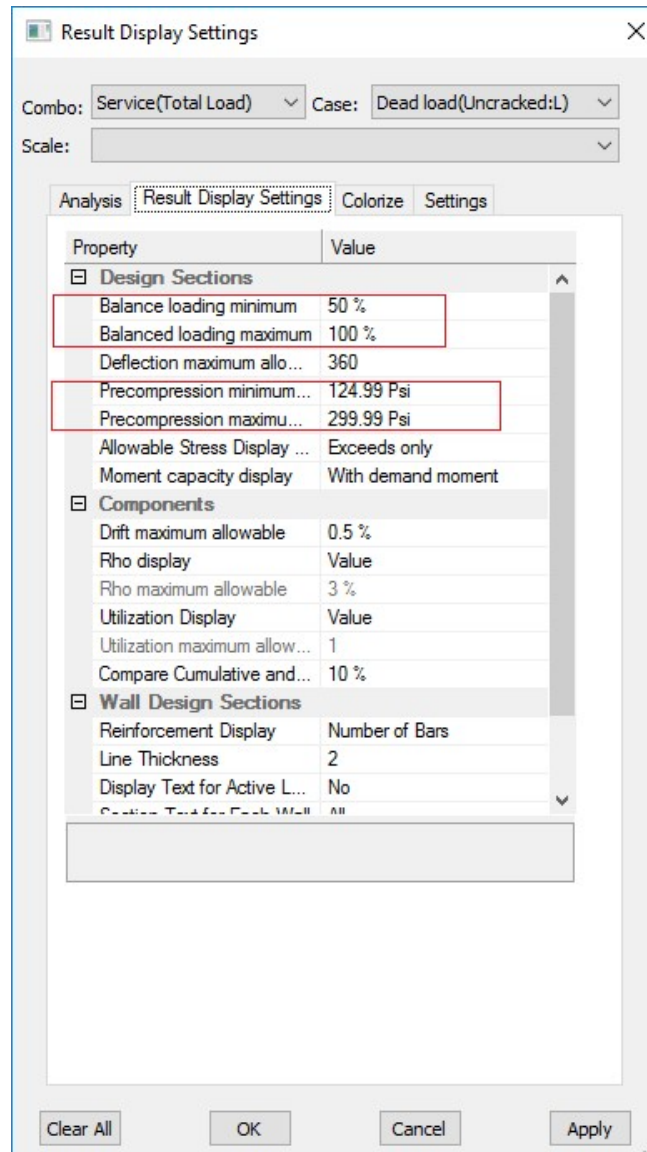


Figure 3.4.1-1

The current, estimated and calculated vertical lines are color coded. If they're drawn in red, the force doesn't meet the criteria. If they're drawn in green, the force does meet all the of the design criteria. The Min Stress vertical line is always drawn in black. The force value is shown at the bottom of the vertical lines.

A workable solution happens in the range where the load balance and pre-compression bars overlap and, if stress is applicable, is greater than the min required force to resolve stress issues. If the stress doesn't fail in tension, stress does not apply. If stress does

fail in tension, the optimizer finds the minimum force that overcomes the stress failure.

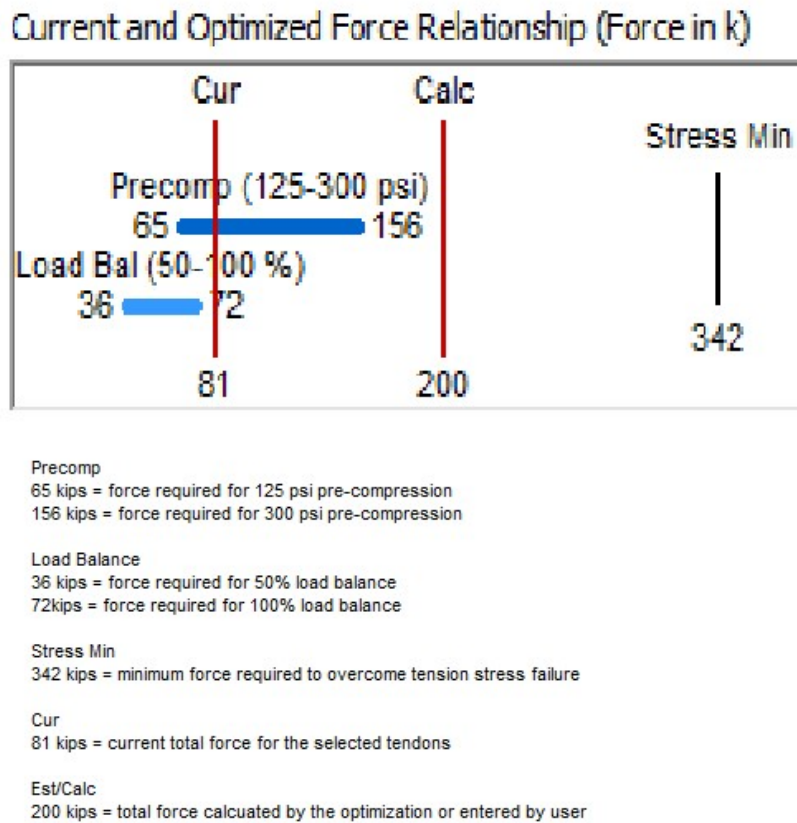


Figure 3.4.1-2

## 3.4.2 Section B: Input/Output

### 3.4.2.1 General Display

This section shows the current values for Total Force, Total Strands, CGS, Pre-compression, and Load Balance percentage. It also shows the Estimated (optimized) or Calculated (manual override) values for the same properties.

When a group of tendons is selected, the program gathers information about the selected tendons and calculates each of the properties above and displays them in the Current column. If the total force meets the design criteria, then the optimization does not run. The

same values shown in the Current column are shown in the Estimated column. If the Current total force does not meet the design criteria, the optimization algorithm runs to find a total force that meets the design criteria. Regardless of the success of the optimization routine, a total force is determined and the other properties are calculated and those values are then shown in the Estimated column.

- **Total Force:** Total effective force for all the tendons in the selected group. Effective force is always used, even if Calculated Force is turned on for one or more tendons in the selected group.
- **Total Strands:** Total strands for all the tendons in the selected group.
- **CGS:** This is the average low point relative to the bottom of the slab for the selected tendons.
- **Precompression:** This is the theoretical precompression value at cross section B, in the middle of the tributary area:  $\text{Total Force} / \text{Cross-sectional Area}$ . The desired range for the pre-compression optimization can be set on the Settings tab. The pre-compression numbers are color coded. If it's green it means the total force puts the pre-compression in the desired range. If it's red the total force puts the pre-compression outside the desired range.
- **Load Bal:** This is the percentage of the self-weight (SW) or self-weight + dead load (SWDL) based on the area of the tributary area and the total uplift generated by the selected tendons. The label for this property changes to show whether self-weight or self-weight + dead load is being used for this criteria: Load Bal- SW; Load Bal – SWDL. The governing load can be changed on the Settings tab as well as the desired range for load balance optimization. The load balance numbers are color coded. If it's green it means the total force puts the load balance in the desired range. If it's red the total force puts the load balance outside the desired range.

### 3.4.2.2 Editing

The user can choose to override the optimized solution by clicking the **Edit** check box on. This will make the radio buttons active and the box in the Calculated column next to the selected radio button editable. The user can then change the total force, total number of strands or the CGS to change the solution. Clicking the Estimate button recalculates the properties based on the user input and shows the results in the Calculated column and on the diagram. It also updates the Calculated stress at the bottom of the tab. Clicking the Edit check box off re-runs the optimization routine and the number go back as if Edit had not been run.

Changing Total Force, Total Strands is calculated based on the average force per strand for all the strands for all the tendons selected. Changing Total Strands, the total force is calculated based on the same average force per strand for all the strands for all the tendons selected. Changing Total Force or Total strands will affect the Pre-compression, Load Balance and Stress calculations. Changing CGS will only affect the Load Balance calculation.

### 3.4.2.3 Apply to Model

The Apply to Model button takes the current values in the Estimated/Calculated column and opens an Apply dialog with options to apply the changes to the total force and CGS to the selected tendons. See the **Apply to Model Dialog** section below for details on Apply to Model.

Precomp (125-300 psi)  
96 ————— 231

Load Bal (50-100 %)  
30 ————— 60

	Current	Estimated	
Total Force	270.00	270.00	k
Total Strands	10.00	10.00	
CGS	0.75	0.75	in
Precompression	350.64	350.00	ps
Load Bal - SW	451.09	451.09	%

Apply to Model ☐ Edit

Estimated Status

Optimizer Status: No Solution

Figure 3.4.2-1

### 3.4.3 Section C: Status

The Status section shows the status of the estimated/calculated values for Pre-compression, Load Balance and Stress. The status fields are color coded green and show 'OK' if the values are within the user-defined range, or below stress allowables. The status fields are color coded red and show 'NG' if the values fall outside the user-defined range. It's possible to turn off individual components of the optimization routine on the Settings tab. If one of the components is turned off, 'NA' will be displayed in the status box.

NOTE: The stress status only represents the stresses for the selected load combination and criteria below. Changing the load combination and/or criteria could change the stress status.

The **Optimizer Status** field tells what component of the design governed in the optimization, show which one was most critical it is also color coded: green, overall pass; red, overall fail.

- **Pass:** The current effective force meets all the design criteria and optimization was not used.
- **Calc Passes:** The user used the editor to override the optimization and the new calculation pass the design criteria.

- **Calc Fails:** The user used the editor to override the optimization and the new calculation failed the design criteria.
- **Pre-comp Governs:** Optimizer ran and the effective force is closest to the min pre-compression making this most critical.
- **Load Balance Governs:** Optimizer ran and the effective force is closest to the min load balance making this most critical
- **Stress Governs:** Optimizer ran and there was a tendon stress failure and a minimum effective force was calculated to overcome the stress failure. If stress governs, the effective force must be larger than the Min Stress value.
- **No Solution:** If the pre-compression and load balance ranges do not overlap, no solution is possible. Desired ranges for pre-compression and load balance need to be modified to find a solution or redesign of the tendon layout is required.
- **Failed by rounding to whole strands:** If the Whole Strands flag is set on the settings screen, the optimizer calculates the required total force, then increases the total force to match the next highest whole number of strands. The original calculation can pass, but increasing the force for the next highest whole number could cause the solution to fail.

#### 3.4.4 Section D: Load combo/Criteria

This string identifies the building code, load combination, and if applicable, the load criteria. The stress allowables are dependent on this settings. You can change the governing load combination and load criteria (two-way, one-way, beam) on the Settings tab. Changing this value will re-evaluate the status of the current stresses and recalculate the estimated stresses. This can change the overall status of the solution.

### 3.4.5 Section E: Critical Stresses

#### 3.4.5.1 Stress display

Stress values can be formatted in one of 3 ways: Ratio, Factored, or Actual. This setting is found on the Settings tab.

- **Ratio:** The absolute value of the actual stress / stress allowable. A negative sign is added to the ratio to show compression stress versus tension stress.
- **Factored:** The actual stress value multiplied by the appropriate factor based on  $F'_c$ . This is how stress allowables are entered in the Criteria setup dialog. Factored stresses are usually always positive. A negative sign is added to show compression stress versus tension stress.
- **Actual:** The actual stress value. Here the negative sign indicates compression stress (psi or MPa).
- Stress values are color coded:  $\text{abs}(\text{stress value}) < \text{allowable}$  is green.  $\text{Abs}(\text{stress value}) > \text{allowable}$  is red.

#### 3.4.5.2 Current Stresses

Current stresses are generated by the Design Section output at the 3 section cuts defined for the tributary area: A, B, C and are shown in columns A, B and C respectively. A and C are near the ends of the span and represent the high side of the span. B is in the center of the tributary area representing the low point.

#### 3.4.5.3 Estimated Stresses

Estimated stresses take the calculated stresses and estimate what the new stresses will be based on the change in total force. NOTE: This calculation is an approximation. After applying the changes to the tendons, reanalyze the model to determine the actual effect on the FEM stresses.

#### 3.4.5.4 Min Force for Stress

If there is a tension stress failure in the current stresses, adding total force can overcome the stress failure. The program uses the allowable tension stress to calculate a total force that brings the tension stress down to the allowable. This force represents the minimum total force required to meet the stress design criteria.

If there is a tension stress failure, the total force is calculated and shown in these fields. If one of the sections doesn't have a failure, the box will show 'NA'. The maximum of the minimum forces is the force selected as the governing force for the optimization, unless adding more force is required to meet the pre-compression and load balance requirements.



### 3.5 Details Tab

The Details tab shows all of the same information as the Optimizer tab but without the diagram and with more detailed stress data. Stress values are displayed the same as on the Optimizer tab. See Stress Display section above for details. This is found on the Settings tab.

Dynamic Tendon Optimizer

Optimizer Details Settings Calcs

US: Two-way:

Section A: Load Combo/Criteria

Current

Total Force	Force/Length	Total Strands	CGS
81.00 k	15.00 k/ft	3.00	0.75 in

Load Balance - SW 112.92 %

Current Stress Ratio: (- compression)

Section B: Current Values

	A	B	C
Top Stress	5.346	-1.011	5.346
P/A (FEM)	-149.49	-159.94	-149.20
P/A (Strands)	156.25	156.25	156.25
Bottom Stress	-0.970	5.556	-0.970

Optimizer Status: Calc Fails

Section C: Status

Precompression NG Load Balanced NG Stress OK

Calculated Status

Total Force	Force/Length	Total Strands	CGS
200.00 k	37.04 k/ft	7.41	0.75 in

Load Balance - SW 278.81 %

Calculated Stress Ratio: (- compression)

Section D: Estimated/Calculated Values

	A	B	C
Top Stress	0.790	-1.732	0.790
P/A (Strands)	659.00	385.80	659.00
Bottom Stress	-1.690	1.000	-1.690

Exit Tendon Editor

Figure 3.5-1

#### 3.5.1 Section A: Load combo/Criteria

This string identifies the building code, load combination, and if applicable, the load criteria. The stress allowable is dependent upon these settings. You can change the governing load combination and load criteria (two-way, one-way, beam) on the Settings tab

### 3.5.2 Section B: Current Values

This section shows the current values for Total Force, Force per Length, Total Strands, and CGS, and Load Balance percentage, Pre-compression, and Stresses.

When a group of tendons is selected, the program gathers information about the selected tendons and calculates each of the properties above and displays them in the Current section.

- **Total Force:** Total effective force for all the tendons in the selected group. Effective force is always used, even if Calculated Force is turned on for one or more tendons in the selected group.
- **Force/Length:** Total effective force for all the tendons in the selected group divided the cross-sectional length at Section B.
- **Total Strands:** Total strands for all the tendons in the selected group.
- **CGS:** This is the average low point relative to the bottom of the slab for the selected tendons.
- **Top Stress:** Stress at the top of the slab at cross-sections A, B, and C, from FEM calculations.
- **P/A (FEM):** Stress at the neutral axis of the slab at cross-sections A, B, and C, from FEM calculations. This is always shown as actual stress and is not controlled by the stress format on the Settings tab.
- **P/A (Strands):** Theoretical pre-compression: Total force/Cross-sectional area at cross-sections A, B and C. This is always shown as actual stress and is not controlled by the stress format on the Settings tab.
- **Bottom Stress:** Stress at bottom of slab at cross-sections A, B and C, from FEM calculations.

### 3.5.3 Section C: Status

This status works the same as on the Optimizer tab. See the Status section above for details.

### 3.5.4 Section D: Estimated/Calculated Values

Same as the Current values, Section B, above, except that the stresses are estimated based on the current stresses and the change in total force.

## 3.6 Settings Tab

Changes to the values on the Settings tab are automatically applied when you leave the tab and go back to the Optimizer or Details tab, except for Trib Width Settings. Trib Width Settings requires a click of the Update button to apply the changes.

The screenshot shows the 'Dynamic Tendon Optimizer' window with the 'Settings' tab selected. The window is divided into several sections, each highlighted with a red box and a red label to its right:

- Section A: Trib Width Settings**: Includes 'Trib Width Settings' with 'Tributary Width' (5.40 ft) and 'End Section Cut % of Span' (5.00 %), and an 'Update' button.
- Section B: Display Settings**: Includes 'Display Settings' with 'Load to Balance' (radio buttons for SW and SW+DL, with SW selected) and 'Stress Value Format' (radio buttons for Ratio, Factored, and Actual, with Ratio selected).
- Section C: Desired Ranges**: Includes 'Desired Ranges' with a table:
 

	Min	Max	
Precompression	125.00	300.00	psi
Load Balance	50.00	100.00	%
- Section D: Load Combo/Criteria**: Includes 'Load Combination' (Service(Total Load)) and 'Criteria' (Two-way slab criteria), both with dropdown arrows.
- Section E: Stress Allowables**: Includes 'Stress Allowables' with 'US: Two-way: : Total' and a table:
 

Top Tension	Bot Tension	Compression
379.47	379.47	2400.02
- Section F: Optimization Parameters**: Includes 'Optimization Parameters' with checkboxes for 'Precomp', 'Load Balance', and 'Stress', all of which are checked.
- Section G: Whole Strands**: Includes a checkbox for 'Use whole number of strands per tendon', which is unchecked.

At the bottom of the window is an 'Exit Tendon Editor' button.

Figure 3.6-1

### 3.6.1 Section A: Trib Width Settings

This section of the tab allows the user to change the tributary area width and the location of the section lines at the ends of the tributary area. The width of the tributary area at the center section line is shown. Change the trib width value and click the Update button to regenerate the trib area and recalculate the data for the new trib area.

To change the location of the end section lines, change the percent of span value and click the Update button. The section lines will be regenerated and the data related to those section lines will be regenerated.

### 3.6.2 Section B: Display Settings

#### 3.6.2.1 Load to Balance Settings

Load balance can be based on either self-weight or self-weight + dead load. The dead load used is that assigned to the pre-defined, reserved “Dead Load” case in the program. It does not apply to user-defined load cases that dead load is assigned to in lieu of the reserved load case. That choice is set here. If you change this setting and return to the Optimizer tab, the load balance will be recalculated based on the new setting.

#### 3.6.2.2 Display Stress Settings

Stresses on the Optimizer tab can be displayed in three different formats: Ratio, Factored or Actual. Ratio shows the actual stress / allowable stress. Any value greater than 1 fails. Factored shows the actual stress factored by the square root of  $f'_c$  for tension and  $f'_c$  for compression. If the value is greater than the factored allowables the stress fails. Actual shows the stress in actual stress units. If the actual value is greater than the actual allowable the stress fails. Changing this setting and returning to the Optimizer tab will reformat the stresses on the Optimizer tab.

### 3.6.3 Section C: Desired Ranges

These ranges can also be set on the Results Display Settings dialog (Figure 3.4.1-1).

#### 3.6.3.1 Pre-compression Range

There are no building code requirements for an allowable pre-compression range. The user is allowed to enter a range here. These values can also be set on the Result Display Settings dialog (red eyeglasses). This range is used in color coding the pre-compression values on the Optimizer tab as well as used by the optimizer to find a valid solution. Therefore, changing this range can change the optimizer results. Changing this range and returning to the Optimizer tab will change the color coding for the pre-compression values and re-run the optimizer.

#### 3.5.3.2 Load Balancing Range

There are no building code requirements for an allowable load balancing range. The user is allowed to enter a range here. These values can also be set on the Result Display Settings dialog (red eyeglasses). This range is used in color coding the load balancing values on the Optimizer tab as well as used by the optimizer to find a valid solution. Therefore, changing this range can change the optimizer results. Changing this range and returning to the Optimizer tab will change the color coding for the load balance values and re-run the optimizer.

### 3.6.4 Section D: Load Combination/Criteria

Stress allowables on the Optimizer tab depends on the building code, the load combination and, in some cases, the stress criteria. Changing these values will update the stress allowables and cause the current and estimated/calculated stresses update their status and recalculate min stress force if necessary.

### 3.6.5 Section E: Stress Allowables (read only)

This section displays the current values of the allowables for Top Tension, Bot Tension and Compression. The allowables are show relative to the selected stress format. The number that the stress on the Optimizer tab is compared to for determining the pass/fail status is show. So, if the format is Ratio, the values are 1. If the format is Factored, they will be the factored values. If they are Actual, they will be the actual values.

### 3.6.6 Section F: Optimizer Parameters

This section allows the user to control the optimization algorithm. The user can select which components of the optimization process to use. Clicking any of the check boxes off will cause the optimization routine to not fail a solution based on that component. Turning all of them off will effectively allow all optimized solutions to pass. This is not recommended.

### 3.6.7 Section G: Whole Strands

Checking this button on will tell the optimizer to take it's optimized force value and round it up such that the resulting force gives a whole number of Total Strands. It is possible for this round up to cause a working solution to fail, and this failure mode has its own status should it occur. If the user override edit check box is checked, enter a whole number of strands to see the effect.

### 3.7 Calcs Tab

This tab shows the initial values and intermediate results for the calculations of all the values on the optimizer screen. This screen is for reference only to help explain the calculations going on behind the scenes.

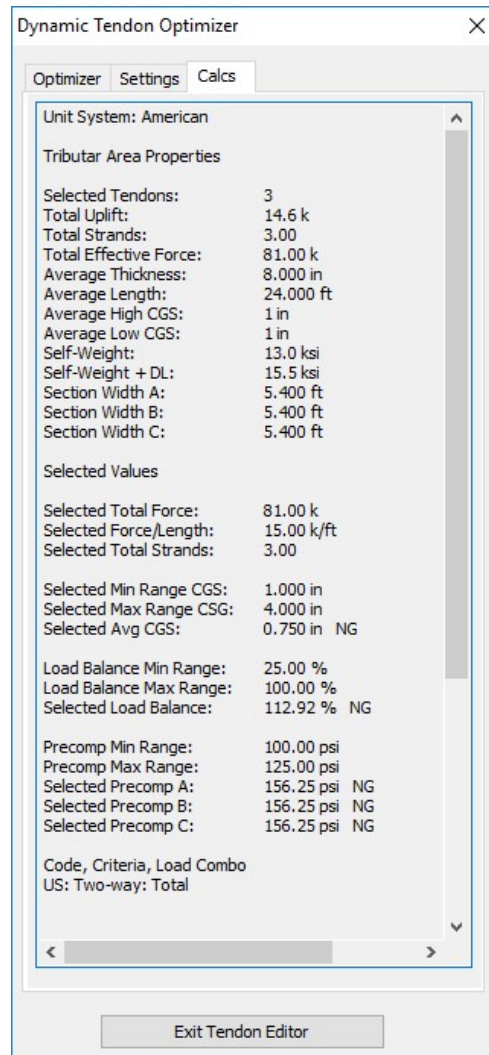


Figure 3.7-1

### 3.8 Apply to Model Dialog

The Apply dialog gives the user 3 options for applying a change in strands and/or CGS to the model. Each option is on a tab: **Distribute**, **Single Tendon**, **Add Tendon**. Distribute takes the required change in strands and distributes the change across all of the selected tendons. Distribute can only be used with a selected group of consistent tendons. Single applies the required change to one of the selected tendons. Add Tendon adds new tendons to the selection, either full or partial, to add force to the selection. Add Tendon option can't be used to reduce force in a section.

The figure displays two instances of the 'Apply Options' dialog box, illustrating the 'Distribute' and 'Single Tendon' tabs.

**Left Dialog (Distribute Tab):**

- Tab: Distribute
- # Tendons: 3.00
- Table:

	Req Change	Applied Change per Tendon
Total Force	-19.213	-6.404 k
Strands	-0.71	-0.24
CGS		0.75 in

☐ Rerun Model Analysis

Buttons: Apply, Cancel

**Right Dialog (Single Tendon Tab):**

- Tab: Single Tendon
- Select tendon to modify: 1
- Effective Force: 27.000 k
- Table:

	Req Change	Applied Change per Tendon
Total Force	-19.213	-19.213 k
Strands	-0.71	-0.71
CGS		0.75 in

☐ Rerun Model Analysis

Buttons: Apply, Cancel

Figure 3.8-1



Apply Options

Distribute Single Tendon Add Tendon

Select tendon to duplicate 1

Effective Force 27.000 k

	Req Change	Applied Change per Tendon
Total Force	-19.213 k	-19.213 k
Strands	-0.71	-0.71
CGS	0.75 in	0.75 in

Add Tendons

☒ Create number of tendons 1 # Tendons

☐ Max strands per tendon 1 0

☒ Add full tendons

☐ Add partial tendons from section A to edge of slab

☐ Add partial tendons from section C to edge of slab

☐ Add partial tendons alternating from A and C

% of span to extend tendon tail 30.00 %

New tendon offset 0.00 in

☐ Rerun Model Analysis

Apply Cancel

Figure 3.8-2

### 3.8.1 Distribute Tab

The Distribute tab takes the required changes and divides the changes over all the selected tendons and apply the changes evenly for consistent selection groups.

	Req Change	Applied Change per Tendon
Total Force	-19.213	-6.404 k
Strands	-0.71	-0.24
CGS		0.75 in

Figure 3.8.1-1

### 3.8.1.1 Consistent/Inconsistent Selections

If the effective force and the cross-sectional area of all the tendons selected in the group are the same, the selected tendon group is consistent. This allows the changes in values to be applied across all tendons equally as well as to a single tendon or by adding new tendons.

If the effective force and cross-sectional area of any of the tendons selected in the group are different, the selected tendon group is inconsistent. This limits the apply options to making changes to a single tendon or adding new tendons.

### 3.8.1.2 Section A: Number of Tendons

Section A shows the number of tendons selected in the group.

### 3.8.1.3 Section B: Apply Data

Section B shows the required change in terms of total force and number of strands and the change per tendon that will be applied. The first column shows the total required change in total force and number of strands based on the Estimated/Calculated column on the Optimizer tab. The second column shows the total force and number of strands divided by the number of tendons in the group. This is how much the number of strands will change for each tendon in the group, resulting in the correct overall change in force.

CGS: the CGS for the low points in the selected spans will be set to this value.

## 3.8.2 Single Tendon Tab

The Single Tendon tab takes the required changes and adds them to one of the selected tendons. This is especially useful to maintain whole numbers of strands per tendons. Distributing the changes across all selected tendons most likely leads to decimal numbers of strands, while adding a whole number of strands to a single tendon will maintain the whole number of strands.

Apply Options

Distribute Single Tendon Add Tendon

Select tendon to modify 1

Effective Force 27.000 k

Section A: Selection

	Req Change	Applied Change per Tendon
Total Force	-19.213	-19.213 k
Strands	-0.71	-0.71
CGS		0.75 in

Section B: Apply Data

☐ Rerun Model Analysis

Apply Cancel

Figure 3.8.2-1

### 3.8.2.1 Section A: Selection

Select the tendon to apply the changes to with the combo box, shown graphically on the model. The effective force for the given tendon is shown since this option can be used with inconsistent selection groups. If the effective force is different for various tendons in the selection, the number of strands required to create the required for can change. The change will be reflected in Section B of this tab.

### 3.8.2.2 Section B: Apply Data

Section B shows the required change in terms of total force and number of strands and the change per tendon that will be applied. The first column shows the total required change in total force and number of strands based on the Estimated/Calculated column on the Optimizer tab. The second column shows the total force and number of strands divided by the number of tendons in the group. This is how much the number of strands will change for each tendon in the group, resulting in the correct overall change in force.

As stated in the previous section, the number of strands to apply can change based on the effective force of the selected tendon. The number of strands shown is what will be applied to the selected tendon.

CGS: the CGS for the low points in the selected spans will be set to this value.

### 3.8.3 Add Tendon Tab

The Add Tendon tab creates new tendons between the selected tendons to increase the force in the section without modifying existing tendons. Add Tendon can only be used when increasing the total force. Full tendons or partial tendons can be created using this feature.

Apply Options

Distribute Single Tendon Add Tendon

Select tendon to duplicate 1

Effective Force 27.000 k

Section A: Template

	Req Change	Applied Change per Tendon
Total Force	-19.213	-19.213 k
Strands	-0.71	-0.71
CGS		0.75 in

Section B: Data to Apply

Add Tendons

☒ Create number of tendons 1 # Tendons

☐ Max strands per tendon 1 0

☒ Add full tendons

☐ Add partial tendons from section A to edge of slab

☐ Add partial tendons from section C to edge of slab

☐ Add partial tendons alternating from A and C

% of span to extend tendon tail 30.00 %

New tendon offset 0.00 in

Section C: # of Tendons

Section D: Type

☐ Rerun Model Analysis

Apply Cancel

Figure 3.8.3-1

### 3.8.3.1 Section A: Select Template

Select the tendon in the selected group to be used as a template for the newly added tendons. Use the combo box to select the number of the tendon, shown graphically on the model. The effective force for the given tendon is shown since this option can be used with inconsistent selection groups. If the effective force is different for various tendons in the selection, the number of strands required to create the required for can change. The change will be reflected in Section B of this tab.

The template tendon also defines where the new tendon will be placed. If the template tendon is #2 out of 5, the new tendons will be added starting between #2 and #3, then between #3 and #3, etc. If the #5 tendon is selected out of 5, the new tendon will start between #4 and #5.

### 3.8.3.2 Section B: Apply Data

Section B shows the required change in terms of total force and number of strands and the change per tendon that will be applied. The first column shows the total required change in total force and number of strands based on the Estimated/Calculated column on the Optimizer tab. The second column shows the total force and number of strands divided by the number of tendons in the group. This is how much the number of strands will change for each tendon in the group of new tendons, resulting in the correct overall change in force.

Changing the number of tendons to be added in Section C will change the number of strands per tendon to be applied.

CGS: the CGS for the low points in the selected spans will be set to this value.

### 3.8.3.3 Section C: Number of Tendons

This section sets the number of new tendons to create either directly, or calculated based on the maximum number of strands per tendon. This feature adds new tendons between existing tendons in the selected group so maximum number of new tendons is 'number of selected tendons – 1'. If only 1 tendon is in the selected group, this section defaults to adding 1 new tendon.

Create Number of Tendons: Select the number of new tendons to add.

Max strands per tendon: Setting the max strands per tendon calculates the number of tendons to add to get the required force. This is shown in the # Tendons box.

### 3.8.3.4 Section D: Type

Added tendons will be copies of the tendon selected as the template in Section A. All new tendons will have the same spans, shapes and settings as the template tendon. In this section select the type of new tendons

that will be created. For all new tendons, the CSG for the selected span will be updated as well as the number of strands for the whole tendon.

Partial tendons start from one end of the tributary area and go through to the opposite slab edge. The partial tendon is extended partially into the span on the end. The distance is set in the ‘% of span to extend tendon tail’ box. Partial tendon options are limited for selected spans on the ends of the tendon. If the selected span is on a slab edge, a partial tendon cannot be added on the slab edge end. Alternating A and C partial tendons is only available if 2 or more tendons are being added.

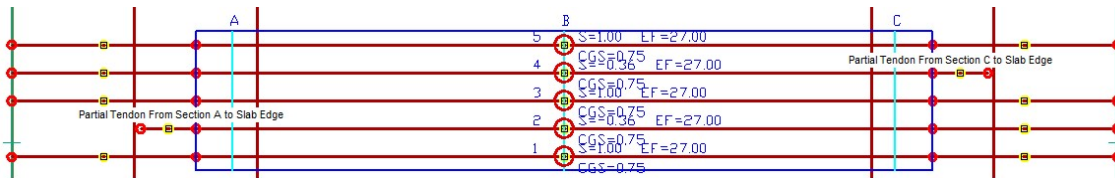


Figure 3.8.3.4-1

If only 1 tendon is selected in the selection group, only 1 new tendon will be created and it will be created at a distance from the template tendon entered in the ‘New tendon offset’ box.

- **Add Full Tendons:** This copies the template tendon, updating the CSG and number of strands.
- **Partial Tendons from Section A to slab edge:** This copies the template tendon, deleting to portion of the template on the section A end of the template and extending a new first span a percentage into the span on the section A end.
- **Partial Tendons from Section C to slab edge:** This copies the template tendon, deleting the portion of the template on the section C end of the template and extending a new last span a percentage into the span on the section C end.
- **Partial Tendons alternating from A and C:** If more than 1 new tendon is being created, the program will alternate new tendons as partial from A and partial from C as it creates each new tendon.



- **% of span to extend partial tendon:** Enter the percentage of the span adjacent to the selected span where the partial tendon is being extended to use to place the new end of the tendon.
- **New Tendon Offset:** Enter the distance perpendicular from the selected tendon to add the new tendon.

#### 3.8.4 Rerun Model Analysis

If this check box is checked when the Apply button is clicked, the FEM analysis will be rerun for the whole model. This will recalculate the FEM stresses for the newly applied strands and show the actual effect of the changes.

If this check box is not checked, after Apply, the Optimizer dialog will be shown with the previously estimated stresses set as the current stresses and the Optimizer dialog will be read only. The tendons in the selection will not be re-selectable until the FEM analysis is re-run.

If the model is large and it takes a long time to analyze, work on many areas of the slab

#### 3.8.5 Apply Button

Click the Apply button to affect the changes to the model as prescribed by the selections above.

#### 3.8.6 Cancel Button

Exits the Apply dialog without changes.