AASHTOWare™ BRIDGE DESIGN AND RATING

BrD Substructure Capabilities & What's Coming in BrDR 7.7

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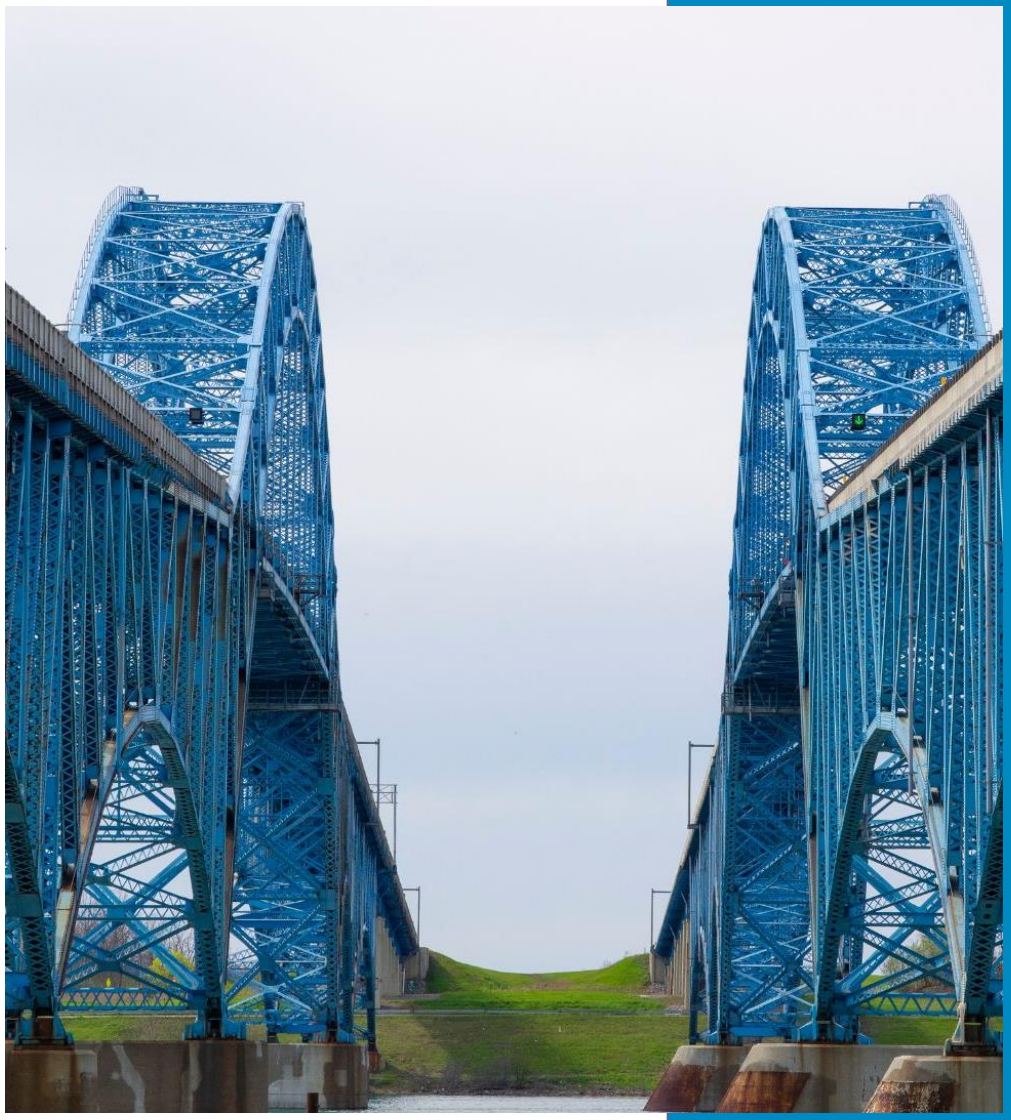


RADBUG 2024 | August 6-7 | Buffalo, NY

BrD Substructure Capabilities

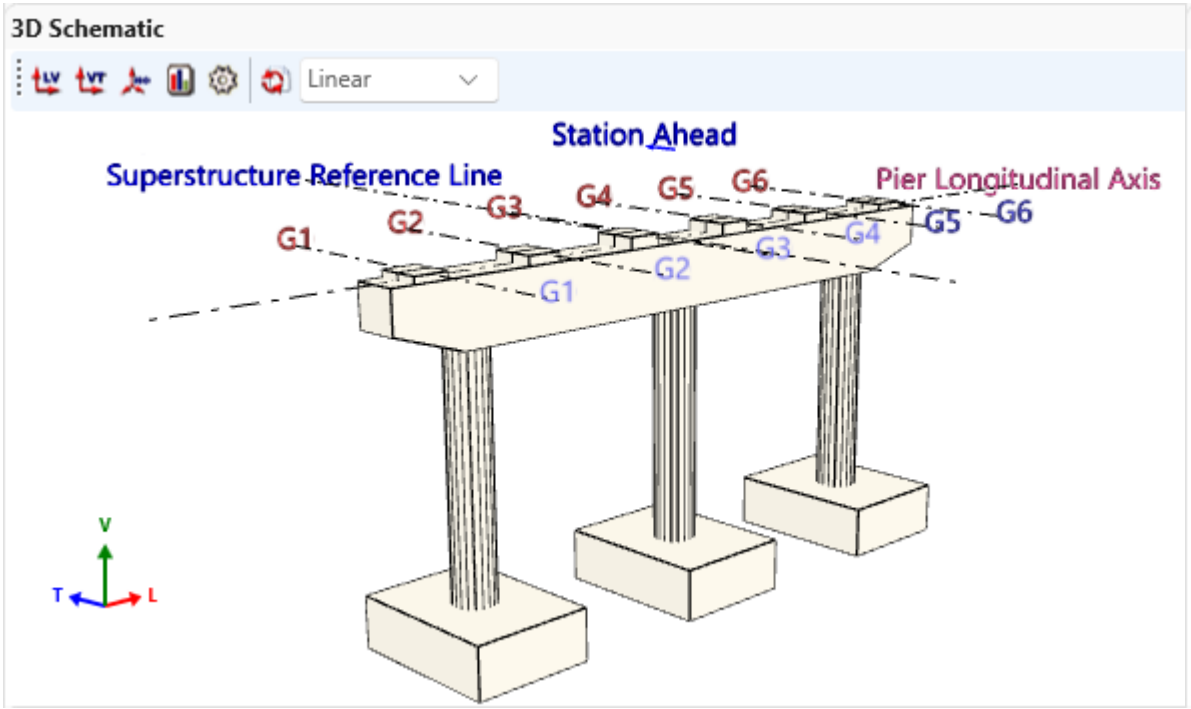
- Describe/spec check 4 types of piers
- LRFD Specifications
  - 4th Edition, 2008 interims through 9th Edition
- Integrated with BrD Superstructure or stand-alone pier
- Load transfer from BrD Superstructure
- Computed loads or user defined loads
- User control of loads and FE model

BrD Substructure Capabilities

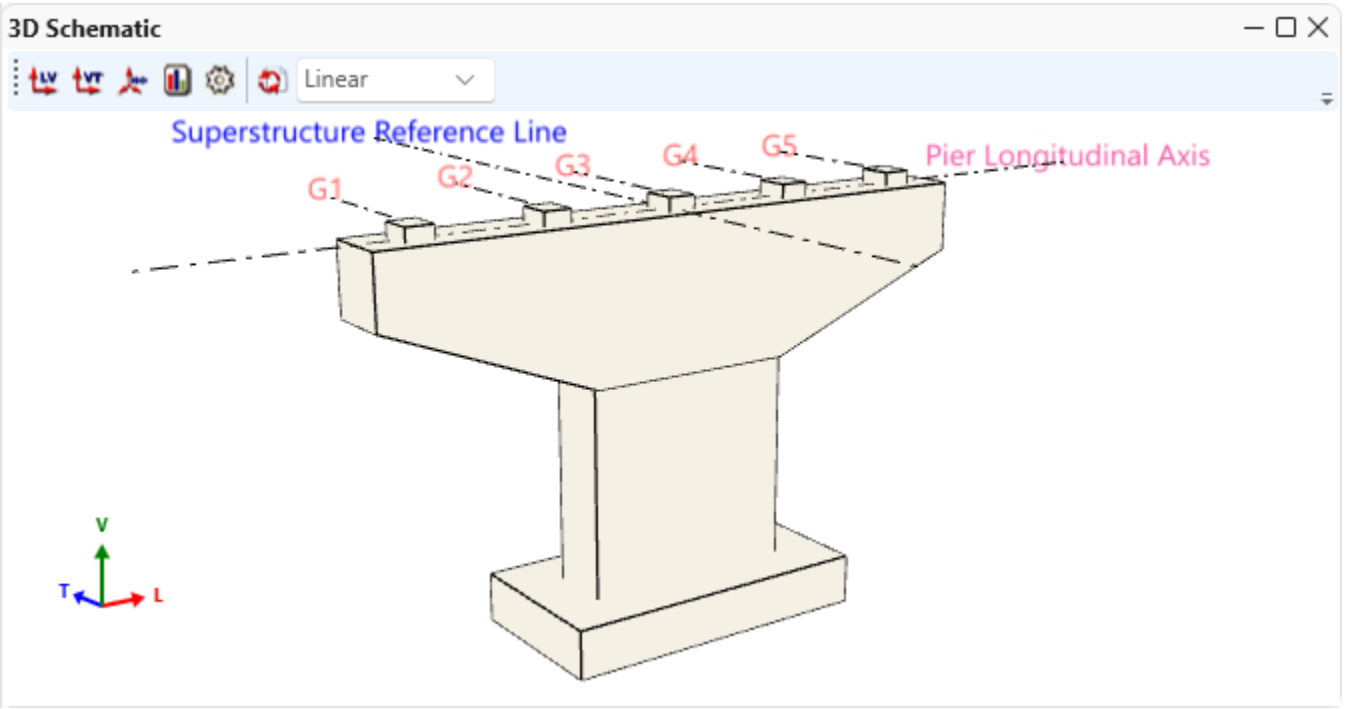
- Schedule-based reinforcement with development length calculations
- Pier – Linear finite element analysis, moment magnification
- Drilled Shaft – Nonlinear finite element analysis
- Load combination generation
- Tabular and graphical FE results

Four Types of Piers

Frame

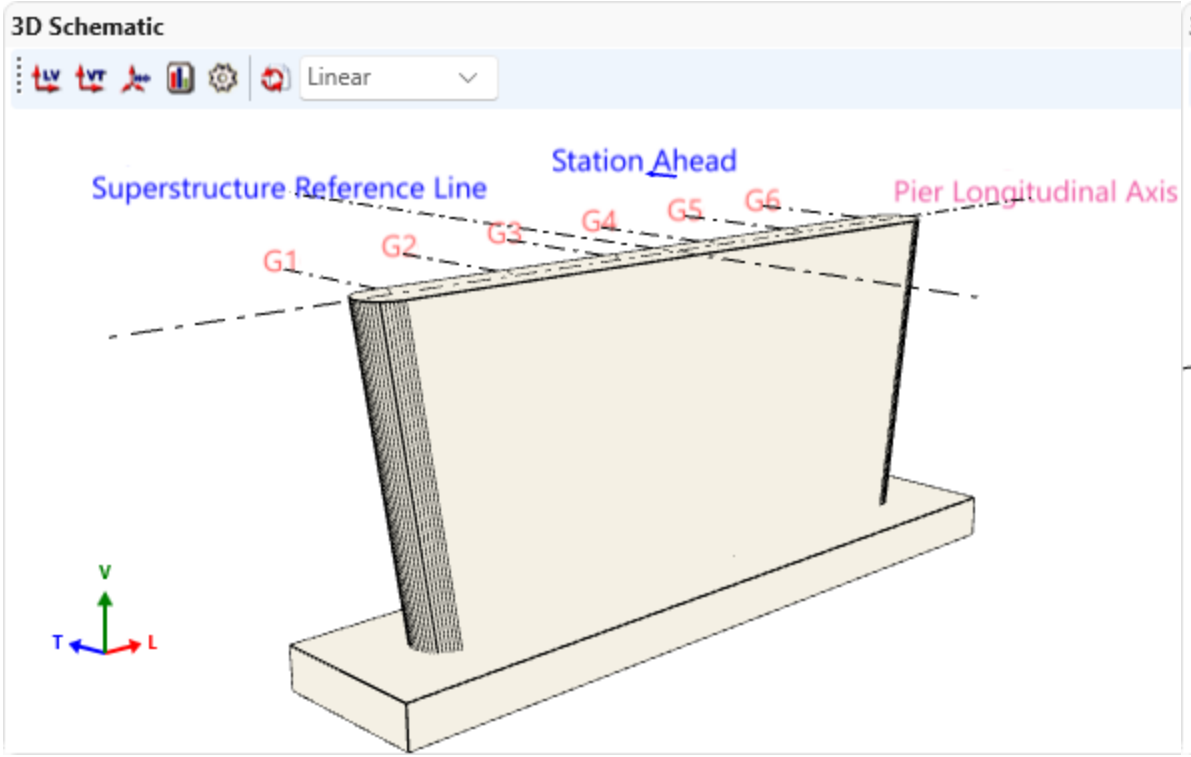


Solid Shaft

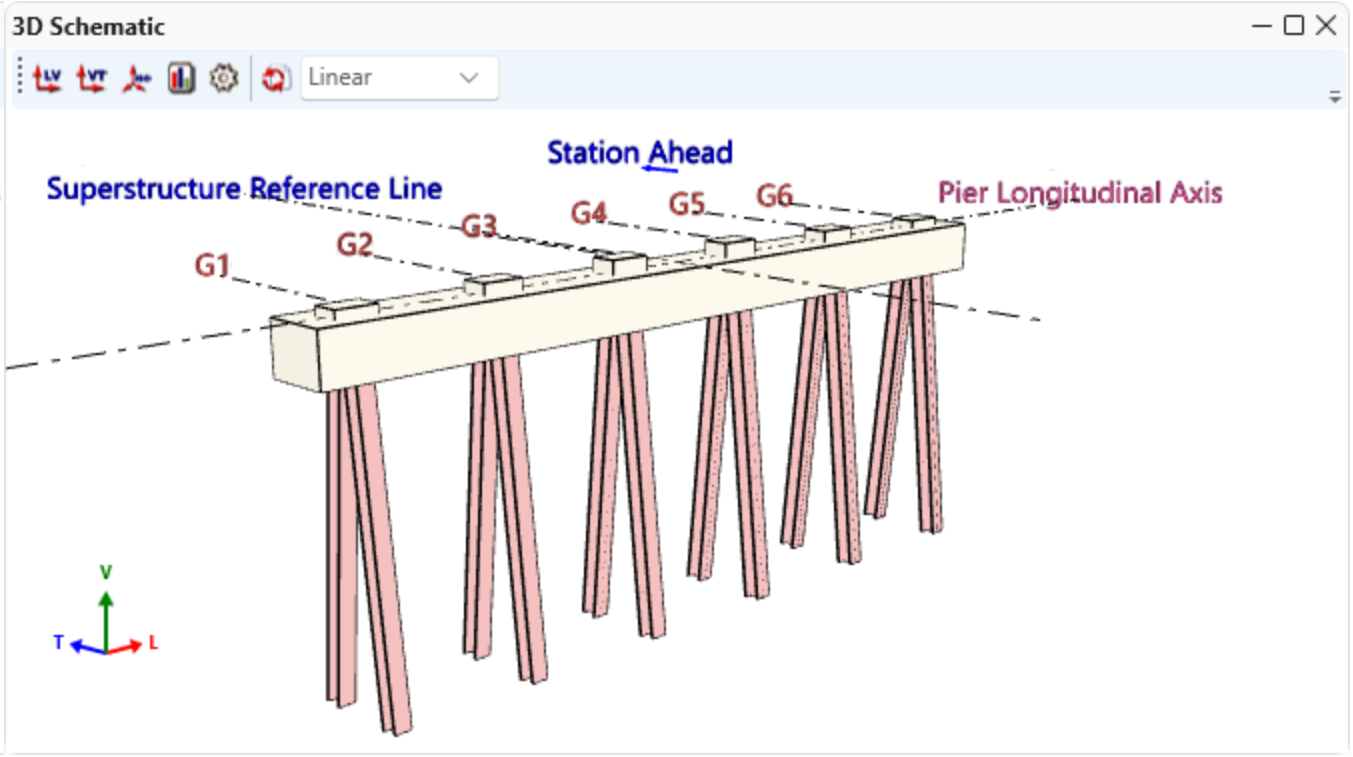


Four Types of Piers

Wall

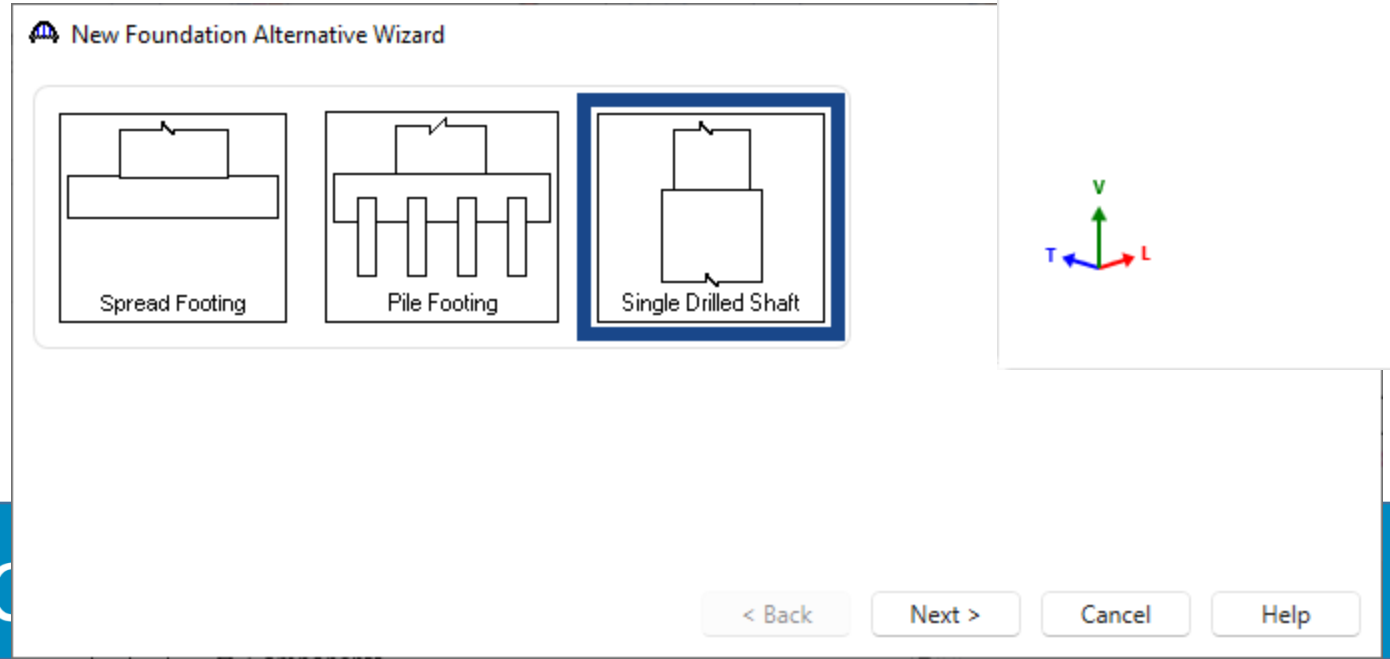


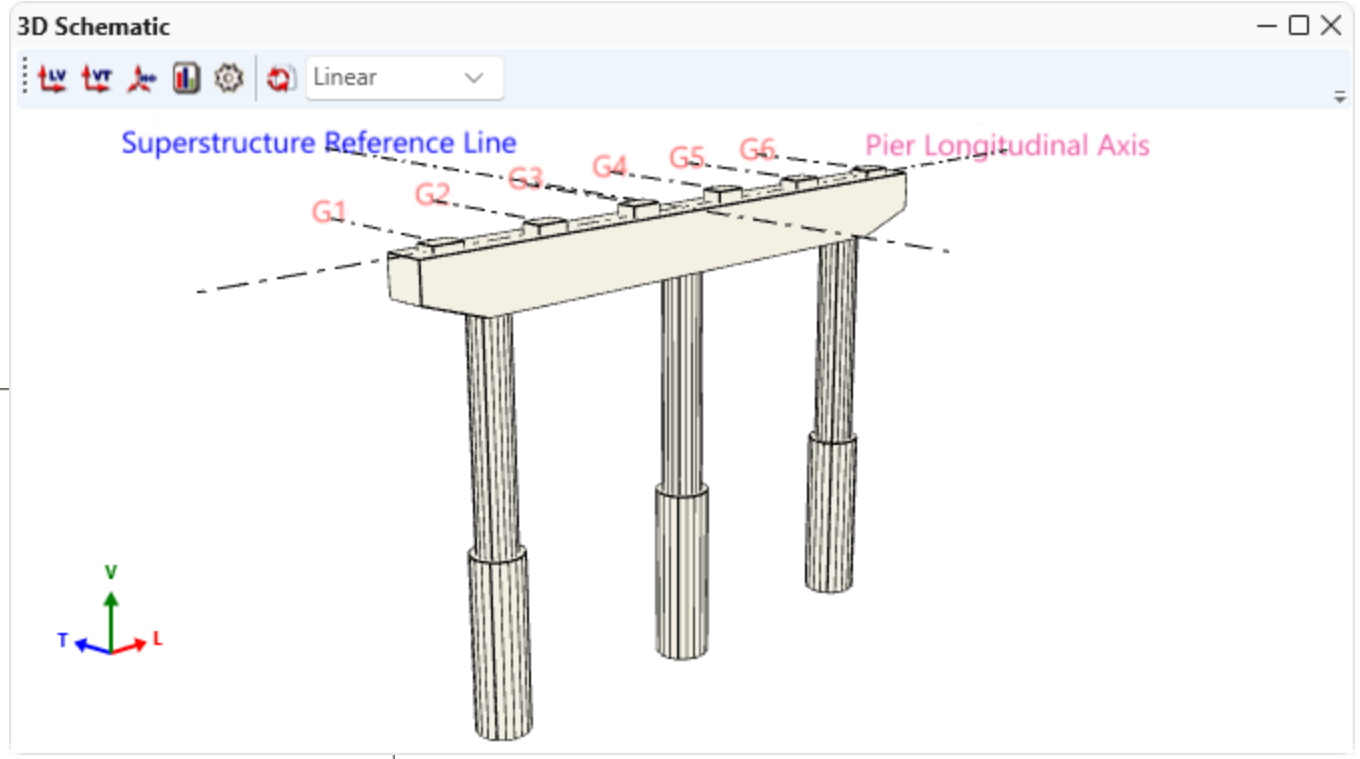
Pile Bent



Foundation Types

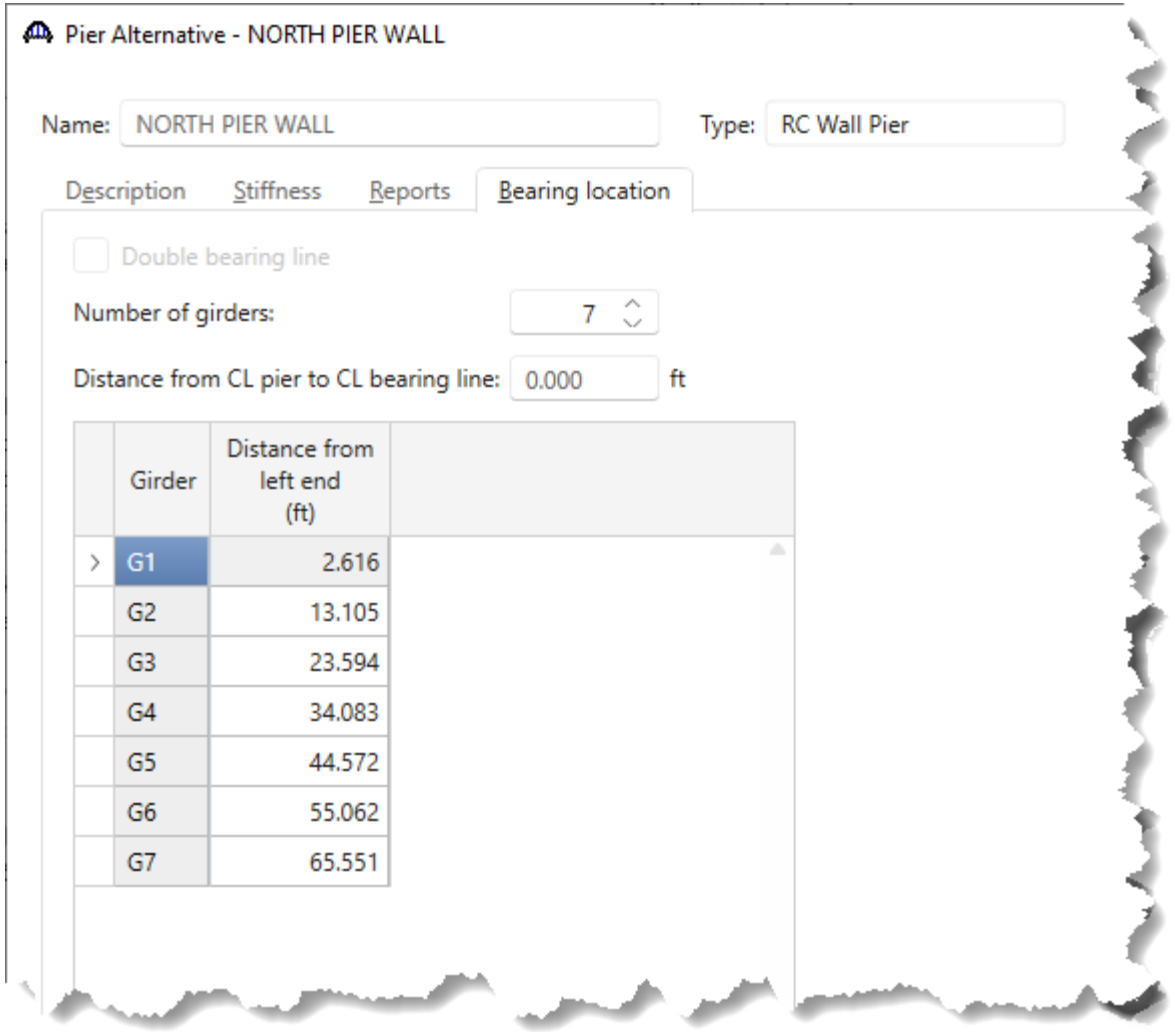
- Spread
- Pile
- Drilled Shaft





Stand-Alone Pier

- User defines girder locations
- User enters dead load reactions & superstructure loads
- User enters live load pier reactions
- BrD distributes user defined LL lanes to the girders



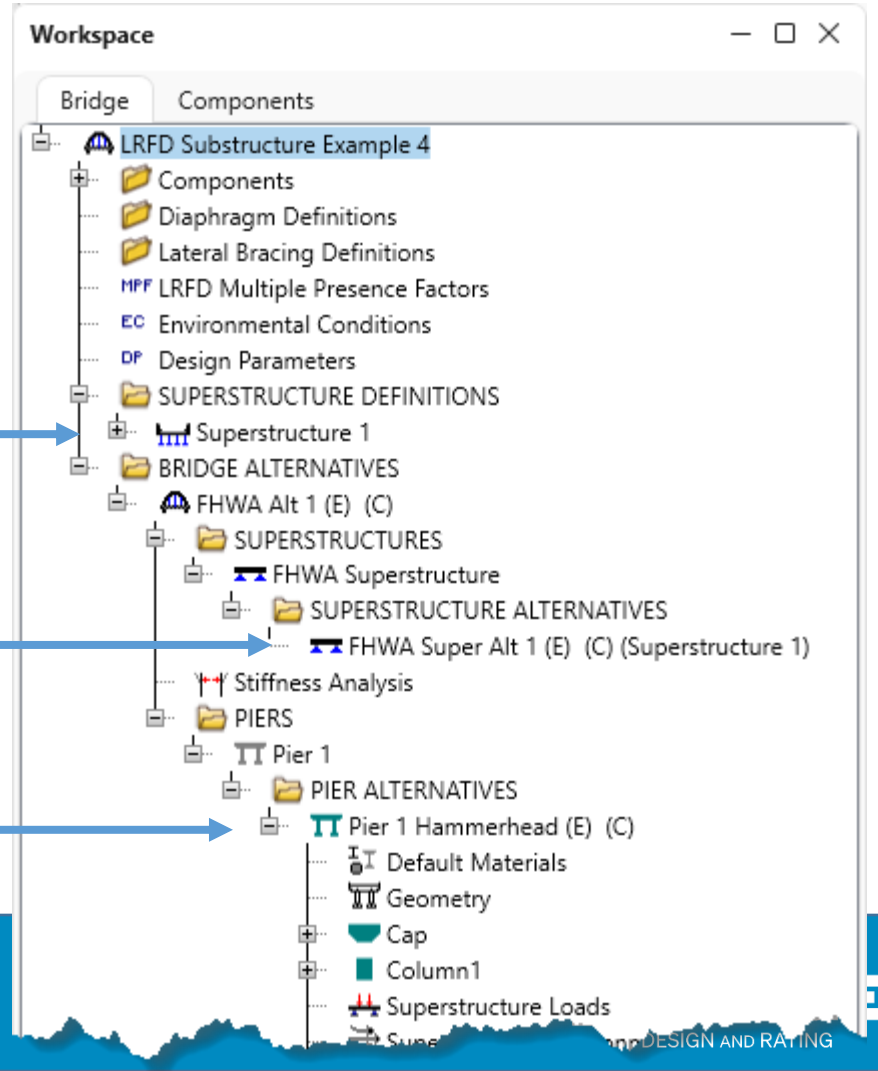
Integration with BrD Superstructure

- Automated dead and live load computations
- Dead load and live load transfer from BrD Superstructure

Create a superstructure definition

Assign to a superstructure alternative

Piers support the superstructure alternative

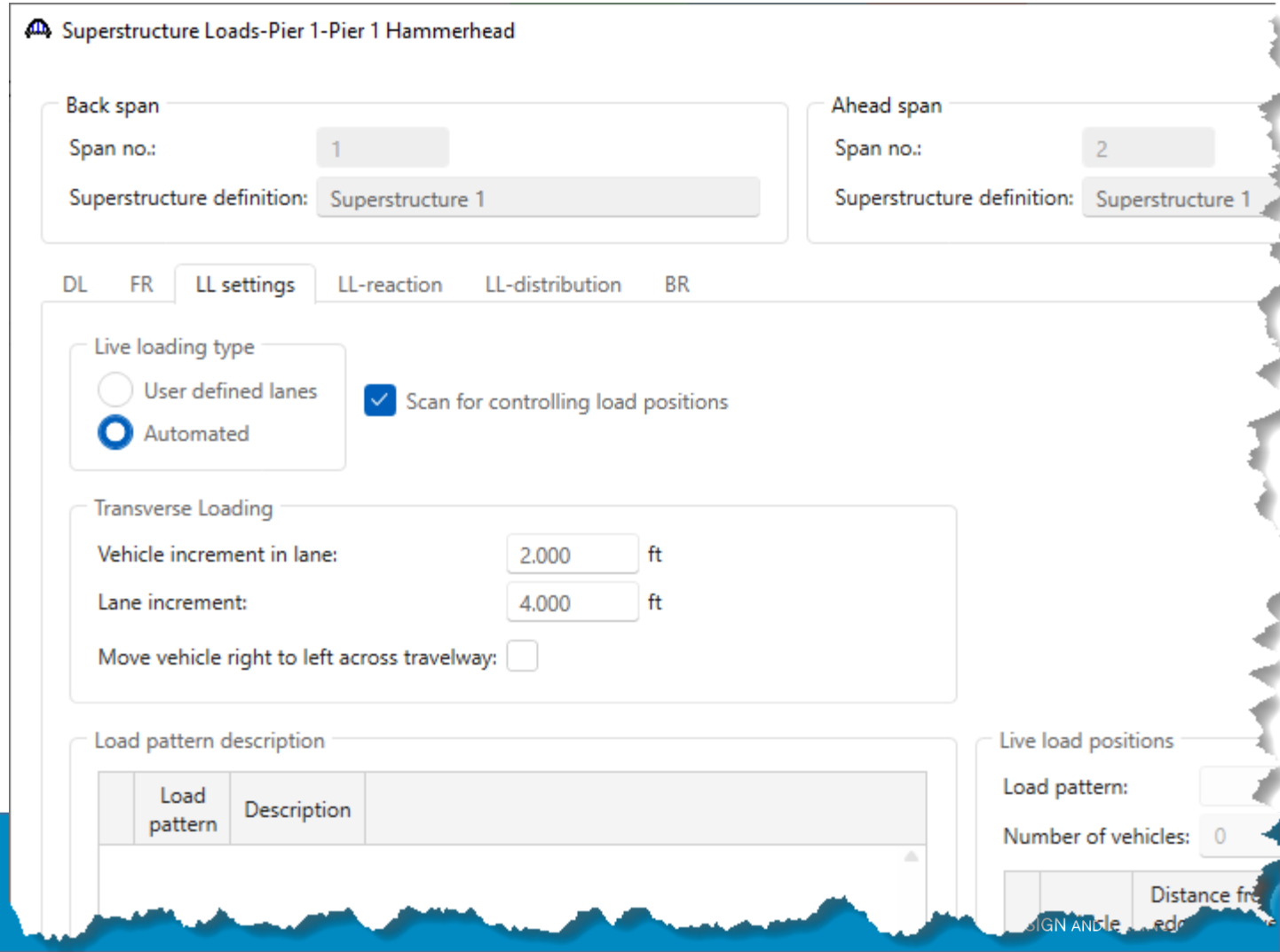


Live Load Generation

- Longitudinal live load analysis
  - 2-D “line” analysis of superstructure to generate influence line
  - Single lane reaction without distribution factors
  - Piers supporting 2 independent superstructures are handled

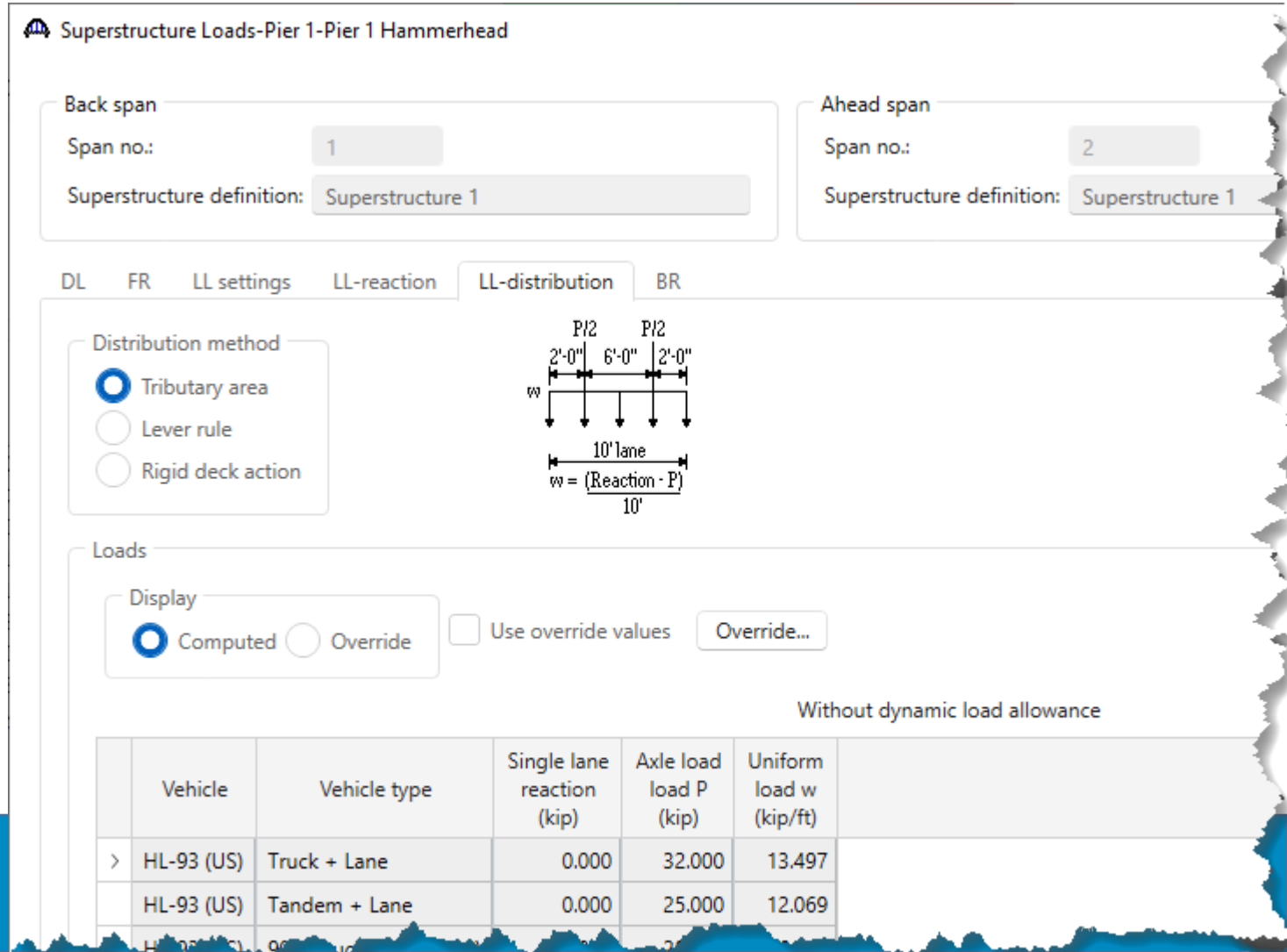
Live Load Generation

- Transverse live load analysis
  - User controls lane application



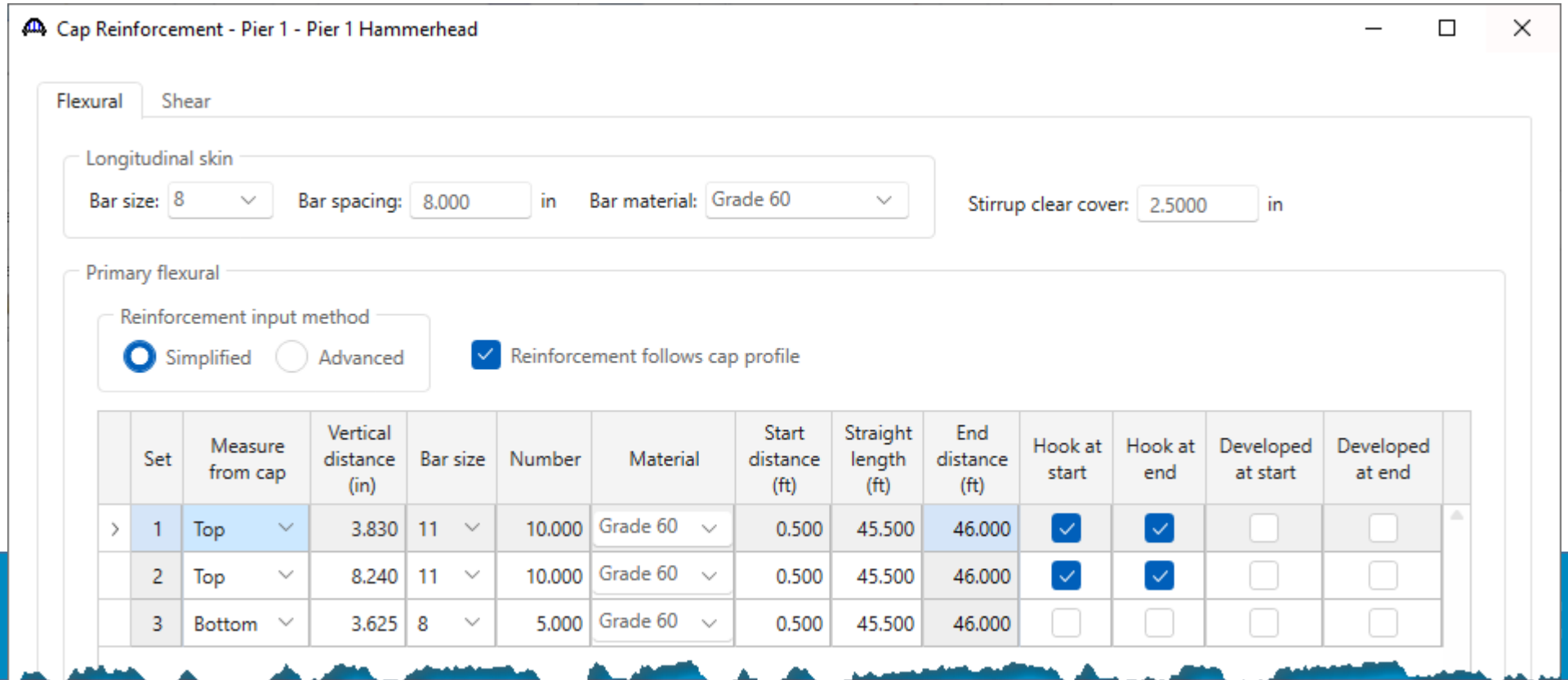
Live Load Generation

- Transverse live load analysis
  - User controls distribution of single lane reaction



Schedule Based Reinforcement

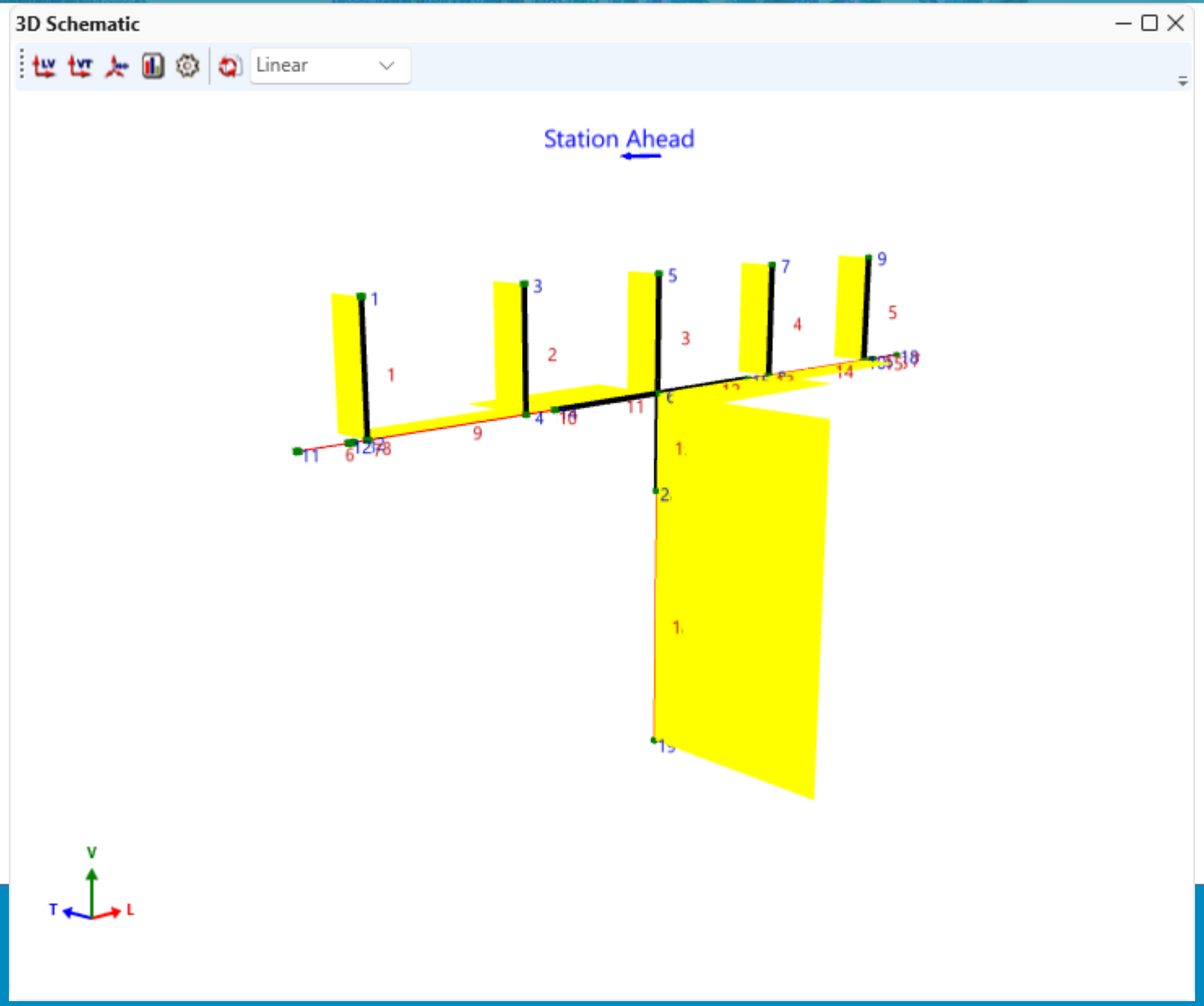
- BrD computes the development length and takes it into consideration in the spec checks



Set	Measure from cap	Vertical distance (in)	Bar size	Number	Material	Start distance (ft)	Straight length (ft)	End distance (ft)	Hook at start	Hook at end	Developed at start	Developed at end
1	Top	3.830	11	10.000	Grade 60	0.500	45.500	46.000	☑	☑	☐	☐
2	Top	8.240	11	10.000	Grade 60	0.500	45.500	46.000	☑	☑	☐	☐
3	Bottom	3.625	8	5.000	Grade 60	0.500	45.500	46.000	☐	☐	☐	☐

Pier Schematic

- Dimensions
- Zoom
- Rotate
- View FE model
- View FE results



Pier Loads

- Computed for you or enter your own

Superstructure environmental load generation progress

```
Info: Getting computation event...
Info: Using created model domain...
  Computing forces for Wind on Superstructure...
  Computing forces due to wind acting on the superstructure...
Info: Wind on superstructure forces computed successfully!
Info: Getting computation event...
Info: Using created model domain...
Generating model loads for Wind on Superstructure...
  Computing forces due to overturning wind acting on superstructure...
Info: Overturning wind on superstructure forces computed successfully!
Info: Getting computation event...
Info: Using created model domain...
  Computing forces for Wind on Live...
  Computing forces due to wind acting on the live load...
Info: Wind on live forces computed successfully!
Info: Getting computation event...
Info: Using created model domain...
Generating model loads for Temperature on Superstructure...
  Generation of model loads will use User-Defined forces due to tempera
  Skipping computation of forces due to temperature effects on the supe
```

Superstructure Environmental Loads - Pier 1 - Pier 1 Hammerhead

Back span
Span no.: 1
Superstructure definition: Superstructure 1

Ahead span
Span no.: 2
Superstructure definition: Superstructure 1

WS-super | WS-over | WL | TU | SH

Input

AASHTO LRFD Spec Article 3.8.1.2.2 Loads from Superstructure

Transverse load distribution option:	Fixed & Expansion Bearings		Friction velocity, VO:	12.00 mph
Transverse superstructure length:	120.000	ft	Friction length, ZO:	8.20 ft
Superstructure design elevation:	35.594	ft	Base design wind velocity, VB:	100.00 mph
Design height, Z:	30.094	ft	V30:	100.00 mph
Override design height, Z		ft		

Loads for wind from left to right

Display: (•) Computed ( ) Override

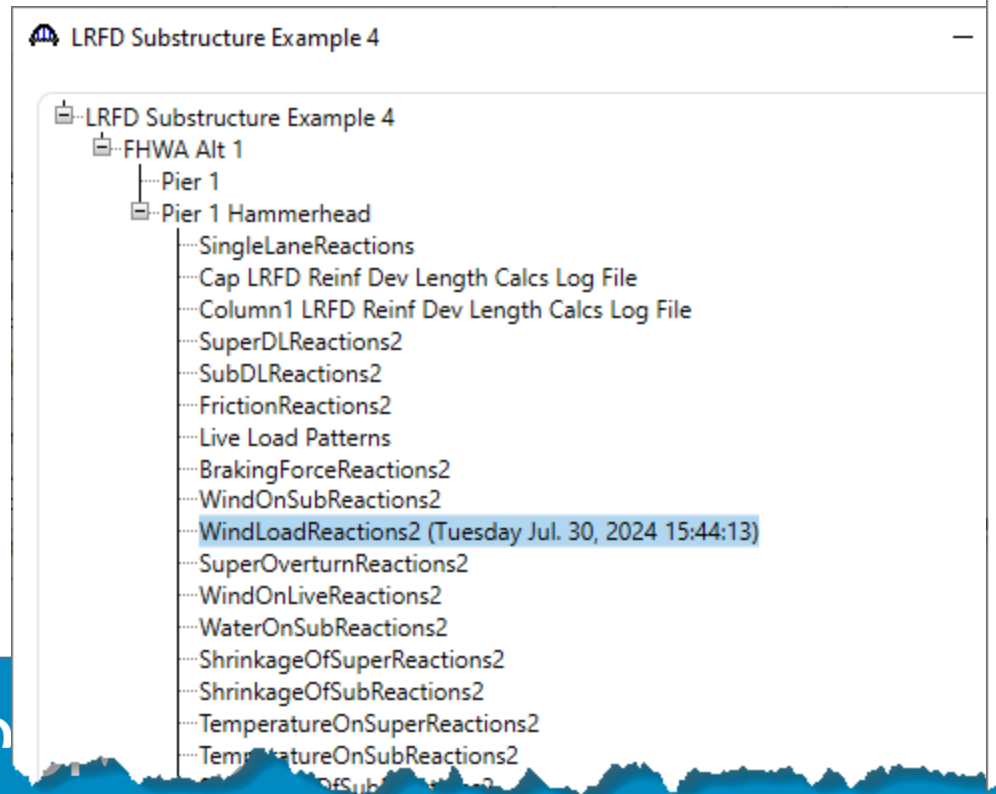
[ ] Use override values Override... Calcs...

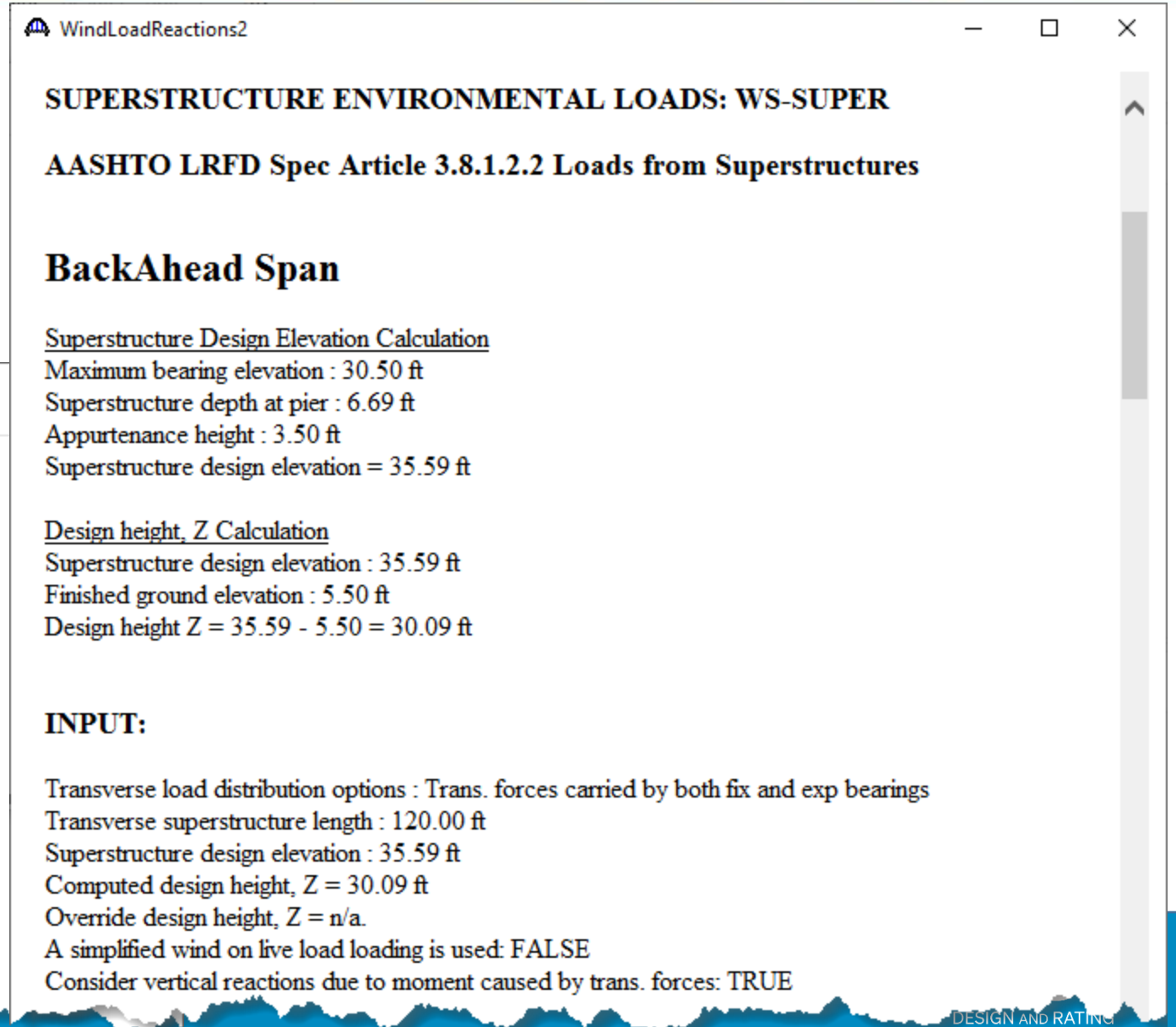
Superstructure longitudinal force (kip)

Wind skew angle (Degrees)	G1	G2	G3	G4	G5
0	12.188	12.188	12.188	12.188	12.188
15	10.725	10.725	10.725	10.725	10.725
	9.994	9.994	9.994	9.99	9.99

Pier Loads

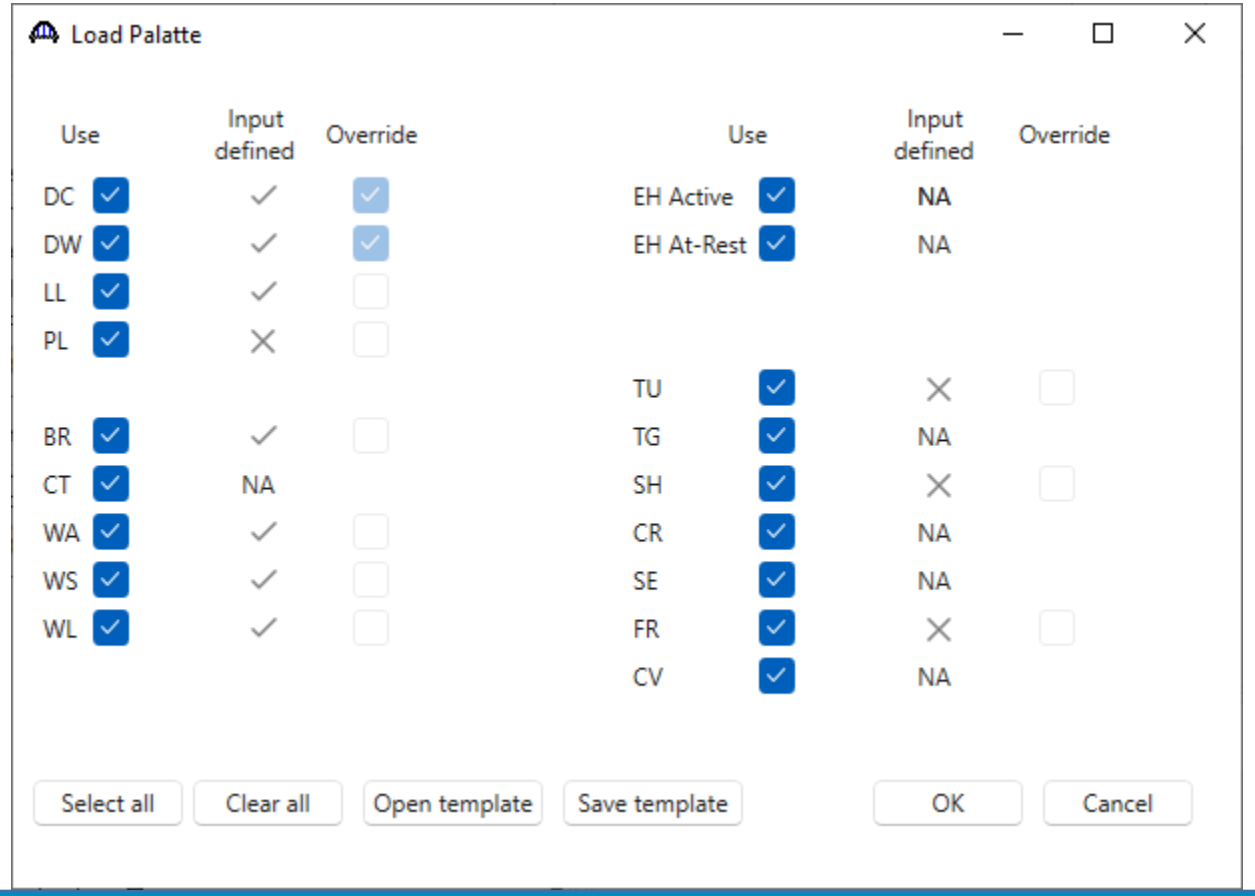
- Reports are available for all computed loads





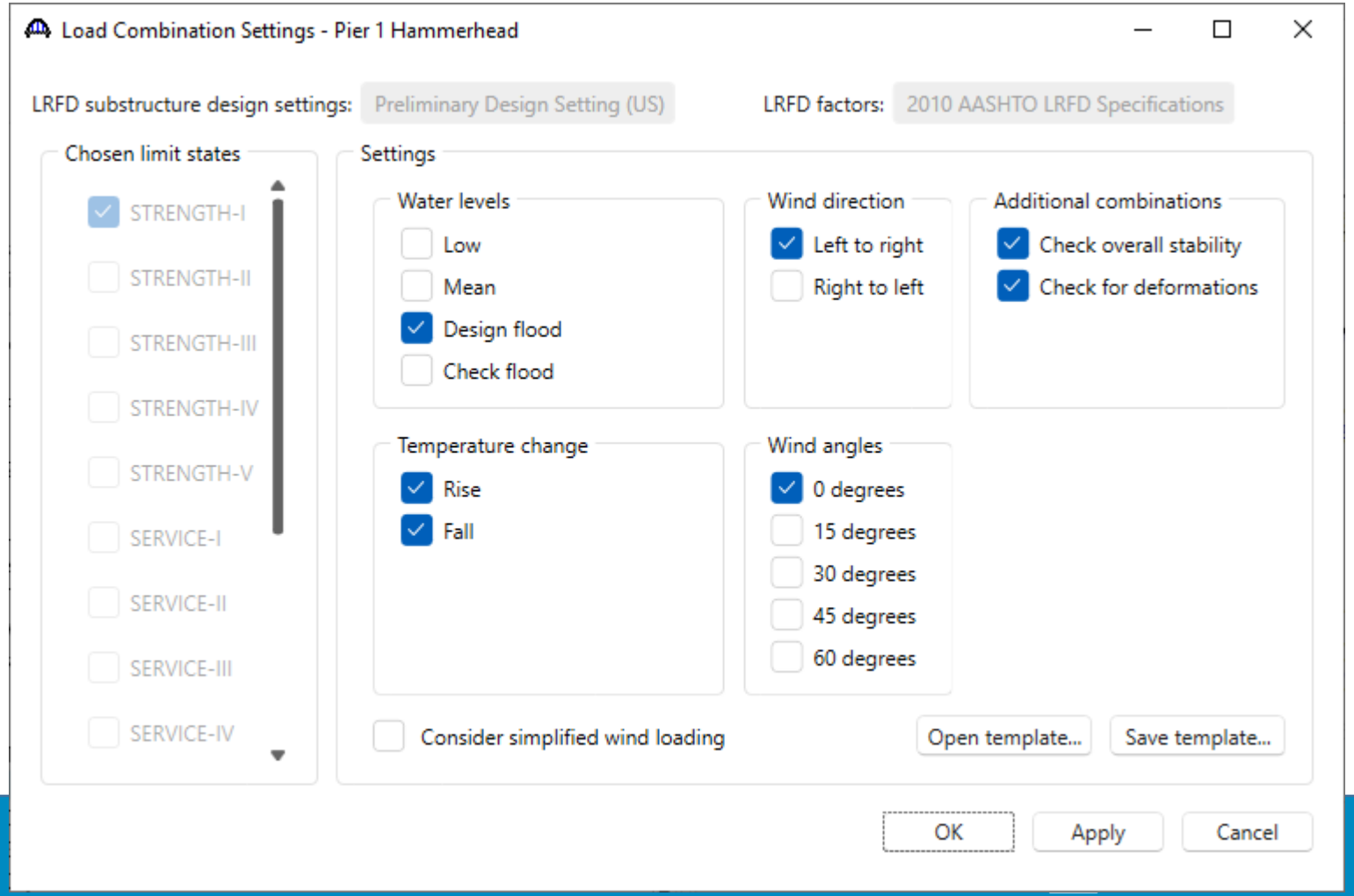
User Control of Loads

- Load palette controls usage of load types



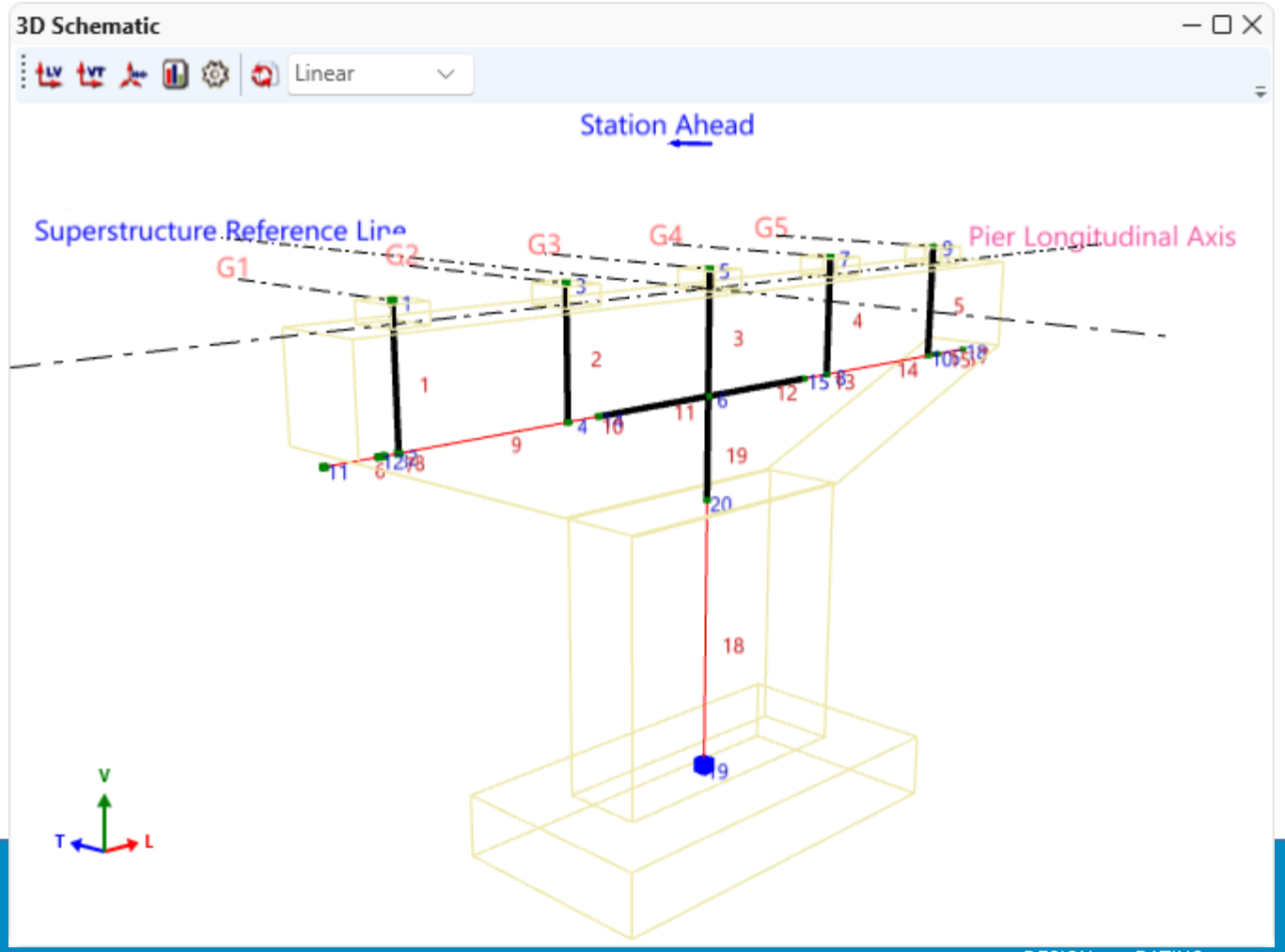
User Control of Loads

- Load combinations can be controlled



Finite Element Model

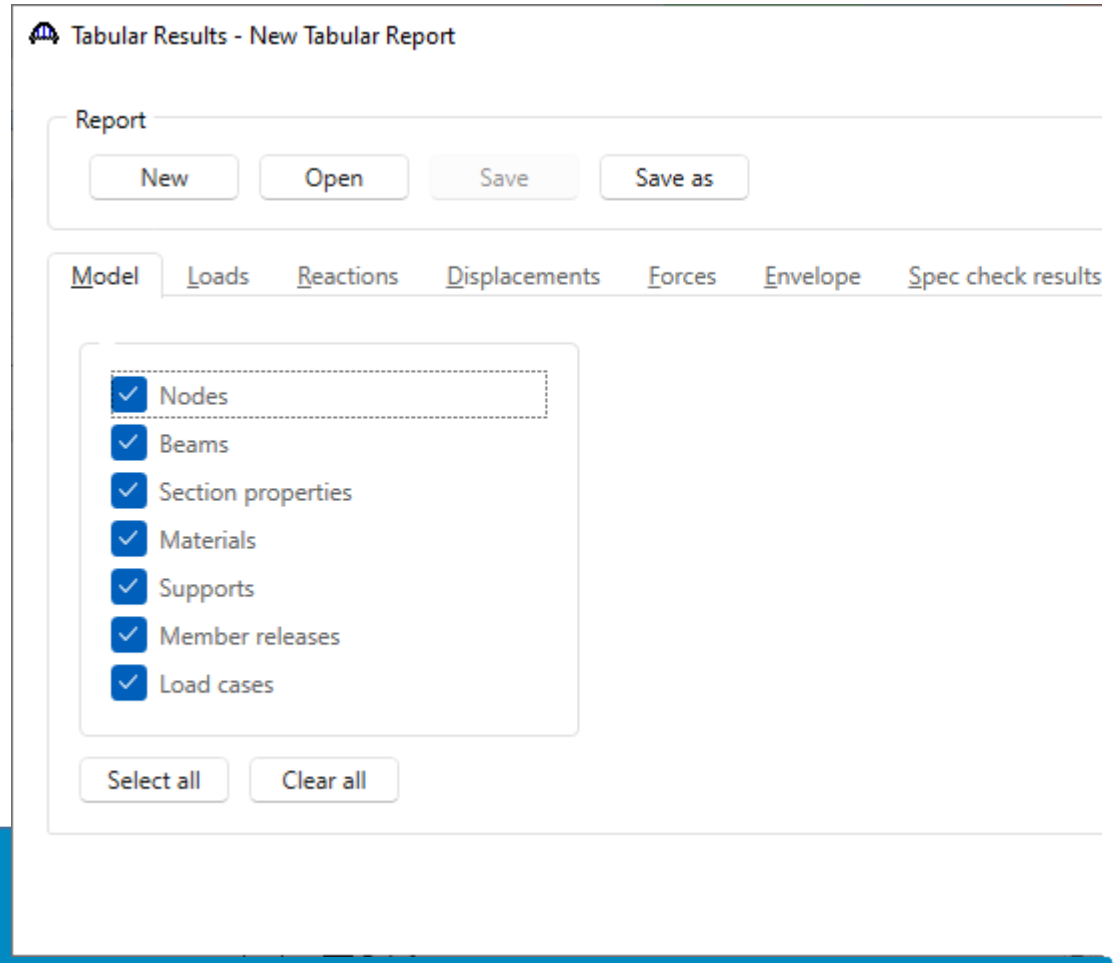
- Generate and view the FE model before analysis



Finite Element Analysis

- First order elastic analysis
- First order elastic analysis with moment magnification
- Non-linear analysis – only piers with drilled shafts
- Load combination generation
- Force envelope generation

Tabular Results



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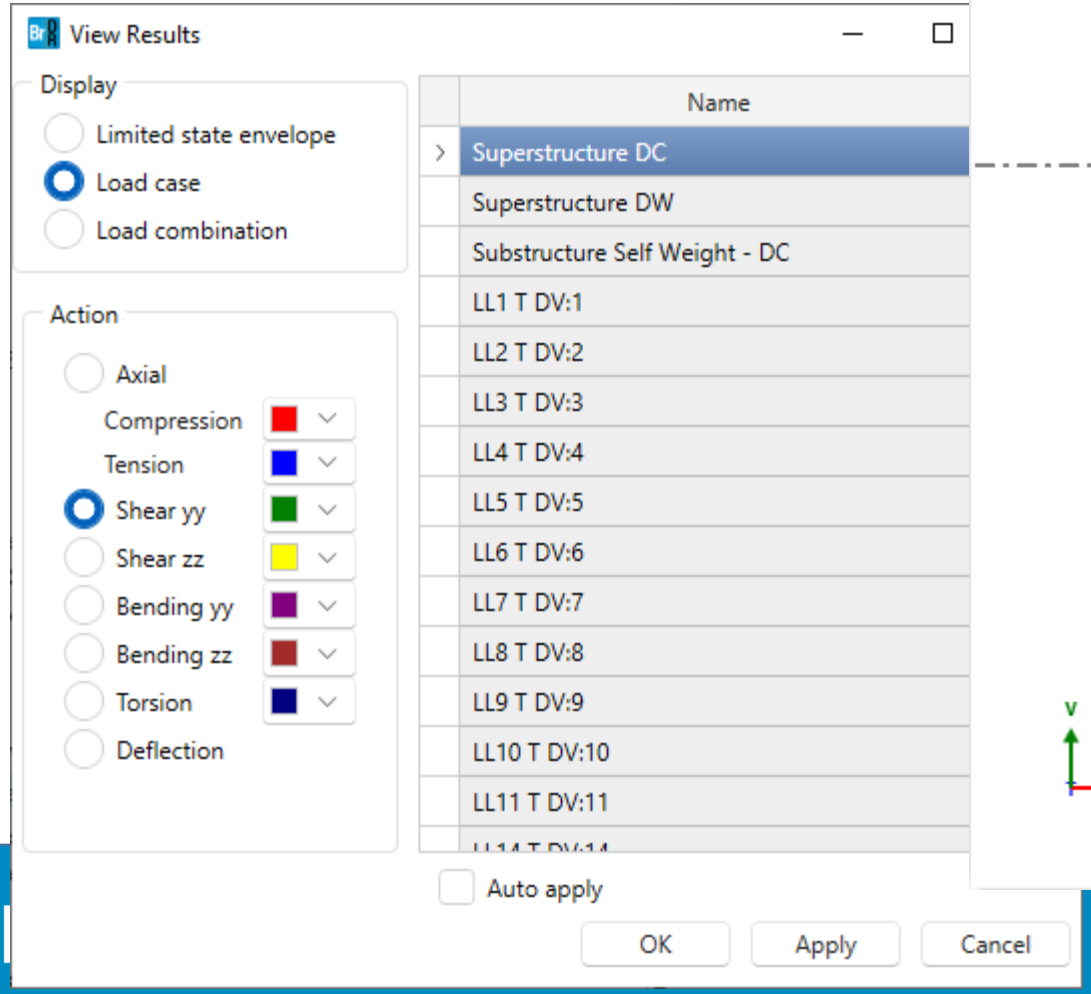
Specification Check Summary

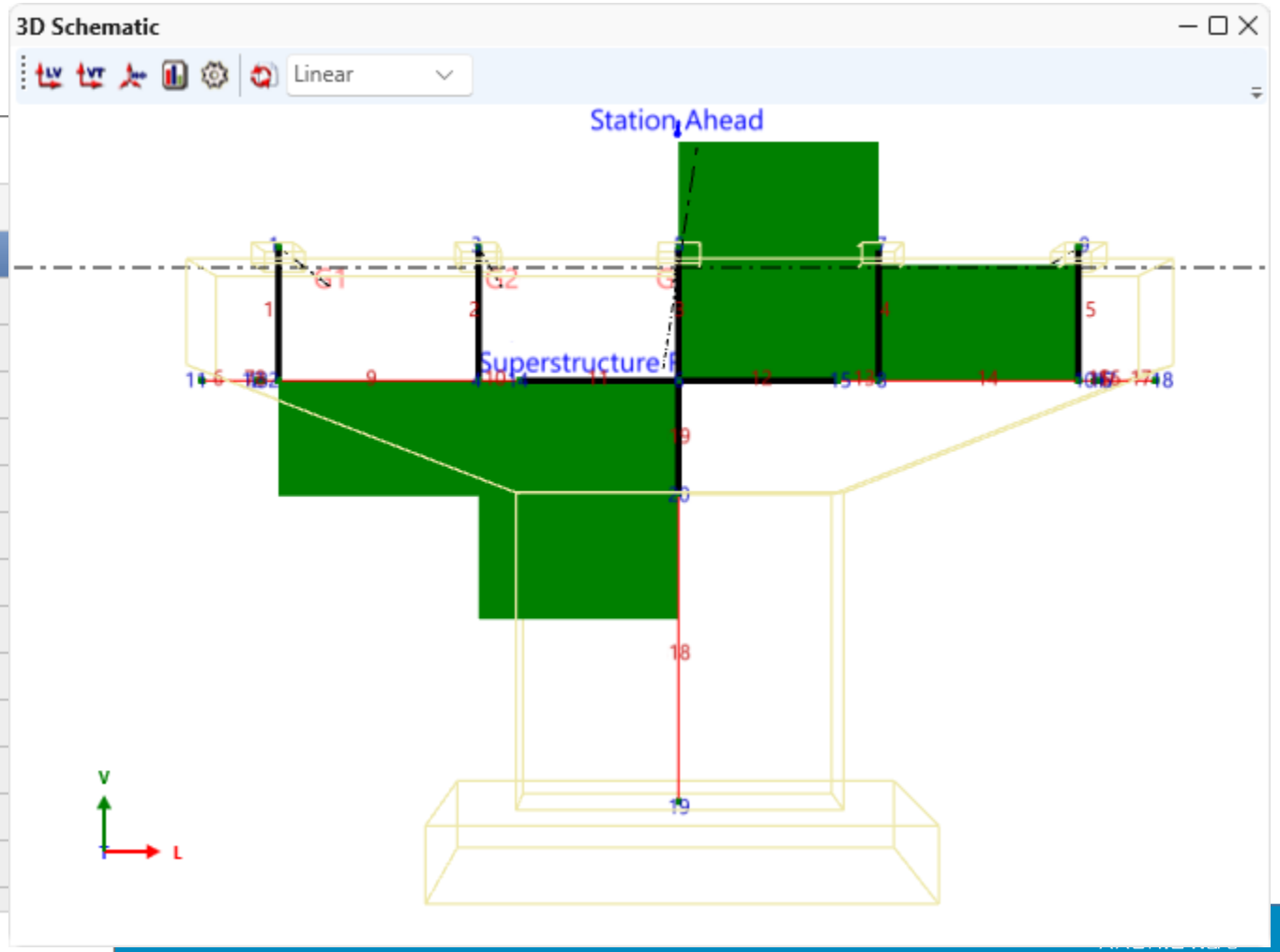
Article	Status
Cap Flexure (5.7.3.2, 5.7.3.3.2)	Fail
Cap Shear (5.8.2.5, 5.8.2.7, 5.8.3.3, 5.8.3.5)	Fail
Cap Serviceability (5.7.3.4 crack, 5.7.3.4 long skin, 5.10.8 shrink & temp)	Pass
Cap Fatigue (5.5.3.2)	Pass
Column1 Biaxial Moment Interaction (5.7.4.5)	Pass
Column1 Shear (5.8.2.5, 5.8.2.7, 5.8.3.3, 5.8.3.5)	Pass
Column1 Serviceability (5.10.8 shrink & temp)	Pass
Column1:Pile footing Pile Forces (5.13.3.2)	Pass
Column1:Pile footing Flexure (5.7.3.2, 5.7.3.3.2)	Pass
Column1:Pile footing Shear (5.8.3.3, 5.13.3.6.3, 5.8.3.5)	Pass
Column1:Pile footing Serviceability (5.7.3.4 Crack, 5.10.8 shrink & temp)	Pass
Column1:Pile footing Fatigue (5.5.3.2)	Pass

NR = Spec check not required at this location

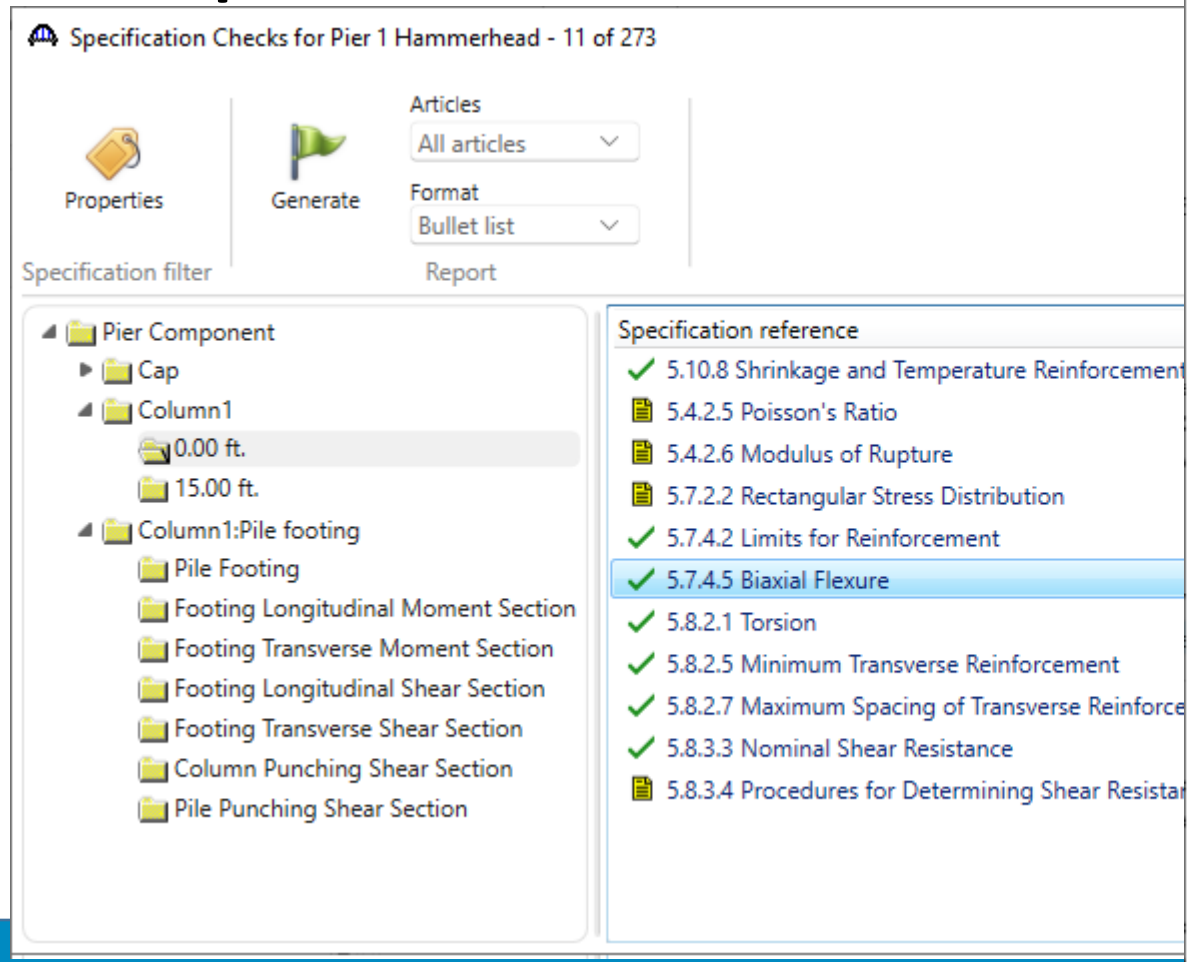
Cap LRFD Analysis Spec Check Results

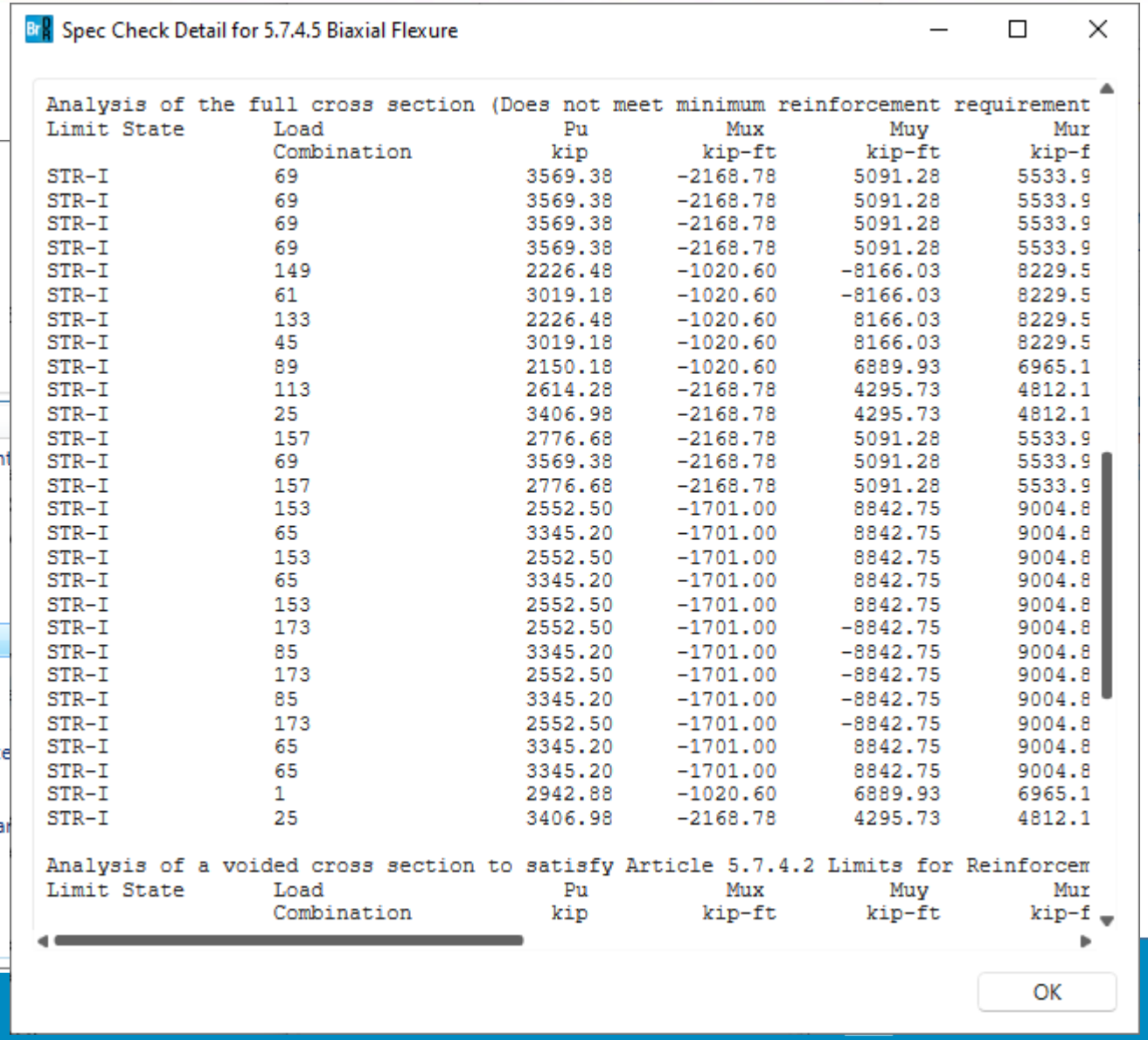
Graphical Results





Specification Checks



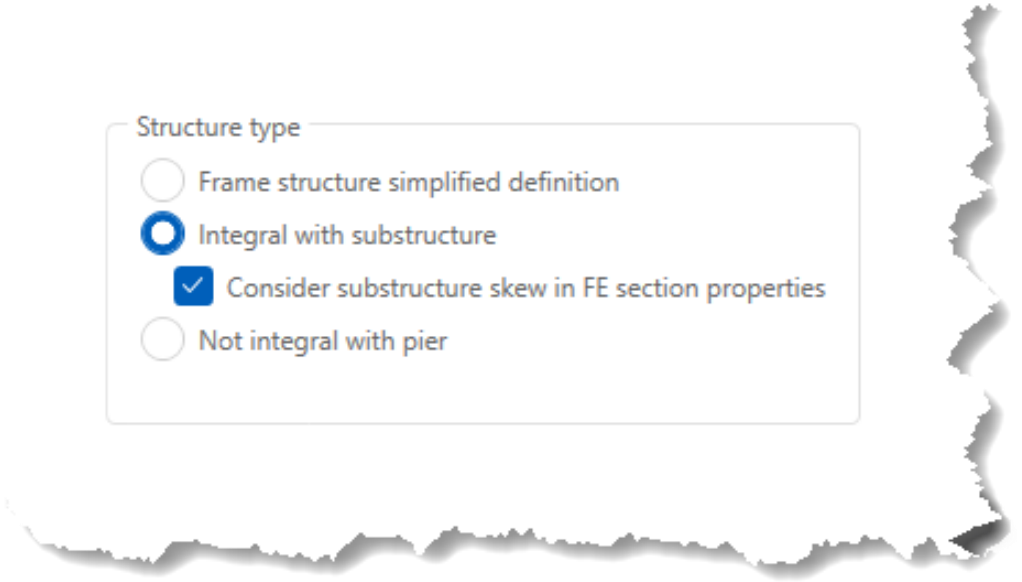


Drilled Shaft Analysis

- Linear analysis
- FE model stops at the base of the columns
- Unfactored load cases applied to the pier
- Superposition and load factors used to combine into factored loads to find critical load combinations
- Factored and combined loads applied to the pier as load cases
- Soil layers are described
- FE model includes the drilled shaft and rock sockets
- Non-linear analysis of this model

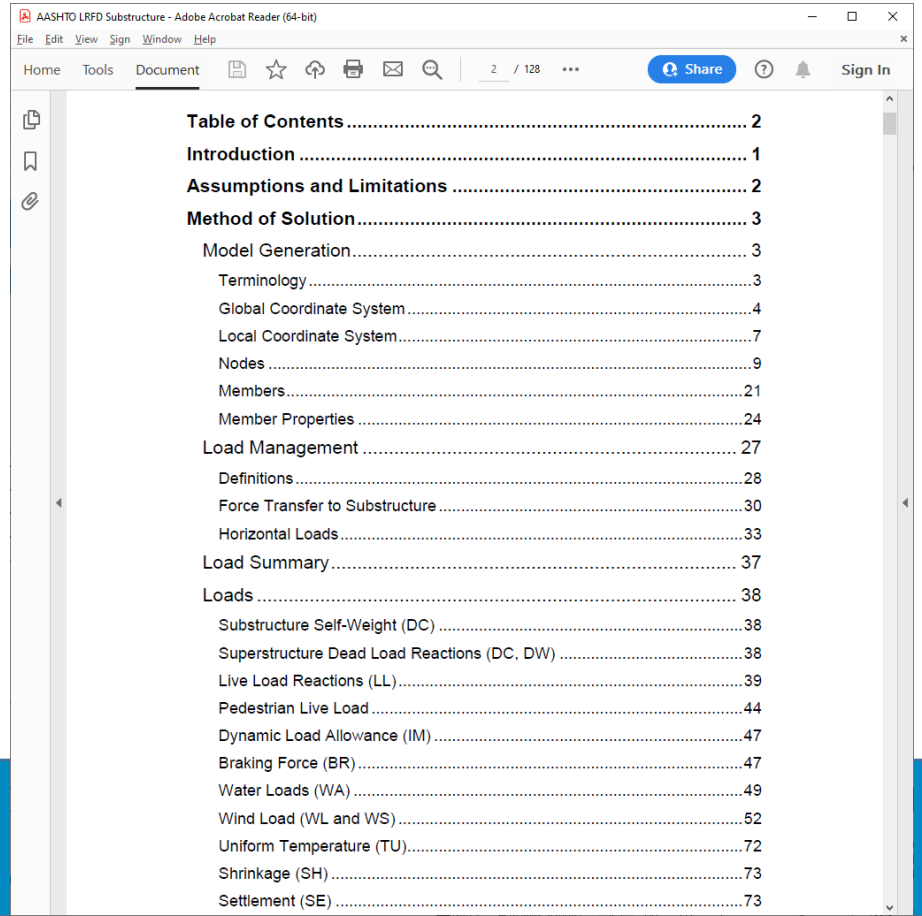
Superstructure Integral with Pier

- Only available for RC Slab System and Concrete MCB
- Pier stiffness is included in the FE model for the superstructure
- Pier itself is not analyzed or spec-checked



Help

- AASHTO LRFD Substructure Method of Solution Manual


AASHTO LRFD Substructure - Adobe Acrobat Reader (64-bit)

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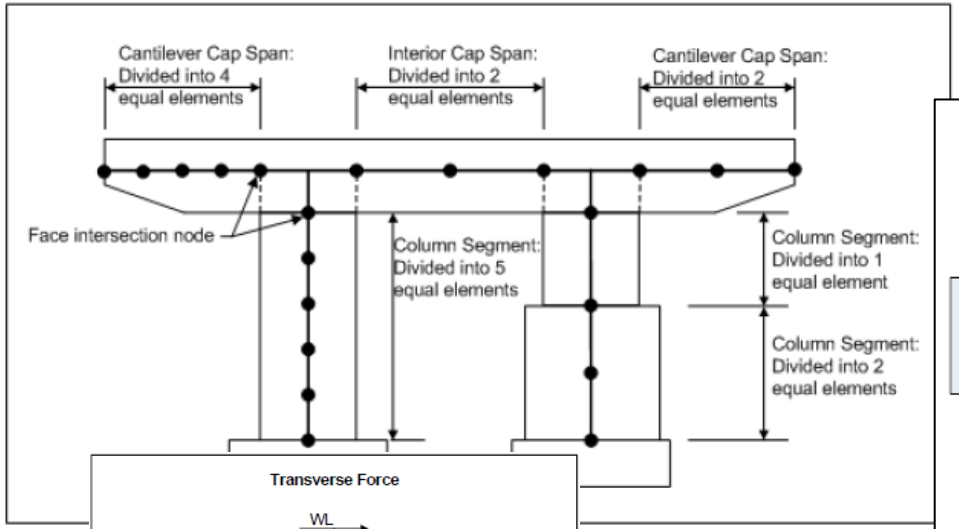
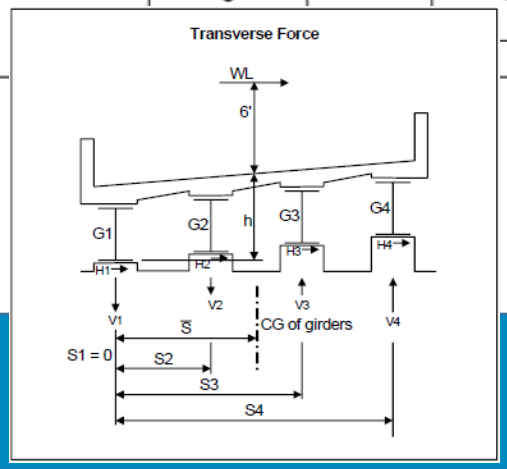
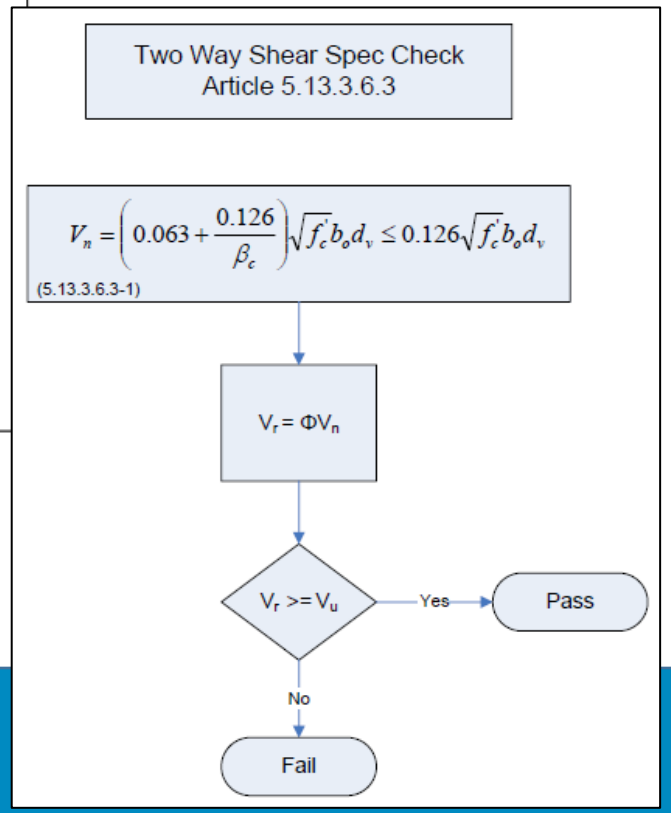
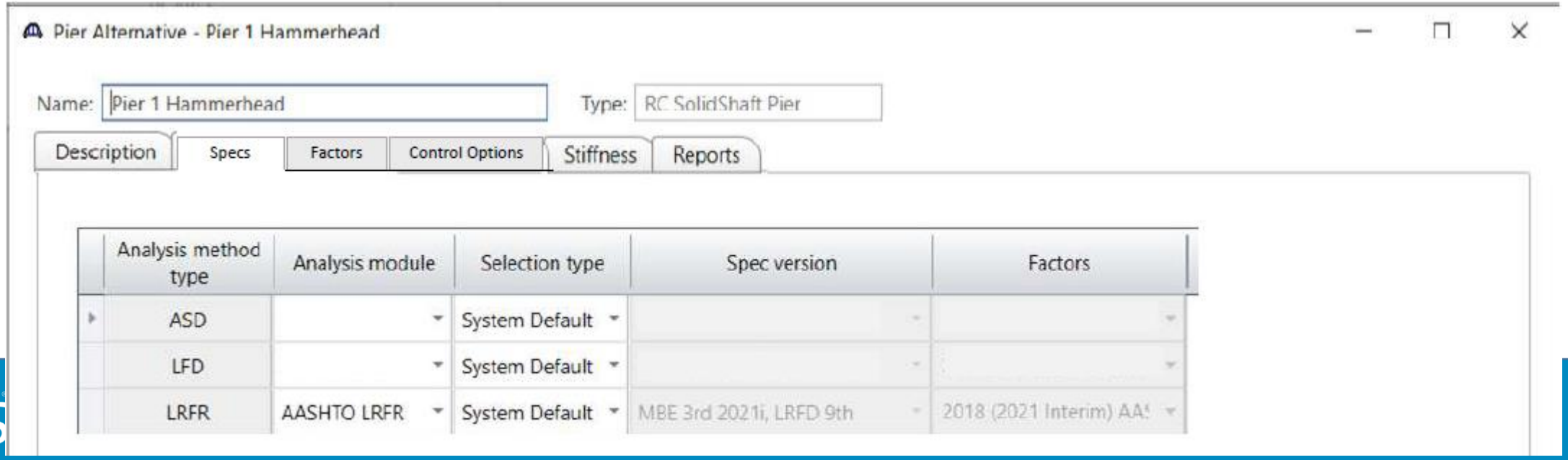






What's Coming in BrDR 7.7

- Reinforced concrete pier cap LRFR analysis
  - LRFR factors
  - Additional inputs for load rating purpose including deterioration profiles
  - Adjacent vehicle analysis and NSG vehicle analysis



What's Coming in BrDR 7.7

- Substructure Bridge Workspace architecture revisions
  - Associating pier alternatives to link certain pier geometry and data between alternatives
  - User fully enters a pier alternative for a pier. This pier alternative is considered as the control pier alternative.
  - For another pier within the same bridge alternative, user creates a new pier alternative of the same type and associates this new pier alternative with the control pier. This pier alternative is considered as the dependent pier alternative.

What's Coming in BrDR 7.7

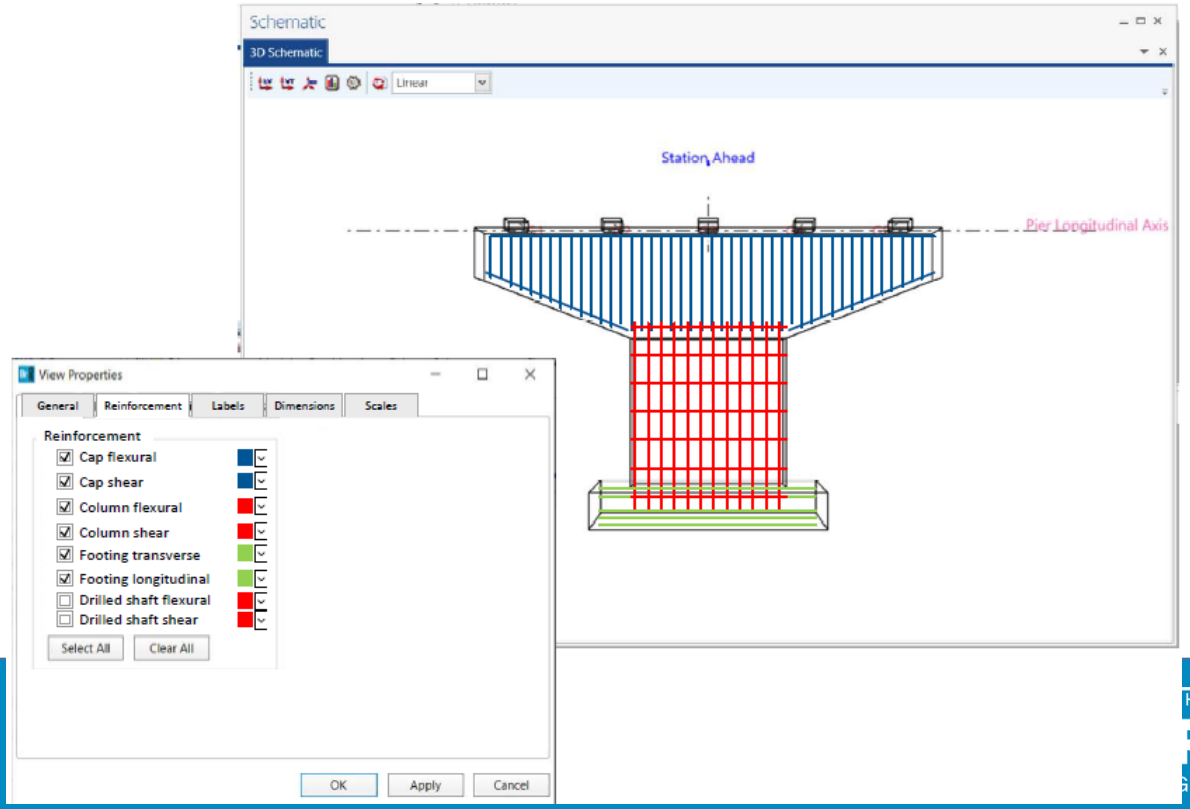
- Substructure reinforcement data entry revisions
  - Control point data entry method

Data entry method
◎ Distance ◉ Control point

Set	Pattern	① Start control point	Start distance (ft)	① End control point	End distance (ft)	Length (ft)	Hook at start	Hook at end	Developed at start	Developed at end	Follows profile
1	Def #1	Bottom of column	-3.00	Bottom of column	7.00	10.00	☑	☐	☐	☐	☐
2	Def #1	Bottom of column	0.00	Bottom of column	15.00	15.00	☐	☐	☐	☐	☐
3	Def #1	Top of column	-10	Top of column	3.00	13.00	☐	☑	☐	☐	☐

What's Coming in BrDR 7.7

- 10 Additional Substructure TAG enhancement requests
  - 3D Schematic - predefined plan view, show reinforcement
  - Copy/paste enhancement
  - Hexagon column shape



Thank you for your time!