THE **QuikBeamAASHTO** PROGRAM
Version 5.01
User Instructions

PRELIMINARY SELECTION AND OPTIMIZATION OF CONVENTIONAL UNITS, PRESTRESSED CONCRETE BRIDGE SECTIONS
(PER AASHTO LRFD SPECIFICATIONS)

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Northeast Prestressed Products
TopRoc Newcrete Products Company
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Bayshore Concrete Products Corp.
Jersey Precast Corp.

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Note: * PCEF stands for “Prestressed Concrete Economic Fabrication”. This is an effort spearheaded by the Federal Highway Administration Resource Center in Baltimore to achieve economic bridge construction by having regional standards that allow prestressed concrete producers to have uniform standards to which they have to design and produce. This effort is supported by the various State Departments of Transportation in the Central Atlantic region and has now resulted in this Bulb Tee beam standard.

DISCLAIMER

This QuikBeamAASHTO design aid was developed to assist in the preliminary selection and optimization of prestressed concrete bridges in the central Atlantic states.

The professional engineer user must clearly understand the basic assumptions and their limitations inherent in the design and analysis of prestressed concrete girders. Final design must also be conducted using appropriate software. Neither the Prestressed Concrete Association of Pennsylvania, nor its affiliated companies, nor any person acting on their behalf:

- Make any warranty, express or implied, with respect to the use of information, methods, software or procedures disclosed in this program and its instruction or that such use may not infringe upon existing rights.

- Assumes any liability of whatever kind with respect to the use of, or damages derived from the use of, any information, methods, software or procedures disclosed.

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INTRODUCTION

A full preliminary analysis of prestressed concrete beams is highly desirable but seldom performed in practice due to the time consuming requirements in determining the reinforcement and initial concrete strengths. Design engineers usually face the situation where several initial estimates of the beam size, amount of reinforcement, concrete release strength and material quantities are needed before final framing and layout decisions are made. In the final design stage they will proceed to run detailed calculations and check conformance to the design requirements (by AASHTO LRFD). Commonly used bridge beam types are shown in Figure 1.

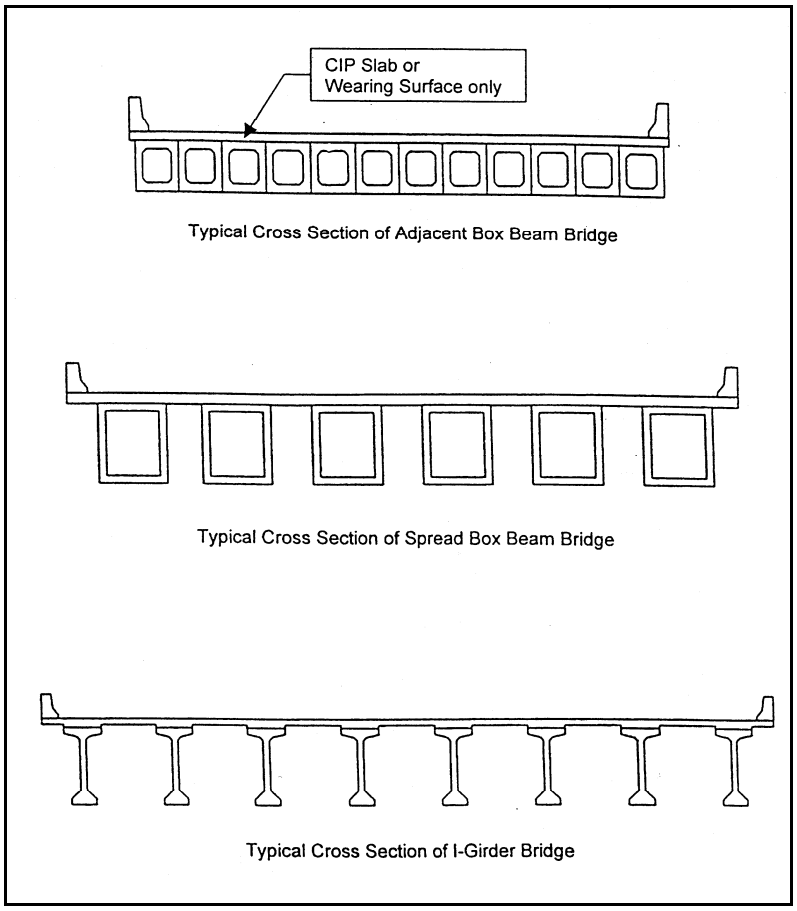

Figure 1

These tedious design steps usually take a substantial amount of time. Even with the use of current software available to the designer, the program input and iterations are still time consuming. Furthermore, a previous design of a 98 feet span structure, for example, cannot simply be extrapolated to a subsequent 118 feet span structure because of other variables such as girder spacing, concrete strength and beam size which are associated with a specific project.

In the Type, Size and Locations (T. S. & L.) phase of a bridge selection process, designers are often faced with the following questions for a bridge with a given width:

(1) Given an alternative solution with a span, L_1, a number of beams, N_b (or a girder spacing S_1), is the solution feasible? The answer is yes, if:

(a) the sections require a number of ½ inch special strands, N, that is less than the maximum number physically allowed by the form design, and
(b) if the required release strength for concrete does not exceed a maximum regional, structural, or producer limit, f'_{ci}.

(2) If one pier is eliminated a new alternate design is possible with a deeper section and a longer span, L_2. Is a new spacing $S_2<S_1$ required? Is the solution in (2) more economical than (1)?

(3) If one girder line is eliminated, would the new solution with a spacing $S_3> S_1$ be feasible and more economical?

A fast prediction of N and f'_{ci} is essential at the conceptual, T. S. & L. or estimating stages since producers have limitations on concrete strengths and the amount of reinforcement they can place in a beam. In order to answer these questions in a systematic way, a relationship between N (or f'_{ci}), the girder spacing, S, and the span, L, was first developed in the early 1990s.

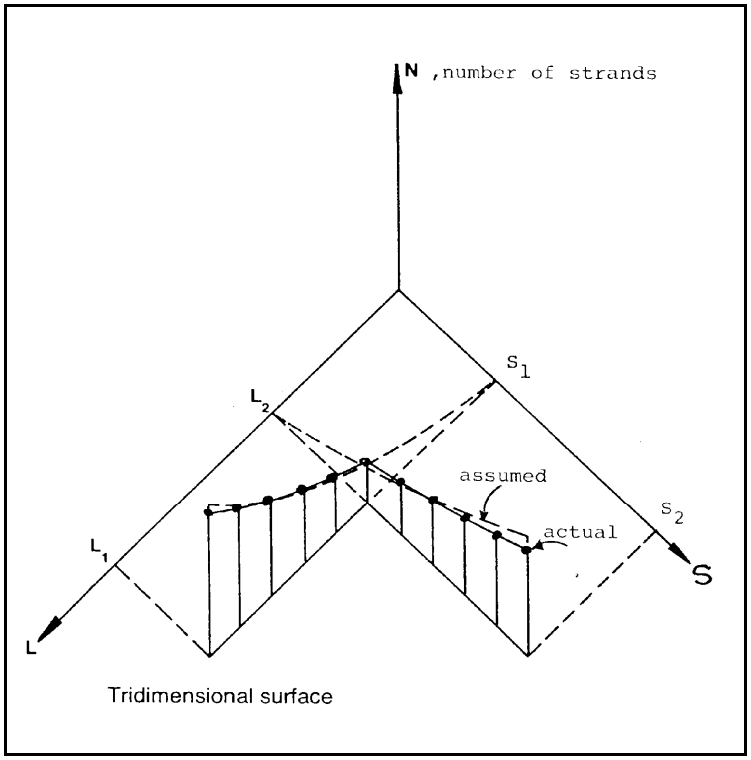

Figure 2

In this study, it was assumed that L and S are the dominant variables. Based on several thousand exact solutions, it was found that the following equations are excellent predictor formulas (also see Fig. 2 above) where N is the number of standard ½ inch special diameter, low relaxation strand, and f'_{ci} is the required concrete release strength:

$$N = A(L)^x (S)^y \qquad [1]$$
$$f'_{ci} = B(L)^u (S)^v \qquad [2]$$

QuikBeamAASHTO, a macro driven Microsoft Excel spreadsheet using AASHTO, PCEF and other commonly used box girder sections used in the Central Atlantic states, was also developed using these equations. For 95 % of the cases the average relative prediction error using Equations [1] and [2] was found to be 4% only, with a range of 0 to 8%. It requires inputting a limited number of data such as bridge type (AASHTO I-beam, spread box, adjacent box, or PCEF Bulb Tee), bridge width, and simple span length. Additional variables, such as slab overhang, the minimum number of girders, smallest desirable beam depth and maximum permissible release strength are optional. The program then generates up to 9 solutions with prestressing and strength requirements in addition to summarizing the material quantities (concrete volume and number of strands).

QuikBeamAASHTO TECHNICAL FEATURES AND LIMITATIONS

The program database of version 1.0 includes almost all of the beam sections that are commonly used in the central Atlantic states.

The basic underlying assumptions are as follows:

Specifications

AASHTO LRFD Bridge Design Specifications, 3rd Edition, 2004

Bridge Configuration

Girder Spacing/Slab Thickness
- 7.50 ft / 8.00 in
- 10.00 ft / 8.00 in
- 12.50 ft / 9.00 in
- (Note: 0.5 in. discounted for section properties)

Materials

Girder Concrete
- 28-day strength, f'_c: 8.500 ksi
- Release strength, f'_{ci}: 6.500 ksi (assumed for computing prestress losses)
- Unit weight: 0.150 kcf

Deck Concrete
- 28-day strength, f'_c: 4.000 ksi
- Unit weight: 0.150 kcf

Prestressing Strand
- ½" Special, low-relaxation strand
- Diameter: 0.500 in
- Area: 0.167 in^2
- f_{pu} (U.T.S.): 270 ksi
- Pull: 75 % of U.T.S.

Loads

Concrete Barriers
- Weight: 0.650 klf/each
- No. Barriers: 2
- Weight per Girder for I-shapes and spread boxes:

7.50 ft girder spacing:	0.217 klf/girder
10.00 ft girder spacing:	0.217 klf/girder
12.50 ft girder spacing:	0.260 klf/girder

- Weight per Girder for Adjacent boxes: 1/3rd of a barrier weight.

Future Wearing Surface
Weight: 0.030 ksf
Weight per Girder
7.50 ft girder spacing: 0.225 klf/girder
10.00 ft girder spacing: 0.300 klf/girder
12.50 ft girder spacing: 0.375 klf/girder
Live Load
HL-93

Strand Pattern Design Constraints

Profile
2-point draped @ 0.38L for I-girders; straight pattern for box beams
Prestress Loss Calculations
Relative Humidity: 75%
Hours to release of strand: 18 hrs
Load Table Generation Parameters
Approximate target limits:
For f'_{ci}:
Min: 3.300 ksi
Max: 7.200 ksi
For number of strands:
Max: 80 for girder depths ≤ 76 in
Max: 84 for girder depths > 76 in
Allowable final bottom tension stress: $-0.19\sqrt{(f'_c)} = -0.554$ ksi

Design Notes

- Pattern designs are based on satisfaction of service stresses and strength requirements. Required f'_{ci} values are computed at the drape point at release time for I-shapes and near the ends for boxes.
- Prestressing of adjacent box beams was often increased to limit the predicted sag. Estimate of potential negative camber (sag) should be verified according to local practice.
- No consideration is given to maximum girder haul weight, maximum girder length, maximum live load deflection, or maximum or minimum camber.
- Stability of girder during handling and hauling is not checked.
- Feasibility of shear design is not checked.
- No upper or lower limits are placed on total prestress loss.

The default values for the input variables are as follows:

1) Minimum number of girders in the cross section: for Option A this is 4. In Option B and Option C, the number of girders is incremented by 1 and 2, respectively.

2) Maximum desirable concrete strengths: 6.67 ksi at release and 7.55 ksi at 28 days. Note that release strengths in excess of 6.67 ksi are possible in some cases. However, the user should

carefully check feasibility with producers. In many cases of adjacent box beams, the structural requirements set a limit on the maximum number of strands, which limits f'_{ci} to less than 5.80 ksi.

3) Unless set by the user, the deck overhang for spread beams is automatically set at ½ of the girder spacing for Options A, B, and C (Beam Selections 1, 2 and 3).

4) Minimum desirable basic beam depth: the default value is set internally using complex formulas which will result in a predicted release strength near the practical maximum for the first solution (Option A, Selection1).

INPUT MESSAGES AND WARNINGS

The program has built-in messages that will be displayed when inputs exceed certain established program limits. These warnings are:

Entered value is below industry recommended minimum concrete release strength: Whenever the predicted release strength is below 3.3 Ksi, this message ("LOW") indicating the required f'_{ci} is low will be shown, and, therefore the section size is too big for the given span and spacing. Note that there is nothing structurally wrong with the deeper section. However, a shallower depth (or a wider spacing) would probably result in a more economical design.

Entered value is above industry recommended maximum concrete release strength: When the predicted release strength exceeds the desirable ("target") value, a message to that effect ("HIGH") will be printed out. It is suggested that a deeper section or smaller beam spacing be used. But, since the program also checks other options with smaller spacings and deeper sections, often there is no need for additional runs.

Entered span length is outside of program limits: The study is based on a database of exact solutions within a practical range of prestressed concrete bridge girder applications that vary for different girder types. This warning reflects the limit of the underlying research.

This small girder spacing is out of the domain of this program: The study is based on exact solutions within a practical range of prestressed concrete bridge girder applications that vary for different girder types. This warning reflects the limit of the underlying research for Solution Option A.

This large girder spacing is out of the domain of this program: The study is based on exact solutions within a practical range of prestressed concrete bridge girder applications that vary for different girder types. This warning reflects the limit of the underlying research for Solution Option A.

Consider a minimum of 4 girders per span: In order to allow deck replacements while in use, practice frequently requires a minimum of four girder cross sections for spread beam structures.

The number of girders per span is probably too large: When the total number of girders per span of spread beam structures exceeds 8 girders this warning is given.

Total width of computed beams does NOT match out-to-out bridge width.
Suggested out-to-out bridge width _____ ft

This warning and suggestion will appear when the inputted out-to-out bridge width for adjacent box beam structures does not match to an integer multiple of the selected beam width (48 inch or 36 inch). The solutions presented will be based on the recommended bridge width. Mixing 48 inch and 36 inch beams is not recommended for new designs, although feasible

OUTPUT SUMMARY AND WARNINGS

A summary table, showing a maximum number of nine potential solutions for spread box beams or I-beams and three potential solutions for adjacent box beams, may be requested in hard copy form of a specific run. This printout is optional and contains the basic variables: span, number of girders, beam overhang, beam sizes, predicted strands, precast concrete volume and weight. Any warnings generated by the input data or user selections are also repeated. When the results of a particular solution's beam selection or spacing falls outside of the industry's general design limits, additional warnings may be displayed for individual solution Options.

Resulting Girder Spacing: When out of the range of the exact solutions used for the development of QuikBeamAASHTO will generate an appropriate warning.

Number of ½ inch Strands: When exceeding individual beam's structural limits or industry constraints will indicate HIGH.

Concrete Release Strength Required: When the solution requires a higher or lower strength than the default or user selected limit.

When the beam section with a maximum inventory depth has been tried as one of the alternatives, then a message will be displayed indicating no more sections are available in the program database. Therefore, fewer solutions will be presented.

For practical reasons, the precast concrete volume and mass is always listed for all the beams in the span. The number of ½ inch strands is always given per beam.

QuikBeamAASHTO PROGRAM OPERATION
Microsoft Excel Version

QuikBeamAASHTO.xls is a Microsoft Excel spreadsheet, which uses a self-executing Visual Basic macro that guides the user through a number of choices. On opening of the file, Microsoft provides a warning that the file contains a macro and gives the user the option to enable or not to enable the macro. For QuikBeamAASHTO to operate, the macro mode must be enabled.

Viewing the 'Use Agreement' is not necessary for program operation every time; however, it contains important disclaimers and other information on the use and distribution of the program as well as additional acknowledgements.

If the project involves unusual or additional dead loads the macro will terminate, as the program does not reflect such load conditions.

On the Beam Selection form the mandatory inputs are:

- Span Length – enter dimension (ft)
- Bridge Width – enter dimension (ft)
- Girder Type – select from drop-down box. After the girder type has been selected the beam shapes that the program will consider for its potential solutions can be viewed from the "VIEW BEAMS" button.

All other fields are optional and have built-in default values that can be over-ridden with specific user selected inputs.

Should a condition be specified that generates an input warning, a "VIEW WARNINGS" button becomes available. On clicking this button the warnings are displayed. Once the warnings window is closed make appropriate changes to the inputs and select the "RECALC" button to ensure that all warnings have been cleared or that a decision has been made that the condition generating the warning is acceptable.

The "VIEW RESULTS" button will present the Solutions page.

Occasionally some solutions may show an output warning for the required concrete release strength or number of strands. The "RUN ANOTHER CALC" option will allow the user to change the minimum beam depth to a larger or smaller beam. Every time a new trial is attempted the user must click on the "RECALC" button before selecting "VIEW RESULTS".

The Solution page presents five options:

The “RUN ANOTHER CALC” option takes the user to the selection window for an additional iteration.

The “PRINT SOLUTION” option will print the summary report of the available options.

The “WELCOME” option takes the user back to the opening screen.

The “DISCLAIMER” option takes the user to the “Use Agreement’ of the opening screen.

The “EXIT QUIKBEAM” option will close the spreadsheet and exit the Microsoft Excel program after giving the option to save the spreadsheet with the current information.

EXAMPLE 1: AN I-GIRDER BRIDGE

A 36 ft wide bridge section for a two-lane bridge plus shoulders is to be designed for a 114.8 ft simple span (c-to-c of bearings) and AASHTO LRFD criteria. The project requires that bare beam depth be limited to 70 inches. Make a preliminary selection of beam sections for T.S & L. purposes. Desirable strength limit at release is not to exceed 7.25 Ksi.

DATA ENTRY:

Enter:	Span Length:	114.8 ft
	Out-to-Out Bridge Width:	36.0 ft
	Girder Type:	I-Beam
	Min. # of Girders:	Accept Default
	Max. Overhang:	Accept Default
	Min Concrete Strength at Release:	Accept Default
	Max Concrete Strength at Release, f'_{ci}:	7.5 ksi

On entering this Maximum Concrete Strength at Release value, we note that the VIEW WARNINGS button becomes available. The message indicates that this value of 7.5 Ksi for this beam is above industry recommended default maximum of 6.67 Ksi that was indicated. We decide not to exceed the maximum program recommendation.

The program indicates that the default (estimated) girder depth would be 56 inches. The VIEW GIRDERS button shows the database of available types. Three section depths that are less or equal to 70 inches may be considered: 54, 63 and 66 inches.

Min Starting Depth:	We will try 54

The VIEW RESULTS button displays the QuikBeamAASHTO solutions as shown on the next page.

SOLUTIONS:

Scanning the three beam solutions presented, we find that in **Option A (4 beam lines)** the AASHTO IV 26 X 54 inch section requires release strength slightly in excess of the default "target value" of 6.67 Ksi and that the number of strands for this section at 69 is high. Acceptable sections are: AASHTO V 28 X 63 which requires 51 strands, a concrete release strength of 4.812 Ksi, and uses 122 cu yd of concrete; the AASHTO Va 28 X 66 beam requires 48 strands and a concrete release strength of 4.428 Ksi. The concrete volume per span is 125 cu yd.

Option B (5 beam lines) also shows the 26 X 54, 28 X 63 and the 28 X 66 AASHTO sections. The 26 X 54 section requires 54 strands, a release strength of 5.988 Ksi, and a concrete volume of 119 cu yd; the 28 X 63 section requires 41 strands, a concrete release strength of 3.728 Ksi, and a concrete volume of 152 cu yd; the 28 X 66 section requires 39 strands, a concrete release strength of 3.476 Ksi, and a concrete volume of 156 cu yd.

Option C (6 beam lines) shows that the resulting small girder spacing of 6.0 feet is outside of the domain of the program database and may not be efficient.

After checking with two producers, Option A, with four 28 X 63 beams, turns out to be the most economical for the superstructure.

QuikBeamAASHTO LRFD Solutions

Span Length (c-to-c) Assigned by User 114.80 feet
Bridge Width (out-to-out) Assigned by User 36.00 feet
Girder Type Selected by User AASHTO I-Beam

Starting Girder Depth			**Maximum f'ci**		
Program Estimate	56	inches	Program Default *	6.670	Ksi
User Selected	56	inches	User Selected	6.670	Ksi

Preliminary Beam Selections			AASHTO IV 26 X 54		AASHTO V 28 X 63		AASHTO Va 28 X 66	
4 Girder lines per span								
Resulting girder spacing	9.00	feet						
Resulting overhang ****	4.50	feet						
Number of 1/2 inch strands			69 Strands	**High!**	51 Strands		48 Strands	
Concrete release strength required **			7.729 Ksi	**High!**	4.812 Ksi		4.428 Ksi	
Cubic yards of concrete per span ***			95 cu yd		122 cu yd		125 cu yd	
Tons of concrete per span ***			192 tons		246 tons		253 tons	
5 Girder lines per span								
Resulting girder spacing	7.20	feet						
Resulting overhang ****	3.60	feet						
Number of 1/2 inch strands			54 Strands		41 Strands		39 Strands	
Concrete release strength required **			5.988 Ksi		3.728 Ksi		3.476 Ksi	
Cubic yards of concrete per span ***			119 cu yd		152 cu yd		156 cu yd	
Tons of concrete per span ***			240 tons		308 tons		316 tons	
6 Girder lines per span								
Resulting girder spacing	6.00	feet						
Resulting overhang ****	3.00	feet						
Number of 1/2 inch strands			45 Strands		34 Strands		32 Strands	
Concrete release strength required **			4.861 Ksi		3.026 Ksi	**Low, section too deep!**	2.852 Ksi	**Low, section too deep!**
Cubic yards of concrete per span ***			142 cu yd		183 cu yd		187 cu yd	
Tons of concrete per span ***			288 tons		370 tons		379 tons	

Note: * applies only to first beam solution at initial spacing option
Note: ** assumes draped strands.
Note: *** includes 12 inches beam length (at each end) from C.L. of bearing to end of beam.
Note: **** overhang measured from center of external girder to outside of barrier edge.

Input Warnings:

For more information please contact any of the following:

New Enterprise Stone and Lime Company, Inc. Telephone: (814) 224-2121 FAX: (814) 224-6809
301 Plum Creek Road, P.O. Box 34, Roaring Spring, PA 166
Northeast Prestressed Products Telephone: (570) 385-2352 FAX: (570) 385-2404
121 River Street, Cressona, PA 17929
TopRoc Newcrete Products Company Telephone: (570) 385-2352 FAX: (570) 385-2404
2210 Manchester Road, Erie, PA 16506

Central Atlantic Bridge Associates Telephone: (610) 395-2338 FAX: (610) 395-8478
1042 North Thirty Eigth Street, Allentown, PA 18104
Find us on the World Wide Web at: http://'www.pcap.org
E-Mail: info@pcap.org

EXAMPLE 2: A COMPOSITE, ADJACENT BOX BEAM BRIDGE

A three-lane bridge plus shoulders with limited clearance will use adjacent box beams and a minimum 5 inch C.I.P. slab to span 122 feet (c-to-c of bearings). Maximum imposed precast beam depth is 48 inches. Explore various potential solutions.

DATA ENTRY:

Enter:	Span Length:	122.0 ft

Adjacent box sections are often used when clearance is limited. For the same beam depth, they go further than I-beams and spread-box girders. Generally, the 48 inch wide section is more economical. We find that twelve 48 inch beams will satisfy the bridge width requirements.

Out-to-Out Bridge Width:	48.0 ft
Girder Type: Adjacent Box Beams Composite –	48 inches wide
Min. # of Girders:	Accept Default
Min Concrete Strength at Release:	Accept Default
Max Concrete Strength at Release:	Accept Default
Min Starting Depth:	Accept Default

The VIEW RESULTS button displays the QuikBeamAASHTO Solutions as shown on the next page.

SOLUTIONS:

The output shows that all three solutions that the program generated meet the maximum beam depth requirement. The 48 X 42 requires 50 strands, a concrete release strength of 7.476 Ksi, and uses 286 cu yd of concrete. The 48 X 45 requires 46 strands, a concrete release strength of 6.847 Ksi, and uses 298 cu yd of concrete. The 48 X 48 beam requires 43 strands, a concrete release strength of 6.238 Ksi, and uses 309 cu yd of concrete.

The 48 X 42 section has a warning that indicates that the number of fifty ½-inch strands and concrete release strength of 7.476 for this solution is HIGH. But it should not be discarded outright because these numbers are only an estimate and loads and future wear surface may be lighter than assumed in the program; the actual required number may be lower and close to the maximum for this beam.

An appropriate check for long-term camber is always desirable for adjacent box beams.

QuikBeamAASHTO LRFD Solutions

Span Length (c-to-c) Assigned by User 122.00 feet
Bridge Width (out-to-out) Assigned by User 48.00 feet
Girder Type Selected by User Adjacent Box Beam - Composite 48 inches wide

Starting Girder Depth			**Maximum f'ci**		
Program Estimate	43	inches	Program Default *	6.670	Ksi
User Selected	43	inches	User Selected	6.670	Ksi

Preliminary Beam Selections			48 x 42			48 x 45			48 x 48	
12 Girder lines per span										
Resulting girder spacing	4.00	feet								
Resulting overhang ****	2.00	feet								
Number of 1/2 inch strands			50	Strands	**High!**	46	Strands		43	Strands
Concrete release strength required **			7.476	Ksi	**High!**	6.847	Ksi	**High!**	6.238	Ksi
Cubic yards of concrete per span ***			286	cu yd		298	cu yd		309	cu yd
Tons of concrete per span ***			580	tons		603	tons		626	tons
Girder lines per span										
Resulting girder spacing		feet								
Resulting overhang ****		feet								
Number of 1/2 inch strands			0	Strands		0	Strands		0	Strands
Concrete release strength required **			0.000	Ksi		0.000	Ksi		0.000	Ksi
Cubic yards of concrete per span ***			0	cu yd		0	cu yd		0	cu yd
Tons of concrete per span ***			0	tons		0	tons		0	tons
Girder lines per span										
Resulting girder spacing		feet								
Resulting overhang ****		feet								
Number of 1/2 inch strands			0	Strands		0	Strands		0	Strands
Concrete release strength required **			0.000	Ksi		0.000	Ksi		0.000	Ksi
Cubic yards of concrete per span ***			0	cu yd		0	cu yd		0	cu yd
Tons of concrete per span ***			0	tons		0	tons		0	tons

Note: * applies only to first beam solution at initial spacing option
Note: ** assumes straight debonded strands.
Note: *** includes 12 inches beam length (at each end) from C.L. of bearing to end of beam.
Note: **** overhang measured from center of external girder to outside of barrier edge.

Input Warnings:

Reminders:

Note: Check long term camber by an appropriate method to avoid sag under sustained loads. May require additional strands.
Note: Required release strengths can be lower, if strand debonding is used.

For more information please contact any of the following:

New Enterprise Stone and Lime Company, Inc. Telephone: (814) 224-2121 FAX: (814) 224-6809
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E-Mail: info@pcap.org

EXAMPLE 3: A SPREAD-BOX GIRDER BRIDGE

A 69 ft wide bridge section is planned for the expansion of a current interstate bridge and consists of four traffic lanes plus shoulders. It is to be designed for a 67.25 ft simple span (c-to-c of bearings) and AASHTO LRFD criteria. One of the project geometric constraints requires a precast beam depth between 30 inches and 35 inches (to match the existing northbound lane). Make a preliminary selection of beam sections for T.S.&L. purposes. Release strength should preferably be limited to 5.8 Ksi.

DATA ENTRY:

Enter:	Span Length:	67.25 ft
	Out-to-Out Bridge Width:	69.0 ft
	Girder Type:	48 inch wide spread-boxes
	Min. # of Girders:	Try 7
	Overhangs from C.L. of Ext. Girders:	2.9 ft
	Min. Concrete Strength at Release:	Accept Default
	Max. Concrete Strength at Release:	5.8 Ksi

SOLUTIONS:

Under **Option A, (7 beam lines),** we see only one potential selections without exceeding the set limits on concrete release strength or number of strands. But by selecting "Run Another Calculation" allows us to set the Starting Girder Depth to 27 inches. Now we see that two solutions meet our requirements. Therefore, **Option B, (8 beam lines),** and **Option C, (9 beam lines),** will be disregarded as being non-economical. Release strength may be further reduced by appropriate de-bonding (sleeving) of strands at the ends.

Under Option A the second solution, the 48 x 30 precast box, satisfies the aforementioned geometric constraint and will be used for this case. It predicts 37 required strands, concrete release strength of 5.228 Ksi and a concrete volume of 80 cu yd per span.

QuikBeamAASHTO LRFD Solutions

Span Length (c-to-c) Assigned by User 67.25 feet
Bridge Width (out-to-out) Assigned by User 69.00 feet
Girder Type Selected by User Spread Box Beam 48 inches wide

Starting Girder Depth			**Maximum f'ci**		
Program Estimate	25	inches	Program Default *	5.800	Ksi
User Selected	27	inches	User Selected	5.800	Ksi

Preliminary Beam Selections			48 x 27		48 x 30		48 x 33	
7 Girder lines per span								
Resulting girder spacing	10.53	feet						
Resulting overhang ****	2.90	feet						
Number of 1/2 inch strands			44	Strands	37	Strands	32	Strands
Concrete release strength required **			6.371	Ksi **High!**	5.228	Ksi	4.339	Ksi
Cubic yards of concrete per span ***			76	cu yd	80	cu yd	84	cu yd
Tons of concrete per span ***			154	tons	162	tons	145	tons
8 Girder lines per span								
Resulting girder spacing	9.03	feet						
Resulting overhang ****	2.90	feet						
Number of 1/2 inch strands			37	Strands	31	Strands	27	Strands
Concrete release strength required **			5.373	Ksi	4.397	Ksi	3.622	Ksi
Cubic yards of concrete per span ***			87	cu yd	91	cu yd	96	cu yd
Tons of concrete per span ***			176	tons	185	tons	166	tons
9 Girder lines per span								
Resulting girder spacing	7.90	feet						
Resulting overhang ****	2.90	feet						
Number of 1/2 inch strands			32	Strands	27	Strands	23	Strands
Concrete release strength required **			4.636	Ksi	3.785	Ksi	3.097	Ksi **Low, section too deep!**
Cubic yards of concrete per span ***			98	cu yd	103	cu yd	108	cu yd
Tons of concrete per span ***			198	tons	208	tons	187	tons

Note: * applies only to first beam solution at initial spacing option
Note: ** assumes straight debonded strands.
Note: *** includes 12 inches beam length (at each end) from C.L. of bearing to end of beam.
Note: **** overhang measured from center of external girder to outside of barrier edge.

Input Warnings:

Reminders:

Note: Required release strengths can be lower, if strand debonding is used.

For more information please contact any of the following:

New Enterprise Stone and Lime Company, Inc. Telephone: (814) 224-2121 FAX: (814) 224-6809
301 Plum Creek Road, P.O. Box 34, Roaring Spring, PA 166
Northeast Prestressed Products Telephone: (570) 385-2352 FAX: (570) 385-2404
121 River Street, Cressona, PA 17929
TopRoc Newcrete Products Company Telephone: (570) 385-2352 FAX: (570) 385-2404
2210 Manchester Road, Erie, PA 16506

Central Atlantic Bridge Associates Telephone: (610) 395-2338 FAX: (610) 395-8478
1042 North Thirty Eigth Street, Allentown, PA 18104
Find us on the World Wide Web at: http://'www.pcap.org
E-Mail: info@pcap.org

Example 4: A PCEF Bulb Tee Girder Bridge

A 72 ft wide superstructure for a four-lane bridge plus shoulders is to be designed for a 115 ft simple span (center-to-center of bearings) and AASHTO LRFD criteria. The project requires that bare girder depth be limited to 70 in. Make a preliminary selection of girder sections for type, size and location purposes (T.S. & L.). Desirable strength limit at release is not to exceed 6.5 ksi.

DATA ENTRY:

Enter:	Span Length:	115 ft
	Out-to-out bridge width	72 ft
	Girder Type	PCEF Bulb Tee, Top Flange 47" / Bulb 7" / Web 7"
	Minimum number of girders	Use 7; default (4) is too small by inspection
	Overhang	3'-9" (i.e. 3.75 ft)
	Minimum concrete strength at release	Accept default
	Maximum concrete strength at release, f'ci	Use 6.500 ksi

The program indicates that the default (estimated) girder depth would be 60 in. which is less than the 70 in. maximum allowed depth. The VIEW BEAMS button shows the database of available types. Therefore, we will use the program's estimated depth. Two potential sections are the 32 x 61 and 32 x 69. By pressing the VIEW RESULTS, we get the available solutions from QuikBeamAASHTO. It is observed that there are no special warning messages, and that the desirable limit for f'ci, 6.500 ksi, is well below the standard industry limit (7.200 ksi)

SOLUTIONS:
Scanning the three girder solutions presented, we find that in Option A (6 girder lines) the 32 x 61 section requires a slightly higher concrete release strength (6.550 ksi) than we specified but it should not be eliminated from consideration. A detailed design should be done since QuikBeamAASHTO is only a preliminary sizing software, and its predictions may have a small relative error. The 32 x 69 section requires a predicted release strength of 5.208 ksi. The concrete volume per span is 193 cu yds and the number of ½" strands is 52 per girder. This design is well within the desirable limits of depth and release strength.

For comparison purposes, the program from Eriksson Technologies, Inc. was used to design an 'exact' solution for the bridge superstructure with the same geometry using a 33 x 61 section. The obtained solution requires a total N= (62) ½" strands and shows a maximum bottom compression stress of 3.544 ksi. The corresponding release strength would be: f'ci =3.544/0.6 = 5.907 ksi. Both N and f'ci are very close to the QuikBeamAASHTO predictions.

Option B (8 girder lines) and Option C (9 girder lines) also show the same three girder sections with five possible solutions within the strength limit. However, it is observed that the concrete volume per span is quite high (between 207 and 248 cu yds). A quick check with two precasters confirmed that these solutions are not economical.

QuikBeamAASHTO LRFD Solutions

Span Length (c-to-c) Assigned by User 115.00 feet
Bridge Width (out-to-out) Assigned by User 72.00 feet
Girder Type Selected by User PCEF Bulb Tee - Top Flange 47" / Bulb 7" / Web 7"

Starting Girder Depth			**Maximum f'ci**		
Program Estimate	60	inches	Program Default *	6.670	Ksi
User Selected	60	inches	User Selected	6.500	Ksi

Preliminary Beam Selections			32/61		32/69		32/77		
7 Girder lines per span									
Resulting girder spacing	10.75	feet							
Resulting overhang ****	3.75	feet							
Number of 1/2 inch strands			64	Strands	52	Strands	43	Strands	
Concrete release strength required **			6.550	Ksi	5.208	Ksi	4.236	Ksi	
Cubic yards of concrete per span ***			181	cu yd	193	cu yd	205	cu yd	
Tons of concrete per span ***			367	tons	390	tons	414	tons	
8 Girder lines per span									
Resulting girder spacing	9.21	feet							
Resulting overhang ****	3.75	feet							
Number of 1/2 inch strands			54	Strands	44	Strands	36	Strands	
Concrete release strength required **			5.540	Ksi	4.401	Ksi	3.564	Ksi	
Cubic yards of concrete per span ***			207	cu yd	220	cu yd	234	cu yd	
Tons of concrete per span ***			419	tons	446	tons	474	tons	
9 Girder lines per span									
Resulting girder spacing	8.06	feet							
Resulting overhang ****	3.75	feet							
Number of 1/2 inch strands			47	Strands	38	Strands	31	Strands	
Concrete release strength required **			4.791	Ksi	3.804	Ksi	3.069	Ksi	**Low, section too deep!**
Cubic yards of concrete per span ***			233	cu yd	248	cu yd	263	cu yd	
Tons of concrete per span ***			471	tons	502	tons	533	tons	

High!

Note: * applies only to first beam solution at initial spacing option
Note: ** assumes straight debonded strands.
Note: *** includes 12 inches beam length (at each end) from C.L. of bearing to end of beam.
Note: **** overhang measured from center of external girder to outside of barrier edge.

Input Warnings:

For more information please contact any of the following:

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