# THE QuikBeamPennDOT PROGRAM

## Version 5.01

## User Instructions

## PRELIMINARY SELECTION AND OPTIMIZATION OF CONVENTIONAL UNITS, PRESTRESSED CONCRETE BRIDGE SECTIONS

(PER PennDOT LRFD SPECIFICATIONS)

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**Prestressed Concrete Association of Pennsylvania:**

**Northeast Prestressed Products**
**TopRoc Newcrete Products Company**
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# CONTENTS

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This QuikBeamPennDOT design aid was developed to assist in the preliminary selection and optimization of prestressed concrete bridges in Pennsylvania.

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 PennDOT's PSLRFD software. Neither the Prestressed Concrete Association of Pennsylvania, nor its member companies, nor any person acting on their behalf:

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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 PennDOT's DM-4, Publication 15M). Commonly used bridge beam types are shown in Figure 1.

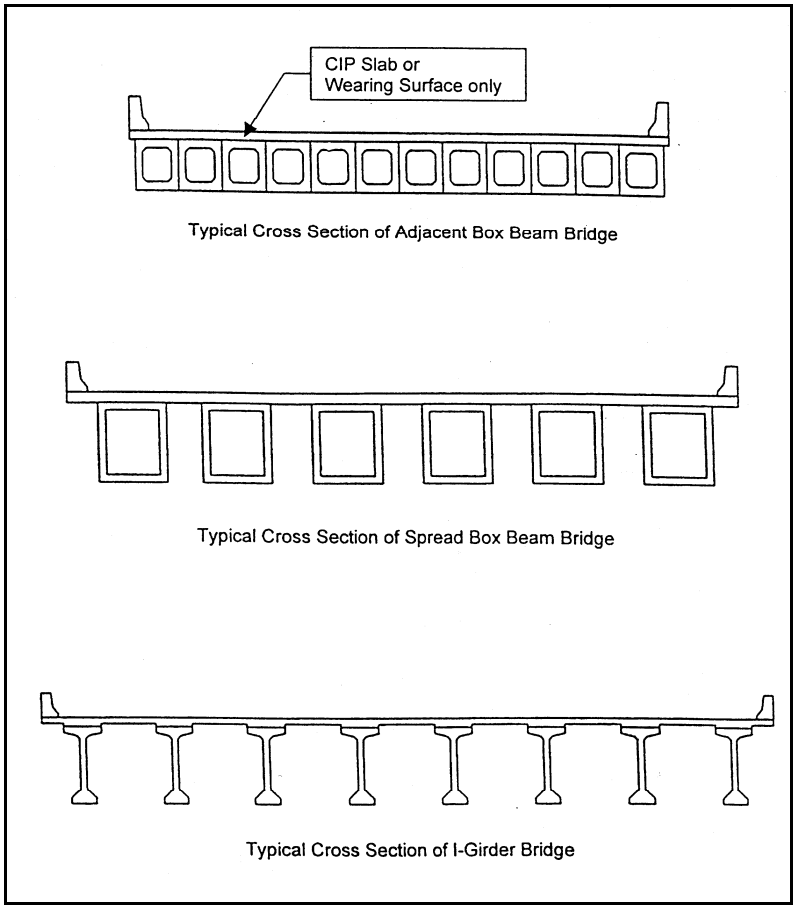


Figure 1

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 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.

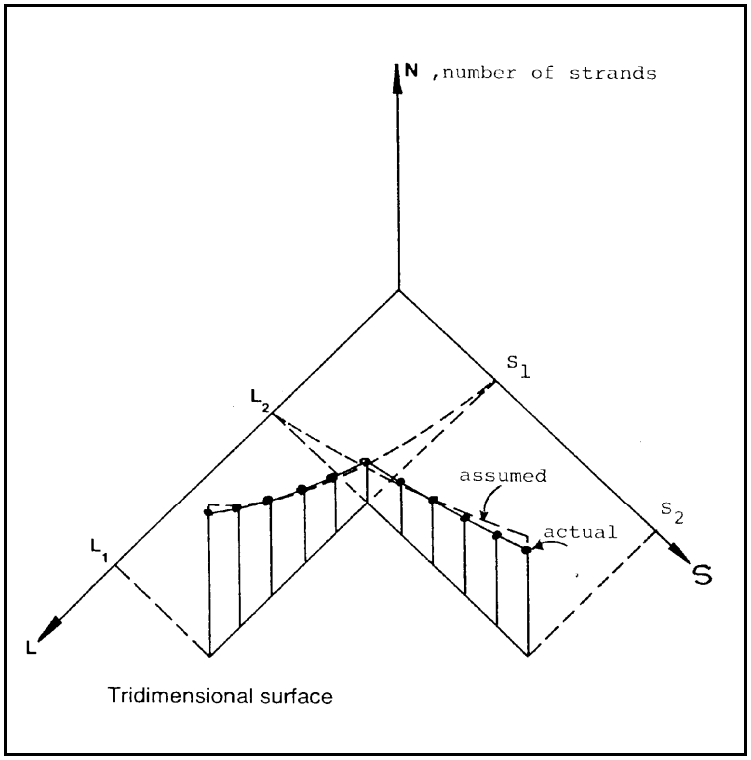


Figure 2

In this study, it was assumed that L and S are the dominant variables. Based on more than 1,100 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 diameter, low relaxation strand, and $f'_{ci}$ is the required concrete release strength:

$$N = A(L)^x (S)^y \qquad [1]$$

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

QuikBeamPennDOT, a macro driven Microsoft Excel spreadsheet using PennDOT sections, 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 (I-beam, spread box, adjacent box, or PA 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).

## QuikBeamPennDOT TECHNICAL FEATURES AND LIMITATIONS

The program database of version 5.01 includes almost all of the beam sections that are commonly used in Pennsylvania.

Live load is PennDOT's PHL-93 and P-82. Slab thickness varies with girder spacing and conforms to PennDOT practice. For the case of adjacent boxes, a cast-in-place slab thickness of 5.25 inches was assumed. For spread box beams, I-beams, and PA Bulb Tees an 8 inch cast-in-place slab thickness was considered. Stay-in-place forms (15 psf), wear surface (30 psf) and two standard concrete barriers were included in the design. For practical reasons four or five design lanes were considered in the database.

Shear design was not a consideration in preparation and development of the QuikBeamPennDOT program. However, in certain rare instances shear may control the design and the next deeper section may have to be used.

I-Beam and PA Bulb Tee designs assume draped and bonded strands. Because of the common practice of debonding at box beam ends, the predicted $f'_{ci}$ is based on straight, debonded strands for all box girders. When the number of design lanes is small (say two or three) the predicted solution may be somewhat unconservative.

If a bridge deck carries heavy or wide sidewalks or if a beam carries a heavy utility line (such as water or sewer) then the program should not be used as these loads are quite heavy and the program will terminate. More exact tools, such as PennDOT PSLRFD software, should be used.

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) The Deck Overhang for spread beams is automatically set at ½ of the girder spacing for Option A (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.

**PENNDOT standards require a minimum of 4 girders per span:** In order to allow deck replacements while in use, PennDOT practice 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.

## 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 or PennDOT's specifications or general design limits of the PSLRFD program, 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 QuikBeamPennDOT will generate an appropriate warning.

**Number of ½ inch Strands:** When exceeding individual beam's structural limits or 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.

## QuikBeamPennDOT PROGRAM OPERATION
Microsoft Excel Version

QuikBeamPennDOT.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 QuikBeamPennDOT 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 QuikBeamPennDOT” 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 PennDOT LRFD criteria. The project requires that bare beam depth be limited to 75 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, $f'_{ci}$: | 7.25 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 7.25 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 66 inches. The VIEW BEAMS button shows the database of available types. Three section depths that are less or equal to 75 inches may be considered: 63, 66 and 72 mm.

| | |
|---|---|
| Min Starting Depth: | We will try 63 |

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

**SOLUTIONS:**

Scanning the three beam solutions presented, we find that in **Option A (4 beam lines)** the 28 X 63 inch section requires release strength slightly in excess of the default "target value" of 6.67 Ksi. Acceptable sections are: 28 X 68 which requires 69 strands, a concrete release strength of 6.385 Ksi, and uses 125 cu yd of concrete; the 28 X 72 beam requires 62 strands and a concrete release strength of 5.612 Ksi. The concrete volume per span is 131 cu yd.

**Option B (5 beam lines)** also shows the 28 X 63, 28 X 66 and the 28 X 72 sections. The 28 X 63 section requires 58 strands, a release strength of 5.644 Ksi, and a concrete volume of 152 cu yd; the 28 X 66 section requires 56 strands, a concrete release strength of 5.252 Ksi, and a concrete volume of 156 cu yd; the 28 X 72 section requires 50 strands, a concrete release strength of 4.598 Ksi, and a concrete volume of 163 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 68 beams, turns out to be the most economical for the superstructure.

## QuikBeamPennDOT 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** I-Beam

| **Starting Girder Depth** | | | **Maximum f'ci** | | |
|---|---|---|---|---|---|
| Program Estimate | 65 | inches | Program Default ' | 6.672 | Ksi |
| User Selected | 63 | inches | User Selected | 6.672 | Ksi |

| **Preliminary Beam Selections** | | | 28 X 63 | 28 X 66 | 28 X 72 |
|---|---|---|---|---|---|
| 4 Girder lines per span | | | | | |
| Resulting girder spacing | 9.00 | feet | | | |
| Resulting overhang **** | 4.50 | feet | | | |
| Number of 1/2 inch strands | | | 73 Strands | 69 Strands | 62 Strands |
| Concrete release strength required ** | | | 6.843 Ksi | 6.385 Ksi | 5.612 Ksi |
| Cubic yards of concrete per span *** | | | 122 cu yd | 125 cu yd | 131 cu yd |
| Tons of concrete per span *** | | | 247 tons | 253 tons | 264 tons |
| 5 Girder lines per span | | | | | |
| Resulting girder spacing | 7.20 | feet | | | |
| Resulting overhang **** | 3.60 | feet | | | |
| Number of 1/2 inch strands | | | 58 Strands | 56 Strands | 50 Strands |
| Concrete release strength required ** | | | 5.644 Ksi | 5.252 Ksi | 4.598 Ksi |
| Cubic yards of concrete per span *** | | | 152 cu yd | 156 cu yd | 163 cu yd |
| Tons of concrete per span *** | | | 308 tons | 316 tons | 330 tons |
| 6 Girder lines per span | | | | | |
| Resulting girder spacing | 6.00 | feet | **This Small Girder Spacing is out of the domain of this program** | | |
| Resulting overhang **** | 3.00 | feet | | | |
| Number of 1/2 inch strands | | | 48 Strands | 46 Strands | 41 Strands |
| Concrete release strength required ** | | | 4.822 Ksi | 4.478 Ksi | 3.907 Ksi |
| Cubic yards of concrete per span *** | | | 183 cu yd | 187 cu yd | 196 cu yd |
| Tons of concrete per span *** | | | 370 tons | 379 tons | 396 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:


**TopRoc Newcrete Products Company** Telephone: (814) 838-2011 FAX: (814) 838-9018
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301 Plum Creek Road, P.O. Box 34, Roaring Spring, PA 16673

**The Prestressed Concrete Association of Pennsylvania** 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: bonstedt@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 130 mm C.I.P. slab to span 31000 mm (c-to-c of bearings). Maximum imposed precast beam depth is 1200 mm. Explore various potential solutions.

**DATA ENTRY:**

Enter: Span Length: 102.0 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 1220 mm wide section is more economical. We find that eight 1220 mm 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 QuikBeamPennDOT 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 36 requires 43 strands, a concrete release strength of 5.455 Ksi, and uses 222 cu yd of concrete. The 48 X 39 requires 42 strands, a concrete release strength of 5.168 Ksi, and uses 232 cu yd of concrete. The 48 X 42 beam requires 38 strands, a concrete release strength of 4.614 Ksi, and uses 242 cu yd of concrete.

The 48 X 36 section has a warning that indicates that the number of 43 ½-inch strands for this solution is HIGH. But it should not be discarded outright because: this number of strands is only an estimate; the actual required number may be lower and close to the maximum for this beam.

## QuikBeamPennDOT Solutions

**Span Length (c-to-c) Assigned by User** 102.00 feet
**Bridge Width (out-to-out) Assigned by User** 48.00 feet
**Girder Type Selected** Adjacent Box Beam - Composite 48 inch

| **Starting Girder Depth** | | | **Maximum f'ci** | | |
|---|---|---|---|---|---|
| Program Estimate | 38 | inches | Program Default ' | 5.801 | Ksi |
| User Selected | 38 | inches | User Selected | 5.801 | Ksi |

| **Preliminary Beam Selections** | | | 48 x 36 | | 48 x 39 | | 48 x 42 | |
|---|---|---|---|---|---|---|---|---|
| 12 Girder lines per span | | | | | | | | |
| Resulting girder spacing | 4.00 | feet | | | | | | |
| Resulting overhang **** | 2.00 | feet | | | | | | |
| Number of 1/2 inch strands | | | 43 | Strands **High!** | 42 | Strands | 38 | Strands |
| Concrete release strength required ** | | | 5.455 | Ksi | 5.168 | Ksi | 4.614 | Ksi |
| Cubic yards of concrete per span *** | | | 222 | cu yd | 232 | cu yd | 242 | cu yd |
| Tons of concrete per span *** | | | 450 | tons | 470 | tons | 489 | 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:

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# 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 PENNDOT LRFD criteria. One of the project geometric constraints requires a precast beam depth between 36 inches and 40 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 two potential selections without exceeding the set limits on concrete release strength or number of strands. Therefore, **Option B, (8 beam lines),** and **Option C, (9 beam lines),** will be disregarded as being non-economical.

Under Option A the last solution, the 48 x 39 precast box, satisfies the aforementioned geometric constraint and will be used for this case. It predicts 38 required strands, concrete release strength of 4.684 Ksi and a concrete volume of 92 cu yd per span.

## QuikBeamPennDOT 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** Spread Box Beam 48 inch

| **Starting Girder Depth** | | | **Maximum f'ci** | | |
|---|---|---|---|---|---|
| Program Estimate | 33 | inches | Program Default ' | 5.947 | Ksi |
| User Selected | 33 | inches | User Selected | 5.800 | Ksi |

| **Preliminary Beam Selections** | | | 48 x 33 | 48 x 36 | 48 x 39 |
|---|---|---|---|---|---|
| 7 Girder lines per span | | | | | |
| Resulting girder spacing | 10.53 | feet | | | |
| Resulting overhang **** | 2.90 | feet | | | |
| Number of 1/2 inch strands | | | 47 Strands | 42 Strands | 38 Strands |
| Concrete release strength required ** | | | 6.072 Ksi | 5.273 Ksi | 4.684 Ksi |
| Cubic yards of concrete per span *** | | | 84 cu yd | 88 cu yd | 92 cu yd |
| Tons of concrete per span *** | | | 170 tons | 178 tons | 186 tons |
| 8 Girder lines per span | | | | | |
| Resulting girder spacing | 9.03 | feet | | | |
| Resulting overhang **** | 2.90 | feet | | | |
| Number of 1/2 inch strands | | | 41 Strands | 37 Strands | 33 Strands |
| Concrete release strength required ** | | | 5.363 Ksi | 4.778 Ksi | 4.185 Ksi |
| Cubic yards of concrete per span *** | | | 96 cu yd | 101 cu yd | 105 cu yd |
| Tons of concrete per span *** | | | 195 tons | 204 tons | 212 tons |
| 9 Girder lines per span | | | | | |
| Resulting girder spacing | 7.90 | feet | | | |
| Resulting overhang **** | 2.90 | feet | | | |
| Number of 1/2 inch strands | | | 36 Strands | 33 Strands | 30 Strands |
| Concrete release strength required ** | | | 4.817 Ksi | 4.388 Ksi | 3.795 Ksi |
| Cubic yards of concrete per span *** | | | 108 cu yd | 113 cu yd | 118 cu yd |
| Tons of concrete per span *** | | | 219 tons | 229 tons | 239 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:

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## Example 4: A Bulb Tee Girder Bridge

A 72 ft wide superstructure for a four-lane bridge plus shoulders is to be designed for a 105 ft simple span (center-to-center of bearings) and PENNDOT-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.), and compare to an 'exact' solution using PSLRFD, V. 2.0a. Desirable strength limit at release is not to exceed 6.5 ksi.

**DATA ENTRY:**

| | | |
|---|---|---|
| Enter: | Span Length: | 105 ft |
| | Out-to-out bridge width | 72 ft |
| | Girder Type | Bulb Tee, 42-in. top flange, 7-in. bulb |
| | 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 58 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 33 x 61.25 and 33 x 69.25. By pressing the VIEW RESULTS, we get the available solutions from QuikBeamPennDOT. It is observed that there are no special warning messages, and that the desirable limit for f'ci, 6.500 ksi, is close enough to the industry limit (6.800 ksi)

SOLUTIONS:
Scanning the three girder solutions presented, we find that in Option A (7 girder lines) the 33 x 53.25 section requires a very high concrete release strength (8.817 ksi) and is eliminated from consideration. The 33 x 61.25 section requires a predicted release strength of 7.059 ksi which is about 8% in excess of the "target value" of 6.500 ksi. The concrete volume per span is 177 cu yds and the number of ½" strands is 77 per girder. Although f'ci somewhat exceeds the desirable limit, this solution should not be discarded outright. A detailed design should be done since QuikBeamPennDOT is only a preliminary sizing software, and its predictions may have a small relative error. For this example, however, we will concentrate on the 33 x 69.25 section which shows a predicted release strength of 5.835 ksi and a concrete volume per span of 189 cu yds. The number of ½" strands is 65 per girder. This design is well within the desirable limits of depth and release strength.

For comparison purposes, the PSLRFD program was used to design an 'exact' solution for the bridge superstructure with the same geometry using a 33 x 69.25 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 QuikBeamPennDOT 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 202 and 243 cu yds). A quick check with two precasters confirmed that these solutions are not economical.

## QuikBeamPennDOT Solutions

**Span Length (c-to-c) Assigned by User** 105.00 feet
**Bridge Width (out-to-out) Assigned by User** 72.00 feet
**Girder Type Selected** PA Bulb-Tee - 42 inch Top Flange / 7 inch Bulb

| **Starting Girder Depth** | | | **Maximum f'ci** | | |
|---|---|---|---|---|---|
| Program Estimate | 58 | inches | Program Default ' | 6.800 | Ksi |
| User Selected | 58 | inches | User Selected | 6.500 | Ksi |

| **Preliminary Beam Selections** | | | 33/53.25 | | 33/61.25 | 33/69.25 |
|---|---|---|---|---|---|---|
| 7 Girder lines per span | | | | | | |
| Resulting girder spacing | 10.75 | feet | | | | |
| Resulting overhang **** | 3.75 | feet | | | | |
| Number of 1/2 inch strands | | | 93 | Strands | 77 Strands | 65 Strands |
| Concrete release strength required ** | | | 8.817 | Ksi **High!** | 7.059 Ksi | 5.835 Ksi |
| Cubic yards of concrete per span *** | | | 164 | cu yd | 177 cu yd | 189 cu yd |
| Tons of concrete per span *** | | | 332 | tons | 358 tons | 383 tons |
| 8 Girder lines per span | | | | | | |
| Resulting girder spacing | 9.21 | feet | | | | |
| Resulting overhang **** | 3.75 | feet | | | | |
| Number of 1/2 inch strands | | | 78 | Strands | 65 Strands | 55 Strands |
| Concrete release strength required ** | | | 7.643 | Ksi **High!** | 6.187 Ksi | 5.107 Ksi |
| Cubic yards of concrete per span *** | | | 188 | cu yd | 202 cu yd | 216 cu yd |
| Tons of concrete per span *** | | | 380 | tons | 409 tons | 438 tons |
| 9 Girder lines per span | | | | | | |
| Resulting girder spacing | 8.06 | feet | | | | |
| Resulting overhang **** | 3.75 | feet | | | | |
| Number of 1/2 inch strands | | | 67 | Strands | 56 Strands | 48 Strands |
| Concrete release strength required ** | | | 6.754 | Ksi | 5.519 Ksi | 4.551 Ksi |
| Cubic yards of concrete per span *** | | | 211 | cu yd | 227 cu yd | 243 cu yd |
| Tons of concrete per span *** | | | 427 | tons | 460 tons | 492 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:

For more information please contact any of the following:


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