# PENNDOT e-Notification

Bureau of Information Systems
Application Development Division



**BXLRFD**
**No. 002**
August 6, 2003

## BXLRFD Version 1.3
## Serviceability Output Issue

Two issues with the BXLRFD serviceability output have been identified. The first issue is an incorrect conversion factor used for stresses for US units. The second issue is a problem with the BXLRFD program reporting the incorrect crack control allowable for tensile stress.

**Issue #1 - Incorrect Conversion Factor for Stress**

**Problem**
The US units for the Allowable Crack Control Stress and the Actual Tensile Steel Stress in the "Serviceability Spacing Check" Table are not converted properly before displaying. Shown below is output from BXLRFD Example #5.

```
LRFD Box Culvert Design and Rating, Version 1.3                PAGE  11
Input File: ex5.DAT                                     07/21/2003  13:37:30
---------------------------------------------------------------------------
                         BXLRFD EXAMPLE PROBLEM #5
                       SERVICEABILITY SPACING CHECK
---------------------------------------------------------------------------

                             Bottom Slab No. 1
```

| Dist (ft) | Loc | Bar Size | Input Spacing (in) | Minimum Primary Spacing (in) | Maximum Primary Spacing (in) | Temp/ Shrink Spacing (in) | Crack Control Stress (ksi) | Tens Reinf Stress (ksi) | |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | | | |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | 302.38 | 208.46 | 2 |
| 0.91 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 4.21 | 2 |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | | | |
| 2.05 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 17.26 | 2 |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | | | |
| 4.10 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 178.74 | 2 |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | | | |
| 6.15 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 250.30 | 2 |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | | | |
| 8.20 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 289.19 | 2* |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | | | |
| 10.25 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | **274.20** | **302.45** | 2* |
| | B | 5 | 5.50 | 2.50 | 18.00 | 18.00 | | | |
| 12.30 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 289.10 | 2* |
| | B | 6 | 6.00 | 2.50 | 18.00 | 18.00 | | | |
| 14.35 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 242.16 | 2 |
| | B | 6 | 6.00 | 2.50 | 18.00 | 18.00 | | | |
| 16.40 | T | 9 | 6.00 | 2.50 | 18.00 | 18.00 | 274.20 | 183.18 | 2 |

**Work Around**

To determine the allowable and actual tensile steel stress, divide the reported value by 12. For Location 10.25 ft in the above output, the Tensile Reinforcement Stress should be 302.45/12 = **25.204** ksi. This issue only affects US units for stress in the "Serviceability Spacing Check" output report. Program reported SI units are accurate.

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**Issue #2 - Allowable Tensile Stress**

**Problem**
Under certain circumstances the program, when reporting the actual tensile stress, may report the allowable crack control stress for the opposite face. This may cause a misleading flag to appear that the section fails crack control, or possibly no indication when the section has failed crack control.

**Work Around** - **Effective immediately, designers are required to calculate the Allowable Crack Control Stress by hand (as shown in Appendix A) and compare to the program reported Tensile Reinforcement Stress.** Note - this applies to Analysis runs only for both US and SI units.

Below is the suggested method for performing the necessary check of the program as an interim measure:

1. Calculate the Allowable Crack Control Stress for each face of a component, and when rebar size and spacing changes.

2. Compare the reported Tensile Reinforcement Stress value to the hand calculated allowable. Make note of which component face the tensile stress is reported for and use the corresponding allowable. For US units only, divide the reported Tensile Reinforcement Stress value by 12.

Direct any questions concerning the above program to:

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## Appendix A - Crack Control Stress Calculation Method & Example

### Crack Control Allowable Stress

The crack control is checked as per D5.7.3.4 where the stress in the main tensile reinforcement is checked against the result of Equation A5.7.3.4-1

$$f_{sa} = \frac{Z}{(d_c A)^{1/3}} \leq 0.6 f_y$$

where Z = 100 kip/in (17200 N/mm) for a culvert (**The BXLRFD program uses 98 kip/in)**

The program uses a simplified version of equation A5.7.3.4-1 where A is replaced by its definition of

$A = 2d_c s$ where $d_c$ = (cover + $^1/_2$ bar diameter) $\leq$ ( 2.0 in (50mm) + $^1/_2$ bar diameter )

A = area of concrete having the same centroid as the principle tensile reinforcement and bounded by the surfaces of the cross-section and a straight line parallel to the neutral axis, divided by the number of bars or wire. See Figure 1.

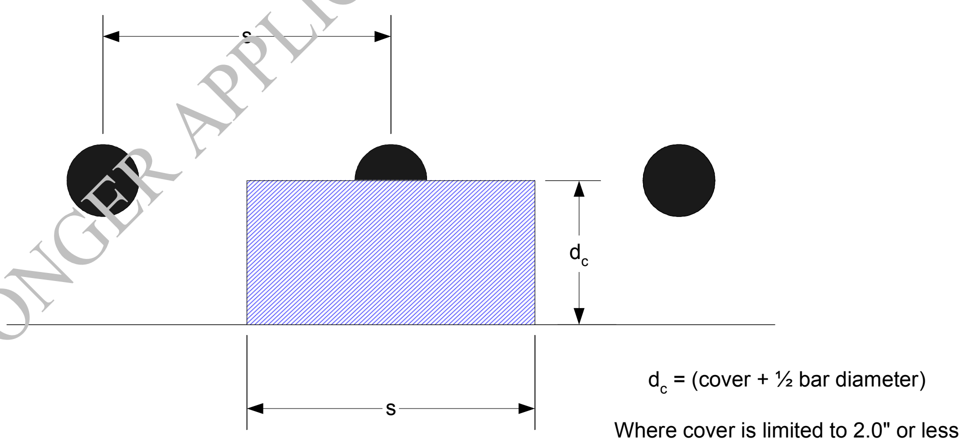


Figure 1. - Definition of A

The final form of the equation used by the program is shown below:

$$f_{sa} = \frac{Z}{(2d_c^{\,2} s)^{1/3}} \leq 0.6 f_y$$

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**Example Calculation** - The following calculation is the allowable for the Bottom Slab of the culvert from Issue #1.

If moment is positive along the entire span, only look at the bottom steel. For changes in rebar size and spacing within the same face of a component, the allowable must be recalculated. If there are points of inflection, such as a two-cell culvert, calculate the allowable for both faces.

Bottom Slab #1 Location: 10.25 ft
Tensile Steel Information : #9 @ 6.0 in

Spacing s = 6.0 in
Bar Diameter Dia = 1.128 in
Clear Cover $c_b$ = 2.5 in

$d_c$ based on 2.0 in cover controls

$$d_c = (c_b, 2.0\text{ in}) + \frac{1}{2}\,Diam\ of\ Bar = (2.5\text{ in}) + \frac{1}{2}(1.128\,in) = \underline{\mathbf{3.064\ in > 2.564\ in}} = 2.0 + \frac{1}{2}(1.128\,in)$$

$$F_{sa} = \frac{Z}{\left(2 * d_c^{\,2} * s\right)^{\frac{1}{3}}} \leq 0.6 f_y = \frac{\left(98\,\frac{kip}{in}\right)}{\left(2*(2.564\,in)^2*(6.0\,in)\right)^{\frac{1}{3}}} \leq 0.6(60\,ksi)$$

$F_{sa} = 22.85\,ksi$ or **<u>22.85 *ksi* < 36 *ksi* ← Use 22.85 *ksi*</u>**

To determine the correct Tensile Steel Stress for comparison from BXLRFD v1.3 take the reported value and divide by 12 (US units only). This converts the reported values into ksi.

<u>Stress at Location: 10.25 ft in the Bottom Slab #1</u>

**<u>$f_{sy}$ = 302.405/12 = 25.204 ksi > 22.85 ksi ← Stress at location is no good!!</u>**

This verifies that the allowable crack control stress was exceeded at this particular location in the span.