DISCUSSION

Prestressed Steel Girders for Single Span Bridges

Paper by RUSSELL D. SNYDER, P.E.
(3rd Quarter, 1995)

Discussion by Peter Kocsis, P.E., S.E.

Mr. Snyder has presented a very useful and interesting concept—the concept of prestressed steel. He shows that prestressing results in a significant reduction in the amount of steel required for a given span length and loading. The cost of prestressing will partially offset the reduction in steel costs.

The writer has made a study of the actual dollar savings made available by prestressing.

The following comparison of cost differences illustrates the dollar savings made possible by prestressing. In each case the design is for a 70-ft span four lane bridge with eight A36 rolled stringers spaced at 7 ft-6 in. carrying an AASHTO HS20 truck. The slab is 7.5-in. thick with a 2-in. wearing surface. A typical interior stringer is used in the study. Anchors are placed 12 feet from each end, requiring the use of two 46-ft long 1.375-in. Dywidag threadbars or equal.

Without Prestressing	W36×230
With Prestressing	W36×135
Steel Saved (230 – 153) × 70 × 8	53,200 lbs.

AT $0.45 per lb. Gross Savings (See Note 1)	$23,940
Threadbars & Accessories (See Note 2)	– 7,663
32 Anchors @ 68 lbs./ea. @ $.50/lb.	1,088
Tensioning Costs	– 400
Net Savings In Steel Costs	$14,789

Note 1: A36 Rolled sections in place: $0.45/lb. (1994)
Note 2: 16 pcs 1.375-in. dia. Gr 150 Dywidag thdbar—46-ft long and accessories—epoxy treated $7,663. (1994)

In those cases where the non-prestressed bridge requires built up girders and the prestressed bridge requires rolled sections, the savings will be considerably greater than that shown above. In addition to the savings in steel costs, there will be additional savings due to smaller bearings, smaller substructures and less fill in the bridge approaches.

Peter Kocsis is a structural engineer in the Chicago Area.

The writer has prepared a program for determining the required prestressing force for a given girder cross section. The program is named PRCB (Prestressed Composite Steel Beams). By means of this program, the data in Table One has been prepared, showing how much the span length of a beam can be extended by prestressing.

The author mentions applying the prestress after the deck has become composite. This means the concrete could be in tension, (depending on the tendon location) and must be checked for tensile stress. If small cracks occur, water will enter the concrete and lead to accelerated deck deterioration, especially in areas with freezing and thawing cycles. There is however, also an advantage to applying the prestress after the deck is composite: The bottom flange will be in tension due to the weight of the concrete, and when the prestress is applied the bottom flange will receive little if any net compression. The chief advantage in applying the prestress before the concrete is placed is that the concrete will not be subjected to tensile stresses. Another advantage is that the top flange will most likely be in tension due to the tendon force (depending on the tendon location). This will somewhat relieve the top flange compression due to the wet concrete. Thus, each method has advantages and disadvantages. The writer prefers placing the deck after tensioning to protect the deck, even though it means more bracing for the bottom flange that is in compression due to the prestressing force. Deck replacement is very costly and disruptive to traffic.

Use of the greater span lengths made possible by prestressing may result in $(LL+I)$ deflections larger than the $\frac{1}{800}$ usually used. AASHTO[1] allows this, and refers to Bulletin No. 19 of the American Iron and Steel Institute, which shows that increased stringer flexibility does not cause deck deterioration.[2]

Table 1. Span Lengths: Prestressed vs. Non-Prestressed				
Section	***LP*** **(ft)**	***LO*** **(ft)**	***P*** **(kips)**	***e*** **(in.)**
W36×300	96	75	464	11.37
W33×152	69	48	350	10.25
W24×76	39	28	181	5.96
W16×40	24	15	119	2.26

LP = the maximum span with prestressing
LO = the maximum span without prestressing
P = the prestressing force (part of the output)
e = the eccentricity of the tendons
Beams (A36) are spaced at nine feet with an eight inch slab and two inch wearing surface.

A major drawback to using prestressed composite steel beams was the large amount of computations involved. The aforementioned program (PRCB) greatly simplifies the work. PRCB is very user friendly, and asks the user for each input item. PRCB can also be used to analyze non-composite and non-prestressed steel girders and rolled sections. The required prestressing force, tendon anchorage locations, dead and live load deflections, stresses during various construction stages and actual and allowable moments are part of the output. A sample input and output are included with this discussion.

A manual which accompanies PRCB contains a design example, including two anchorage designs.

REFERENCES

1. American Association of State Highway and Transportation Officials, *Standard Specifications for Highway Bridges*, 1989.
2. Wright, R. N. and Walker, N. H., *Bulletin No. 19—Criteria for the Deflection of Steel Bridges*, American Iron and Steel Institute, 1971.

```
                         ** INPUT **

EXAMPLE PROBLEM W36X135
SPAN LENGTH: 70 FEET
BEAM SPACING: 7.5 FEET
SLAB THICKNESS: 7.5 INCHES
CONCRETE UNIT WEIGHT: 150 LBS/CUBIC FOOT
SUPERIMPOSED DL: 188 LBS/FT
FILLET HEIGHT: 0 INCH(ES)
MODULAR RATIO N: 8
COEFFICIENT OF P: 1
TYPE OF STEEL: A36
BEAM: W36X135 A= 39.7 D= 35.55 FW= 11.95 IMAX= 7800 RMIN= 2.38
UNSUP. LENGTH OF COMPRESSION FLANGE: 20.25 FEET
DISTANCE FROM N.A. OF STEEL BEAM TO CABLE: 12.74 INCHES
INTERIOR BEAM
ALLOWABLE TENSILE STRESS, STEEL: 20 Ksi
NUMBER OF LANES: 4
NUMBER OF BEAMS: 8

     **TO COPY INPUT PUNCH PrtSc. TO CONTINUE,PUNCH RETURN**

              PRESTRESSING FORCE P = 235.8768 KIPS

MAX AASHTO (LL+I) MOMENT = 844.3078 FT-KIPS
MAX. ALLOW. (LL=I) MOM. WITH P. (BOTTOM FLANGE GOVERNS) = 853.7712 FT-KIPS.
MAX ALLOW. (LL+I) MOM. WITH P. (TOP FLANGE GOVERNS) = 3157.557 FT-KIPS.
MAX ALLOW. (LL+I) MOM. -NO P. (BOTTOM FLANGE GOVERNS) = 172.9787 FT-KIPS.

     *** NOTE! IF THE ABOVE VALUE IS NEGATIVE, THE BEAM IS
         OVERSTRESSED WHEN THERE IS NO PRESTRESSING.***

*** INTERIOR BEAM *** TABLE OF STRESSES (P= VALUE SHOWN ABOVE)
```

LOADING	TOP CONC (ksi)	TOP STEEL (ksi)	BOT STEEL (ksi)
DL STEEL	-	-2.60	2.60
PRESTRESS FORCE P	-	0.91	-12.79
DL STEEL+P	-	-1.70	-10.19
DL CONC	-	-11.78	11.78
TOTAL DL:STEEL+CONC+P	-	-13.47	1.59
SDL	-0.06	-0.79	2.37
TOTAL DL+P+SDL	-0.06	-14.26	3.96
AASHTO (LL+I)	-0.65	-1.54	15.86
TOTAL DL+P+SDL+LL+I	-0.71	-15.79	19.82

```
TO COPY THE ABOVE PUNCH PrtSc. PUNCH RETURN TO CONTINUE.
```

```
**PLACE ANCHOR CABLES NO MORE THAN 12.733 FEET FROM EACH END OF BEAM.**

               ***DEAD LOAD DEFLECTIONS (inches)***
             LOADING      QUARTER POINTS      MIDPOINT
             ----            -------           -----
             STEEL             0.26              0.37
             PRESTRESS P      -0.71             -1.02
             CONCRETE          1.20              1.68
             SDL               0.16              0.23
             TOTAL             0.91              1.26

   THE LL+I DEFL IS .8378069 INCHES. RATIO TO SPAN = 1/1002.618
   TO DISPLAY THIS PROBLEM AGAIN, PUNCH 1, OTHERWISE 2.
```