CE 435/535 – Spring 2008

Homework #9 (Due Thursday March 13th)
The objective of this homework is to develop a spreadsheet that can be used in the design of AASHTO Girders.

a) Prepare a spreadsheet identical to mine that is shown on the next page. The cells that are shaded contain values that are calculated by the spreadsheet. First, verify the accuracy of your spreadsheet by showing that you can duplicate my calculations.

b) Recall the bridge example of HW#2, which consists of 4 equal spans each 100 feet long. The AISC design tables give the following values per lane of highway:
   Max. Positive Moment: 1215 k-ft at midspan
   Max. Negative Moment: -1099 k-ft at interior support
   Max. Shear: 68 kips

   Use your spreadsheet to complete the design of a typical interior girder by selecting the required area of prestressing steel. Assume that the prestress losses are 55 ksi. Assume that the strands are depressed at 0.4L. The various moments, allowable stresses, etc. that you need to use for this problem are shown in my handwritten notes on the spreadsheet.

	Girder only	Girder & Slab
M_b at midspan (k-ft)	1560	2830
M_b at L/3 (k-ft)	1380	2530
M_{LL} at midspan (k-ft)		
C_t (in.)	35.62	28.25
C_b (in.)	36.38	51.75
I (in.^{4})	733,320	1,397,890

NOTES:
The Dead Load (DL) for a typical interior girder consists of:
a) the girder weight
b) the 2-inch hunch
c) the 8-inch thick deck slab

Each diaphragm weighs 4.0 kips. The Live+Impact Load is calculated by multiplying the given Live Load times the Impact Factor and times the Live Load Distribution Factor (AASHTO 3.23). Note that to get the loads per girder, the distribution factors given in the tables must be divided by two. (For this problem, the code gives S/5.5, so you should use S/11. Make sure you verify this yourself).

The girder must then be designed for the following:
1) Immediately after release; Check the ends and L/3; assume elastic losses are 12.5 ksi, so f_{si} =0.75*270 – 12.5 = 190 ksi.
2) Immediately after casting of wet deck slab; Check the ends and L/3 using effective prestressing force
3) During service (DL+ Live*Impact*Dist. Factor); Check midspan, using composite cross section properties

AASHTO Type VI BEAM DESIGN (Sample)					
Strand arrangement at Midspan:			**Strand arrangement at ends:**		
No.	y_I	No. *Y_I	No.	y_I	No. *Y_I
11	2	22	8	2	16
13	4	52	10	4	40
13	6	78	10	6	60
11	8	88	8	8	64
9	10	90	6	10	60
7	12	84	4	12	48
2	14	28	2	14	28
0	16	0	18	65	1170
66		**442**	**66**		**1486**
6.70			**22.52**		

A_ps (in.^2)	**10.10**		
F_si (ksi)	182		
P_I (kips)	**1839.04**		
F_se (ksi)	141.35		
P_e (kips)	**1428.29**		
	Girder:	**Composite:**	
A (in.^2)	1085		
height of beam (in.)	72		
I (in.^4)	733320	1512157	
c_t (in.)	35.62	27.7	
c_b (in.)	36.38	53.8	
S_top (in.^3)	**20587**	**54591**	
S_bottom (in.^3)	**20157**	**28107**	
	At end:	**At L/3:**	**At midspan:**
M_g (k-ft.)	0	1969.5	2215.9
M_(g+slab+diaph) (k-ft.)	0	3000	4397.7
M_(L+I+SDL) (k-ft.)	0	2000	2428.8
e (in.)	**13.86**	**29.68**	**29.68**
Stress Checks:			
Release @ Top:	**456**	**191**	**335**
Release @ Bottom:	**2960**	**3231**	**3084**
Erection @ Top:	**354**	**1006**	**1820**
Erection @ Bottom:	**2299**	**1634**	**802**
Service @ Top:	**354**	**1295**	**2171**
Service @ Bottom:	**2299**	**780**	**-235**

Allowable Stresses (psi):		
	Initial:	**Service:**
Comp.	3240	2400
Tension	-200	-232

Notes: For erection and service stages, use effective prestressing force.

In the erection stage, the beam only (not the composite section) resists moments due to (girder+slab+diaphragms).

Homework #10 (Due Tuesday March 25th)

This problem is different from the previous HW where you designed an AASHTO girder in that here the eccentricity is constant at 6.94 in. So, the only choice that the designer has is to select the required number of strands based on the point of maximum moment and then reduce the number of strands (or P) for points subjected to smaller moment.

The Speedway Underpass Tunnels are designed with precast prestressed sections as shown below. The following information is available:

Section Properties:

A	=	612 in.^{2}	I	=	21384 in.^{4}
S_b	=	2392 in.^{3}	S_t	=	2360 in.^{3}
f'_c	=	5000 psi	f'_{ci}	=	3500 psi

0.5-in. ϕ; 270k strands

The slabs are simply supported on a span of 31 ft. The overall width of the bridge is 48 ft with 4 lanes of traffic and a total of 16 longitudinal slabs.

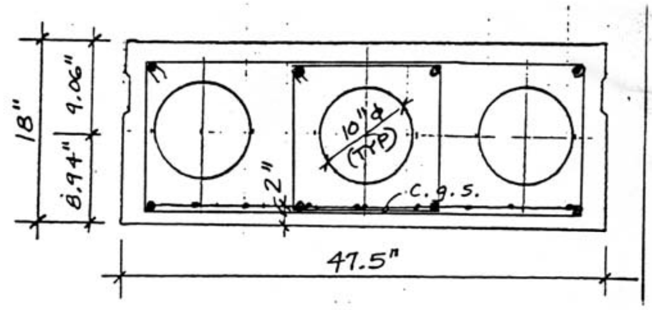
The strands are initially stressed to 189 ksi, of which 5.5 ksi is lost due to elastic shortening. Therefore, f_{si} = 183.5 ksi. Total losses are 37 ksi, giving f_{se} = 152 ksi. Allowable stresses are according to AASHTO 9.15.2.

The structure is designed for HS20-44 Truck Loading. Dead load includes the weight of the slab, 14 in. of fill @ 120 pcf, plus a 6-in. thick concrete roadway. For these calculations, your should assume that the slab covers a width of 4 feet.

As shown in the sketch, 4 No. 4 Grade 60 bars are used at the corners of the stirrups that contribute to the nominal moment capacity of the slab.

Complete the design of the slabs by selecting the required number of strands. For the calculation of L+I moments, use a spreadsheet and evaluate the moments (for both truck loading and uniform lane plus concentrated load) at 1-ft intervals along the span. Calculate and plot the P_{min} and P_{max} for each point along the span. On this diagram, show the points where some of the strands could be debonded?

The live load per 4-ft wide slab must be calculated according to AASHTO 3.23.4.3.
W = 48 ft
L = 31 ft
K = 0.8 (as given in the Table at the end of this section)
C = 0.8 * (48/31) = 1.24; Therefore Eq. 3-12 must be used
N_L = 4 lanes of traffic
D = 5.33 (Equation 3-12)
S = 4 ft
Load Fraction = S/D = 4/5.33 = 0.75



The wheel loads for the truck then become:
(8k/2)*0.75 = 3 kips or for the heavier wheels in the rear of the truck:
(32k/2)*(0.75) = 12 kips
For the uniform loads, the load per girder becomes (640/2)*(0.75)= 240 pounds per foot and the Accompanying concentrated load will be (18k/2)*(0.75) = 6.75 kips.
The above live loads must be multiplied by the Impact Factor which is 1.3 for this problem.

Midterm exam on Tuesday April 1st will cover through this homework.