Repair and rehabilitation of structures

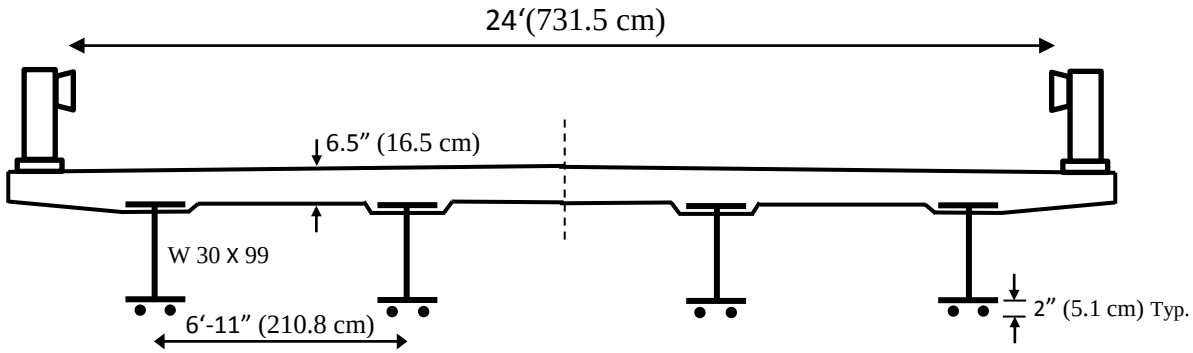
Homework no.3

A composite bridge which was originally designed for H15 truck loading is to be upgraded to HS20 truck loading by prestressing the steel girders. It is assumed that this operation is carried out when the old deck is removed and before the new deck is cast. The design parameters for the bridge are summarized by the following:

- 60 ft (1828.8 cm) long simple span;
- 24 ft (731.5 cm)wide roadway;
- Composite construction-- rolled beam with concrete deck;
- AASHTO H15 loading to be upgraded to HS20;
- Steel beam: four W 30 x 90 beams spaced 6 ft-11 in. (210.8 cm) on centers-- yield stress= 50 ksi (344.7 MPa);
- Concrete deck: 6.5 in. (16.5 cm) thick with a compressive strength of 4000 psi (27.5 MPa);
- Unshored construction;
- Diaphragms: spaced at 10 ft (304.8 cm) intervals;
- Loading: 5,000,000 cycles.

The dead load consisting of the weights of the steel beam, concrete deck, and the prestressing bars is 0.71 k/ft (10.36 kN/m) per girder. The superimposed dead load consisting of the weight of the curbs, railings, and wearing surface is 0.17 k/ft (2.48 kN/m) per girder.

The beams are to be prestressing only in the regions where the stress in the beams due to HS20 loading exceeds the AASHTO allowable stress. Use 1-in. (2.54 cm) diameter prestressing bars located 2 in. (5.1 cm) below the tension flange of the steel beam as shown in the figure.



The allowable stresses are as follows:

- Steel beam= 26.6 ksi (183.4 MPa).
- Concrete deck= 1.6 ksi (11 MPa).
- Prestressing bars= 105 ksi (724 MPa).
- Allowable shear stress in the steel beam is 16.5 ksi (113.8 MPa).

In your solution show the followings:

(1) Shear and moment diagrams for dead load and superimposed dead load; shear and moment envelopes for live load plus impact for H15 and HS20 truck loadings.

(2) Flexural stress in the tension flange, compression flange and the concrete deck and shear stress in the web of steel beam for dead load, superimposed dead load, and live load plus impact for both H15 and HS20 loading before strengthening.

(3) Flexural stress in the tension flange, compression flange, concrete deck, web shear stress and tendon axial stress for HS20 loading after the bridge is strengthened. In each one of the above cases, calculate total stresses and compare against allowable values. Also, design the shear connectors; show the location of anchorages for the prestressing bars along the girder length and check the lateral stability requirements of AASHTO during prestressing.