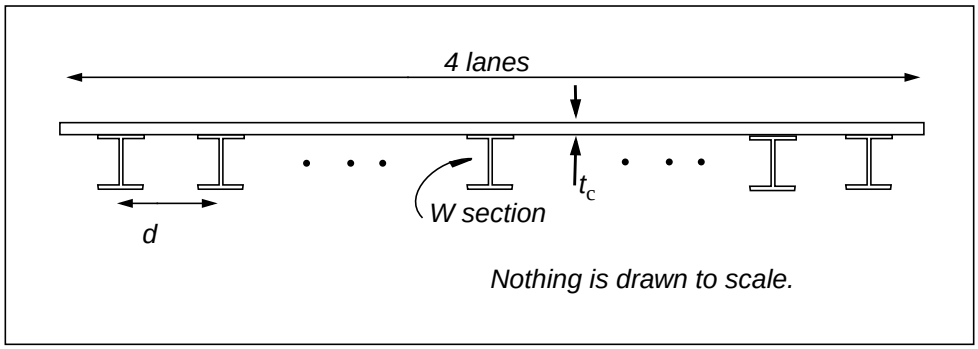
Design Exercise 5
1.050 Solid Mechanics
Fall 2004

A bridge, with length of span section measuring ***s = 70 feet***, is to carry four lanes of industrial weight traffic. Longitudinal, *W* section, steel beams are to support a concrete slab roadway and traffic "live" loads. Your job is to do an initial sizing of the *W* section beams and determine their number and, hence, spacing. The figure shows a *transverse section* of the beam with all pertinent dimensions labeled.



You are to first take the concrete and steel as acting independently. In fact, in this part you are to take the contribution of the concrete to bending strength and stiffness of the steel beams as nil.

The concrete is just dead weight loading as far as you are concerned. Some one else has responsibility for detailed design of the concrete - reinforcing etc. She, however, has told you that you that the distance between beams, ***d*, is not to exceed *10 feet*.** And according to prevailing code, the **minimum thickness of the concrete** is to be taken as

$t_c|_{min} = d/28$ where ***d* is the distance between girders**.

The **weight density of concrete** is to be taken as ***145 lb/ft*^{3}**.

The **allowable stress in the steel** is given as ***20,000 psi***.

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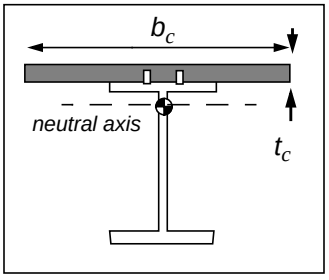
In a second part, you are to consider the contribution of the concrete to the bending strength and stiffness of the steel beams. In actual practice, shear connectors - e.g.,studs welded to the top flange of the beam and embedded in the concrete slab when poured - prevent slip at the interface of the steel and concrete, the strain across the interface is continuous, and we can model the system as a composite beam with the concrete carrying a portion of the compressive stress due to bending of the beam.

The figure at the right shows a composite cross-section. The **effective width of the concrete compression flange**, according to code, **shall not exceed the minimum of**



1 The distance center to center of the beams (= *d*)

2. Twelve times the thickness of the slab.

Re-work your design, showing how much steel might be saved taking into account the effect of the concrete slab. In this, take

The **allowable stress in the concrete as 40% of its compressive strength**. (Compressive strength = 4000 psi).

The **ratio of Young moduli, steel to concrete, as *10*.**

Due at the start of class on Monday, 22 November