1.054/1.541 Mechanics and Design of Concrete Structures (3-0-9)

Exam #2

Date: Tuesday, May 4, 2004 **Time:** 2:30pm ~ 4pm

Note: This is an open-book and open-note exam.
This exam is designed to test your knowledge of the concepts. Be brief and specific in your discussions.

Question 1 – Bridge Torsion (45%)

A small simply supported bridge in an industrial plant carrying a conveyor and spanning over 40 ft. has a T cross section as shown in Fig. 1. The bridge is to carry a full service live load of 110 lb/ft^2 over its entire width; when only one half of the width of the bridge is loaded a service live load of 180 lb/ft^2 shall be considered. Neglect the weight of the concrete for brevity. Capacity reduction factor for shear and torsion is $\phi = 0.85$.

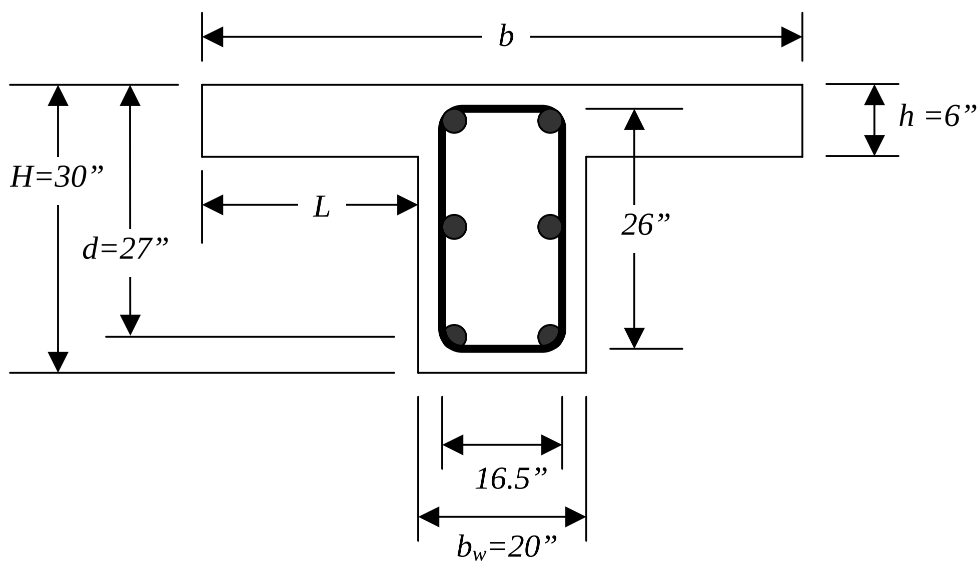

Fig. 1 Dimensions of the T cross section

Material strengths are provided below:
Concrete
Uniaxial compressive strength of concrete: f_c'= 4000 *psi*;
Steel
Yield stress: f_y = 40 *ksi*

The beam has been reinforced for shear and torsion. Combined shear reinforcement (A_v) and torsional reinforcement ($2A_t$) have the following relationship

$$\rho_{v,total} = \frac{A_v + 2A_t}{b_w \cdot s} = 0.01$$

where s = uniform spacing of the reinforcement. Also, we assume $A_v = A_t$.

Compute the maximum allowable width, *b*, of the bridge deck for:

(a) pure shear considering that the bridge is fully loaded (neglect bending effects).
(b) combined shear and torsion. (Describe your methodology and set up the equations for solving b_{max}. If an explicit solution is difficult, describe briefly the procedure for a solution based on numerical iteration.)

Hints:

Check the ultimate shear capacity when the bridge is carrying load over its entire width, and the shear and torsional capacities when the bridge is loaded only on one half of the width.

$V_u \leq \phi\left(V_s + V_c\right)$, (Use live load factor of 1.7 in computing V_u)

For pure shear: $V_s = f_y \cdot d \cdot \dfrac{A_{v,total}}{s}$

Question 2 – Yield Line Slab Analysis (35%)

The one-way slab shown in Fig. 2 is uniformly reinforced to provide a positive and negative moment capacity of M_u.

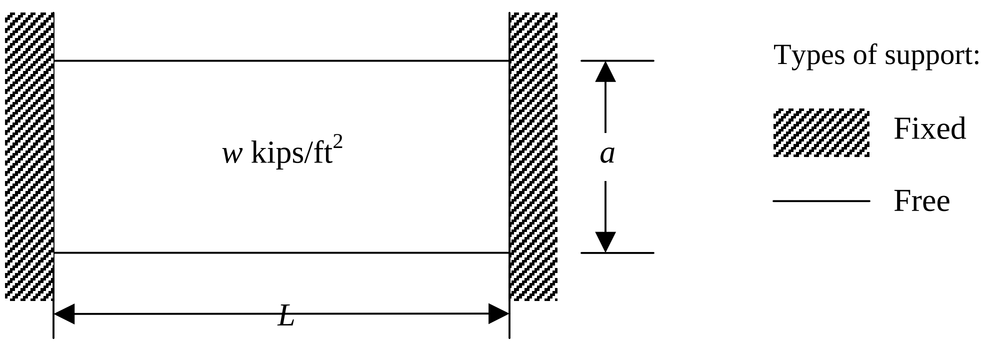

Fig. 2 One-way slab

(a) Sketch the most likely yield line pattern for the slab, and obtain an expression for the ultimate load capacity, w_u, for this slab.
(b) The collapse mechanism shown in Fig. 3 is considered for this slab. Compute the ultimate load capacity, w_u, for this collapse mechanism.

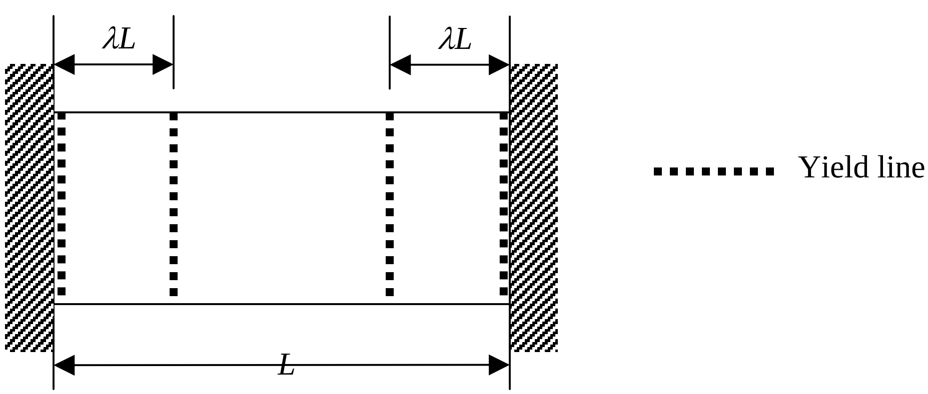

Fig. 3 The collapse mechanism

Compare the values found from (a) and (b). Explain any difference in these values for varied λ. Comment on the safety implication of this solution.

Question 3 – Thin Shell Structures (20%)

Consider the cylindrical shell under uniformly distributed surface load.

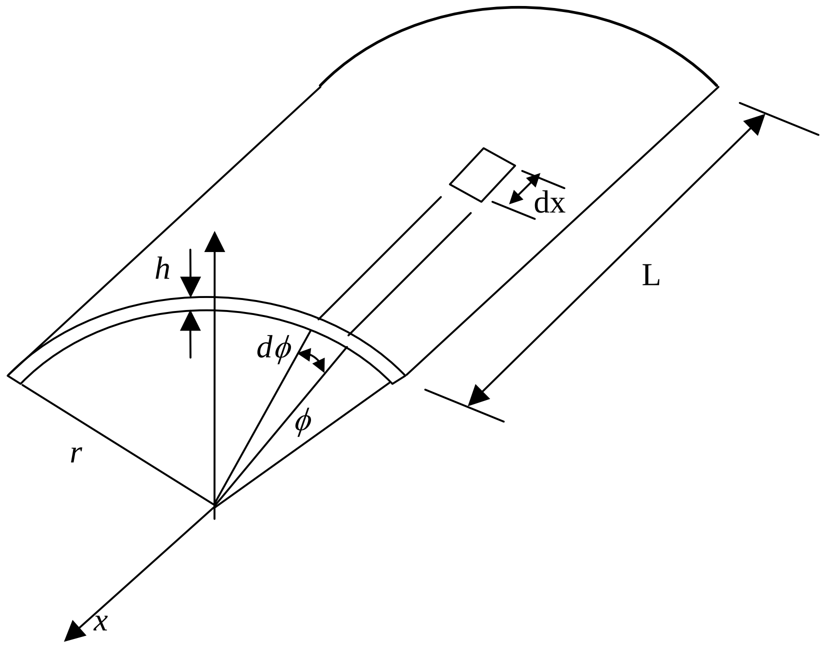

Fig. 4 The cylindrical shell

(a) What are the conditions (or parameters) that approximately classify this shell as i) a long shell; ii) a short shell.

(b) Describe briefly the behavioral difference of the short and long shells and indicate the significant internal effects associated with each of these shell types.

(c) You are asked to provide an approximate solution of internal effects as a basis for preliminary design of this shell. Briefly explain your analysis methodology for each of these shell types.