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

## Homework #4

**Assigned:** Tuesday, April 13, 2004                    **Due:** Tuesday, April 27, 2004

### Torsion / Yield Line Theory

## 1. Torsion

### Introduction

Architectural and clearance requirements call for the use of a transfer girder (shown in Fig. 1) spanning 28 ft between supporting column faces. The girder carries a concentrated load of 25 kips at midspan, applied with eccentricity of 25 in. from the girder centerline (considering load factors and including girder self weight). Dimensions of the member are x = 10 in., y = 22 in., $x_1$ = 6 in., $y_1$ = 17 in., and d = 19 in. Assuming supporting columns provide full torsional rigidity. Flexural rigidity at the ends of the span may also be assumed to develop 40 percent of the maximum moment that would be obtained if the girder were simply supported. Material strengths are

Concrete
Uniaxial compressive strength: $f_c' = 5000$ psi;
Steel
Yield stress: $f_y = 40$ ksi;
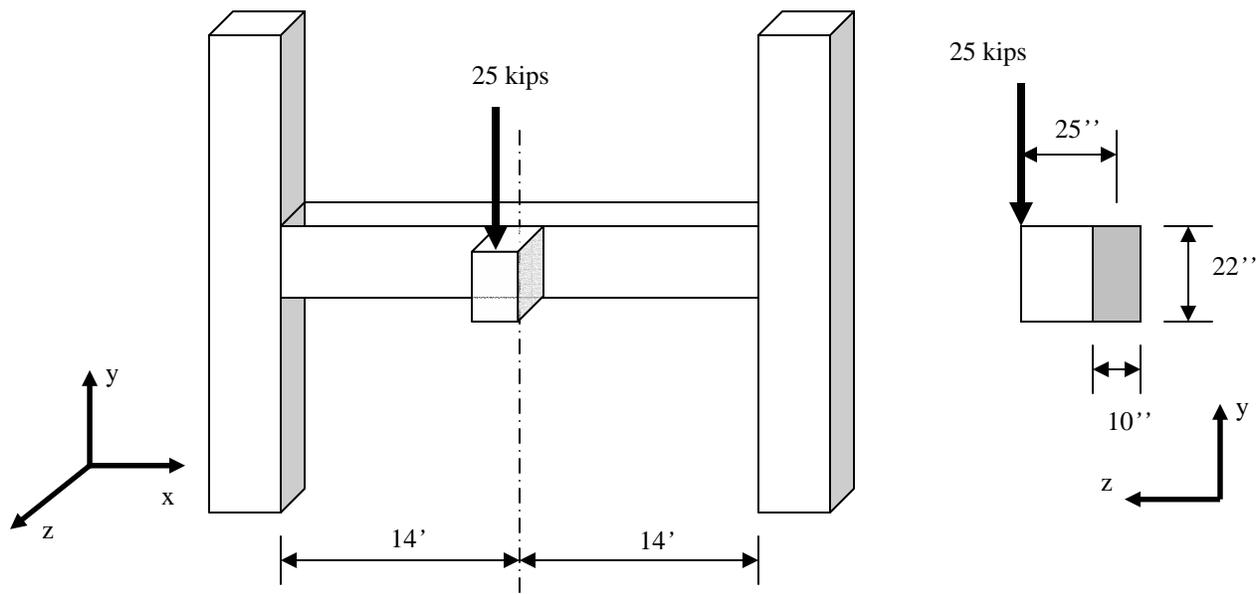


**Figure 1.** Transfer girder and its dimensions

### Question

Design both transverse and longitudinal steel for the girder.

## 2. Yield Line Theory

### Introduction

A reinforced concrete slab (shown in Fig. 2) is supported by two fixed edges and one simply supported edge but has no support along one long side. It has a uniform thickness of 8 in., resulting in effective depths in the long direction of 7 in. and in the short direction of 6.5 in. Bottom reinforcement consists of #4 bars at 15 in. centers in each direction, continued to the supports and free edge. Top negative steel in the x direction consists of #4 bars at 12 in. on center, except that in a 2 ft. wide "strong band" parallel and adjacent to the free edge, four #5 bars are used. Top negative steel in the y direction consists of #4 bars at 24 in. on center. Material strengths are

Concrete

Uniaxial compressive strength: $f_c^{'} = 4000$ psi;

Steel

Yield stress: $f_y = 60$ ksi;
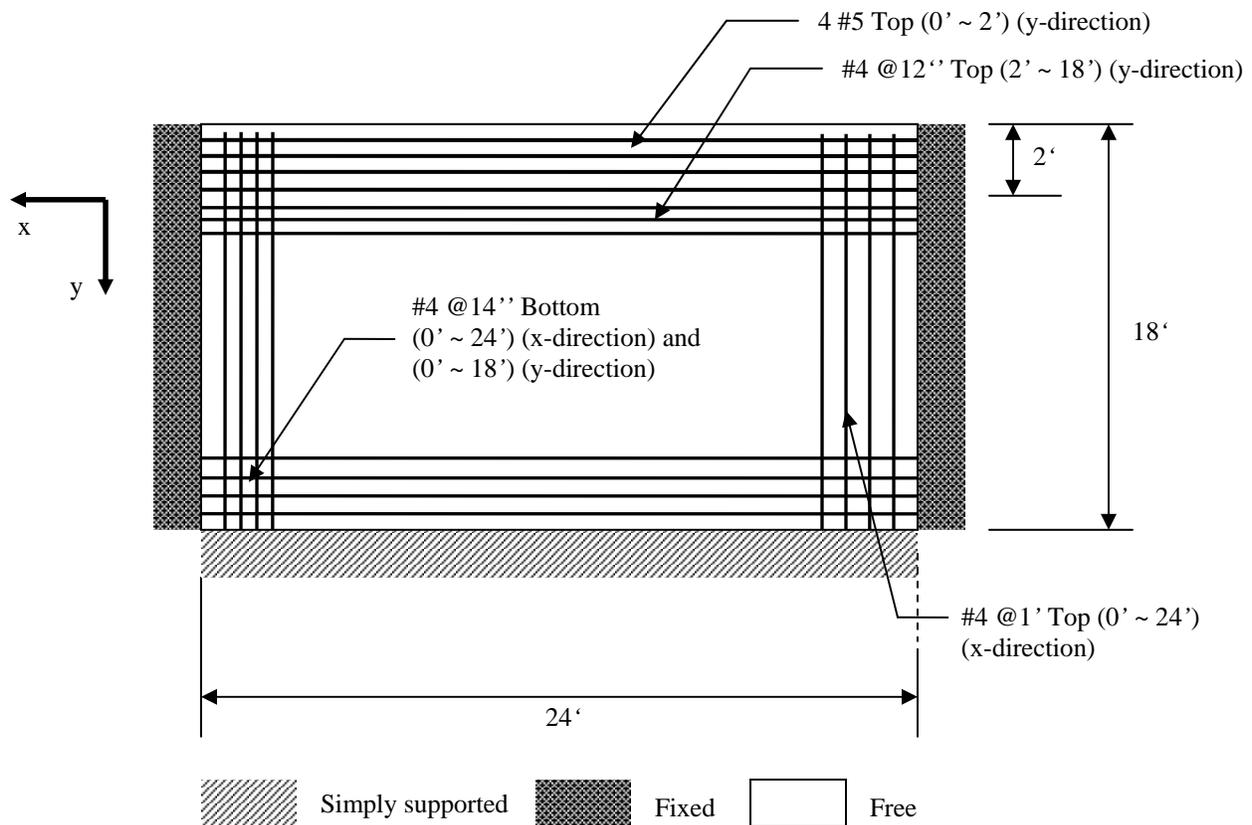


**Figure 2.** Reinforced concrete slab and its dimensions

### Question

Using the yield line theory method, determine the ultimate load $w_u$ that can be carried by the slab.