Structural Design Assignment 1

a) State the purpose of structural design

b) Differentiate between limit state and elastic method of design

c) It is required to design a straight flight with the following data;

$f_y = 410 N/mm^2$

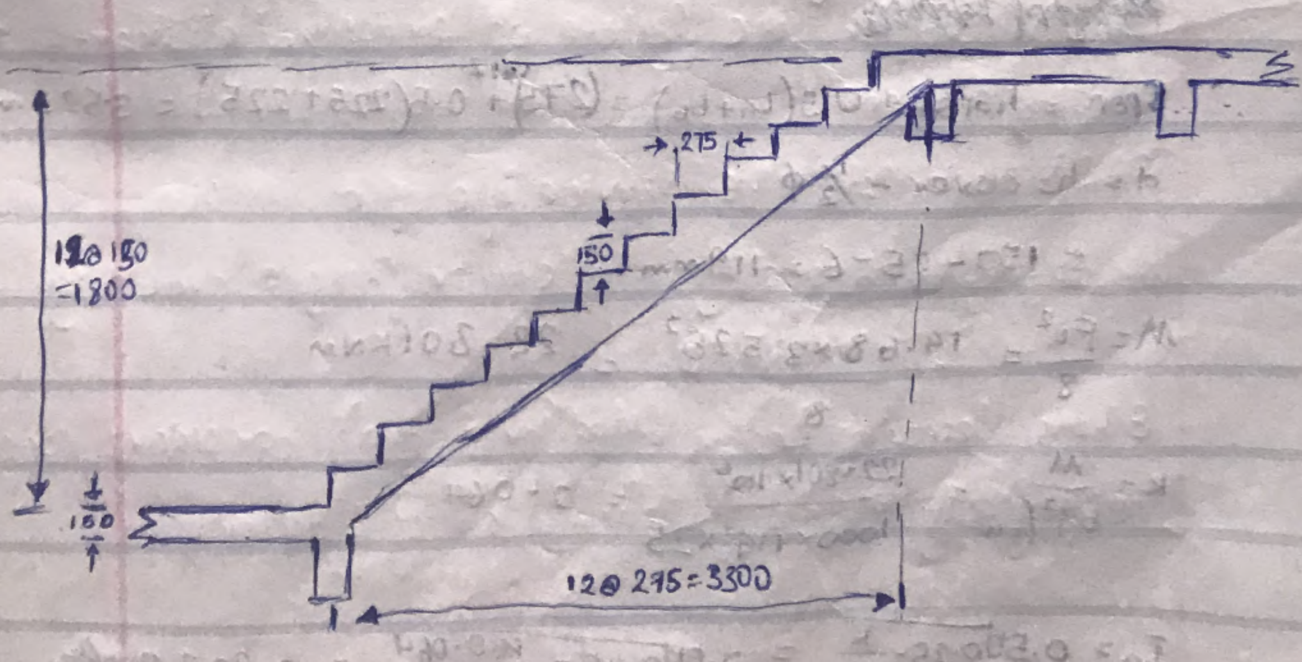
$f_{cu} = 25 N/mm^2$

rise = 150mm

tread = 275mm

slab thickness = 150mm

* Assume 12 steps
* Check for deflection



STAIR CASE Design

slope Factor = $\frac{\sqrt{R^2+T^2}}{T} = \frac{\sqrt{150^2+275^2}}{275} = 1.14$

* Load Analysis

A. WAIST = $R \times 24KN/m^2$

$= 0.15 \times 24 = 3.6KN/m^2$

B. FINISHES = $1.2KN/m^2$

C. STEPS = $T \times 1/2 \times 24KN/m^2$

$= 0.275 \times 0.5 \times 24 = 3.3KN/m^2$

D. G.K = $((A+B) \times S_F) + C$

$= (4.8 \times 1.14) + 3.3$

$= 8.77 KN/m$

D.L, F = $1.4GK + 1.6QK$

$= 1.4(8.77) + 1.6(1.5)$

$= 14.68 KN/m^2$

Span = $T_{total} + 0.5(la + lb) = (275 \times 12) + 0.5(225 + 225) = 3.525m$

$d = h - cover - \frac{1}{2}\phi$

$= 150 - 25 - 6 = 119mm$

$M = \frac{FL^2}{10} = \frac{14.68 \times 3.525^2}{10} = 18.24 KNm$

$K = \frac{M}{bd^2 f_{cu}} = \frac{18.24 \times 10^6}{1000 \times 119^2 \times 25} = 0.052$

$I_a = 0.5 + \sqrt{0.25 - \frac{K}{0.9}} = 0.5 + \sqrt{0.25 - \frac{0.052}{0.9}} = 0.938$

$Z = I_a d = 0.938 \times 119 = 111.622mm$

$A_s = \frac{M}{0.95 f_y Z} = \frac{18.24 \times 10^6}{0.95 \times 410 \times 111.622} = 419.53$

$A_{s\,prov} = 452mm$

Provide Y12 @259 c/c ($A_{s\,prov} = 452mm$)

Deflection Check

$$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{A_{req}}{A_{prov}} \times f_y$$

$$f_s = \frac{2}{3} \times 1 \times \frac{419.53}{452} \times 250$$

$$= 154.69 \text{ N/mm}^2$$

$$M.F = 0.55 + \frac{477 - 154.69}{120\left(0.9 + \frac{18.24 \times 10^6}{1000 \times 119^2}\right)} = 1.78$$

$$d_{req} = \frac{span}{mf \times edr} = \frac{3525}{1.78 \times 26} = 76.17 \text{ mm}$$

since $d_{req} < d$, Deflection is OK

a Purpose of Structural design

The purpose of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and resistance to the effects of misuse and fire.

b Limit State Design considers all the disadvantages of elastic method of design and Load Factor design & any other failure that can cause the structure to be unfit for use. It is divided into Ultimate Limit State Design & Serviceability Limit state design.

- ULSD considers the failure of structural elements due to Bending & shear
- SLSD considers the service life of a structural element which may be caused by; deflection, fatigue, cracking, shrinkage, etc

while

Elastic Method of Design (Modular Ratio) considers concrete to be perfectly elastic following "law of Elasticity".

Question 2

a) Identify the panels in figure 1

for P1 ⇒ P6; $L_y = 4300$
$L_x = 4000$

$$\frac{L_y}{L_x} = \frac{4300}{4000} = 1.08$$

$\frac{L_y}{L_x} < 2$ ∴ They are 2 way slabs

for P7 ⇒ P9; $L_y = 4500$
$L_x = 4000$

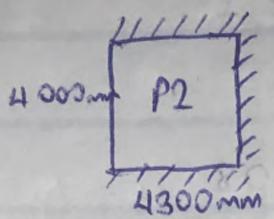
$$\frac{L_y}{L_x} = \frac{4500}{4000} = 1.125$$

$\frac{L_y}{L_x} < 2$ ∴ They are 2 way slabs

for P10 ⇒ P12 $L_y = 4000$
$L_x = 1500$

$$\frac{L_y}{L_x} = \frac{4000}{1500} = 2.67$$

$\frac{L_y}{L_x} > 2$ ∴ They are 1 way slabs b Design for Tension Reinforcement



Thickness = 175 mm

f_{cu} = 25 N/mm²

f_y = 410 N/mm²

$\frac{l_y}{l_x} = \frac{4300}{4000} = 1.08 \simeq 1.1$

One short edge discontinuous

short span coefficient;

-0.044 0.033

long span coefficient;

-0.037 0.028

Loading;

slab = 0.175 × 24 = 4.2 KN/m²

partitions = 1.0 KN/m²

finishes = 1.2

GK = 6.4 KN/m²

Design load (D.L); 1.4 GK + 1.6 QK

= 1.4 (6.4) + 1.6 (3.0)

= 13.76 ≃ 14 KN/m

- Short Span

Mid Span;

$* \; d = h - cover - \frac{1}{2}\phi = 175 - 25 - \frac{1}{2}(12) = 144$

$M = \beta_{sx} w l_x^2 = 0.033 \times 14 \times 4^2 = 7.392 \text{ kNm}$

$K = \frac{M}{bd^2 f_{cu}} = \frac{7.392 \times 10^6}{1000 \times 144^2 \times 25}$

$= 0.014$

$l_a = 0.5 + \sqrt{0.25 - \frac{K}{0.9}} = 0.984 \; (\leq 0.95)$

$Z = l_a d = 0.95 \times 144 = 136.8 \text{ mm}$

$A_s = \frac{M}{0.95 f_y Z} = \frac{7.392 \times 10^6}{0.95 \times 410 \times 136.8} = 138.73$

$A_{s\,prov} =$

Provide Y12 @ 300 c/c ($A = 377 \text{ mm}^2$)

Continuous Edge;

$M = \beta_y w l_x^2 = 0.044 \times 14 \times 4^2 = 9.856 \text{ kNm}$

$K = \frac{9.856 \times 10^6}{1000 \times 144^2 \times 25} = 0.019$

$l_a = 0.5 + \sqrt{0.25 - \frac{0.022}{0.9}} = 0.978 \; (\leq 0.95)$

$Z = l_a d = 0.95 \times 144 = 136.8 \text{ mm}$

$$A = \frac{\cancel{11.39}\ 9.856 \times 10^6}{0.95 \times 410 \times 136.8}$$

$= 184.972$

Provide Y12 @ 300 c/c ($A = 377 m^2$)

- Long Span

Mid-Span

$d = 144 - 12\ mm = 132 mm$

$M = B_{sy} n l_y^2$

$= 0.028 \times 14 \times 4^2 = 6.272$

$$K = \frac{M}{bd^2 f_{cu}} = \frac{6.272 \times 10^6}{1000 \times 132^2 \times 25} = 0.014$$

$$I_a = 0.5 + \sqrt{0.25 - \frac{0.014}{0.9}} = 0.98\ (\leq 0.95)$$

$Z = I_a d = 0.95 \times 132 = 125.4$

$$A_s = \frac{M}{0.95 f_y z} = \frac{6.272 \times 10^6}{0.95 \times 410 \times 125.4} = 128.41$$

Provide Y12 @ 300 c/c ($A = 377 m^2$)

continuous Span

$d = 132mm$

$M = \beta_{sy} w l_x^2 = 0.037 \times 14 \times 4^2 = 8.29$

$K = \frac{M}{bd^2 f_{cu}} = \frac{8.29 \times 10^6}{1000 \times 132^2 \times 25} = 0.019$

$I_a = 0.5 + \sqrt{0.25 - \frac{0.019}{0.9}} = 0.98 \ (\leq 0.95)$

$Z = I_a d = 0.95 \times 132 = 125.4$

$A_s = \frac{M}{0.95 f_y Z} = \frac{8.29 \times 10^6}{0.95 \times 410 \times 125.4} = 169.7$

Provide Y12 @ 300 c/c ($A = 377 m^2$)

- Deflection Check

$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{Area}{A_{prov}} \times f_y V$

$f_s = \frac{2}{3} \times 1 \times \frac{184.972}{377} \times 250$

$= 81.77 \ N/mm^2$

$M.F = 0.55 + \frac{477 - 81.77}{120(0.9 + \frac{9.856 \times 10^6}{1000 \times 142^2})} = 2.94 \ (\leq 2)$

$d_{req} = \frac{span}{mf \times edr} = \frac{4000}{2 \times 26} = 76.92$

Deflection is OK