HOUSE PROJECT IN UMITKOY

ARCH 332
STRUCTURAL DESIGN IN ARCHITECTURE

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GROUP 27
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Our aim is to create a living space which connects different area at different floor. In addition, we aimed to associate house to back garden with open air terrace which is at the south part of house. At facade, we try to emphasize shear wall in terms of color, height and form. We use horizontal and vertical continuous elements as eaves and balconies.
Open Air Terrace connect House and Back Garden
Facades

North Facade

East Facade

South Facade

West Facade
Living Area and Gallery Space with Vertical Opening

Sun shading devices above Staircase

Living Area with Open Air Terrace and Gallery
**SELECTION OF STRUCTURAL SYSTEM**

**GEOMETRIC CENTER**
Geometric center is at the center of the building because its symmetric.

**STIFNESS CENTER**

\[
x_{sc} = \frac{l_1 \epsilon_1 + l_2 \epsilon_2 + l_3 \epsilon_3}{l_1 + l_2 + l_3}
\]

\[
x_{sc} = \frac{(1/12 \times 0,3 \times (2,5)^3) \times 0 + (1/12 \times 0,3 \times (2,25)^3) \times 0 + (1/12 \times 0,3 \times 3)^3 \times 12}{(1/12 \times 0,3 \times (2,5)^3) + (1/12 \times 0,3 \times (2,25)^3) + (1/12 \times 0,3 \times 3)^3}
\]

\[= 5,998 \text{ m}
\]

\[x_{sc} = 6 \text{ m}
\]

\[
y_{sc} = \frac{l_4 \epsilon_4 + l_5 \epsilon_5}{l_4 + l_5}
\]

\[
y_{sc} = \frac{(1/12 \times 0,3 \times (2,5)^3) \times 12 + (1/12 \times 0,3 \times (2,5)^3) \times 0}{(1/12 \times 0,3 \times (2,5)^3) \times 2}
\]

\[y_{sc} = 6 \text{ m}
\]

Stiffness center is 6,6 so stiffness center and geometric center are coincided.

**SHEAR WALL PERCENTAGE**

Ground floor area: 144m²
Area of shear wall on x direction:
0,3x2,50x2=1,5m²
The ratio of shear wall in x direction is 1%.
Area of shear wall on y direction:
0,3x2,50+0,3x2,25+0,3x3=2,32 m²
The ratio of shear wall in x direction is 1,6%.
In x direction 0,75%<1% and in y direction 0,75%<1,6% so it is acceptable.

Two way solid slab system is chosen as slab system.
FIRST FLOOR SLAB

\[ \alpha = \frac{\text{length of continuous edges}}{\text{total length of all edges}} \]

\[ \alpha_{s_{101}} = \frac{4+4.5+4.5}{4+4+4.5+4.5} = 0.76 \]

\[ \alpha_{s_{102}} = \frac{4+4.5+4.5}{4+4+4.5+4.5} = 0.76 \]

\[ t \geq \frac{t_{\text{short}}}{15+\frac{4}{t_{\text{long}}}} \times (1-\frac{\alpha}{4}) \]

\[ t_{s_{101}} = \frac{4}{15+\frac{4.5}{4}} \times \left(1-\frac{0.76}{4}\right) = 0.1 \text{ m} \]

\[ t_{s_{102}} = \frac{4}{15+\frac{4.5}{4}} \times \left(1-\frac{0.76}{4}\right) = 0.1 \text{ m} \]

For first floor slab most critical slabs are \( s_{101} \) and \( s_{102} \).

ROOF SLAB

\[ \alpha = \frac{\text{length of continuous edges}}{\text{total length of all edges}} \]

\[ \alpha_{s_{201}} = \frac{3+3+8}{3+3+8+8} = 0.63 \]

\[ \alpha_{s_{202}} = \frac{8+8}{4.5+4.5+8+8} = 0.64 \]

\[ t \geq \frac{t_{\text{short}}}{15+\frac{4}{t_{\text{long}}}} \times (1-\frac{\alpha}{4}) \]

\[ t_{s_{201}} = \frac{3}{15+\frac{8}{3}} \times \left(1-\frac{0.63}{4}\right) = 0.11 \text{ m} \]

\[ t_{s_{202}} = \frac{4.5}{15+\frac{8}{4.5}} \times \left(1-\frac{0.64}{4}\right) = 0.14 \text{ m} \]

For first floor slab most critical slabs are \( s_{201} \) and \( s_{202} \).

Since the most critical slab is \( s_{202} \) at roof slab and its thickness is 14 cm. Slab thickness should be more than critical slab thickness.

**SLAB THICKNESS = 15 cm**
Beam depth = \[
\frac{\text{Longest span}}{12.5} = \frac{800}{12.5} = 64 \text{ cm}
\]

Assume beam depth is 65 cm and wall height is 2.35 m.

Design Loads for slab:

**Dead Load:**
- Own weight: 0.15 x 2.4 = 0.36 t/m²
- Levelling: 0.004 x 2.4 = 0.096 t/m²
- Covering: 0.025 x 2 = 0.05 t/m²
- Plastering: 0.02 x 2 = 0.04 t/m²

\[
= 0.54 \text{ t/m²}
\]

**Live Load:** 0.2 t/m²

Total Load = (1.4 x 0.54) + (1.6 x 0.2) = 1.08 t/m²

**Slab load:**
- (3.75 + 2.25) x (2 + 2) x 1.08 = 25.92 t

**Wall load:**
- (2.35) x (2 + 2) x 0.45 x 1.4 = 5.92 t

**Slab load:**
- (2 + 2) x (2.25) x 1.08 = 9.72

**Wall load:**
- (2.25 + 2) x (2.35) x 0.45 x 1.4 = 6.29

**Slab load:**
- (2 + 2) x (2.25 + 2.25) x 1.08 = 19.44

**Total load:**
67.29 t = 67290 kg

Then:
\[
A \geq \frac{N_s}{0.75 x fcd}
\]

\[
= \frac{67290}{0.75 \times 130} = 690.15 \text{ cm²}
\]

Since \( A < 750 \text{ cm²} \)

**Column dimensions are 30cm x 30cm according to TS-500**
After calculating several beams, we realize that the most critical beam is roof beam which passes through the gallery.

For Short Span
$$P_d x \frac{l_{short}}{3}$$

For Long Span
$$P_d x \frac{l_{short}}{3} \left( \frac{1,5-0,5}{(l_{long})^2} \right)$$

$$P_d = (1,4xDL)+(1,6xLL)$$
$$P_d = (1,4x0,54)+(1,6x0,2)$$
$$= 1,08 \text{ t/m}$$

Load Region a:
$$w_{12} = \frac{1,08 \times 3 \times \left( 1,5-0,5 \frac{0,5^2}{(4,5)^2} \right) + 1,08 \times 4}{3} = 2,75 \text{ t/m}$$

Load Region b:
$$w_{24} = \frac{1,08 \times 8 \times 3}{2 \times 8} + 1,08 \times 4.5 \times \left( 1,5-0,5 \frac{0,5^2}{(4,5)^2} \right) = 3,79 \text{ t/m}$$

$$I_{column} = \frac{1}{12} \times 12 \times (0,3)^3 = 0,00675 \text{ m}^4$$
$$I_{shear} = \frac{1}{12} \times 12 \times 2,5 \times (0,3)^3 = 0,0056 \text{ m}^4$$
$$I_{shear2} = \frac{1}{12} \times 12 \times 3 \times (0,3)^3 = 0,0067 \text{ m}^4$$
$$I_{beam} = \frac{1}{12} \times 12 \times 0,3 \times (0,65)^3 = 0,0068 \text{ m}^4$$

$$r_{12} = \frac{0,0068/4}{(0,0068/4)+(0,0056/3)} = 0,477$$
$$r_{21} = \frac{0,0068/4}{(0,0068/4)+(0,0068/8)+(0,000675/3)} = 0,612$$
$$r_{24} = \frac{0,0068/8}{(0,0068/4)+(0,0068/8)+(0,000675/3)} = 0,306$$
$$r_{42} = \frac{0,0068/8}{(0,0068/8)+(0,0067/3)} = 0,276$$

FEM = \frac{W \times l^2}{12} \quad \text{ mid-span moment} = \frac{W \times l^2}{24}

FEM_{12} = \frac{2,75 \times 4^2}{12} = 3,67 \text{ tm}

FEM_{24} = \frac{3,79 \times 8^2}{12} = 20,21 \text{ tm}

mid-span moment_{12} = \frac{2,75 \times 4^2}{12} = 1,83

mid-span moment_{24} = \frac{3,79 \times 8^2}{24} = 10,10 \text{ tm}
Beam Analysis

### Moment Analysis

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</tbody>
</table>

Mid span:
\[
\frac{12.16 - 4.4}{2} = 3.88
\]

Mid span:
\[
\frac{2.86 + 3.89}{2} = 3.37
\]

\[
K = \frac{bwxd^2}{M} \quad \Rightarrow \quad 0.025 = \frac{30xd^2}{1735000} \quad \Rightarrow \quad d = 38.02
\]

\[
h > d + 5 = 42.68 \quad \text{and} \quad h > 3t \text{ and } t = 15 \quad \Rightarrow \quad h > 45
\]

**Beam Depth = 50 cm**