LECTURE NOTE ON
CVE 306 (STRUCTURAL DESIGN I)
Course Unit 2

Course Lecturer: Engr. Akinyele J.O

Duration for lecture: 2 hours per week
(15 weeks)

COURSE OBJECTIVES

- Students should be able to understand design fundamentals
- Design Philosophy .
- Safety factors.
- Design and detailing of reinforced concrete structures.

Design Philosophy (Week1)

- The design of a structure may be regarded as the process of selecting proper materials and proportioned elements of the structure, according to the art, engineering science and technology. In order to fulfill its purpose, the structure must meet its conditions of safety, serviceability, economy and functionality.

Limit state design (Week1)

- It is a further step in the strength design method. It indicates the state of the member in which it ceases to meet the service requirements, such as, loosing its ability to withstand external loads or local damage. According to limit state design, reinforced concrete members have to be analysed with regard to three limit states:
- Load carrying capacity (involves safety, stability and durability)
- Deformation (deflection, vibrations, and impact)
- The formation of cracks
- The aim of this analysis is to ensure that no limiting sate will appear in the structural member during its service life.

Fundamental assumptions for Reinforced Concrete's Behavior (Week 2)

- Reinforced concrete's sections are heterogeneous, because they are made up of two different materials - steel and concrete. Therefore, proportioning structural members by ultimate stress design is based on the following assumptions:
- Strain in concrete is the same as in reinforcing bars at the same level, provided that the bond between the concrete and steel is adequate
- Strain in concrete is linearly proportional to the distance from the neutral axis.
- Modulus of elasticity for all grades of steel is taken as Es = 200 kN/mm2. The stress in the elastic range is equal to the strain multiplied by Es.
- Plane cross sections continue to be plane after bending.
- Tensile strength of concrete is neglected because:
  - Concrete's tensile strength is about 1/10 of its compressive strength.
- Cracked concrete is assumed to be not effective Before cracking, the entire cross section is effective in resisting the external moments.
- The method of elastic analysis, assuming an ideal behavior at all levels of stress is not valid. At high stresses, non-elastic behavior is assumed, which is in close agreement with the actual behavior of concrete and steel.
- At ultimate strength, the maximum strain at the extreme compression fibers is assumed to be equal to 0.0035 by the BS 8110 code provisions. At the ultimate strength, the shape of the compressive stress distribution may be assumed to be rectangular, parabolic or trapezoidal.

Loads
(Week 2)

- Structural members must be designed to support specific loads. Loads are those forces for which a structure should be proportioned. Loads that act on structure can be divided into three categories.
- Dead loads
- Live loads
- Wind loads

BS 8110 Code Safety Provisions (Week 3)

- Structural members must always be proportioned to resist loads greater than service or actual loads, in order to provide proper safety against failure. In the strength design method, the member is designed to resist the factored loads which are obtained by multiplying the factored loads with live loads.
- Ultimate design load= 1.4Gk + 1.6Qk
- Qk = Imposed load, Gk= dead load

Structural Concrete elements (Week 3)

- **Slab:** Slabs are horizontal elements in building floors and roof. They may carry gravity loads as well as lateral loads. The depth of the slab is usually very small relatively to its length and width.
- **Beams:** Long horizontal or inclined members with limited width and height are called beams. Their main function is to transfer loads from the slab to the columns.
- **Column:** Columns are vertical members that support loads from the beam or slabs. They may be subjected to axial loads or moments.
- **Frames:** Frames are structural members that consists of combination of slab, beams and columns
- **Footings:** Footings are pads or strips that support columns and spread their load directly to the soil.
- **Walls:** Walls are vertical plate elements resisting gravity as well as lateral loads e.g retaining walls, basement walls. etc

Design procedure for double reinforced beams (Week 4-5)

- **Step # 1:**

  Find the strength Mu of a singly reinforced beam

  Mu > 0.156Fcubd2

  Md = 0.156Fcubd2

  If Mu required > Md of simply reinforced beam . Proceed with doubly reinforced beam design.
- **Step # 2:**

  Find excess moment i.e

  Mu1 = Mu – Md
- and determine the resulting compression steel area As’ = As and tentatively assume that fs = fy, then

  As' = Mu1 /0.95 fy (d - d')
- **Step# 3:**

  Find the total tensile steel area i.e

  As = As' + As2

  As2 = 0.156Fcubd2/0.95fyz
- **Step # 4:**

  Check for satisfactory minimum and maximum reinforcement ratios and check for shear and design for shear reinforcement
- **Step # 5:**

  Select appropriate bar size and draw the sketches.

Design procedure for reinforced solid slabs (Week 6-7)

- **Step # 1:**

  Find the strength M for two -ways slab by using the BS 8110 slab coefficient factors

  M for one way slab can be obtained depending on the orientation of the slab, for a simply supported one way slab, use $wl^2/8$. for a continuous slab use 0.086fl.

- **Step # 2:**

find $K = m / f_{cu}bd^2$, where b = 1000 mm and d is the effective depth of slab

- **Step # 3:**

  Check for area of steel, for both main and distribution steel,

  As = m/0.95fyz

- **Step # 4:**

  Select appropriate bar size, check for deflection on the short span and draw the sketches.

Design procedure for reinforced concrete columns (Week 7-8)

- Design of different types of columns
- Classified the column to: Braced and Unbraced.
- Determine whether the column is short or slender: For a short column

  l_{ex}/h and $l_{ey}/h < 15$ for braced and <10 for unbraced column.

l_{ex} and l_{ey} are effective heights on the x and y axis of the column. H is the overall depth of column.

Determine the axial load and moments on the column.

Use N=0.45FcuAc +0.95FyAsc. Or column charts to determine the reinforcements.

A minimum of 4 bars and 6 bars are required for rectangular and circular columns respectively.

Staircase design (week 9)

- Types of Stair case and their design
- Straight flight
- Dog leg
- Spiral stair
- Cantilever stair
- Helical stair, etc

References

- Reinforced concrete design. W.H. Mosley, J.H. Bungey & R. Hulse. Macmillan Press Ltd. London.
- Simplified reinforced concrete design. V.O.Oyenuga.Asros Ltd. Lagos, Nigeria.

Assessments

- Week 10 Class test
- Week 11-13, Individual Students' project
  (design of different structures)

Week 14-15 General class revision

- Assignments =15%
- Quiz = 15%
- Examination =70%
- Total =100%