COVENANT UNIVERSITY

ALPHA SEMESTER TUTORIAL KIT
(VOL. 2)

PROGRAMME: BUILDING TECH
400 LEVEL

Raising A New Generation Of Leaders

DISCLAIMER

The contents of this document are intended for practice and learning purposes at the undergraduate level. The materials are from different sources including the internet and the contributors do not in any way claim authorship or ownership of them. The materials are also not to be used for any commercial purpose.

LIST OF COURSES

*BLD411: Advanced Structural Analysis
BLD412: Design of Reinforced Concrete Structure II
*BLD413: Principles of Construction Management
*BLD414: Integrated Studio Project
*BLD415: Research Methods
*BLD416: Economics Analysis of Building Prices and Estimating II
*BLD417: Foundation Engineering
*BLD418: Building Contract Law and Arbitration

*Not included

Building Technology Department,
Covenant University. Canaanland Ota. Ogun State.
Alpha Semester Examination.

Answer Question 1 any other three (3) questions Course Code: BLD 412.

Course Title: Reinforced Concrete Design 2. **Time: 3 Hrs**

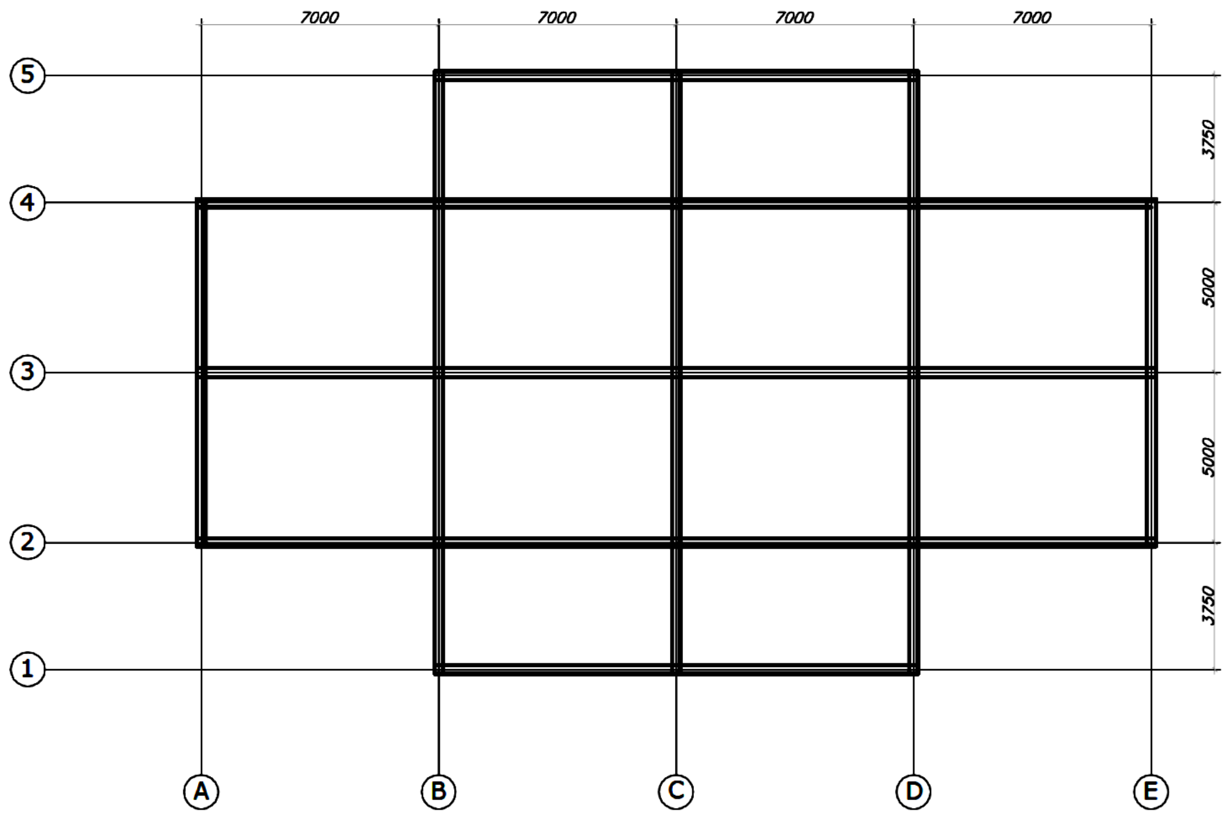


Fig Q1

The above plan is the 1st floor of the proposed School of Environmental Sciences. The thickness of the floor slab is 150mm, the materials strengths are 30N/mm^2 for concrete and 500N/mm^2

for steel. The floor carries an imposed load of 4KN/m^2 and finishes plus ceiling load of 1.25KN/m^2. Use the plan to answer the following questions. The cover to steel reinforcement for the slab is 25mm and 30mm for the beams respectively. The unit weight of concrete is 24KN/m^3.

1. A. Calculate the midspan moments for Panels AB-23 and BC-12.

B. Design slab Panel BC-23 and check for deflection and provide reinforcement details.

(25 marks)

2. Design the continuous flanged beam 3(A-E). The beam dimensions are 250mm width of web and 450mm overall depth. Perform the serviceability checks i.e. (deflection) and provide the reinforcement details. Utilize Table 3.5 for the analysis of the beam.

(15 marks)

3. A. List the classifications of columns.

B. On a sketch of the plan in Fig Q1, identify the three categories of short braced columns and their respective locations.

C. The column B3 has cross-sectional dimensions 250mm x 250mm and a clear height of 4.0m with an effective height coefficient (β) of 0.75. Assuming that the ultimate load from the slab and beams carried by the column is 300KN, design the longitudinal steel and links for the column and check the suitability of the steel provided. (15 marks)

4. Design the corresponding square footing for column B3. Take the safe bearing capacity of the soil to be 150 kN/m^2 and assume the weight of the footing to be 100KN. Take the cover to reinforcement to be 50mm. Perform checks for the critical shear stresses. (15 marks)

Design slab Panel CD-15 as a continuous slab using the slab data provided in the question preamble. Utilize Table 3.12 of BS 8110 for the analysis of the slab and provide reinforcement details of the design. (15 marks

COVENANT UNIVERSITY.

CANAANLAND, KM 10 IDIROKO ROAD
P.M.B. 1023 OTA. OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: **B.SC EXAMINATION.**
COLLEGE: **COLLEGE OF SCIENCE AND TECHNOLOGY**
SCHOOL: **SCHOOL OF ENVIRONMENTAL SCIENCES**
DEPARTMENT: **BUILDING TECHNOLOGY DEPARTMENT**
SEMESTER: **OMEGA**
COURSE CODE: **BLD 412** CREDIT UNIT: **2**
COURSE TITLE: **DESIGN OF REINFORCED CONCRETE STRUCTURES**
MARKING SCHEME

1. (a) Loadings

Slab

Gk = 4.6kN/m^2

Qk = 4kN/m^2

Ultimate design load = 1.4 Gk + 1.6 Qk =12.84 kN/m^2

Self-weights

Beam

0.25x0.45x24x1.4 = 3.78kN/m

Column

0.25x0.25x24x1.4 = 2.1kN/m

Design loads

Beam B1-C1

Assuming the slab is simply supported, Beam B1-C1 supports a UDL from a 1.5mwidth of slab therefore;

Design load = 12.84 x 1.5 + 3.78 = 23.04 kN/m

Reactions RB1 = RC1 = 69.12kN

Beam B2-C2

12.84 x 3 + 3.78 = 42.3kN/m

RB2 = RC2 = 126.9kN

Beam B1-B3

12.84x 1.5 + 3.78 +126.9 (point load from Beam B2-C2)

RB1 =RB3 = 132.57kN

Column B2

Load on column B2 = 126.9 + 34.56 +34.56+ (2.1 x3) = 202.32 kN

Column A3

69.12 (reaction RA3 from beam A1-A3) + 5.67 (reaction A3 from Beam A1-B1) + (2.1x3)= 81.09kN

(b) Design reinforcing steel for beam B2-C2

Design Moment = 0.125 x42.3x6^2 = 190.35kNm

Effective depth d = 450-40-8-8 = 394mm

Mu = 0.156fcubd^2

=151.4< applied moment (190.35kNm)

Therefore provide for compression reinforcement

As' = 230mm^2

As =1538.8mm^2

Provide 4 Y25 btm (As prov. = 1960mm^2)

Modification factor = 1.51

Allowable span to effective depth ratio= 1.51 x 20=30.2

Actual span to effective depth ratio = 6000/394 =15.24< 30.2

Therefore deflection is ok.

2. (a)

moment, M = 270kNm

Mu = 0.156x25x300x600^2 = 421.2kNm> moment

Therefore no compression steel is necessary

K = 0.1

z = 523.61<0.95d

As = M/0.95fyz

$270 \times 10^6/0.95 \times 500 \times 523.61 = 1086mm^2$

Provide 4 Y16 btm (As prov. = $1260mm^2$)

Design stress, Vc = 0.6

V = 180kN

Design concrete shear stress, vc = 0.528 (interpolating from table)

Design shear stress, v = 0.86 N/mm^2

Since 0.5vc < v, provide minimum links

Therefore provide 8mm links at 300mmc/c

(b)

i. **Characteristic load** ; This is the anticipated load levels due to self-weight, contents and users, snow and wind are called characteristic loads. Buildings will be subject to loads from various sources. The principal ones can be classified as dead load, imposed load and wind load

   Design load; For the Ultimate Limit State, the design loads are taken as the characteristic loads multiplied by the appropriate safety factor; for the Serviceability Limit State unfactored characteristic loads are used.

ii. **Effective depth**; The depth of a beam or slab section as measured from the top of the member to the centroid of the tensile reinforcement.

   Overall depth; This is the overall depth of a section from the top fo the compression face to the bottom of the tensile face

iii. **A singly reinforced beam** is one in which the concrete element is only reinforced near the tensile face and the reinforcement, called tension steel, is designed to resist the tension.

Doubly reinforced beam is one in which besides the tensile reinforcement the concrete element is also reinforced near the compressive face to help the concrete resist compression. The latter reinforcement is called compression steel. When the compression zone of a concrete is inadequate to resist the compressive moment

iv. **One way spanning slab;** One way slab is supported on two opposite side only thus structural action is only at one direction. Total load is carried in the direction perpendicular to the supporting beam.

Two way spanning slab; Two way slabs are the slabs that are supported on four sides and the ratio of longer span (l) to shorter span (b) is less than 2. In two way slabs, load will be carried in both the directions. So, main reinforcement is provided in both direction for two way slabs.

v. **Design moment**; this is the maximum moment that the section will be designed for. This is also referred to as applied moment

Ultimate moment of resistance; is the moment at which the entire cross section has reached its yield stress. This is theoretically the maximum bending moment that the section can resist - when this point is reached a plastic hinge is formed and any load beyond this point will result in theoretically infinite plastic deformation.

3. (a)RB1=RB3 = 34.56kN, for any distance x from the left support

When x = 0, **M** = 0, Shear force = 34.56

When x = 1, **M** = -23.04, Shear force = -11.52

When x = 2, **M** = 23.04, Shear force = -11.52

When x = 3, **M** = 0, Shear force = 34.56

When x = 4, **M** = 23.04, Shear force = -11.52

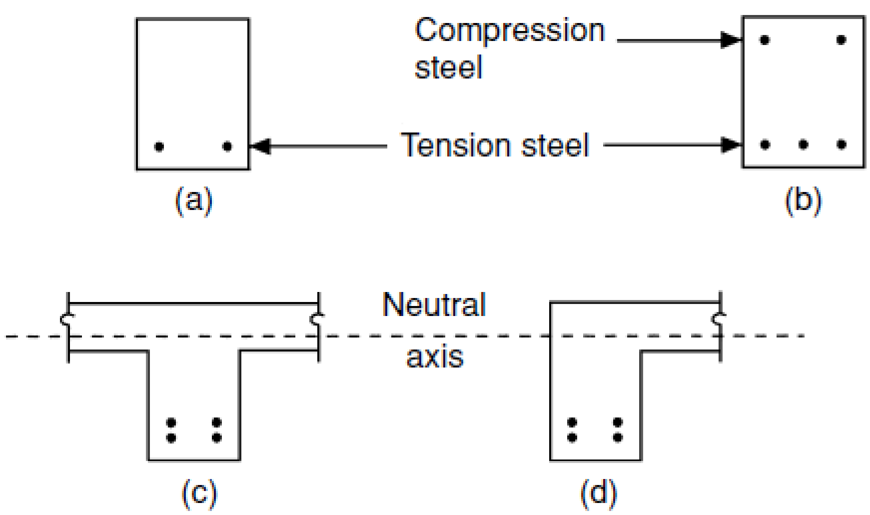
When x = 5, M = -23.04, Shear force = -11.52

When x = 6, M = 0, Shear force = 34.56

(b)

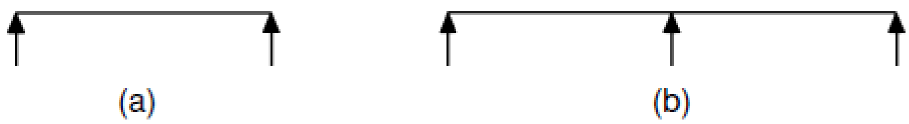
Limit state design (LSD), also known as load and resistance factor design (LRFD), refers to a design method used in structural engineering. A limit state is a condition of a structure beyond which it no longer fulfills the relevant design criteria.[1] The condition may refer to a degree of loading or other actions on the structure, while the criteria refer to structural integrity, fitness for use, durability or other design requirements. A structure designed by LSD is proportioned to sustain all actions likely to occur during its design life, and to remain fit for use, with an appropriate level of reliability for each limit state. Building codes based on LSD implicitly define the appropriate levels of reliability by their prescriptions.

(c)



A and B are classificatopins according to the position of the steel reinforcements ie singly and doubly reinforced sections

C and D are classifications according to the shape of the cross section. Tee beam and El beam

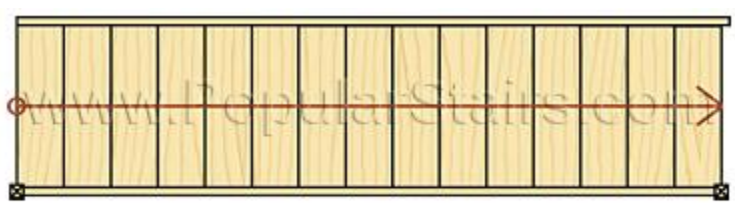


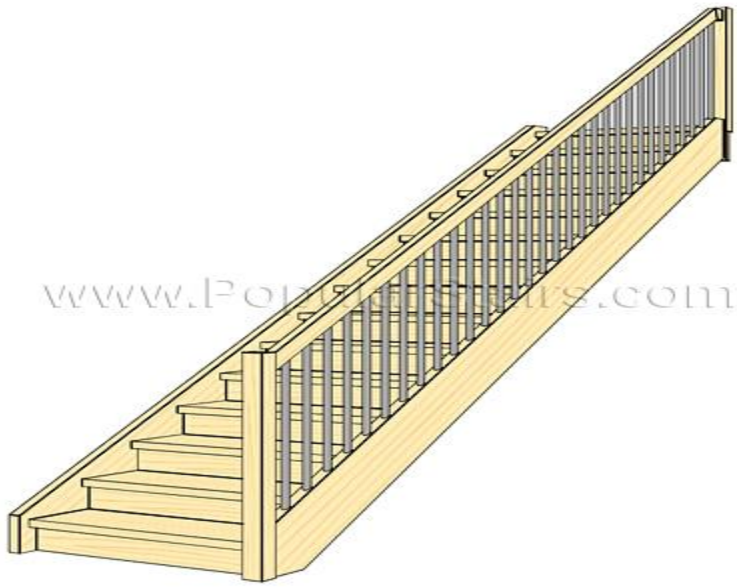
A and B are according to the nature of the beam support ie simply supported and continuously supported beam.

(d) **Reinforced concrete** (RC) is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength and/or ductility. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is usually embedded passively in the concrete before the concrete sets. Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that might cause unacceptable cracking and/or structural failure.

4. (a) ***Straight flight stairs***

Despite its simplicity, it is convenient and functional. It is easy to go up and down it, as also to carry things on the next floor. But the presence of one long flight makes this type of staircases limited in height. As you already know, the amount of treads in one straight flight shall not exceed 16. The usage of staircases with straight flight is feasible only in those cases when we need to join two levels connected by imaginary straight line.



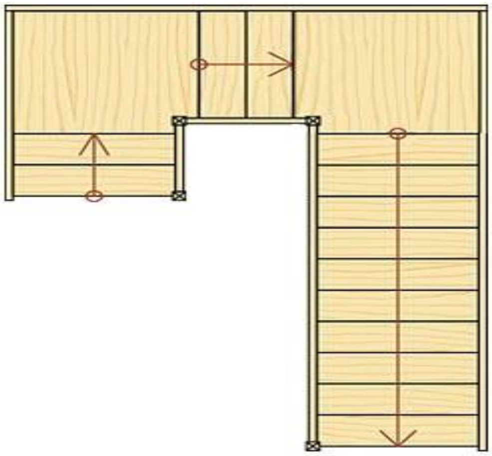


Quarter-turn or open well Stairs

Quarter Landing Stairs represent a variety of straight stairs, which also include a landing. But here the landing is needed to change a direction of the flight by 90 degrees and at the same time it serves as a place for rest when moving. The landing may change its position in the flight from its beginning and up to its end. Staircases of this type are more convenient and safe than straight staircases. Due to the presence of the landing the flight is divided into two, thereby reducing quantity of treads in one flight, and makes walking more comfortable.

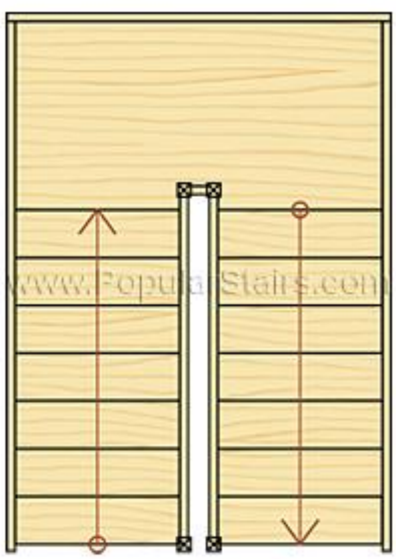
You shall pay particular attention to the shape of landing. As you already know from the section How to build stairs, the depth of landing shall be longer by half of the tread width in each direction, or by the whole tread width in one direction.

Staircases of this type enable rationale use of the space needed for the stair flight construction.



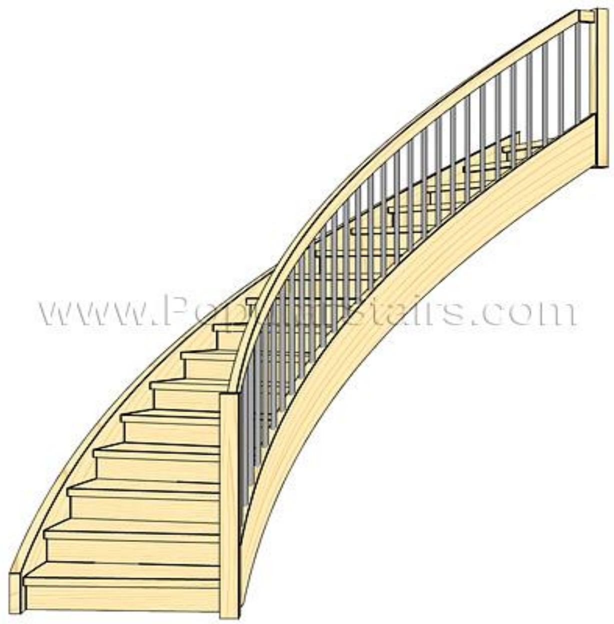
Half –Turn Staircases

Half Landing Stairs are also a variety of staircases with straight flights. Just like Quarter Landing Stairs they also have a landing, but here it changes a direction of the flight by 180 degrees already and also serves as a place for rest when moving. The landing divides the staircase into two, thereby reducing quantity of treads in one flight, and makes walking more comfortable.
Staircases of this type are very convenient, functional, and safe.
Pay attention to the shape of the landing. Just like for Quarter Landing Stairs, the depth of landing shall be longer by half of the tread width in each direction, or by the whole tread width in one direction.



Helical Staircases

Arched Stairs are the stairs with a flight resembling an arch in its shape. The treads in such stairs are wedge-shaped as well, but tapering at one side is not very vital as that at Winder Stairs. They are elegant and graceful in appearance, and with pertinent components the staircase looks very effective. They are very difficult-to-make because all basic details, closed strings and (or) open strings, as well as handrails are curved.



Spiral Staircases

Stairs of this type have stair flight resembling a circle or a part of it in its shape. Here just like in Winder Stairs and Arched Stairs the treads are wedge-shaped, but all of them (except for the last one) are uniform-sized. Spiral stairs have a central vertical post constituting the backup abutment for all treads in the flight. Due to their spiral shape such staircases look very effective. Such staircases are not convenient for frequent use in view of fast climbing up on a confined area.

(b) The design of staircases is either longitudinal or transverse such that each stair is designed separately.

(c) As = M/0.95fyz = 804mm^2

z= 380; fy =500

M= 0.95x500x380x 804 = 145.122kNm

W =Mx 8/L^2 = 145.122 x10^6 x 6^2 =

32.25kN/m

Design load = 1.4Gk +1.6Qk = 32.25kN/m

Qk= 20.17 - 0.875Gk

5. **LOADING**

Gk = 4.6kN/m

Qk =3kN/m

Design load = 11.24

M = 12.65

Mu = 67.4> M

Therefore no compression steel is necessary

K = 0.029

z= 0.95d = 114mm

As = 233.6mm^2/m

As min = 0.13%bh = 195mm^2/m

Provide Y10 @250c/c As = 314mm^2/m)

<u>Deflection</u>

Modification factor = 1.62

Allowable span to effective depth ratio = 1.62 x 20 = 32.4

Actual span to effective depth ratio = 3000/120 = 25< allowable (32.4)

Therefore the deflection is adequate hence the design is ok.