CBCS SCHEME

USN

18CV735

Seventh Semester B.E. Degree Examination, Feb./Mar. 2022
Masonry Structures

Time: 3 hrs. Max. Marks: 100

Note: 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of IS 1905-1987 is permitted.***
3. ***Assume missing data if any, suitably.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain various Tests on Bricks. **(10 Marks)**

b. Enumerate with neat sketches various causes for cracks in masonry and their remedial measures. **(10 Marks)**

OR

2 a. Briefly explain the factors which influence the compression strength of masonry. **(10 Marks)**

b. Discuss the common workmanship errors in masonry construction. **(10 Marks)**

Module-2

3 a. Explain following types of masonry walls with sketches:
(i) Solid wall with piers
(ii) Cavity wall
(iii) Faced wall
(iv) Veneered wall **(10 Marks)**

b. An interior solid wall of a two storey building is 100 mm thick with a storey height of 3m. It is constructed with brick of compressive strength 10 N/mm^2 and M_1 type mortar. The wall is fully restrained both at top and bottom. Determine:
(i) Effective thickness
(ii) Effective height
(iii) Slenderness ratio
(iv) Stress reduction factor for zero eccentricity
(v) Permissible compressive stress **(10 Marks)**

OR

4 a. Define effective height of wall as per IS1905-1987. Indicate its values for different cases with sketches. **(10 Marks)**

b. A solid wall of thickness 150 mm is constructed with solid concrete blocks of unit strength 5 MPa and M_2 type mortar. The floor to floor height is 3.2 m. The load is acting axially on the wall. Determine permissible compressive stress in masonry. **(10 Marks)**

Module-3

5 Design an interior cavity wall of a 3-storyed building the ceiling height of each storey being 3m. The wall is unstiffened and is 3.6 m long. Assume loading as follows:
(i) Load from roof = 12 kN/m
(ii) Load from floor = 10 kN/m (for each floor)
Take overall thickness of cavity wall as 250 mm and thickness of each leaf as 100 mm. **(20 Marks)**

OR

6 Design an interior wall of a single storeyed workshop of height 5.4 m supporting a RCC roof. The bottom of wall rests over a foundation block assume roof load equal to 45 kN/m. Refer Fig.Q6.

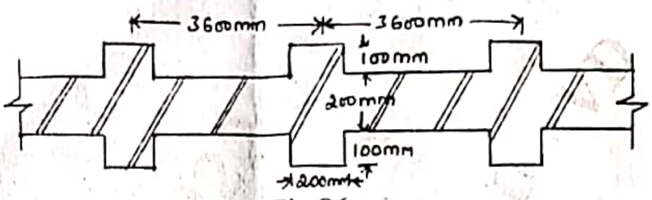

Fig.Q6 **(20 Marks)**

Module-4

7 Design an internal wall of a 2 storeyed building with a storey height 3m and thickness 200 mm. The wall is stiffened by 100 mm thick intersecting walls at 3600 mm c/c. The wall has door opening of size 900 × 2000 mm at a distance of 200 mm from one of the intersecting walls. Assume loading as below:

Load from roof = 15 kN/m

Load from floor = 12.5 kN/m **(20 Marks)**

OR

8 Design an external wall of a single storeyed building the inner leaf of which supports an eccentric load of 7 kN/m at an eccentricity of 25 mm. The wall is unstiffened one which supports a concrete roof at the top and rests over a foundation block. Height of wall is 4m. Take overall thickness of wall as 250 mm and thickness of each leaf as 100 mm. **(20 Marks)**

Module-5

9 Design an exterior wall of a single storey warehouse of 3.5 m height. The loading on the wall consists of vertical load of 25 kN/m from roof and wind pressure of 860 N/m^2. The wall is tied with metal anchor at the floor and roof levels. **(20 Marks)**

OR

10 a. Explain horizontal and vertical reinforcement in brick masonry with sketches. **(08 Marks)**

b. Briefly explain various failure modes in infilled frames with sketch. **(12 Marks)**

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MASONRY STRUCTURES (18CV735)

7th Semester Faculty: Prof. Vijaylaxmi.X.

Module-1

Q1. a. Explain Various Test on bricks.

Sol: Following Test are conducted to check suitability for construction work.

1. Water Absorption
2. Compressive strength
3. Efflorescence
4. Warpage
5. Flexural strength.

Water Absorption Test –

This test is conducted as per IS 3495 part II 1976(8) for bricks

In twenty four hour immersion Test: Over dry brick specimen is weighed and then immersed in cold water for 24 hrs. It is weighed again. The difference in weight indicates the amount of water absorbed by the bricks and from which percentage of water absorption is determined.

Compressive strength test –

The method of testing of solid bricks for compressive strength as per IS 3495 (part I)– 1976 (8)

for Solid bricks: The brick specimens are immersed in water for 24 hours. Then they are removed from water and the frogs are filled and flushed with the face of the brick with 1:1 cement sand mortar. The sample are cured for four days

(1 day under damp jute bags and three days in clean water. Then the sample is placed in a compressive testing machine. with face (flat faces) horizontal and the mortar filled face upwards. The load is applied at a rate of 14 N/mm² mm till the brick specimen fails. The maximum load which the specimen fails is divided by the average bed area of the bed faces of the brick to get the compressive strength.

Efflorescence Test –

A shallow glass dish of specified dimension is filled with distilled water. Then brick sample are placed in it such that the depth of immersion in water is atleast 25 mm. The whole arrangement is kept in well ventilated room until all the water in the dish is absorbed by the bricks and surplus water evaporates. Similarly quantity of water is again poured in the dish and allowed to evaporate as before. The rating of efflorescence is taken as Nil, slight, moderate, heavy or serious in accordance with the standard IS 3495 part III 1976 (8)

Warpage Test-
A straight edge is placed flat over the brick specimen resting on a plane surface so as to leave maximum gap between the straight edge and surface of the brick. A metallic wedge is inserted in this gap and maximum value of warp is measured.

Flexural Strength Test-
The brick specimen is immersed in water at room temperature for 24 hours. The test specimen is placed centrally on bearing A B and C of the testing machine, The load is applied at a uniform rate not greater than 300N/min through bearing C The individual breaking load is recorded and the flexural strength is calculated by the formula.

$$F = \frac{3PL}{2BD^2}$$

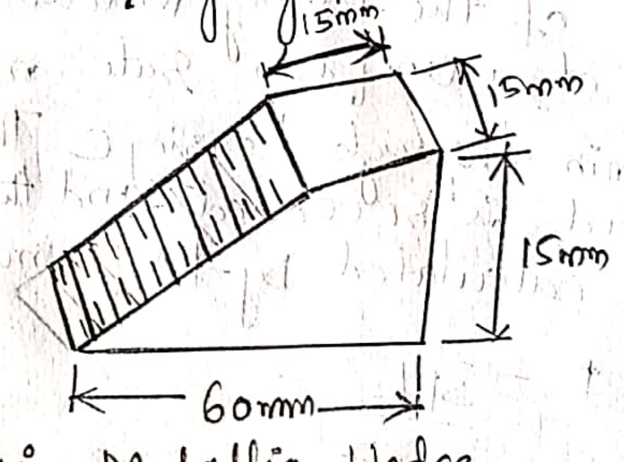
P - Load in Newton.
F - Flexural strength of the brick in N/mm^2
L - Span in mm.
B - Width of the brick in mm.
D - depth of the brick in mm.

Shape and Size -
In this test, the bricks are closely inspected They should be of standard size and the shape

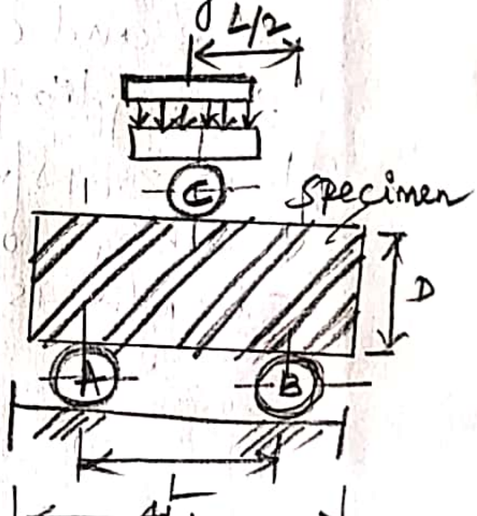
should be truly rectangular with sharp edges.

Hardness Test –
In this Test, a scratch is made on the brick surface with the help of finger nail. If no impression is left on the surface, the brick is assumed to be sufficiently hard

Soundness Test
In this test, bricks are taken and are struck with each other. They should not break and a clear ringing sound should emerge.



Measuring Metallic Wedge



Flexural Test

Q16. Enumerate with neat sketches various causes for cracks in masonry and their remedial measures.

Sol: i) Horizontal cracks at the roof level of the top most floor, below the slab occurs due to any of these reasons.
Type*1
a) The slab undergoes alternate expansion

and contraction due to change in ambient temperature

b) Inadequate protective cover against

c) Provision of large span of the slab in the room inside, causing excessive deflection and having not much vertical brick load above the support to resist uplift of the slab at the support and movement of the slab is restrained on one side.

ii) Crack in non load bearing wall - cladding and cross walls of framed structure -

In case of framed structure roof slab, beams and columns move jointly causing diagonal cracks in wall which are parallel to the movement and horizontal cracks are located below the beams. Extent of movement in a framed structure is comparatively less as columns on account of their stiffness and ability to withstand bending stresses are able to resist and contain the movement to some extent.

Type-2 Vertical cracks at Junction of RCC column and Wall Masonry

These cracks occurs a few months after

construction not only due to differential Strain between RCC and masonry because of elastic deformation, shrinkage and creep in RCC column also act upon.

Type#3 Cracks due to chemical resistance

In case of structural concrete in foundation if sulphate content exceeds 0.2% or sulphate content in groundwater exceed 300ppm, very dense concrete should be used and either concrete mix 1:1½:3 or sulphate resisting Portland cement / super sulphate cement or a combination of the two methods depending upon the sulphate content of the soil should be adopted.

Gypsum plaster contains sulphate and chemically reacts with Portland cement in presence of moisture. Gypsum plaster should, therefore never be used with cement. It should not be used in locations where the wall is likely to be in contact with moisture. Gypsum plaster is not suited for external work which is liable to get wet.

Type#4 Cracks in foundation

plinth protection around the building helps in preventing seepage of rain and surface water into the foundation, possibility of settlement cracks may be avoided.

Type*5 Extension of Existing Building

When extension of existing building is desired, new construction should not be bonded with the old. Two Parts should be separated by a step or expansion joint right form the foundation to top. The old and new work should be separated by an expansion joint with a gap of 25 to 40mm to allow room for unhindered expansion of the two portions.

Type*6 Cracking of Compound wall.

Plant take root and begin to grow in fissures of walls. When soil under the foundation of building happens to be shrinkable clay, cracking in walls and floors of the building occurs. This happens due to dehydrating action of growing action of growing roots on the soil which may shrink and cause foundation settlement. When old trees are cut off the soil that has been dehydrated by roots, swell up getting moisture from some source such as rain, this may cause cracks in foundation

Type*7 Horizontal Cracks in the top most ~~Survey~~ storey

Horizontal Cracks in the top most storey of building at Corner Cause upliftment of the slab corners due to deflection of the slab in both direction. As a preventive measure Proper corner due to deflection in two layers should be provided to resist lifting of corners

Type#8 Cracks in external and Internal Walls of load Bearing Structures -
Vertical cracks in wall built with concrete blocks or sand lime bricks. Cracks occur at weak sections ie midpoints or at regular intervals in long stretches. Vertical cracks at the junction of an old portion of building and new extension. Horizontal cracks in Mortar joints appearing two or three years after construction these are generally due to sulphate attack. Ripping cracks occuring at the ceiling level in crosswall. Cracks are due to relative movement between RCC roof slab and cross wall. Diagonal cracks over RCC lintels spanning large openings. The cracks are due to drying shrinkage of concrete.

Type#9 Random cracks in all directions involving both external and internal walls.
These cracks are formed due to foundation settlement or sulphate action in the foundation concrete and masonry in foundation and plinth.

Type#10 Partition Walls in load-Bearing structures.
Partition wall supported on RCC slab or beam cracks may occur due to excessive deflection of support. Cracks occur due to drying shrinkage of Masonry units. Horizontal cracks in panel walls of RCC framed structures occur, if panels are built

are built too tightly between the beams of the fame.

Type 11 Vertical cracks in building

Vertical Cracks in a building occur due to non-provision of expansion joints as per 3414-1968 where differential Settlements are likely to occur as a result of unequal ground Pressure and cracks which occur at the junction of change of ground pressure.

Type 12 Reinforced Concrete Roofs at different levels.

Cracks are likely to occur in walls, where long roofs at different levels are placed, due to expansion of each slab in opposite directions. To prevent such cracks, Wall should be anchored with the lower slab by providing suitable reinforcement while the upper slab should be kept free.

Figures -

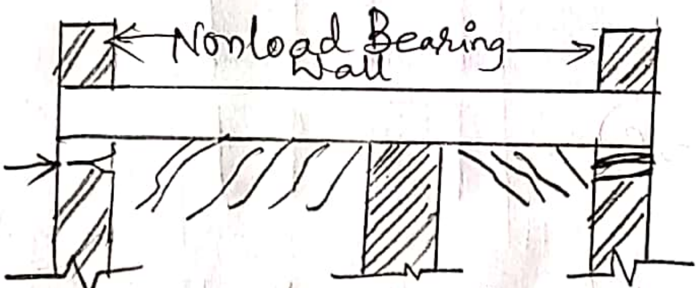
a) 

Fig a) Crack in nonloadbearing wall.

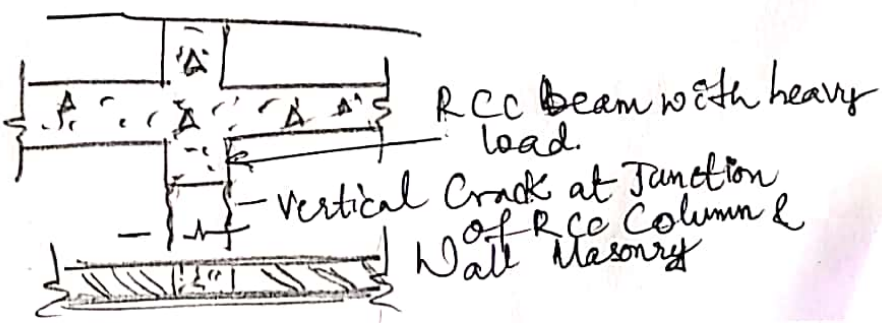
b) 

fig b) Cracks at Junction of RCC column and Wall Masonry

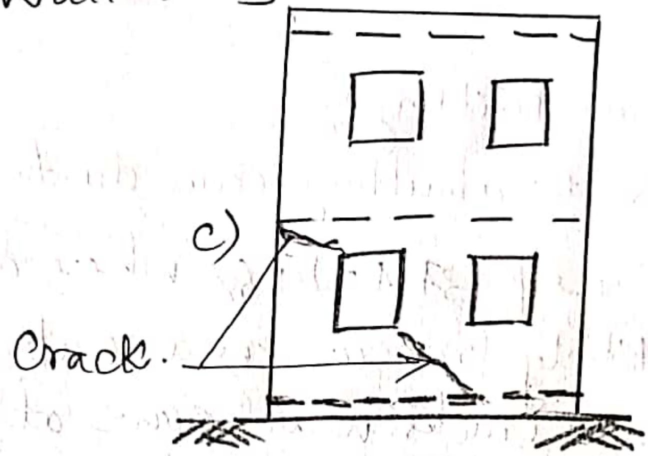


fig c) Crack at the Corner of building due to foundation Settlement.

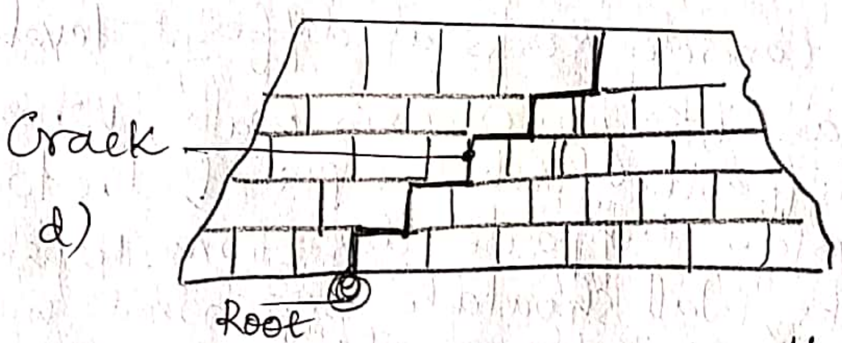


fig d) Cracking of Compound wall due to growing roots under the foundation.

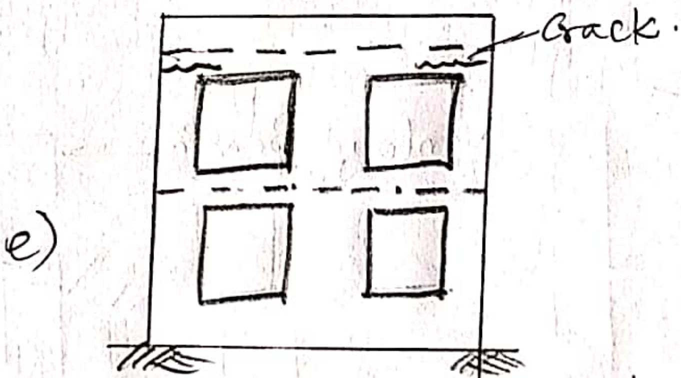


fig e) Horizontal Cracks in topmost Storey

Q2a Briefly explain the factors which influence the compressive strength of Masonry.

Sol. Factors influencing Compressive strength of Masonry are:-

1. Strength of Masonry unit
2. Height of Masonry unit
3. Solidity / Hollowness of Masonry unit
4. Moisture Absorption
5. Strength of Mortar
6. plasticity and flow characteristics of Mortar
7. Thickness of Mortar
8. Type of Masonry loading
9. The Modular ratio of masonry unit & Mortar
10. Direction of loading.

* Increase in Compressive strength of Masonry unit will lead to an increase in the strength of Masonry. Height to thickness ratio of the prism and wallette should be more than 3

* Height of the unit has influence on strength of the unit and masonry efficiency. This is higher as the height of the unit increases. Masonry efficiency ranges from 0.2 to 0.9

* Solid concrete block has a compressive strength

of 23.7 MPa while hollow concrete block of the same size and Material composition has strength of 7.75 MPa where the net Solid area is 52.2 MPa.

* Moisture Absorption of a brick/masonry unit is important when cement mortars or cement based mortars are used. Masonry unit often has moisture absorption value between 10 to 15%. IRA is expressed as Kg/m²/min. IRA of Indian brick varies from 1.17 – 9.33 Kg/m²/min.

* Compressive strength of Masonry is more sensitive to the strength of Mortar.

* Masonry strength is proportioned to fm where fm is the mortar strength. Thus large increase in fm will lead to small increase in masonry strength. Strength of Martar is more important when good bond strength between brick & Mortar is desired. This is important when masonry has to resist lateral loads.

* Plasticity and Flow characteristics of Mortar is an important property of mortar when it is used in masonry construction. When the brick is placed above the fresh Mortar it must readily flow and wet the entire surface of the brick providing good Contact.

* An increase in thickness of Mortar joint reduce the strength of brick Masonry.

Thickness of Mortar joint 1.5 or 2 cm is desirable. (7)
Use of Sand particle coarser than 3mm is not desirable in the Mortar.

* In Type of Masonry bonding, rat trap bonding is promoted because of cost effectiveness and an apparent increase in thermal comfort due to presence of hallow in the wall. It can be used for single storeyed building if the brick strength is 3.5 MPa.

* The ratio of Moduli of Masonry unit and Mortar has an important influence on the nature of stresses in Masonry. Majority of bricks in India have a Modulus which is lower than that of Mortar. If the Mortar Modulus is 10 times the brick Modulus, Vertical stresses tend to get concentrate at the perpend joints.

* In Direction of loading, Verticle loads act ⊥le to the bed joints and it is enough to consider the compressive strength of the masonry in this direction. Strength of Mortar ||le to the bed joints. The strength and elasticity in the direction parallel to the bed joint are higher. This is due to reduction in the number of joints in this direction.

Q2b Discuss the Common Workmanship errors in masonry construction?

Ans

defect in brick masonry due to workmanship is a result of poor supervision of masonry works.

→ Due to failure to fill bedjoints – bedjoints in brick masonry be filled adequately, improper bedjoint filling or gaps in mortar may be due to speed or not paying best practise

→ Failure due to excessive thickness of bedjoint of brickwork lead to reduce masonry compressive strength, larger the thickness of bedjoint produce larger lateral tensile stresses in brick masonry compared to the where bedjoint is thin.

→ Failure due to deviation from Vertically or Alignment Masonry brickwork which is constructed out of plumb and is out of alignment with walls of below or above storey will lead to increase in the amount of eccentric loads and reduce strength of brickwork

→ Failure due to effect of weather – to prevent newly constructed brickwork from experiencing heat or freezing situations before the mortar is curried adequately and gain sufficient Strength when masonry wall exposed to hot weather it may lose considerable moisture and hinder the completion of cement hydration and mortar normal Strength will not be obtained. The problem caused by hot weather & Freezing Conditions could be done by using proper means.

Eg Polythene sheets can be used to cover brickwork in hot conditions to cure it adequately and heating construction Materials may be good practise when laying bricks are done in freezing weather.

→ failure due to adjust suction of bricks - when water is lost by mortar due to brick suction the mortar might not be able to return to original flat shape this lead to create unstable wall due to curving or swelling out shape of mortar bed, the wall strength might be lost by action of suction and if brick and mortar ~~por~~proportioning are not Specified.

→ failure due improper mixing or incorrect mixing proportioning of Mortar. - Mortar Strength may also be deduced because of high water to cement ratio which is used to achieve workable mortar mix. it is highly significant to strickly follow specifications related to the proportioning of Mortar & Utilization of unnecessary large amount of plasticizer as a replacement of lime will lead to create a porous and likely weak mortar.

Module 2

3a. Explain following types of Masonry wall with sketch.

Ans.

(i) Solid Wall with Pier – is a wall thickened at intervals by increasing the cross section. These thickened portions, known as pier or pilasters are used for following purpose –

i) To carry concentrated loads from roof or floor beams

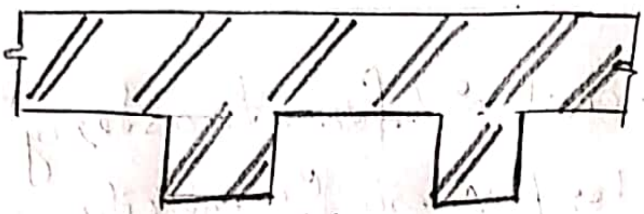
ii) to provide lateral support

iii) To stiffen the wall in order to lower the slenderness ratio within certain limits.

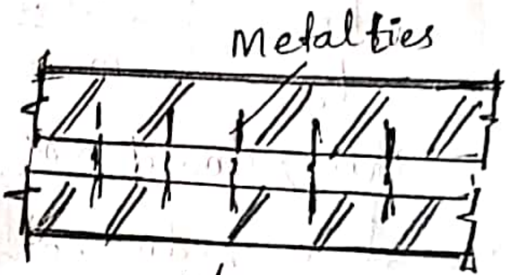
ii) Cavity Wall – A wall separated by two structural leaves by a continuous cavity with the two leaves being interconnected by metal ties. The cavity forms a barrier against penetration of dampness through to the internal wall face. The Inner leaf is load bearing, while the outer leaf carries its own weight only. Bending moment is shared by the stiffness of both the leaves.

iii) Faced Wall – A wall in which the facing and backing are made of two different materials and are bonded togather to ensure a common action under the load.

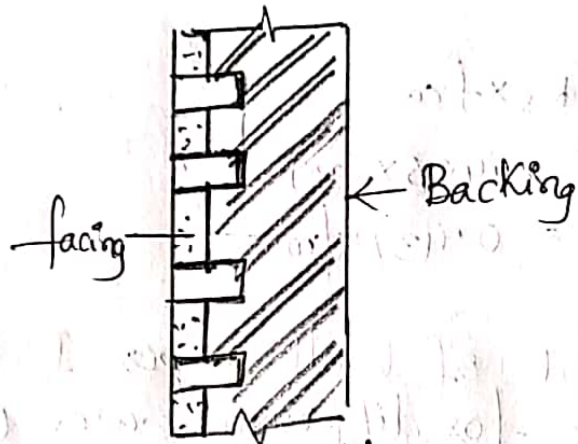
iv) Veneered Wall – A Wall in which the facing is attached to the backing but not bonded as to result in a common action under the load. The backing carries all the imposed load.



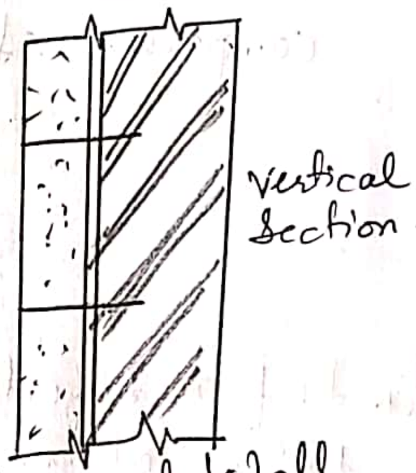
Plan
Solid wall with Pier



Plan
Cavity Wall.



Faced Wall



Veneered Wall.

b. An interior solid wall of a two storey building is 100mm thick with a storey height of 3m. It is constructed with a brick of compressive strength 10N/mm² & M, type mortar. The wall is fully retained both at top and bottom.

i) Effective thickness
For a solid wall the effective thickness is same as actual thickness

Effective thickness $= t_e = 100$mm.

ii) Effective height
Since full restraint (both lateral & rotational) at top and bottom support

$h_e = 0.75(H) = 0.75 \times 3000 = 2250$mm.

iii) Slenderness Ratio -

$\frac{h_e}{t_e} = \frac{2250}{100} = 22.5$

This should not exceed 27 for a two storey wall.

iv. Stress reduction factor for zero eccentricity

$K_s = 0.455$

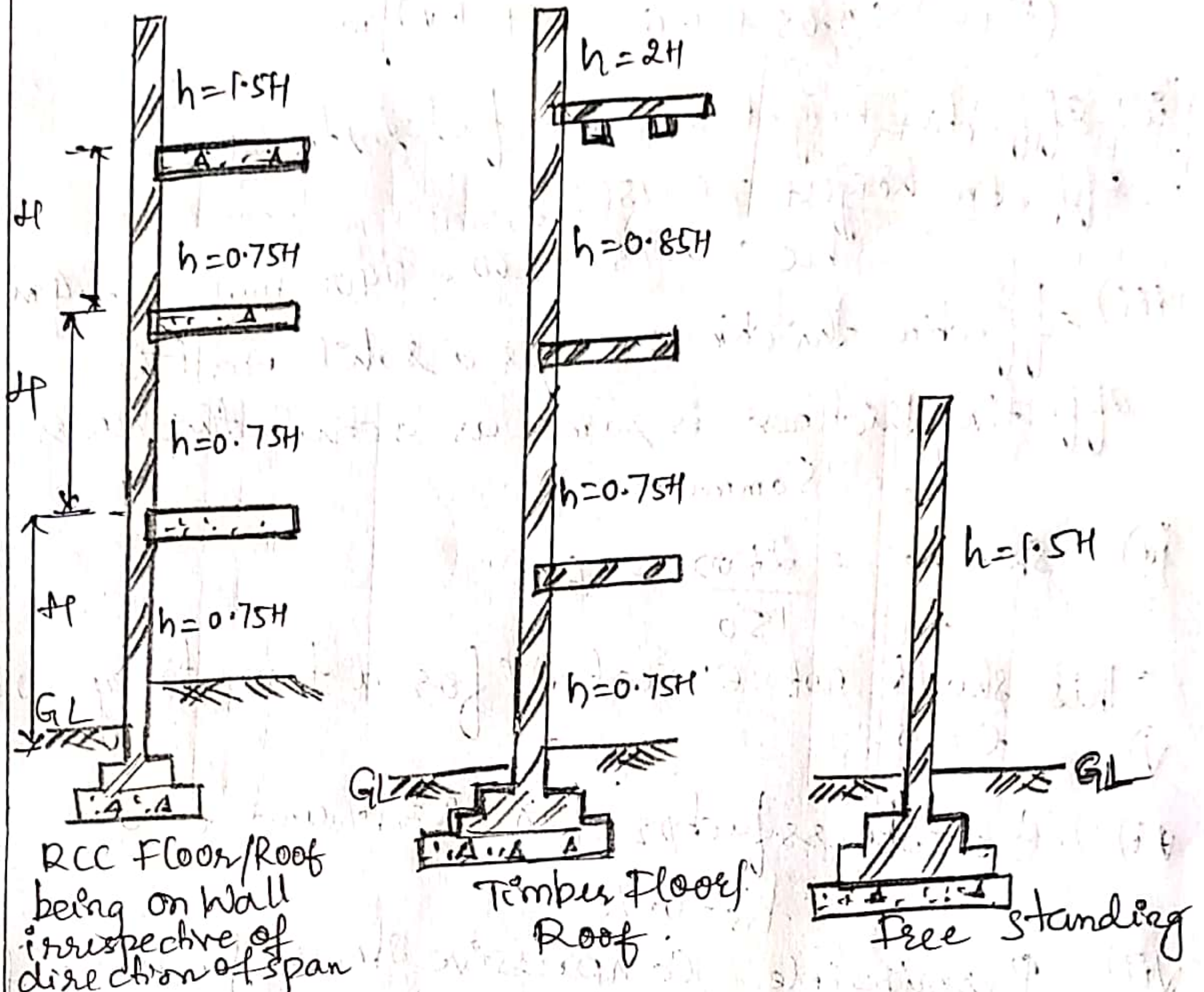
v.) Permissible compressive stress $f_{ac} = K_s$ (basic compressive stress)

$$f_{ac} = K_s \times f_{ca}$$
$$= 0.455 \times 0.96$$
$$= 0.437\ N/mm^2$$

Q4. a. Define Effective height of Wall as per IS 1905-1987. Indicate its value for different cases with sketches.

Sol:- Effective height - In case of a column, effective height shall be taken as actual height for the direction it is laterally supported as a twice the actual height for the direction it is not laterally supported. The opening in the wall such that masonry between the opening is to be defined the effective height of masonry between the openings should be —

Sl-No.	Type of restraint		Effective Height
1.	Top - full	bottom - full	0.75H
2 a)	full	Partial	0.85H
b)	Partial	full	
3.	Partial	Partial	1.00H
4	NO	Full	1.5H
5	NO	partial	2.0H.



Q4b A Solid wall of thickness 150mm is constructed with solid concrete blocks of unit strength 5MPa and M_2 type Mortar. The floor to floor height is 3.2m The load is acting axially on the wall Determine Permissible Compressive Stress in Masonry

Sol:- i) Assume unit weight of brickwork = 20 kN/m³

Self wt. of the wall = 1 × 0.15 × 3.2 × 20 = 9.6 kN/m

Total load on the wall length =

Assume Roof load as 5 kN/m

Floor load as 5 kN/m

∴ Total load by taking wall is unstiffened as it supported by a 2.65 wide slab.

$(5+5) \times 2.65 + 9.6 = 36.1$ KN/m

ii) Effective height = Since full restraint effective height $= 0.75(H)$

$h_e = 0.75 \times 3200 = 2400$ mm $= 2.4$m

iii) effective thickness – for a solid wall the effective thickness is same as actual thickness

$t_e = 150$mm

iv) $SR = \frac{h_e}{t_e} = \frac{2400}{150} = 16$

This should not exceed 27 for a two storey wall

v) $e = 0$.

vi) k_s – Stress factor for SR = 16 and $e = 0$

$\therefore k_s = 0.73$

vii) Permissible compressive stress = $f_{ac} = k_s(f_{oa})$

→ For Basic compressive stress of brick = 5 N/mm² & M_2 type Mortar the $f_{oa} = 0.44$ N/mm²

$\therefore k_s \times f_{oa} = 0.73 \times 0.44 = 0.32$ N/mm²

$\therefore f_{ac} = 0.32$ N/mm².

Module-3

Q5. Design a interior cavity wall of 3 storeyed building the ceiling height of each storey being 3m The wall is unstiffened & is 3.6m long. Assuming loading as follows.

load from roof = 12 KN/m

load from floor = 10 KN/m for each floor

Take overall thickness of cavity wall as 250 mm and thickness of each leaf as 100 mm.

Sol. Assume, unit wt of Masonry as $20\ kN/m^3$

Cavity wall with over all thickness 250 mm and thickness of each leaf equal to 100 mm.

Self wt. of the Wall $= 1 \times 3 \times 3 \times 2 \times 0.1 \times 20 = 36\ kN/m$

$\therefore$ Total load $= 32 + 36 = 68\ kN/m$

$\therefore$ Compressive stress developed is

$$\sigma_c = \frac{P}{bt} = \frac{68 \times 10^3}{200 \times 1000} = 0.34\ N/mm^2$$

1) Effective Height $= he = 0.75 \times H$

Since full restraint is provided at the top and bottom of the wall

$$he = 0.75 \times 3000 = 2250\ mm$$

(by refering Fig. No. 11A Pg. 12 of IS 1905 – 1987)

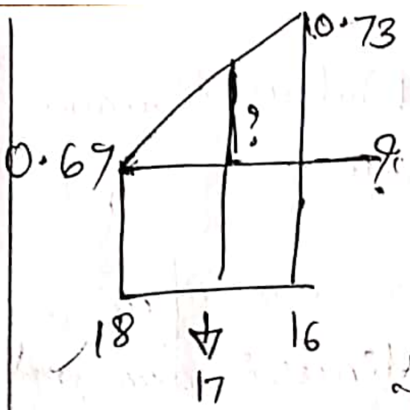
2) Effective thickness of a cavity wall is equal to $\frac{2}{3}$ of (Sum of actual thickness) of two leaves

$$\frac{2}{3} \times (100 + 100) \quad \therefore te = 133\ mm$$

(Clause No. 4.5.4 pg 13 of IS 1905)

3) Slenderness Ratio of Wall $SR = \frac{he}{te} = \frac{2250}{133} = 17$

Thus, the SR = 17 (for zero eccentricity (axial load) the stress factor is obtained as.



$$\left(\frac{0.73-0.67}{2}\right)=\frac{x}{1}$$

$= 0.06 \times 1 = 2x$

$\therefore x = 0.03$

$\therefore$ Total $= 0.67 + 0.03 = 0.7$

$\therefore$ K_s - Stress Reduction factor $= 0.70$.

(From Table 9 of pg. 16 of IS 1905-1987)

$\therefore$ The brick crushing strength $= 7.5\ N/mm^2$ and Considering Mortar Mix M_1 type.

The basic compressive strength $= 0.74\ N/mm^2$

(Table 8 of pg 16 of IS 1905-1987)

Permissible Compressive stress $= f_{ac} = 0.70 \times 0.74$

$\therefore$ $f_{ac} = 0.52\ N/mm^2$.

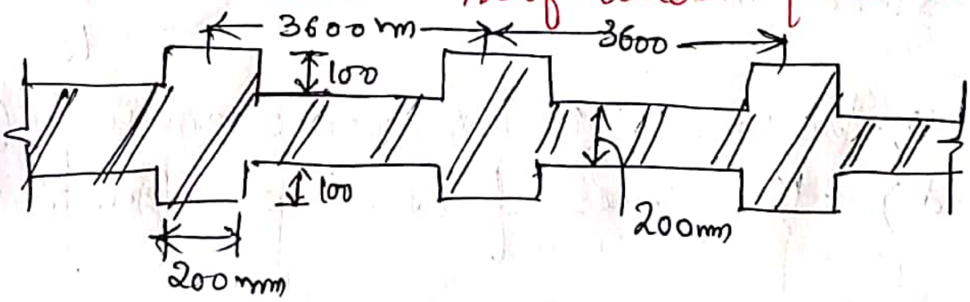
Actual Stress $= 0.34\ N/mm^2$

$\therefore$ Actual stress < Permissible Compressive stress

Hence the design is <u>safe</u>.

Q6. Design an interior Wall of a single storeyed workshop of height $= 5.4$ m. supporting a RCC Roof. The bottom of wall rests over a foundation block assume roof load equal to 45 kN/m

Fig:



Sol. Thickness of the Wall = 200mm

Pier Width = 200 mm

Spacing of Column = 3600mm c/c

thickness of column on either side of the Wall = 100mm

Crushing strength of brick unit = 10 N/mm² & M-1 type of mortar

∴ Basic Compressive strength of Masonry = 0.96 N/mm²

(Table 8 pg 16 of IS 1905–1987)

loading Total load from Roof / bay

length × wt/m. run from roof -

$$\frac{3600 \times 45}{1000} = 3.6m \times 45 KN/m = 162 KN$$

Self weight of the Wall =

$3.6 \times 0.2 \times 5.4 \times 20 + 2 \times 0.2 \times 0.1 \times 5.4 \times 20 = 82.08 kN$

Assuming unit wt of Masonry = 20 KN/m³

∴ Total load / Bay = 162 + 82.08 = 244.08 KN

∴ Cross sectional area of the Wall / Bay

$(3600 \times 200) + (2 \times 200 \times 100) = 76 \times 10^4 mm^2$

(l × t) (l t)

1) effective height = Support Conditions at the top and bottom are such that there is full restraint (lateral as Wall as rotational)

∴ Hence effective height = 0.75H

$h_e = 0.75 \times$ Actual Height

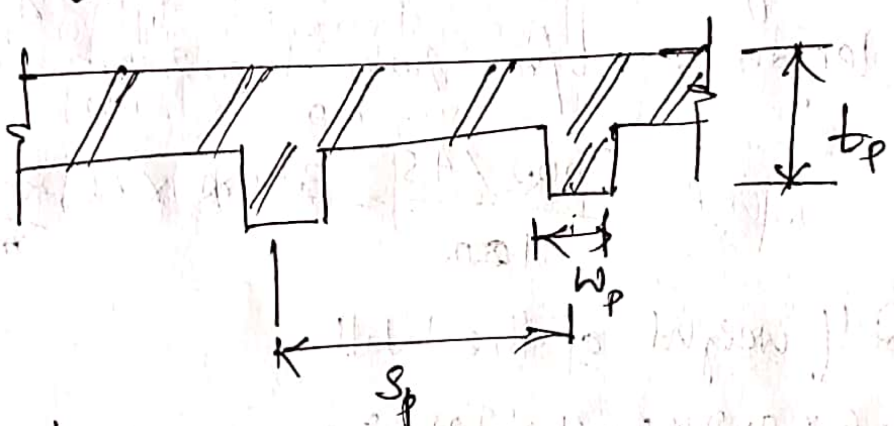
$= 0.75 \times 5400 = 4050$ mm

(Refering fig 11A, pg. 12 of IS 1905-1987)

2) Effective thickness t_e

The Wall is Supported by piers at 3600mm c/c therefore by (Refering cal. 4.5.2 pg 13)

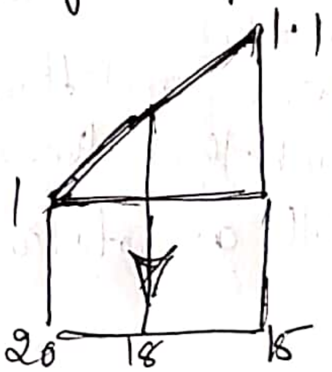
$$\frac{t_p}{t_w} = \frac{400}{200} = 2$$



$$\frac{t_p}{t_w} = 2 \qquad \frac{S_p}{W_p} = \frac{3600}{200} = 18$$

Refer Table 6 pg 14 of IS 1905-1987 Stiffening Co-efficient S_c

By interpolation



$$\left(\frac{1.1 - 1}{5}\right) = \frac{x}{2}$$

$\therefore x = 0.04$

$(1 + 0.04) = 1.04$

1.04 is stiffening coefficient

∴ Effective thickness $t_e = 1.04 \times 200$

t_e = stiffing Coeff × Actual thickness

∴ $t_e = 208$ mm.

3) Slenderness Ratio

SR based on Height $= \frac{h_e}{t_e} = \frac{4050}{208} = 19.5$

SR based on length $= \frac{l_e}{t_e}$

∴ SR based on Height $= 19.5 \simeq 20$

∴ $l_e = 0.8 \times$ Actual length (Fig 8A pg 14 IS 1905-1987)

$0.8 \times L = 0.8 \times 3600 = 2880$ mm

∴ SR based on length $= \frac{2880}{208} = 13.8 \simeq 14$

The smaller of the two is selected as SR ∴ SR = 14

∴ Permissible stress is computed for a SR equal to 14 and zero eccentricity.

∴ the stress factor $K_s =$

From table 9 of pg 16 of IS 1905-1987

$K_s = 0.78$

And permissible stress $= f_{ac} = K_s \times f_{ck} = 0.78 \times 0.96$

$f_{ac} = 0.748 \simeq 0.75$ N/mm²

The design criteria is

Actual load $P \leq f_{ac}$ (Cross-sectional Area)

$0.7488 \times (76 \times 10^4)$

$\simeq 570$ KN. – Permissible load.

where Actual load = 244.08 KN

244.08 < 570 KN.

Hence the design is safe.

Module-4

Q7. Design an internal Wall of 2 storeyed building with a storey height 3m and thickness 200mm The Wall is stiffened by 100mm thick intersecting walls at 3600mm c/c. The Wall has door opening of size 900×2000mm at a distance of 200mm from one of the intersecting wall.

load from roof = 15 KN/m

Load from Floor = 12.5 KN/m.

Ans- let the Wall thickness be assumed as 200mm for the purpose of calculating self weight and slenderness Ratio.

Selfweight of the Wall = 1×0.2×2×3×20 = 24 KN/m

Total load = 15 + 12.5 + 24 = 51.5 KN/m

1) effective Height = Since the Wall is fully restrained at the top and bottom supports

∴ Effective Height = 0.75H = 0.75×3000 = 2250mm

∴ h_e = 2.25m.

2) Effective thickness = average effective thickness to account for the reduction in the area

At the level of opening effective area $= (L-a)t$

$= (3600-900)\,200 = 540000\ mm^2$

$\therefore$ Effective thickness $= \frac{540000}{3600} = 150mm$

Above the level of the opening the effective thickness equal to the thickness $= 200mm$.

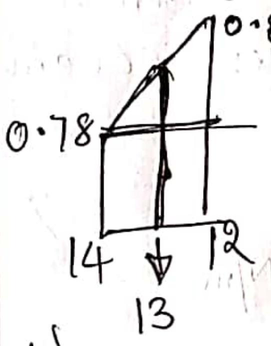
$\therefore$ Average effective thickness

$t_{we} = \frac{200+150}{2} = 175mm$

3) Slender Ratio $= \frac{h_e}{t_{we}} = \frac{2250}{175} = 12.85 \simeq 13$

For SR $= 13$ & $e = 0$, stress factor is obtained from Table 9 pg. 16 of IS 1905–1987

$K_s =$



$\frac{0.84-0.78}{(14-12)} = \frac{x}{1}$ $\therefore x = 0.03$

$\therefore x = 0.78 + 0.03 = 0.81$

$\therefore K_s = 0.81$

4) Maximum Compressive Stress developed

$f_{ca} = \frac{P}{\text{Maximum Area}} = \frac{51500 \times 3.6}{540000} = 0.34$

$\therefore f_{ca} = 0.34\ N/mm^2$

Choosing Brick unit of crushing strength $7.5\ N/mm^2$

and ~~Mortar~~ Mix type M1 or L1, Assuming as L1
The Basic compressive stress $f_{bck} = 0.53\ N/mm^2$
The Allowable stress

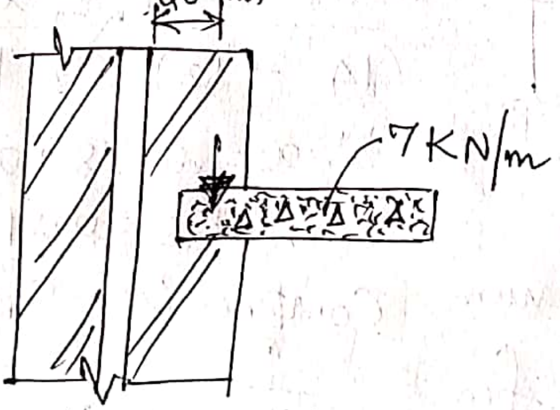
$$f_{ac} = 0.53 \times 0.81$$
$$= 0.43\ N/mm^2$$

$\therefore\ f_{ac} = 0.43 > 0.34\ N/mm^2$

permissible > Actual calculated Value.
Hence Design is safe.

Q8. Design an external Wall of a single storeyed building, the inner leaf of which supports an eccentric load of 7 KN/m at an eccentricity of 25 mm. The Wall is unstiffened on which supports a concrete roof at the top and rests over a foundation block. Height of the Wall is 4m. Take overall thickness as 250mm and thickness of each leaf as 100mm.

Sol:- Cavity Wall with inner leaf under eccentric loading



The Critical load for design is taken at the base of the Wall over the foundation block
Cavity wall of 250mm - Over all thickness

Thickness of inner and outer leaves is 100mm for the purpose of calculating self weight and sectional properties

Area of cross section of each leaf

$A = 100 \times 1000 \; mm^2/m = 10^5 \; mm^2/m$

Sectional Modulus

$Z = \frac{1}{6} \times 1000 \times 100^2 = 1.67 \times 10^6 \; mm^3/m$

Self weight of each leaf $1 \times 4 \times 0.1 \times 20 = 8 \; KN/m$

Assuming unit weight of brick work $= 20 \; KN/m^3$

loading on Inner leaf

Super imposed load $W_s = 7 \; KN/m$

Self weight $W_g = 8 \; KN/m$

$\therefore$ Total load $W_c = 15 \; KN/m$

Total bending moment $= 7000 \times 25 = 175000 \; Nmm/m$

Since both the leaves have equal stiffness the bending moment is shared equally by the two leaves

Bending moment on each leaf

$M = \frac{175000}{2} = 87500 \; Nmm/m$

Outer leaf carries its self weight and the bending moment

The force on the outer leaf are

$W_c = 8 \; KN/m$

$M = 87500 \; Nmm/m$

1) Inner leaf

Compressive stress developed in 1) Innerleaf

Compressive stress due to axial load

$$f_{ca} = \frac{W_1}{A} = \frac{15\times10^3}{1000\times100} = 0.15\ N/mm^2$$

Compressive stress due to bending moment

$$f_{cb} = \frac{M}{Z} = \frac{87500}{1.67\times10^6} = 0.05\ N/mm$$

Maximum. Compressive stress $\frac{W}{A} + \frac{M}{Z}$

$$f_c = 0.15 + 0.05 = 0.20\ N/mm^2$$

2) Outerleaf

Compressive stress developed in 2) Outerleaf due to axial load.

$$f_{ca} = \frac{W}{A} = \frac{8000}{100\times1000} = 0.08\ N/mm^2$$

Compressive stress developed due to BM

$$f_{cb} = \frac{M}{Z} = \frac{87500}{1.67\times10^6} = 0.05\ N/mm^2$$

Maximum compressive stress

$$\frac{W}{A} + \frac{M}{Z} = 0.08 + 0.05 = 0.13\ N/mm^2$$

1) Effective Height

Since the wall is fully restrained at both the ends, the effective height

$$0.75\times H = 0.7\times4 = 3m$$

2) Effective thickness

Thickness of a cavity wall is two thirds the sum of a actual thickness of the leaves

∴ Effective thickness

$$t_e = \frac{2}{3}(100+100)$$

$$= 133\,mm$$

3) Slenderness Ratio $SR = \frac{3000}{133} = 22.5$

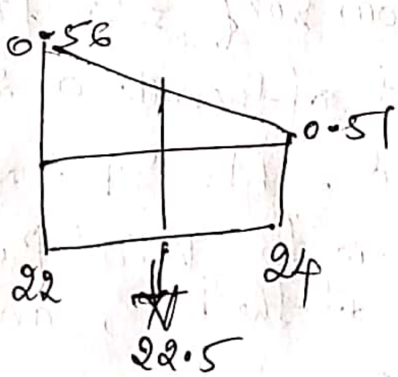
4) Equivalent eccentricity

$$\bar{e} = \frac{M}{W} = \frac{175000}{15000} = 11.7\,mm.$$

$$\frac{\bar{e}}{t_e} = \frac{11.7}{250} = 0.05\,mm$$

Hence the $SR = 22.5$ & $\frac{\bar{e}}{t_e} = 0.05$

Table 9 pg 16 of IS 1905-1987



$$\therefore \frac{0.56-0.51}{(24-22)} = \frac{?}{1.5}$$

$$= 0.0375$$

$$\therefore K_s = 0.0375 + 0.51$$

$$K_s \simeq 0.55$$

Selecting Brick unit of crushing Strength $7.5\,N/mm^2$ & Mortar type M_2 is 0.59 Permissible Compressive stress fac-

$f_{ac} = K_s \times$ Basic Compressive stress
$= 0.55 \times 0.59 \quad = 0.32\ N/mm^2$

Since there is an eccentricity of loading an increase of 25% is allowed in the stress due to eccentricity

Max. stress developed $f_c = 0.2\ N/mm^2 < f_{ac}$

Hence the design is safe.

Module-5

Q9. Design an exterior wall of a single storey Warehouse of 3.5m Height. The loading on the wall consists of Vertical load of 25 kN/m from roof and wind pressure of 860 N/m² The Wall is tied with metal anchor at the floor and roof levels.

Sol. Wall thickness be 200mm for the purpose of calculating self weight and sectional properties

Loading : load from roof $= 25\ kN/m$

Self weight of the wall $= 0.2 \times 20 \times 3.5 = 14\ kN/m$

$\therefore$ Total Axial load $= W = 39\ kN/m$

Bending Moment due to wind pressure can be taken as critical at the base, and at the Mid Height $M = \frac{PH^2}{10}$

where H = Height of the Wall ;
P = Wind Pressure

$$M = \frac{860 \times 3.5^2 \times 1000}{10} = 1053500 \simeq 1.05 \times 10^6 \text{ Nmm/m}$$

Sectional properties and stresses in N/mm²

Area of cross section $A = 200 \times 1000 = 200 \times 10^3$ mm²/m

Sectional Modulus $= Z = \frac{bt^2}{6} = \frac{1000 \times 200^2}{6}$

$= 6.66 \times 10^6$ mm³/m

Compressive stress $f_c = \frac{N}{A} + \frac{M}{Z}$

$$\frac{39 \times 10^3}{2 \times 10^5} + \frac{1053500}{6.66 \times 10^6} = 0.195 + 0.158$$

$\therefore f_c = 0.35$ N/mm².

The Tensile stress becomes critical at Mid Height where the direct axial compression is due to the superimposed load and half of the selfweight

$$W = 25 + \frac{14}{2} = 33 \text{ kN/m}$$

$$f_t = \frac{M}{Z} - \frac{W}{A} = 0.16 - 0.19 = 0.03$$

$\therefore f_t = -0.03$ N/mm²

(This is compressive stress)

Permissible Compressive stress

Effective Height is equal to the actual Height, since partial restraint are provided at top and bottom

Effective Height = 3500 mm.

Effective thickness = Actual thickness = 200mm.

Hence,

Slenderness Ratio $= \frac{3500}{200} = 17.5$

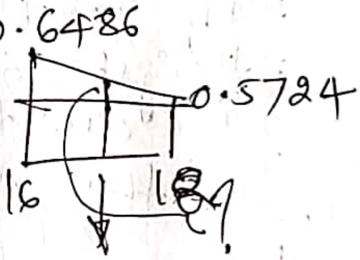
Equivalent eccentricity $\bar{e} = \frac{M}{W} = \frac{1053500}{39000} = 27$ mm

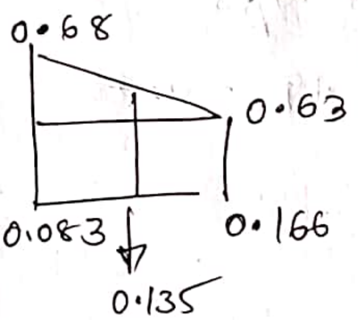
$\frac{\bar{e}}{t} = \frac{27}{200} = 0.135$

∴ from Table 9 of IS 1905 – 1987 for SR 17.5 and $\bar{e} = 0.135$

∴ K_s – Stress factor by linear interpolation

	1/12	$\bar{e}/t$	1/6
16	0.083	↓ 0.135	0.166
17.5	0.68		0.63
18	0.61		0.55



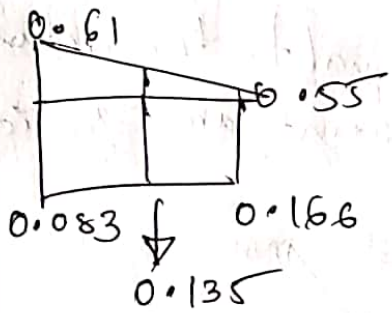


$\Rightarrow \frac{0.05}{0.083} = \frac{?}{0.031}$

∴ 0.6486

$\Rightarrow \frac{0.0762}{2} = \frac{?}{0.5}$

i.e. $K_s = 0.59$



$\Rightarrow \frac{0.06}{0.083} = \frac{?}{0.031}$

∴ 0.5724

Select Brick unit of Crushing strength 7.5 N/mm² and Mortar M1

Basic compressive stress due to axial load is, $f_{ck} = 0.74 N/mm^2$

$f_{ac} = K_s \times f_{ck} = 0.59 \times 0.74$

Permissible compressive stress due to axial load is $= 0.436 N/mm^2$

Permissible compressive stress due to axial load and Bending moment from wind is

$f_{acb} = 1.25 \times K_s \times f_{ck} \therefore 1.25 \times 0.436$

$f_{acb} = 0.545 N/mm^2$

Hence the design is Masonry is safe.

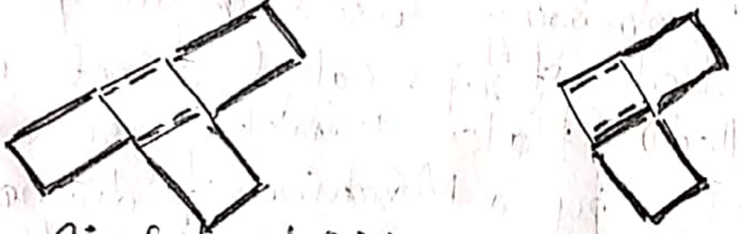
Q10a Explain horizontal and Vertical reinforcement in brick Masonry with sketch.

Sol. Horizontal reinforcement for wall consists of i) Wrought iron flat bars, known as hoop iron ii) Steel mesh. Mild steel flat bars may have width between 22 to 32mm and thickness equal to 0.25 to 1.6mm. Protection against rust is provided by dipping the bars in hot tar, these are then at once sanded to increase the adhesion of the Mortar.

Another form of horizontal reinforcement which is most commonly used is the provision of steel Meshed strips called Exmet made from steel (rolled) plates which are cut and stretched by a Machine to diamond network. To prevent corrosion the Metal in the Coil form is Coated with oil and then dipped in asphalt paint.

Horizontal reinforcement is also used for brick lintel. Mild steel bars (6mm to 12mm dia) are provided through the vertical joint all along the span of lintel. longitudinal steel bars (main reinforcement) should extend 150mm beyond the Jambs.

Vertical Reinforcement, in the form of Mild steelbars, is provided in brick columns, brick wall and brick retaining walls. In such a case special bricks with one or two holes extending up to the face are used. Vertical mild steel bars are then placed in the holes. These bars are anchored by steel plate or wire-tie at some suitable interval. Brick retaining walls are often reinforced since such a work is cheaper than the reinforced cement concrete, when the height of the wall is upto 3m. Vertical reinforced bars are placed vertically near each face, in addition to steel meshed strips at every fourth course. In all types of reinforced brick work, it is essential to embed the steel reinforcement in rich cement mortar (1:3) with proper cover so that reinforcement is not corroded



Single hook joint
Fig (1) a

Double hook joint
(b)

c)


Exmet

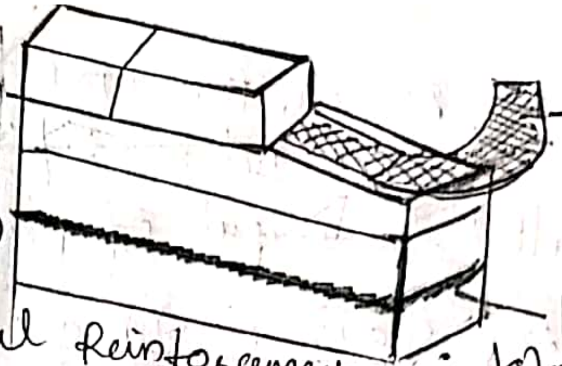
d)


Fig 1 Horizontal Reinforcement
1(a, b, c, d)

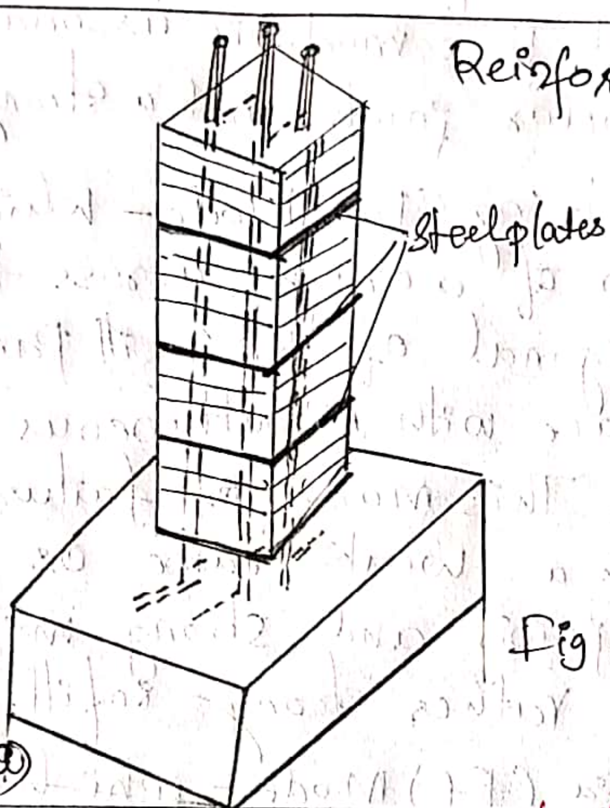


Fig 2(a)

Reinforced with brick work piers.

Fig 2 (b)

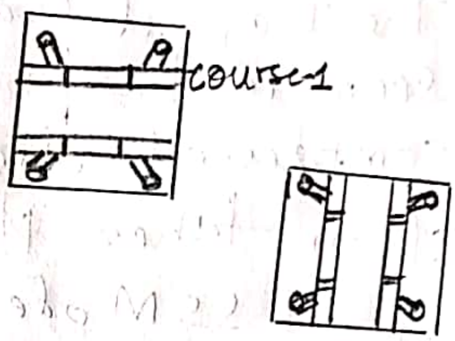


Fig 2 (a, b): Vertical Reinforcemt

Q10 b Briefly explain various failure modes in infilled frames with sketch.

Sol:- Defferent failure Modes of Masonry infilled frames-

1.) Corner crushing (CC) Mode - which represents crushing of the infill in atleast one of its loaded corners. This Mode of failure associated with in filled frames consisting of a weak Masonry in fill panel surrounded by a frame with weak joints and strong members

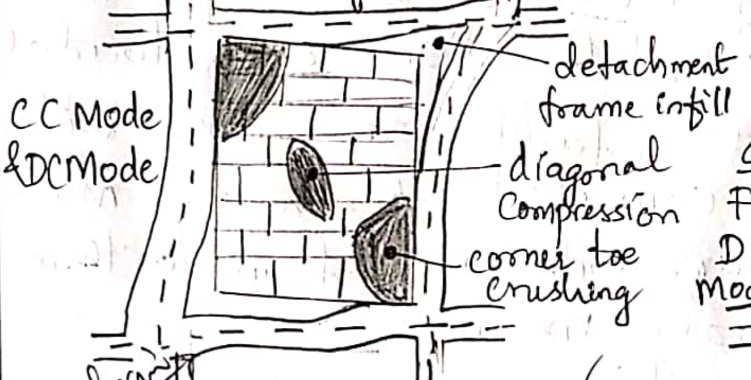
2.) The Diagonal Compression (DC) Mode which represents crushing of the infill within its

Central regeon. This Mode is associated with a relatively Slender infill, where ~~failaure~~ failure results from out of plane buckling of the infill

3.) Sliding shear (SS) Mode - which represents horizontal Sliding shear failure through bed joints of amasonry infill. This mode is associated with infill of weak Mortar joints and a strong frame

4.) The Diagonal Cracking (DK) Mode - which is seen in the form of a cracks across the compressed diagonal of the infill Panel and often takes place with simultaneous initiation of the SS Mode. This mode of failure is associated with a weak frame or a frame with weak joints and strong members infilled with a rather strong infill.

5). The frame failure (FF) Mode - which is seen in the form of plastic hinges developing in ~~the~~ column and ~~bed~~ beam-column connections. This Mode is associated with a weak frame or a frame with a weak joints and strong members infilled with a rather strong infill.



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