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DEPARTMENT OF CIVIL ENGINEERING

Class: ME **Subject: TEAP** **Year: FY**

Sr. No.	Roll No.	Name of Student	Class Test Marks						Average
			I	II	III	IV	V	VI	
01	22ST001	AKASH TELANG	5	7	9	9	9	9	40
02	22ST002	ANIKET HEMRAJ SUKARE	5	7	8	8	8	9	41
03	22ST003	BHARASKAR AAKASH SOMNATH	6	6	8	7	8	9	40
04	22ST004	CHAVANE KALYANI SHIVAJI	5	7	8	8	8	9	43
05	22ST005	CHOUGULE KETAN MANOJ	7	7	8	8	8	8	42
06	22ST006	DHAKE NAYAN KRISHNA	7	6	8	8	8	8	40
07	22ST007	DHULE PUSHKAR BALIRAM	5	6	7	8	7	8	39
08	22ST008	DIVEKAR SNEHA DASHARATH	7	7	8	8	8	8	43
10	22ST010	KHAN MOHD SHABAAZ SALIM	8	7	8	9	9	9	45
11	22ST011	LAHANE PRATIK VISHVANATH	7	7	8	8	9	9	43
12	22ST012	MISAL MRUNMYEE AVINASH	7	7	8	8	8	8	44
13	22ST013	MORALE PRASANNA BHARAT	5	5	5	5	5	5	25
14	22ST014	NAGARE TEJAS BHAGWAN	6	6	8	8	7	8	39
15	22ST015	NAVIN MANOJ BAFNA	5	5	5	5	5	5	25
16	22ST016	PATIL SHRIRANG NANDKISHOR	5	6	7	8	8	7	38
17	22ST017	PATIL SOHAM SURYAJI	5	6	7	8	8	8	40
18	22ST018	TAYADE UNMESH MANOHAR	5	6	8	7	8	7	39

K. D. Kashid

P.G. Coordinator

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Department of Civil Engineering

Test: 1 (Unit I)Class: ME Civil
Date: 01/04/2022 Max. Time: 01 hr
Subject: Theory of Elasticity and PlasticityMax. Marks:10

Course Outcome Statement:

01. To analyse stress and strain in cartesian coordinate system, on inclined plane

Taxonomy Levels:

I-Remember, II-Understand, III-Apply, IV-Analyze, V-Evaluate, VI- Create

Q. No	Question	Marks	Taxonomy level
Q. 1	Derive stress strain equation in cartesian coordinate system	[05]	IV
Q.2	Derive strain compatibility equation in 3D	[03]	IV
Q.3	Find the principal stress from given matrix	[02]	IV

$\tau =$

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Supervisor's Signature

Name KHAN MOHD SHABAAZ SALIM Roll No.: 22ST010

Subject TEAP Division : —

Examination Unit test 1 Day & Date : 23 Dec 2022

Question No.	1	2	3	4	5	6	7	8	9	10			Total Marks
Marks													08/10

Examiner Signature

Q1. Derive stress strain eqn in Cartesian Co-ordinate system

→ Stresses at any point in body is interrelated with the stresses at other point

So, when force acting at x-axis

$$\sigma_x^* = \sigma_x + \frac{\partial \sigma_x}{\partial x} dx$$

$$\tau_{xy}^* = \tau_{xy} + \frac{\partial \tau_{xy}}{\partial x} dx$$

$$\tau_{xz}^* = \tau_{xz} + \frac{\partial \tau_{xz}}{\partial x} dx$$

y-axis

$$\sigma_y^* = \sigma_y + \frac{\partial \sigma_y}{\partial y} dy$$

$$\tau_{yx}^* = \tau_{yx} + \frac{\partial \tau_{yx}}{\partial y} dy$$

$$\tau_{yz}^* = \tau_{yz} + \frac{\partial \tau_{yz}}{\partial y} dy$$

Z-axis —

$$\sigma_z^* = \sigma_z + \frac{\partial \sigma_z}{\partial z} dz$$

$$\tau_{zx}^* = \tau_{zx} + \frac{\partial \tau_{zx}}{\partial z} dz$$

$$\tau_{zy}^* = \tau_{zy} + \frac{\partial \tau_{zy}}{\partial z} dz$$

So, if we take

$$\Sigma F_x = 0,$$

$$= \sigma_x \, dy \, dz + \left(\sigma_x + \frac{\partial \sigma_x}{\partial x} dx\right) dy dz$$

$$-\left(\tau_{yx} \, dx dz\right) + \left(\tau_{yx} + \frac{\partial \tau_{yx}}{\partial y} dy\right) dx \, dz$$

$$-\left(\tau_{zx} \, dx dy\right) + \left(\tau_{zx} + \frac{\partial \tau_{zx}}{\partial z} dz\right) dx \, dy$$

$$+ \bar{X} \, dx \, dy \, dz$$

$$= -\sigma_x dy dz + \sigma_x dy dz + \frac{\partial \sigma_x}{\partial x} dx \, dy dz - \tau_{yx} dx dz$$

$$+ \tau_{yx} dx dz + \frac{\partial \tau_{yx}}{\partial y} dy dx dz - \tau_{zx} dx dy +$$

$$\tau_{zx} dx dy + \frac{\partial \tau_{zx}}{\partial z} dz dx dy + \bar{X} \, dx dy dz$$

$$0 = dx dy dz \left[\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + \bar{X}\right]$$

$$\boxed{\bar{X} + \frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} = 0}$$

$\Sigma F_y = 0$

$$0 = \left(-\sigma_y \, dx\, dz\right) + \left(\sigma_y + \frac{\partial \sigma_y}{\partial y} dy\right) dx\, dz$$

$$+ \left(\tau_{xy} + \frac{\partial \tau_{xy}}{\partial x} dx\right) dy\, dz - \tau_{xy}\, dy\, dz$$

$$+ \left(\tau_{zy} + \frac{\partial \tau_{zy}}{\partial z} dz\right) dx\, dy - \tau_{zy}\, dx\, dy + \bar{Y}\, dx\, dy\, dz$$

$$= -\sigma_y\, dx\, dz + \sigma_y\, dx\, dz + \frac{\partial \sigma_y}{\partial y} dy\, dx\, dz$$

$$+ \tau_{xy}\, dy\, dz + \frac{\partial \tau_{xy}}{\partial x} dx\, dy\, dz - \tau_{xy}\, dy\, dz$$

$$+ \tau_{zy}\, dx\, dz + \frac{\partial \tau_{zy}}{\partial z} dx\, dy\, dz - \tau_{zy}\, dx\, dy + \bar{Y}\, dx\, dy\, dz$$

$$0 = dx\, dy\, dz \left(\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{zy}}{\partial z}\right) + \bar{Y}$$

$$\boxed{\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{zy}}{\partial z} + \bar{Y} = 0}$$

$\Sigma F_z = 0$

$$= \sigma_z\, dx\, dy + \left(\sigma_z + \frac{\partial \tau_z}{\partial z} dz\right) dy\, dx$$

$$- \tau_{yz}\, dy\, dx + \left(\tau_{yz} + \frac{\partial \tau_{yz}}{\partial y} dy\right) dx\, dz$$

$$- \tau_{xz}\, dy\, dz + \left(\tau_{xz} + \frac{\partial \tau_{xz}}{\partial x} dx\right) dy\, dz$$

$$= -\sigma_z\, dx\, dy + \sigma_z\, dy\, dx + \frac{\partial \sigma_z}{\partial z} dz\, dx\, dy$$

$$- \tau_{yz}\, dy\, dx + \tau_{yz}\, dx\, dz + \frac{\partial \tau_{yz}}{\partial y} dx\, dy\, dz$$

$$- \tau_{xz}\, dy\, dz + \tau_{xz}\, dy\, dz + \frac{\partial \tau_{xz}}{\partial x} dx\, dy\, dz =$$

$$= dx\,dy\,dz\left(\frac{\partial \sigma_z}{\partial z} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{xz}}{\partial x}\right) + \bar{Z}$$

$$\boxed{\frac{\partial \sigma_z}{\partial z} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{xz}}{\partial x} + \bar{Z} = 0}$$

$$\Sigma M_x = 0$$

$$= \left(\sigma_y\,dx\,dz\,\frac{dz}{2}\right)\left(\sigma_y + \frac{\partial \sigma_y}{\partial y}dy\right)\frac{dz}{2} - \left(\tau_{yz} + \frac{\partial \tau_{yz}}{\partial y}dy\right)$$

$$dx\,dz\,\frac{dz}{2} + \left[\left(\tau_{yz} + \frac{\partial \tau_{yz}}{\partial y}dy\right)dx\,dz\right]dy -$$

$$\left(\sigma_z\,dy\,dx\,dy/2\right) + \left(\sigma_z + \frac{\partial \sigma_z}{\partial z}dz\,dx\,dy\right)dy/2$$

$$+ \left[\left(\tau_{zy} + \frac{\partial \tau_{zy}}{\partial z}dz\right)dx\,dy\right)dz\Big]$$

$$- \left[\left(\tau_{xy}\,dz\,dy\right)\frac{dz}{2}\right] - \left[\tau_{xz}\,dz\,dy\right]\frac{dy}{2} +$$

$$\left[\tau_{xz} + \frac{\partial \tau_{xz}}{\partial z}\right]dz\,dy/2\Big] + \tau_{xy} + \left[\frac{\partial \tau_{xy}}{\partial x}dx\,dz\,dy\right]\frac{dz}{2}$$

$$\left[\tau_{yz} + \frac{\partial \tau_{yz}}{\partial y}dy\right](dx\,dz)\left(\frac{dy}{2}\right) + \tau_{yz}(dx\,dz)\left(\frac{dy}{2}\right)$$

$$-\left[\tau_{zy} + \frac{\partial \tau_{zy}}{\partial z}dz\right](dx\,dy)\left(\frac{dz}{2}\right)$$

$$-\tau_{zy}\,(dx\,dy)\left(\frac{dz}{2}\right) = 0$$

$$\tau_{xz} = \tau_{zx}$$

$\Sigma M(z) = 0.$

$$\left(\sigma_x \, dy\, dz\right)\frac{dy}{2} \quad \left(\sigma_x + \frac{\partial \sigma_x}{\partial x} dx\right)\frac{dy}{2}$$

$$- \left(\tau_{yx} \, dx\, dz\right) \frac{dy}{2} + \left(\left(\tau_{yx} + \frac{\partial \tau_{yx}}{\partial y} dy\right) dx\,dz\right)\frac{dy}{2}$$

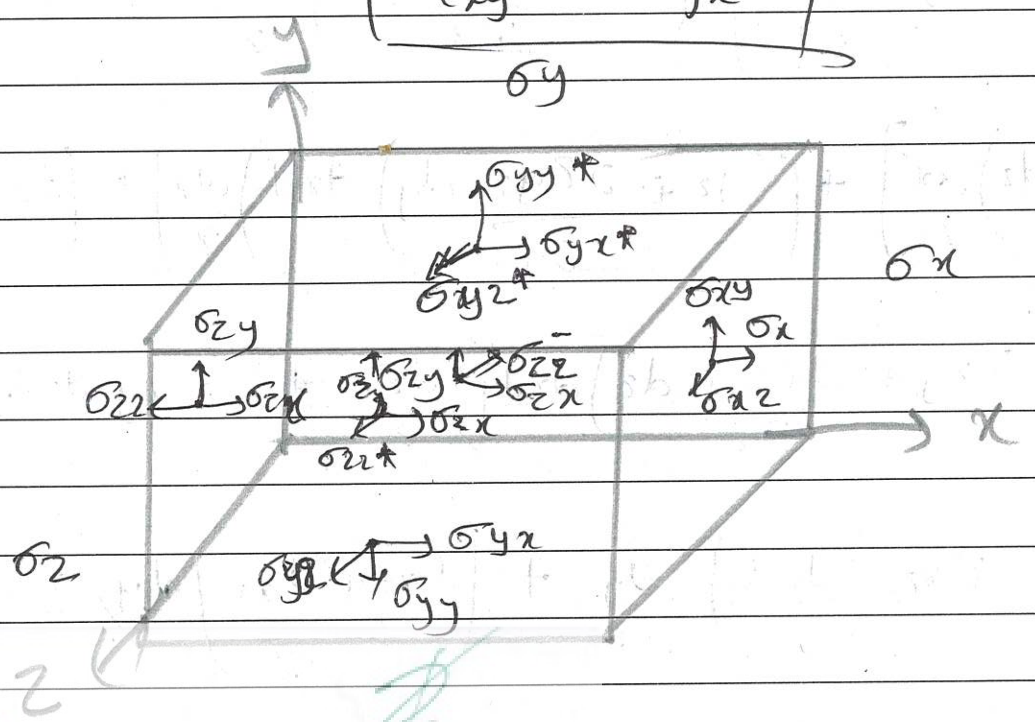
$$+ \left(\sigma_y \, dx\, dz\right)\frac{dy}{2} - \left(\tau_{yz} + \frac{\partial \tau_{yz}}{\partial y} dy\right) \frac{dy}{2} +$$

$$- \left(\tau_{xy} + \frac{\partial \tau_{xy}}{\partial x} dx\right)\frac{dy}{2}$$

$$\tau_{xy} \, dy\, dx - \tau_{yx} \, dy\, dx = 0$$

$$\tau_{xy} - \tau_{yx} = 0$$

$$\tau_{xy} = \tau_{yx}$$



Q3 →

$\sigma_1 = ?$
$\sigma_2 = ?$
$\sigma_3 = ?$

$$\tau = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

So $\tau = \begin{bmatrix} \tau_{xx} & \tau_{yx} & \tau_{zx} \\ \tau_{xy} & \tau_{yy} & \tau_{zy} \\ \tau_{xz} & \tau_{yz} & \tau_{zz} \end{bmatrix}$

So

$\sigma_n^3 = \sigma_I \sigma_n^2 + \sigma_2 \sigma_n - \sigma_3 = 0$

$\sigma_1 = \tau_{xx} + \tau_{yy} + \tau_{zz} = 1+1+1 = 3$

$\boxed{\sigma_1 = 3}$

$\sigma_2 = \begin{bmatrix} \tau_{xx} & \tau_{yx} \\ \tau_{xy} & \tau_{yy} \end{bmatrix} + \begin{bmatrix} \tau_{xx} & \tau_{zx} \\ \tau_{xz} & \tau_{zz} \end{bmatrix} + \begin{bmatrix} \tau_{yy} & \tau_{zy} \\ \tau_{yz} & \tau_{zz} \end{bmatrix}$

$= \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

$= 1 + 1 + 1$

$\boxed{\sigma_2 = 3}$

$$\sigma_3 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\boxed{\sigma_3^2 = 1}$

So, the Solved eqn's are

$\sigma^2 = 1$

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Supervisor's Signature

Name: KHAN MOHD SHABAAZ SALIM Roll No.: 22ST010

Subject: TEAP Division:

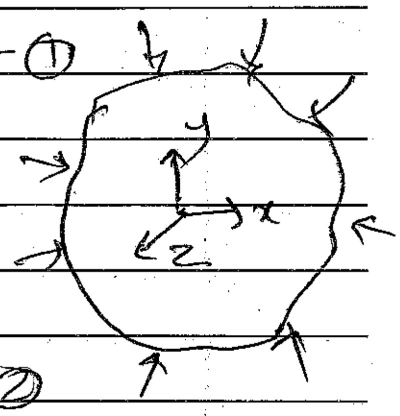
Examination: Unit Test - 1 Day & Date: 23 Dec 2022

Question No.	1	2	3	4	5	6	7	8	9	10			Total Marks
Marks													

Examiner Signature

Q.2 Strain Compatibility eqn in 3D

→ $\frac{\partial^2 \gamma_{xy}}{\partial x \partial y} = \frac{\partial^2 \epsilon_x}{\partial y^2} + \frac{\partial^2 \epsilon_y}{\partial x^2}$ —(1)



Similarly,

$\frac{\partial^2 \gamma_{xz}}{\partial x \partial z} = \frac{\partial^2 \epsilon_x}{\partial z^2} + \frac{\partial^2 \epsilon_z}{\partial x^2}$ —(2)

$\frac{\partial^2 \gamma_{yz}}{\partial y \partial z} = \frac{\partial^2 \epsilon_y}{\partial z^2} + \frac{\partial^2 \epsilon_z}{\partial y^2}$ —(3)

$\gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$

$\gamma_{xz} = \frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}$ } γ equations

$\gamma_{yz} = \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}$

$$\frac{\partial \gamma_{xy}}{\partial z} = \frac{\partial^2 u}{\partial y \partial z} + \frac{\partial^2 v}{\partial x \partial z} \quad \text{--- (4)}$$

$$\frac{\partial \gamma_{xz}}{\partial y} = \frac{\partial^2 u}{\partial z \partial y} + \frac{\partial^2 \omega}{\partial x \partial y} \quad \text{--- (5)}$$

$$\frac{\partial \gamma_{yz}}{\partial x} = \frac{\partial^2 v}{\partial x \partial z} + \frac{\partial^2 \omega}{\partial x \partial y} \quad \text{--- (6)}$$

$$\frac{\partial}{\partial x}\left(\frac{\partial \gamma_{xy}}{\partial z}\right) + \frac{\partial}{\partial x}\left(\frac{\partial \gamma_{xz}}{\partial y}\right) - \frac{\partial}{\partial x}\left(\frac{\partial \gamma_{yz}}{\partial x}\right)$$

$$\left[\frac{\partial^3 u}{\partial x \partial y \partial z} + \frac{\partial^3 v}{\partial x^2 \partial z}\right] + \left[\frac{\partial^3 u}{\partial x \partial y \partial z} + \frac{\partial^3 \omega}{\partial x^2 \partial y}\right] =$$

$$- \left[\frac{\partial^3 v}{\partial x^2 \partial z} + \frac{\partial^3 \omega}{\partial x^2 \partial y}\right].$$

$$= \frac{2\partial^3 u}{\partial x \partial y \partial z} = \frac{2\partial^3 \epsilon_x}{\partial y \partial z} \quad \text{--- (7)}$$

Similarly —

$$\frac{\partial}{\partial y}\left[\frac{\partial \gamma_{xy}}{\partial z}\right] + \frac{\partial}{\partial y}\left[\frac{\partial \gamma_{xz}}{\partial y}\right] - \frac{\partial}{\partial y}\left[\frac{\partial \gamma_{yz}}{\partial z}\right]$$

$$= \frac{2\partial^3 v}{\partial x \partial y \partial z} = \frac{2\partial^2 \epsilon_y}{\partial x \partial z} \quad \text{--- (8)}$$

$$\frac{2\partial^3 \omega}{\partial x \partial y \partial z} = \frac{2\partial^2 \epsilon_z}{\partial x \partial y} \quad \text{--- (9)}$$

eqn (7), (8), (9) are called as Strain Compatibility eqn in 3D.

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Department of Civil Engineering

Test: 2 (Unit II)Class: ME Civil
Date: Max. Time: 01 hr
Subject: Theory of Elasticity and PlasticityMax. Marks:10

Course Outcome Statement:

01. To determine the relationship between stress and strain in polar coordinate system

Taxonomy Levels:

I-Remember, II-Understand, III-Apply, IV-Analyze, V-Evaluate, VI- Create

Q. No	Question	Marks	Taxonomy level
Q. 1	Explain in detail Plane stress problem	[05]	III
Q.2	What is mean by stress function? Explain in detail Airy's stress function.	[05]	III

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Supervisor's Signature

Name Unmesh M. Tayade Roll No. 22ST018

Subject TEAP Division : ME Structural

Examination Unit Test - 2. Day & Date :

Question No.	1	2	3	4	5	6	7	8	9	10	Total Marks
Marks											06/10

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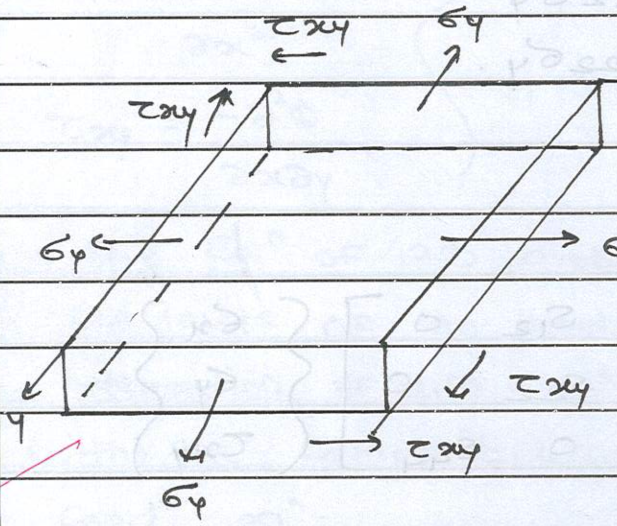
Q.1 Explain detail plain stress problem.

→



Non-Zero stress are:

$\sigma_x, \sigma_y, \tau_{xy} = 0$

Zero stress are:

$\sigma_z, \tau_{xz}, \tau_{yz} = 0$

Dirⁿ will not be considered

i.e. displacement in z dirⁿ will not considered.

i) Strain displacement Relationship.

$\varepsilon_x = \frac{\partial u}{\partial x}$; $\varepsilon_y = \frac{\partial v}{\partial y}$, $\gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$.

$F_x \neq 0$, $\gamma_{yz} \neq 0$, $\varepsilon_z \neq 0$ .. (But not consider)

ii) Eqⁿ Equillibrium

$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + x = 0$

$$\frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + Y = 0$$

iii) Material Constretative Relation.

$$\begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \\ \gamma_{xy} \\ \gamma_{yz} \\ \gamma_{xz} \end{Bmatrix} = [S] \begin{Bmatrix} \sigma_x \\ \sigma_y \\ \sigma_z \\ \tau_{xy} \\ \tau_{yz} \\ \tau_{xz} \end{Bmatrix}$$

$$\varepsilon_x = S_{11}\sigma_x + S_{12}\sigma_y$$

$$\varepsilon_y = S_{22}\sigma_x + S_{22}\sigma_y.$$

$$\gamma_{xy} = S_{44}\tau_{xy}$$

Reduced Matrix

$$\begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} = \begin{bmatrix} S_{11} & S_{12} & 0 \\ S_{21} & S_{22} & 0 \\ 0 & 0 & S_{44} \end{bmatrix} \begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix}$$

Compliance Matrix

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} = \begin{bmatrix} C_{11} & C_{12} & 0 \\ C_{21} & C_{22} & 0 \\ 0 & 0 & C_{44} \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix}$$

3

$S_{11} = 1/E$, $S_{12} = -\mu/E$, $S_{21} = -\mu/E$, $S_{22} = 1/E$

$S_{44} = 1/G$.

$C_{11} = \frac{E}{(1-\mu^2)}$; $C_{12} = \mu C_{11}$; $C_{22} = C_{11}$

$$C_{44} = G = \frac{E}{2(1+\mu)}$$

Q.2 What is mean by stress F^n? Explain in detail Airy's stress F^n.

→ stress F^n : A F^n which satisfy equillibrium eq^n is called as stress F^n. It is denoted by ϕ, ψ.

Airy's stress $F^n(\phi)$:

It defined as the F^n of stresses in the form of ϕ

$$\left.\begin{aligned} \sigma x &= \partial^2\phi/\partial y^2 \\ \sigma y &= \frac{\partial^2\phi}{\partial x^2} \\ \tau xy &= \frac{-\partial^2\phi}{\partial x\partial y} \end{aligned}\right\} \text{Airy's Stress Funct}^n.$$

The Sol^n of 2D problem of elasty with constants or no body force replace to an integration of diff. eq^n of Equillibrium together with the compatibility eq^n and ~~dourd~~ boundry $cond^n$ eq^n.

$$\left.\begin{aligned} \frac{\partial\sigma xx}{\partial x} + \frac{\partial\tau xy}{\partial y} &= 0 \\ \frac{\partial\sigma yy}{\sigma y} + \frac{\partial\tau yx}{\partial x} &= 0 \end{aligned}\right\} \text{Equillibrium } Eq^n.$$

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)(\sigma x + \sigma y)$$

$$\nabla^2(\sigma x + \sigma y) = 0$$

These eq^{ns} can be combined into a single eq^n of 4^{th} order by new F^n ϕ called Aries stress F^n.

$\sigma_x = \frac{\partial^2 \phi}{\partial y^2}$, $\sigma_y = \frac{\partial^2 \phi}{\partial x^2}$; $\tau_{xy} = -\frac{\partial^2 \phi}{\partial x \partial y}$.

Stress define in f^n satisfy the eq^n of equillibrium f^n of all value of y.

Put , σ_x, σ_y and τ_{xy} in equillibrium eq^n.

$$\frac{\partial}{\partial x}\left(\frac{\partial^2 \phi}{\partial y^2}\right) + \frac{\partial}{\partial y}\left(\frac{-\partial^2 \phi}{\partial x \partial y}\right) = 0$$

They will also satisfy the compatibility eq^n

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)\left(\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2}\right) = 0$$

$$\frac{\partial^2 \phi}{\partial x^4} + \frac{\partial^2 \phi}{\partial x^2 \partial y^2} + \frac{\partial^4 \phi}{\partial y^2 \partial x^2} + \frac{\partial^2 \phi}{\partial y^4} = 0$$

If ϕ is a sol^n of bi harmonic eq^n then

$$\nabla^2 \phi = 0$$

3

This is a bi harmonic diff. eq^n of 4^{th} order and is known as compatibility eq^n in terms of stress f^n.

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Department of Civil Engineering

Test: 3 (Unit III)Class: ME Civil
Date: Max. Time: 01 hr
Subject: Theory of Elasticity and PlasticityMax. Marks:10

Course Outcome Statement:

- To examine the stress strain relationship in axisymmetric problem including plane stress problem and plane strain problem.

Taxonomy Levels:

I-Remember, II-Understand, III-Apply, IV-Analyze, V-Evaluate, VI- Create

Q. No	Question	Marks	Taxonomy level
Q. 1	What is compatibility condition in axisymmetric problem?	[05]	III
Q.2	Find the maximum shear stresses in hollow cylinder subjected to internal pressure	[05]	IV

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Supervisor's Signature

Name: Chavane kalyani Shivaji Roll No.: 22ST004

Subject: TEAP Division: ME structural.

Examination: UT-3. Day & Date:

Question No.	1	2	3	4	5	6	7	8	9	10	Total Marks
Marks											08/10

Examiner Signature

Q1

→ Compatibility condition in polar co-ordinate system (Airy's stress function) :-

Airy's stress function ϕ has to satisfy the biharmonic equation $\nabla^2\phi = 0$; provided the body forces are zero or constant.
In the polar co-ordinate the stress function must satisfy the same equation; However, the defination of ∇^4 operator must be modified to suit the polar co-ordinates system. This modification may be accomplished by transforming the ∇^4 operator from the cartesian system to the polar system.

Now, we have $x = r\cos\theta$, $y = r\sin\theta$.
$r^2 = x^2 + y^2$ & $\theta = \tan^{-1}\left(\frac{y}{x}\right)$ ——— (1)

Where, r & θ are defined in figure

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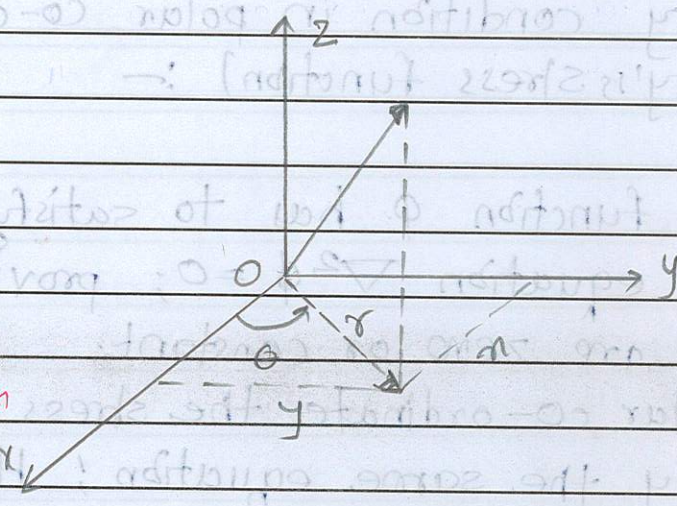
Differentiating equation ① gives

$$\frac{\partial r}{\partial x} = \frac{x}{r} = \frac{r\cos\theta}{r} = \cos\theta$$

$$\frac{\partial r}{\partial y} = \frac{y}{r} = \frac{r\sin\theta}{r} = \sin\theta$$

$$\frac{\partial \theta}{\partial x} = -\left(\frac{y}{r^2}\right) = \frac{r\sin\theta}{r^2} = -\left(\frac{\sin\theta}{r}\right)$$

$$\frac{\partial \theta}{\partial y} = \frac{x}{r^2} = \frac{r\cos\theta}{r^2} = \frac{\cos\theta}{r}$$



$$2r\,dr = 2x\,dx + 2y\,dy$$

$$dr = \left(\frac{x}{r}\right)dx + \left(\frac{y}{r}\right)dy$$

Also,

$$\sec^2\theta\, d\theta = -\left(\frac{y}{x^2}\right)dx + \left(\frac{dy}{x}\right)$$

$$\frac{\partial\phi}{\partial x} = \frac{\partial\phi}{\partial r}\frac{\partial r}{\partial x} + \frac{\partial\phi}{\partial\theta}\frac{\partial\theta}{\partial x}.$$

$$= \frac{x}{\sqrt{x^2+y^2}}\frac{\partial\phi}{\partial r} + \left(\frac{-1}{\sec^2\theta}\left(\frac{y}{x^2}\right)\right)\frac{\partial\phi}{\partial\theta}$$

$\therefore \frac{\partial \phi}{\partial x} = \cos\theta \left(\frac{\partial \phi}{\partial r}\right) - \frac{\sin\theta}{r}\left(\frac{\partial \phi}{\partial \theta}\right)$

Now,

$$\frac{\partial^2 \phi}{\partial x^2} = \left(\cos\theta\left(\frac{\partial \phi}{\partial r}\right) - \frac{\sin\theta}{r}\left(\frac{\partial \phi}{\partial \theta}\right)\right)^2$$

$$= \cos^2\theta \frac{\partial^2 \phi}{\partial r^2} - \left(\frac{2\sin\theta\cos\theta}{r}\right)\frac{\partial^2 \phi}{\partial r\partial\theta} +$$

$$\frac{2\sin\theta\cos\theta}{r^2}\left(\frac{\partial \phi}{\partial \theta}\right) + \frac{\sin^2\theta}{r}\left(\frac{\partial \phi}{\partial r}\right) \text{ — (I)}$$

Similarly,

$$\frac{\partial^2 \phi}{\partial y^2} = \sin^2\theta \frac{\partial^2 \phi}{\partial r^2} + \frac{2\sin\theta\cos\theta}{r}\frac{\partial^2 \phi}{\partial r\partial\theta}$$

$$- \left(\frac{2\sin\theta\cos\theta}{r^2}\right)\frac{\partial \phi}{\partial \theta} + \frac{\cos^2\theta}{r}\left(\frac{\partial \phi}{\partial r}\right)$$

$$+ \frac{\cos^2\theta}{r^2}\frac{\partial^2 \phi}{\partial \theta^2} \text{ — (II)}$$

&

$$\frac{\partial^2 \phi}{\partial x \partial y} = -\left(\frac{\sin\theta\cos\theta}{r}\right)\frac{\partial \phi}{\partial r} + \sin\theta\cos\theta\frac{\partial^2 \phi}{\partial r^2}$$

$$+ \frac{\cos 2\theta}{r}\frac{\partial^2 \phi}{\partial r\partial\theta} - \left(\frac{\cos 2\theta}{r^2}\right)\frac{\partial \phi}{\partial \theta} - \left(\frac{\sin\theta\cos\theta}{r^2}\right) \cdot \frac{\partial^2 \phi}{\partial \theta^2} \text{ — (III)}$$

Adding eqn (1) & eqn (2) we get,

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = \frac{\partial^2 \phi}{\partial r^2} + \left(\frac{1}{r}\right)\frac{d\phi}{\partial r} + \left(\frac{1}{r^2}\right)\frac{\partial^2 \phi}{\partial \theta^2}$$

i.e., $\nabla^2\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = \frac{\partial^2\phi}{\partial r^2} + \left(\frac{1}{r}\right)\frac{\partial\phi}{\partial r} + \left(\frac{1}{r^2}\right)\frac{\partial^2\phi}{\partial\theta^2}$

Or

$$\nabla^4\phi = \nabla^2(\nabla^2\phi) =$$

$$\left(\frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{1}{r^2}\frac{\partial^2}{\partial\theta^2}\right)\left(\frac{\partial^2\phi}{\partial r^2} + \frac{1}{r}\frac{\partial\phi}{\partial r} + \frac{1}{r^2}\frac{\partial^2\phi}{\partial\theta^2}\right) = 0$$

The above biharmonic equation is the stress equation of compatibility in terms of Airy's stress function reffered in polar-co-ordinate system.

Q2.

→ Thick cylinder :-

When the thickness wall of cylinder has considerable diamensions with outer or inner radius is called thick cylinder.

– Principle stresses, max. shear stresses & its distribution using Lamme's solution when internal radius of cylinder is half the outside radius.

for,

case I) —

The general solution for the compatibility

$$\phi = A \log r + Br^2 \log r + Cr^2 + D.$$

so,

Radial stress.

$$\sigma_r = \frac{1}{r}\frac{\partial \phi}{\partial r} = \frac{1}{r}\left[\frac{A}{r} + \frac{Br^2}{r} + B\,2r\log r + 2Cr\right]$$

$$\sigma_r = \frac{A}{r^2} + 2C + B(1+2\log r)$$

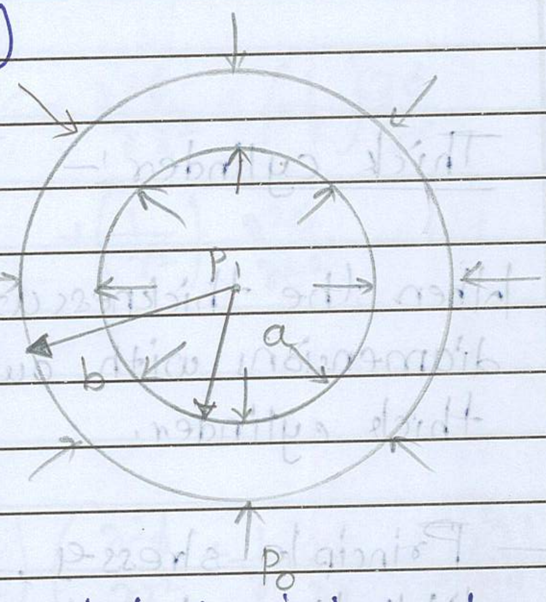
Circumferencial Stressing (σ_θ) :—

$$\sigma_\theta = \frac{\partial^2 \phi}{\partial r^2}\left[-\frac{A}{r^2} + B + 2B\log r + \frac{2Br}{r} + 2Cr\right]$$

$$= \left[-\frac{A}{r^2} + 2C + B(3+2\log r)\right]$$

for thick cylinder,

let, B = 0 (assume)



$\sigma r = \frac{A}{r^2} + 2c$ —— ①

$\sigma_\theta = \frac{A}{r^2} + 2c$ —— ②

Case I) - Cylinder subjected to internal pressure P:

at $r = b$, $\sigma r = -P$

at $r = a$, $\sigma r = 0$

$-P = \frac{A}{b^2} + 2c$

$- \quad 0 = \frac{A}{a^2} + 2c$

$-P = -\frac{A}{a^2} + \frac{A}{b^2}$

$A = \frac{-P(a^2 b^2)}{(a^2 - b^2)}$

$\sigma r = \frac{Pa^2 b^2}{r^2(a^2 - b^2)} + \frac{Pb^2}{a^2 - b^2}$

$\sigma\theta = \frac{Pa^2 b^2}{r^2(a^2 - b^2)} + \frac{Pb^2}{a^2 - b^2}$

Stress variation when $r = b \longrightarrow$ outer radius

$$\sigma_\theta = \frac{p(a^2+b^2)}{(a^2-b^2)}$$

$$\sigma_r = -p$$

$r = a$

σ_θ & σ_r are the principal stresses

Maximum shear stress at $r = a$.

$$\text{Maximum shear} = \frac{\sigma_\theta - \sigma_r}{2} = \frac{-pb^2}{(a^2-b^2)}$$

at, $r = b$

$$\text{Maximum shear stress} = \frac{pa^2}{(a^2-b^2)}$$

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Department of Civil Engineering

Test: 4 (Unit IV)Class: ME Civil
Date: Max. Time: 01 hr
Subject: Theory of Elasticity and PlasticityMax. Marks:10

Course Outcome Statement:
To obtain torsion equation of noncircularsections

Taxonomy Levels:

I-Remember, II-Understand, III-Apply, IV-Analyze, V-Evaluate, VI- Create

Q. No	Question	Marks	Taxonomy level
Q. 1	Derive torsional equation for circular and ellipse section	10	IV

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Supervisor's Signature

Name: Chavane kalyani Shivaji Roll No.: 22ST004

Subject: Unit Test 4 (TEAP) Division: Structure - ME - FY

Examination: Unit Test - 4 Day & Date:

Question No.	1	2	3	4	5	6	7	8	9	10	Total Marks
Marks											08/10

Examiner Signature

Q1.

→ Torsional Equation of ⓐ circular section.
ⓑ Ellipse section.

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = \nabla^2 \phi = 0 \text{ --- satisfied Laplace eq}^n$$

The simplest solution to the laplace equation is,

ψ = constant = c

with $\psi = c$ the boundry condition becomes,

$$-y\frac{dy}{dx} - x\frac{dx}{ds} = 0$$

or,

$$\frac{d}{ds}\frac{x^2+y^2}{2} = 0$$

i.e. x^2+y^2 = constant

Where, (x, y) are the co-ordinates of any point on the boundry.

Hence, the boundry is a circle.

$U_x = \theta_c$

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$$I = \iint_R (x^2+y^2)\, dx\, dy = J_p$$

The polar moment of inertia for section,

Hence

$$T = G J_p \theta$$

or $$\theta = \frac{T}{G J_p}$$

Therefore,

$$V_c = \theta_c = \frac{T_c}{G J_p}$$

Which is a constant.

since, the fixed end has zero V_z at least at one point V_z is zero at every c/s, (other than rigid body displacement).

Thus, the cross-section does not warp.

The shear stresses are given by,

$$\tau_{yz} = G\theta z = \frac{Tx}{J_p}$$

$$\tau_{zx} = -G\theta y = \frac{-Ty}{J_p}$$

There fore, the direction of the resultant shear τ is such that, $\tan\alpha = \frac{\tau_{zy}}{\tau_{zx}} = \frac{-G\theta x}{G\theta y} = \frac{-x}{y}$

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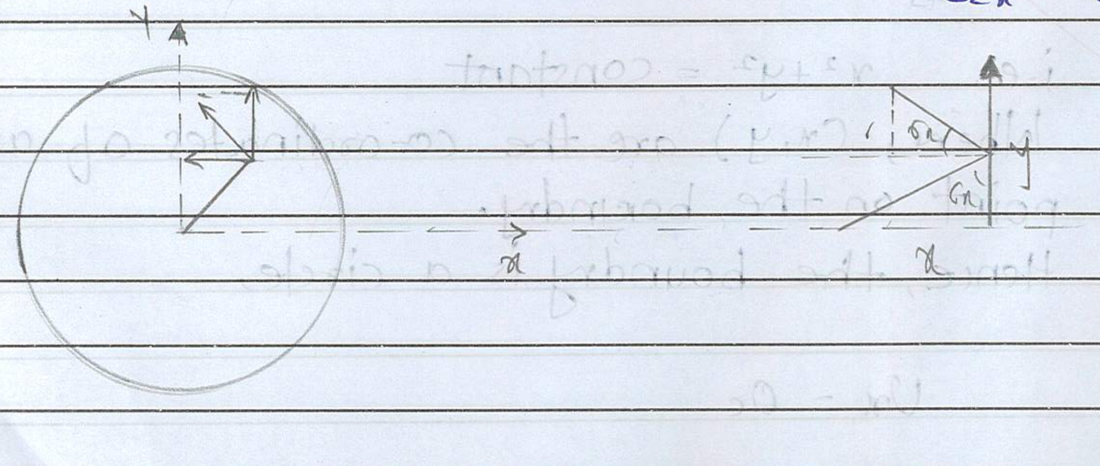


Hence, the resultant shear is perpendicular to the radius

further,

$$\tau^2 = \tau^2_{yz} + \tau^2_{zx} = \frac{T^2 (x^2+y^2)}{I^2_p}$$

Or $$\tau = \frac{Tr}{I_p}$$

Where, r is the radial distance of point (x,y).

Thus, all the resultant of the elementry analysis are justified.

ii) The next case of order of simplicity is is to assume that.

$$\psi = Axy$$

Where, A is constant. This also satisfied the laplace equation. The boundry condition equation.

$$(Ay - y)\frac{dy}{dx} - (Ax + x)\frac{dx}{ds} = 0$$

or $$y(A-1)\frac{dy}{ds} - x\cdot(A+1)\frac{dx}{ds} = 0$$

i.e. $$(A+1)\,2x\frac{dx}{ds} - (A-1)\,2y\frac{dy}{ds} = 0$$

or $$\frac{d}{ds}\left[(A+1)x^2 - (A-1)y^2\right] = 0$$

Which on integration yields.

$$(1+A)x^2 (1-A)y^2 = \text{constant}.$$

This is of the form,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

These two are identical.

If, $\frac{a^2}{b^2} = \frac{1-A}{1+A}$

or, $A = \frac{b^2-a^2}{b^2+a^2}$

Therefore, the function.

$$\psi = \frac{b^2-a^2}{b^2+a^2} xy.$$

represents the waping function for an elliptic cylinder with semi axis a & b under torsion.

The value of J, as given in eq^n as :-

$$J = \iint_R (x^2+y^2+Ax^2-Ay^2)\,dx\,dy$$

$$= (A+1)\iint x^2\,dx\,dy + (1-A)\iint y^2\,dx\,dy$$

$$= (A+1) I_y + (1-A) I_x$$

substituting,

$$I_x = \frac{\pi ab^3}{4} \quad \& \quad I_y = \frac{\pi a^3 b}{4}$$

one gets $J = \frac{\pi a^3 b^3}{a^2+b^2}$

Hence,

$$T = G.J\theta = G\theta \cdot \frac{\pi a^3 b^3}{a^2+b^2}$$

$$\theta = \frac{T}{G} \cdot \frac{a^2+b^2}{\pi a^3 b^3}$$

The shearing stresses are given by,

$$\tau_{yz} = G\theta\left(\frac{\partial \psi}{\partial y} + x\right)$$

$$= \frac{T a^2 b^2}{\pi a^3 b^3}\left[\frac{b^2 - a^2}{b^2 + a^2} + 1\right] x.$$

$$= \frac{2Tx}{\pi a^3 b}$$

& similarly,

$$\tau_{zx} = \frac{2Ty}{\pi a b^3}$$

The resultant shearing stress at any point (x, y) is,

$$\tau = \left[\tau^2_{yz} + \tau^2_{zx}\right]^{1/2} = \frac{2T}{\pi a^3 b^3}\left[b^4 x^2 + a^4 y^2\right]^{1/2}$$

To determine where the maximum shear stress occurs, we substitute for x^2 from,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \quad \text{or} \quad x^2 = a^2\left[1 - \frac{y^2}{b^2}\right]$$

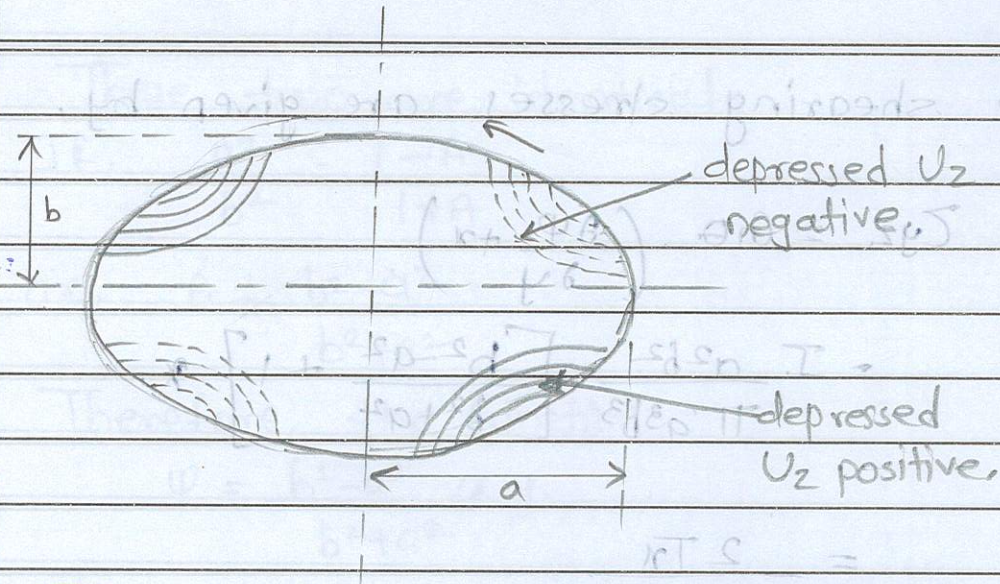
Giving, $\tau = \frac{2T}{\pi a^3 b^3}\left[a^2 b^4 + a^2 (a^2 - b^2) y^2\right]^{1/2}$

i.e.,

When $y = b$, Thus, τ_{max} is given as

$$\tau_{max} = \frac{2T}{\pi a^3 b^3}\left(a^4 b^2\right)^{1/2} = \frac{2T}{\pi a b^2}$$

$$U_z = \theta\psi = \frac{T(b^2 - a^2)}{\pi a^3 b^3 . 6} xy.$$



The countor lines giving U_z = constant are the hyperbolas as shown.
for a torque T as shown, the convex portion of the cross section, i.e., where, U_z is positive are indicated by solid lines & the concave positions where the surface is depressed as shown by dotted lines.
If the ends are free, there are then there are no normal stresses.
However, one end is built in, the warping is prevented at that end & consequently normal stresses are induced which are positive in one quadrant & negative in another quadrant.
These are similar to bending stresses & therefore called the bending stresses induced because of torsion.

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Department of Civil Engineering

Test: 5 (Unit V)Class: ME Civil
Date: Max. Time: 01 hr
Subject: Theory of Elasticity and PlasticityMax. Marks:10

Course Outcome Statement:

01. To analyse stress and strain in cartesian To understand various theories of failure in plasticity

Taxonomy Levels:

I-Remember, II-Understand, III-Apply, IV-Analyze, V-Evaluate, VI- Create

Q. No	Question	Marks	Taxonomy level
Q. 1	Explain the terms i) Rankines theory ii) St. Venants theory iii) Tresca theory iv) Von- Mises Theory	[08]	III
Q.2	The state of stress at a point is given by	[02]	III

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Supervisor's Signature

Name: Pratik Vishvanath Lahane Roll No.: 22ST011

Subject: TEAP Division: ME (Struct) (F.Y)

Examination: UT-5 Day & Date:

Question No.	1	2	3	4	5	6	7	8	9	10	Total Marks
Marks											09/10

Examiner Signature

Q.1. State and explain yield criteria?

⇒ Yield criteria are mathematical expressions used to determine the onset of plastic deformation in material under load. They provide a means of predicting the behaviour of a material when subjected to stress. & are used in the design of engineering structures & components.

The following are some of the most widely used yield criteria.

1] Von mises yield criterion :- This criterion is based on the concept of equivalent stress which is defined as the total strain energy per unit volume that is required to deform a material elastically. The criterion states that yield occurs when the equivalent stress reaches a criteria value known as the yield stress.

2] Tresca yield criterion :- This criterion is based on the maximum shear stress theory which

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states that yield occurs when the maximum shear stress reaches a critical value known as the yield stress.

3] Hill yield criterion :- This criterion is based on a combination of both the von-mises & Tresca yield criteria, and provides a more comprehensive representation of the behaviour of materials under complex loading conditions.

4) Rankine Yield criterion :- This criterion is based on the maximum principal stress theory, which states that yield occurs when either the maximum or minimum principal stress reaches a critical value known as the yield ~~criter~~ stress

~~It's~~ important to note that the yield criteria are empirical in nature & the values of the yield stresses used in these equation are obtained from experiments & are material specific. furthermore the applicability of these yield criteria is limited to materials that exhibit linear elastic behaviour before yielding.

Q What is flow stress & how it is determine.

→ flow stress is a measure of resistance of a material to plastic deformation under load. It is a key property that determines the behaviour of materials in various applications, including metal forming, forging & rolling. flow stress is determined by applying a load to a material and measuring the resulting deformation & it can be expressed as a function of stress, strain or strain rate.

flow stress can be determined experimentally using techniques such as uniaxial tensile testing, compression testing, or shear testing. In these tests, a sample of the material is subjected to a controlled beam load, & the resulting deformation is measured. The flow stress can then be calculated as the maximum stress explained by the material during the test.

In addition to experimental methods, flow stress can be estimated using numerical simulations & material models. These models can take into account various factors that affect the flow stress, such as temp. strain rate & microstructural features.

It is important to note that flow stress is a function of the loading conditions & can vary significance depending on the specific application & the conditions under which it is measured. for this reason, flow stress values must be determined experimentally or estimated using appropriate models for each specific case.

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Department of Civil Engineering

Test: 6 (Unit VI)Class: ME Civil
Date: Max. Time: 01 hr
Subject: Theory of Elasticity and PlasticityMax. Marks:10

Course Outcome Statement:

01. To study the plastic analysis of thick cylinders

Taxonomy Levels:

I-Remember, II-Understand, III-Apply, IV-Analyze, V-Evaluate, VI- Create

Q. No	Question	Marks	Taxonomy level
Q. 1	Derive the equation of thick spherical shape inelastic- plastic analysis due to internal pressure	[10]	IV

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Supervisor's Signature

Name: Misal Mrunmyee A Roll No.: 22ST012

Subject: Teap Division: ME (structural 1st yr)

Examination: UT-06 Day & Date: 13-02-2023 monday

Question No.	1	2	3	4	5	6	7	8	9	10	Total Marks
Marks											08/10

Examiner Signature

Q.2) Derive the equation of thick spherical shape in elastic-plastic analysis due to internal pressure.

① consider the elastic-plastic equilibrium of a hollow sphere under the action of an internal pressure P. Because of the spherical symmetry ($r, \psi, \varkappa$ are spherical co-ordinates) the shears $\gamma_{rp}, \gamma_{\psi\varkappa}, \gamma_{\varkappa r}$ and the tangential stresses $\tau_{rp}, \tau_{\psi\varkappa}, \tau_{\varkappa r}$ are zero and $\epsilon_\psi = \epsilon_\varkappa$, $\sigma_\psi = \sigma_\varkappa$

② each element of sphere experiences simple loading since the principal directional are in-varient and coefficient $\mu_a = \pm 1$

Thus the solution to this problem can be directly obtained from the equation of deformation energy

The intencity of tangential stresses is

$$\tau = \frac{1}{\sqrt{3}} |\sigma_\psi - \sigma_r|$$

The normal stress σ_r, σ_ψ satisfy the equilibrium eq^n

$$\frac{d\sigma_r}{dr} + 2\frac{\sigma_r - \sigma_\psi}{r} = 0 \longrightarrow ①$$

& components of strain

$$\varepsilon_r = \frac{dU}{dr}, \quad \varepsilon_\psi = \frac{U}{r}$$

where U is radial displacements; satisfy the continuity condition

$$\frac{d\varepsilon_\psi}{dr} + \frac{\varepsilon_\psi - \varepsilon_r}{r} = 0 \longrightarrow ②$$

The boundary $cond^n$ have the form

where $r = a$, $\sigma_r = -P \longrightarrow ③$

$r = b$, $\sigma_r = 0 \longrightarrow ④$

③ Initial elastic state.

If the pressure is moderate the sphere is in the elastic state using the above eq^n together with Hooke's law. we find,

$$\left.\begin{aligned} \sigma_r &= \bar{P}\left(1 - \frac{b^3}{r^3}\right) \\ \sigma_\psi &= \bar{P}\left(1 + \frac{1}{2}\frac{b^3}{r^3}\right) \\ U &= \bar{P}r\left(k + \frac{1}{4G}\cdot\frac{b^3}{r^3}\right) \end{aligned}\right\} \longrightarrow ⑤$$

The stress distribution is shown by a dotted line. The intensity of the tangential stress

$$T = \bar{P} \frac{\sqrt{3}}{2} \frac{b^3}{r^3}$$

is a max. where $r = a$

iv) When pressure

$$\bar{P} < \frac{2}{3}\left(\frac{a}{b}\right)^3 \sigma_s = \bar{P}_a$$

the sphere remains in a elastic state where $\bar{P} = P_0$ material of sphere goes over into a plastic state on inner surface $r = a$. on further increase the region of plastic deformation is enlarged.

v) Elastic - plastic state

The yield $cond^n$ takes the form

$$\sigma\psi - \sigma r = \pm \sigma s$$

with the aid of this $cond^n$ we can reduce the equilibrium eq^n to the form

$$\frac{d\sigma r}{dr} - 2\frac{\sigma s}{\sigma r} = 0$$

for which it follows immediately that

$$\sigma r = 2\sigma s \ln r + C_1$$

where C = arbitary constant on determining its value from boundary $cond^n$

$$\sigma_r = 2\sigma_s \ln \frac{r}{a} - P$$

$$\sigma_\psi = \sigma_r + \sigma_s$$

(6) To determine the strains & displacement in yield zone we make use of Hencky's relations

$$\varepsilon_r = \frac{d\omega}{dr} = \psi(\sigma_r - \sigma) + k\sigma$$

$$\varepsilon_\psi = \frac{U}{r} = \psi(\sigma_\psi - \sigma) + k\sigma$$

Since, the strain component have to satisfy the continuity $cond^n$, we obtain the differential eq^n

$$\frac{d\psi}{dr} + \frac{3}{r}\psi + \frac{\sigma k}{r} = 0$$

whose sol^n has the form

$$\psi = 2k + \frac{C_2}{r^3}$$

where C_2 = arbitary constant

- To solve the mixed elastic plastic problem it is necessary to write down the sol^n of elastic problem in the region $(c < r \leq b)$ where the boundary c has to be determined

· If we replace $-P$ & a by quantities q & c where q is stress on the boundary of the regioned of elasticity & yield

To determine the unknown constants c, q & c_2 we have the cond^n of continuity of state,

$$\psi = \frac{1}{2} G, \quad \text{where } r = c$$

the cond^n of continuity of radial stress,

$$\sigma_r |_{r = c-0} = \sigma_r |_{r = c+0}$$

& cond^n of continuity of displacement

$$u|_{r=c-0} = u|_{r=c+0}$$

From the first of these we find

$$\psi = 2k + \left(\frac{1}{2G} + 2k\right) \cdot \left(\frac{c}{r}\right)^3$$

The other lead to the eq^n

$$q = 2\sigma_s \ln \frac{c}{a} - P$$

$$\ln \frac{c}{a} - \frac{1}{3}\left(\frac{c}{b}\right)^3 = \frac{P}{2\sigma_s} = \frac{1}{3}$$

(Q.1)

Plastic torsion is type of loading condⁿ in which a shaft or other cylindrical component is subjected to twisting or rotational deformation. The deformation can be either elastic or plastic, depending on the magnitude of the load and the material properties of the components.

Nadai's sand heap analogy is a mathematical model used to describe the behaviour of materials under plastic deformation. In this analogy, the individual grains of sand represent the individual grains or crystals in a metal or other material.

When a shaft is subjected to plastic torsion, the material experiences plastic deformation as the grains or crystals within the material rotate and reorient relative to one ~~other~~ another. The sand heap as a representation of a material just as a sand heap can flow and reorient under a certain load, material can experience plastic deformation and reorientation under a certain torsional stress.

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Academic Year – 2020-21 (TERM – I)
Civil Engineering Department
Class: M.E. Civil Structure Subject: ADERS Name of Faculty: P R Satarkar

Sr. No.	Roll No.	Name of Student	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Assignment -1	Assignment -2	Assignment -3	Assignment -4	Assignment -5	Assignment -6	Total	Final Marks
		Marks	20	20	20	20	20	20	10	10	10	10	10	10	180	50
1	19ST001	Amrutkar Sonali Bhalchandra	20	18	18	18	17	18	9	9	9	9	8	9	162	45
2	19ST002	Bhavsar Siddharth Sunil	20	AB	18	18	17	18	9	9	4	9	9	8	139	39
3	19ST003	Deshpande Aniket Milind	20	17	17	17	18	17	9	7	9	8	9	8	156	43
4	19ST004	Dhole Prathamesh Rajesh	20	19	14	17	15	15	8	7	9	9	7	8	148	41
5	19ST005	Diwase Sheetal Yashwant	AB	15	18	16	15	16	8	8	AB	AB	AB	AB	96	27
6	19ST006	Gavandgave Pranali Shivaji	20	17	19	18	18	17	9	9	9	9	9	9	163	45
7	19ST007	Ghule Anagh Suresh	19	18	18	17	18	16	9	9	9	9	9	9	160	44
8	19ST008	Gundecha Shreyas Sudhir	20	17	18	17	18	17	9	9	9	9	9	9	161	45
9	19ST009	Joshi Bhavin Kishor	20	18	18	17	18	18	9	9	9	9	9	9	163	45
10	19ST010	Kulkarni Shantanu Abhay	20	17	18	18	18	18	9	9	9	8	7	7	158	44
11	19ST011	Mabrur Ahmed	AB	AB	15	16	15	18	8	8	9	9	8	9	115	32
12	19ST012	Mali Ajinkya Vaijinath	20	18	18	17	17	17	9	9	9	9	9	9	161	45
13	19ST013	Phuge Rushikesh Dilip	20	17	18	17	18	18	9	9	9	9	9	9	162	45
14	19ST014	Ritu Raj	20	18	17	AB	AB	AB	9	9	4	4	4	4	89	25
15	19ST015	Shaikh Muzammil Atif	17	18	15	17	17	17	8	9	9	9	9	9	154	43
16	19ST016	Shikalgar Junaid Naushad	20	17	17	18	18	18	9	9	9	9	9	9	162	45
17	19ST017	Shimpi Piyush Dilip	20	18	17	17	18	18	9	7	9	9	9	9	160	44
18	19ST018	Shubham Devendra Kumar Shukla	19	17	18	17	18	17	9	8	9	9	9	9	159	44
19	19ST019	Suyash Yugalkumar Narnaware	20	18	18	18	18	17	9	7	9	8	9	9	160	44
		Present Total														

Subject Incharge ME Co-ordonator Head of Department

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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Assignment No- 1

Q.1 what are the causes of earthquakes?

Q.2 what is meant by volcanic and tectonic earthquake?

Q.3 why should we study earthquake?

Q.4 Explain elastic rebound theory

Q.5 Explain response spectrum. How do you calculate response spectrum?

Q.6 what is meant by liquefaction? How does liquefaction occur and what are the types of liquefaction?

Q.7. Write Short Note on tsunami.

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Assignment – 1

1 What are the causes of earthquakes?

→ An earthquake is caused by a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that we feel.

In California there are two plates – the Pacific Plate and the North American Plate. The Pacific Plate consist of most of the Pacific ocean floor & the California Coast line. The North American Plate comprises most the North American Continent and parts of Atlantic Ocean floor. The Primary boundary between these two plates is the San Andreas Fault. The San Andreas Fault is more than 650 miles long and extends to depths of atleast 10 miles. Many other smaller faults like the Hayward (Northern California) and the San Jacinto (Southern California) branch from and join the San Andreas Fault Zone.

The Pacific Plate grinds northwestward Past of the North American Plate at a rate of about two inches per year. Parts of the San Andreas fault system adapt to this movement by constant creep resulting in many tiny shocks and a few moderate earth tremors. In other areas where creep is not constant, strain can built up for hundred of years, producing great earthquakes when it finally releases.

2. What is meant by volcanic and tectonic earthquake

→ Volcanic earthquake –
As magma makes its way through the crust to the surface of the earthquake, it breaks apart the surrounding rock thereby generating volcanic earthquake. Volcanic earthquakes are one of the main signs that a volcano is restless.

Tectonic earthquake –
Tectonic earthquakes are caused by the movement of plates when energy accumulated within the plate boundary zones is released. Tectonic earthquakes are usually larger than the volcanic earthquakes.

3. Why should we study earthquake?

→ There are many reasons for studying earthquakes. Earthquakes are the waves travelling through the earth. By studying the detailed structure of the waves, we can decipher the interior structure of the earth. Earthquake also capture the interaction of the regional stress field projected onto existing or new faults. By studying the earthquakes, we can understand how things are moving at the surface and the depth. GPS gives us really good measurements, mostly on land, but not so much underwater or away from the surface of the earth.

There are also people that study earthquakes for the practical reasons for which building codes are required for where based on earthquake recurrence rates and energy attenuation in the crust.
Also Seismology is a key technology for monitoring of the Nuclear explosions.

4. Explain elastic rebound theory.

→ Elastic-rebound theory is an explaination of how energy is released during an earthquake. As the earth's crust deforms, the rocks which span the opposite sides of a fault are subjected to shear stress. Slowly they deform, until their internal rigidity is exceeded. Then they seperate with a rupture along the fault. The sudden movement releases accumulated energy and the rock snap back almost to their original shape. The previously solid mass is then divided between the two slowly moving plates, the energy released through the surroundings in a seismeic wave.
The two sides of an active but locked fault are slowly moving in different directions where elastic strain energy builds up in any rock mass that adjoins them. Thus, if a road is built straight across the fault as fault is locked. When the accumulated strain is great enough to overcome the strength of rocks, the result is a sudden break or a springing back to original shape as much as possible and partly as a seismeic wave

5. Explain Response Spectrum. How do you calculate response spectrum.

→ It is a plot of minimum response of linear single degree of freedom oscillator for a given component of earthquake ground motion. Response quantity may be maximum displacement, maximum velocity or maximum acceleration.

How to create response spectrum —

k. For any given time history, b(t), a response spectrum is created in following way —

1. Select a frequency range for which the spectrum should be generated.
2. Select a frequency step that determines how many points on the response spectrum should be computed
3. Select a certain damping ratio ξ.
4. For each of the selected frequencies ω_0
5. The numerical can be solved by a pure numerical time stepping, but these may be better ways of doing it.
6. If b(t) is given number of points in an accelerogram then it is natural to assume that the acceleration has a linear variation in time between those points.
7. With this formulation, it is possible to check the extreme values of —

Relative displacement

Relative velocity

Relative one absolute acceleration

6. What is meant by liquefication? How does it occur and what are the types of liquefaction?

→ A Phenomenon whereby a Saturated or partially Saturated soil substansially loses strength and stiffness to an applied stress, usually earthquake shaking or other sudden change in stress condition causing it to behave like a liquid is called soil liquefaction.

How does liquifaction occurs –

The Soil is a mixture of soil Particles that are connected together.

These particles naturally rest on each other due to gravity and form grids based on it properties.

Each particle produces its own contact force by the surrounding particles in their place. Soil liquifaction occurs due to sudden and rapid load on soil particle. The sudden water pressure leads to soil losing it's cohesive strength.

Once the soil looses its cohesion, it gets softened and looses its soil properties that are converted to liquid properties.

Types of liquefaction –

1. Flow liquifaction
2. Cyclic mobility

7. Write short note on tsunami

A Tsunami is a series of waves in a water body, caused by the displacement of a large volume of water, generally in an ocean or a large lake. Earthquakes, volcanic eruptions and other under water explosions have the potential to generate a tsunami.

Tsunami waves do not resemble normal undersea currents or sea waves because their wavelength is longer.

Tsunami waves do not resemble normal undersea currents or sea waves because their wavelength is far longer.

Although the impact of tsunami is limited to coastal areas, their destructive powers can be enormous and they can effect entire ocean basins

Causes of Tsunami —

1. Seisimicity
2. Landslides
3. Meterological factors
4. Man-made tsunamis

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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Assignment No- 2

Q.1 what is mean by irregularities. Explain types of irregularities with figures ?

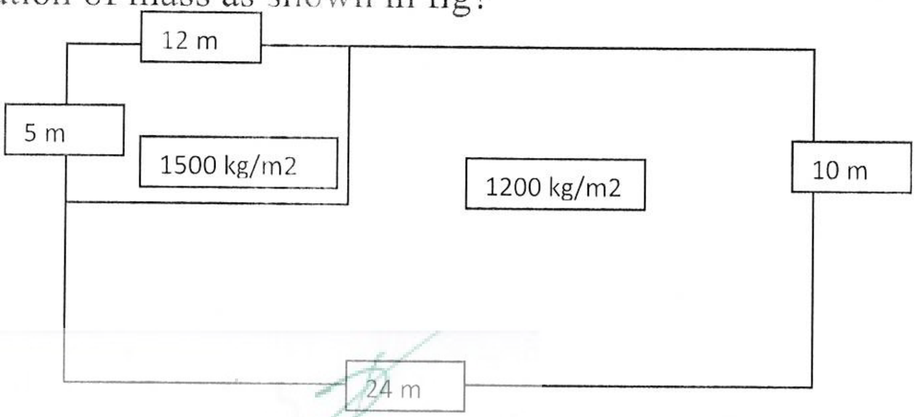
Q.2 Write short note on centre of mass and centre of Rigidity?

Q.3 What are the earthquake deign philosophies?

Q.4 What is earthquake resistance design of Building.

Q.5 Write short note on Unavoidable Damage in Building?

Q.6 Locate centre of mass of Building having non-uniform distribution of mass as shown in fig?



Q.7. Write Short Note on P delta Effect.

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Anagh Suresh Ghule
19ST007

ADERS Assignment -2

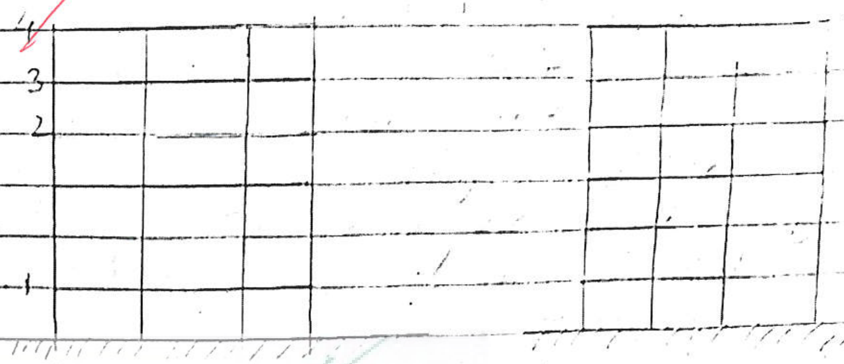
Q1) What is meant by irregularities. Explain types of irregularities with figures.

A1) Irregularities defined in code address: mass and / or stiffness irregularities by requiring a dynamic analysis for taller buildings in higher seismic zones (short period buildings tend to be first mode dominated.

- Post disaster buildings: limit irregularities (basically in higher zones only mass irregularities and non-orthogonal system allowed.
- Types of structural irregularities are as follows:

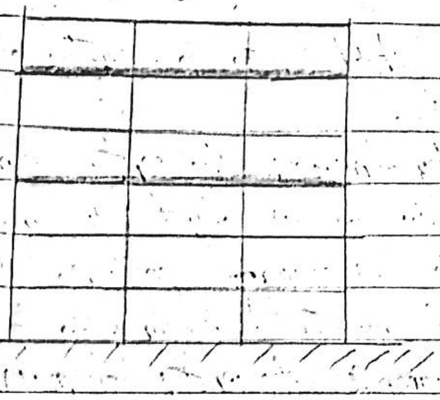
1) Vertical stiffness irregularity: This is considered to exist when the lateral stiffness of the SFR storeys is less than 70% of any adjacent storey or less than 80% of the corresponding average stiffness of the three stories above or below. One-storey penthouses need to be considered.

- Lateral stiffness of the SFR in a storey: - <70% of that in any adjacent storey or,
- <80% of the average stiffness of the 3 storeys above or below.



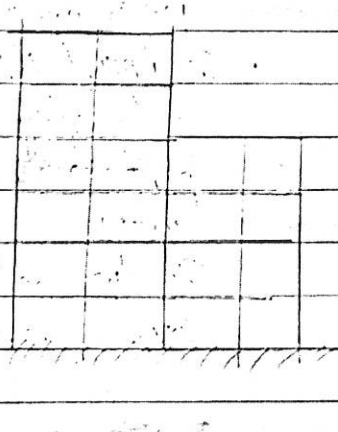
2) Weight (mass) irregularity: Weight irregularity is considered to exist where weight (wi) of any storey is more than 150% of the weight of adjacent storey.

- A roof lighter than the floor below need not to be considered.



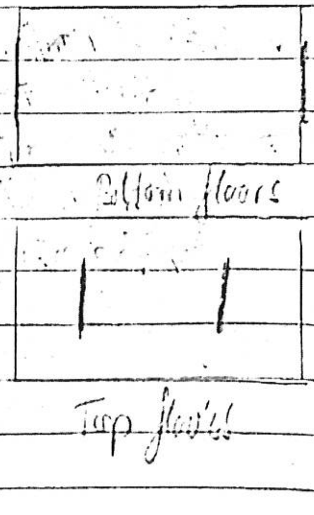
3) Vertical Geometric Irregularity:

- Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the SFRs in any storey is more than 130 percent of that in an adjacent storey. One storey penthouse need not to be considered.

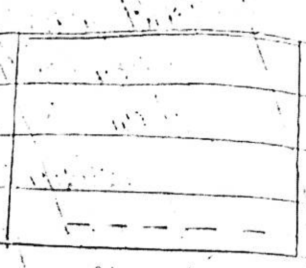


4) Out of plane offsets

Discontinuities in a lateral force path, such as out of plane offsets of the vertical elements of SFRs.



5) Torsional sensitivity:
Torsional sensitivity exists if the ratio of B exceeds 1.2 where $B = \delta_{max}/\delta_{avg}$ calculated for static loads applied at $\pm 0.10 D_n$.



Plan ↑

Q2) Write short note on centre of mass and center of rigidity.

A2) Center of mass: The center of mass is a position defined relative to an object or system of objects.

- It is the average positions of all the parts of the system, weighted according to their masses.
- For example, the centre of mass of a uniform disc shape would be at its center.
- In general the center of mass can be found by vector addition of the weighted position vectors which point to the center of mass of each object in a system.

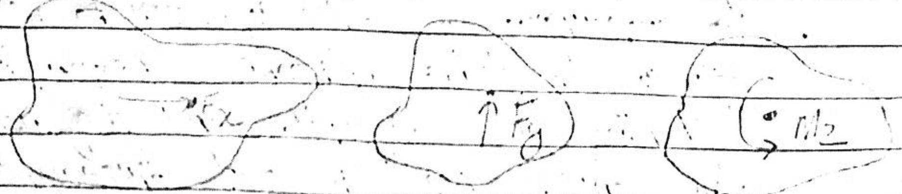
For object positions along x-axis:

$$COM_x = \frac{m_1x_1 + m_2x_2 + m_3x_3 + \cdots}{m_1 + m_2 + m_3}$$

$$COM_y = \frac{m_1y_1 + m_2y_2 + m_3y_3 + \cdots}{m_1 + m_2 + m_3}$$

- Centre of rigidity: Center of rigidity is the stiffness centroid within a floor diaphragm plan.
- When the centre of rigidity is subjected to lateral loading, the floor diaphragm will experience only translational displacement.

- Other levels are free to translate and rotate since behaviour is coupled both in plan and along height.



- Case 1 applies a global-x unit load to an arbitrary point, perhaps the center of mass, such that the diagram rotates R_{zx}.
- Case 2 applies a global-z unit load at the same point, causing rotation R_{zy}.
- Case 3 applies a unit moment about global Z causing rotation R_{zz}.
- Center of rigidity (x, y) is then computed as

$$x = \frac{-R_{zy}}{R_{zz}} \quad \& \quad y = \frac{R_{zx}}{R_{zz}}$$

Q3) What are the earthquake design philosophies?

A) The earthquake design philosophies may be summarized as follows:

a) Under minor but frequent shaking the main members of the building that carry load vertical and horizontal force should not be damaged, however building parts that do not carry load may sustain repairable damage.

b) Under moderate but occasional shaking the main members may sustain repairable damage, while the other parts of the building may be damaged such that they may even have to be replaced after the earthquake and

i) Under strong but rare shaking the main members may sustain severe damage; but the building should not collapse.

- The consequences of damage have to be kept in view on the design philosophy, for example important buildings like hospitals and fire stations play critical role in post earthquake activities and must remain functional immediately after the earthquake.
- These structures must sustain very little damage and should be designed for higher level of earthquake protection.

Q4) What is earthquake resistance design of building?

A4) Earthquake resistant or a seismic structures are designed to protect buildings to some or greater extent from earthquakes.

- While no structure can be entirely immune to damage from earthquakes, the goal of earthquake resistant construction is to erect structures that fare better during seismic activity than their conventional counter parts.
- According to building codes, earthquake resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location.
- This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquake while the loss of the functionality should be limited for more frequent ones.

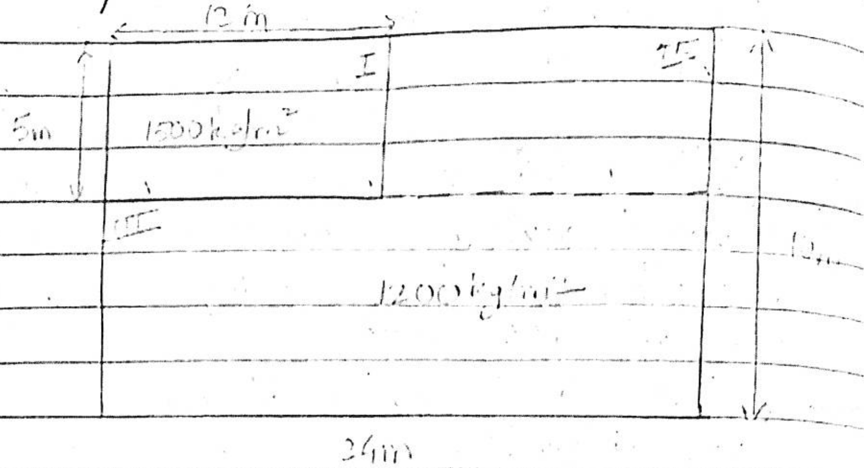
- To combat earthquake destruction the only method available to ancient architects was to build their landmark structures to last often by making them excessively stiff and strong.

Q5) Write a note on unavoidable damage in building.

A5) Design of building to resist earthquakes involves controlling the damage to acceptable levels at a reasonable cost.

- Contrary to the common thinking that only crack in building after earthquake means the building is unsafe for habitation, engineers designing the earthquake resistant building recognizing that some factors affecting the building performance.
- Thus earthquake resistant design strives to predetermine the location where the damage takes place and then to provide good detailing at these locations to ensure ductile behaviour of the building.
- Different types of damage mainly visualized through cracks, especially so in concrete and masonry occurs in buildings during earthquakes.
- Some of these cracks are acceptable while others are not.
- Earthquake resistant design is therefore concerned about ensuring that the damage is in buildings during earthquakes are of the acceptable variety, and also that they occur at right places and in right amounts.

Q6) Locate center of mass of a building having non-uniform mass as shown in figure.



Ans) Let divide roof slab into 3 rectangular parts.

mass of part I = 1500 kg/m^2
mass of part II & III = 1200 kg/m^2

$$x = \frac{(12\times5\times1500)\times6 + (12\times5\times1200)\times18 + (24\times5\times1200)\times12}{(12\times5\times1500) + (12\times5\times1200) + (24\times5\times1200)}$$

x = 11.64 m

$$Y = \frac{(12\times5\times1500)\times7.5 + (12\times5\times1200)\times7.5 + (24\times5\times1200)\times2.5}{(12\times5\times1500) + (12\times5\times1200) + (24\times5\times1200)}$$

Y = 5.14

Coordinates of center of mass are (11.64, 5.14)

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Q7) Write a short note on P-δ effect.

A7) The P-Δ or P-delta effect refers to abrupt changes in ground shear, overturning moment and the axial force distribution at the base of a significantly tall structure or structural component when it is subjected to a critical lateral displacement.

- A distinction can be made between P-delta effects on a multi-tiered building, written as P-Δ and the effects on members deflecting within a bar, written as P-δ.
- P-delta is a second order effect on a structure which is loaded laterally.
- The magnitude of P-delta effect depends on the magnitude of initial deflection.
- The P delta moment is found by multiplying the forces due to weight of structure and applied axial load P, by the first order deflection Δ or δ.
- If the lateral displacement δ and the vertical axis loads through the structure are significant then a P delta analysis should be performed to account for the non-linearities.

DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Assignment No- 3

Q.1 Design and detailing of shear wall, the shear wall of length 11.4m and thickness 200mm it is subjected to the following forces.

Factored Axial force (Pu) – 8550KN

Factored Bending moment – 47392.KN/m

Factored shear force – 206.2KN

Material fck -- 25 N/mm^2 and Fe -- 415 N/mm^2

Q.2 Determine Storey Lateral force for a 4 storey building with given data by

i) Equivalent Lateral Force Method

ii) Response spectrum Method

Zone 3, Assume medium soil

$m_1 = m_2 = m_3 = 5 \times 10^4$ kg and $m_4 = 2.5 \times 10^4$ kg

$K_1 = 30000000$, $K_2 = K_3 = 25000000$ and $K_4 = 9900000$

Ht of ground storey – 4m

Ht of 2nd, 3rd and 4th storey – 3.2m

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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Assignment No- 4

Q.1 Why weak beam and strong column combinations are considered to be more earthquake resistant than strong beam and weak column combination.

Q.2 A RCC beam of Rectangular section has to carry a distributed live load of 20kN/m in addition to its own weight and a dead load of 25kN/m. The maximum bending moment and shear force due to earthquake are 60kN/m and 40kN/m respectively. Centre to centre distance between supports is 6m. Design of beam using M20 grade concrete and Fe415 steel

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HOD, Civil Engg Dept

DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Assignment No- 5

Q.1 Determine seismic force for the building of plan dimension 8m x 8m and height 10.5m using dynamic analysis and show the distribution of the lateral forces with the building height. Consider the free vibration properties of the o the building also determine the maximum moment and axial load in bottom storey column due to seismic forces. The Building is symmetrical in X and Y directions & its properties in both the direction are the same

Q.2 Determine the seismic forces & shears at different floor levels. Also design the ductile shear wall to resist the seismic forces using M25 grade concrete and Tor steel Fe415. Assume unit wt of concrete as $25kN/m^3$ and the beam and column with cross section 600mm x 300mm.

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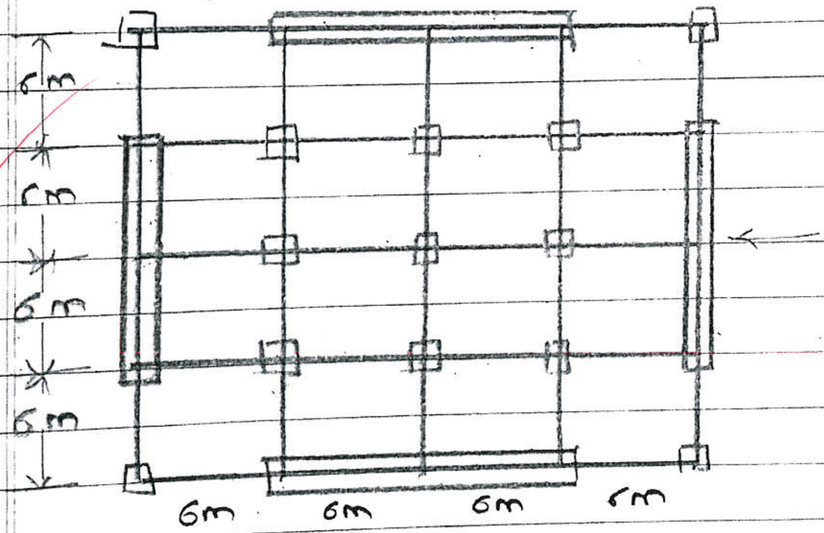
11 12 20

Siddharth Sunil Bhousar

Assignment No-5 (ADERS)

Q.1] A 10 storey building has a plan dimensions as shown in fig. two shear walls are to be provided in the each direction to resist the seismic forces. The axial load and live loads. The ht between floors is 3m. The dead load per unit area of floor which consists of floor slab, finishes, etc. is 4kN/m² and the wt. of partitions on floor is 2kN/m². The intensity of live load on each floor is 3kN/m² and as roof is 1.5 kN/m². The soil below the foundation is hard and the building is located in ~~Shells~~ delhi.



Determine the seismic forces and shear forces at different floor levels also design the ductile shear wall to resist the seismic forces using M-25 wt. of concrete as 25kN/m³ and the beams and the columns with c/s 600mm x 300mm.

→ Seismic wt. of building

As per code provision the % tage of design live load to be considered for the calculation of earthquake forces is 25% for the floors and earthquake forces is not accounted for

∴ effective wt. at each floor will be = 4 + 2 + 0.25×3

= 6.75 kN/m²

and the wt at roof = 4 kN/m²

wt. of 40 beams each of 6m span at each floor and roof = 0.3×0.6 (6×40)×25 = 1080 kN

wt. of 25 columns at each floor

= 0.3×0.6×24×25×25 = 270 kN.

wt. of columns at roof = $\frac{1}{2}$ × 270 = 135 kN.

plan area of building = 24×24 = 576 m²

∴ load at roof level = 4×576 + 1080 + 135 = 3519 kN

load at each floor level = 6.75 × 576 + 1080 + 270 = 5238 kN

Seismic wt. W = 3519 + 5238 × 9 = 50661 kN

= Base shear

$\therefore T = \frac{0.09h}{\sqrt{d}} = \frac{0.09 \times 30}{\sqrt{24}} = 0.551$

Z = 0.24 , I = 1 R = 4 5% damping type I - soil

∴ Sa/g = 1.81

$A_h = \frac{Z}{2} \cdot \frac{I}{R} \cdot \frac{S_a}{g} = \frac{0.24 \times 1.0 \times 1.81}{2 \times 4} = 0.0543$

$V_B = A_h \times W = 0.0543 \times 50661 = 2750.9\,kN$

lateral loads and shear forces at various floor loads. Design loads forces at floor level.

$\therefore Q_i = \frac{V_B \times W_i h_i^2}{\sum_{j=1} W_j h_j^2}$

* Calculating lateral loads and shear stress:-

Mass No	W_i (kN)	h_i (m)	$W_i h_i^2$	$W_i h_i^2 / \Sigma W_i h_i^2$	Q_i (kN)	V_i (kN)
1	3519	30	3167100	0.1907	542.7	524.7
2	5238	27	3017088	0.2299	632.6	1157.3
3	5238	24	2309958	0.1391	499.8	1657.1
4	5238	21	1697112	0.1022	382.8	2039.9
5	5238	18	1178550	0.0709	281.3	2321.2
6	5238	15	754272	0.0454	195.2	2516.4
7	5238	12	424278	0.0255	124.8	2641.3
8	5238	9	188568	0.0255	70.3	2771.7
9	5238	6	188568	0.0114	31.5	2741.1
10	5238	3	471.42	0.0078	7.8	2750.9
			Σ = 16602570			

* Bending moment and shear forces:-

∴ V = 1375.45 kN.

B.M. at max base (M) = (3.9 × 3) + (15.75 × 6) + (35.15 × 9) + (62.45 × 3) + (97.6 × 15) + (140 × 18) + (191.4 × 21) + (249.9 × 24) + (316.3 × 27) + (262.3 × 30)

= 31595.25 kN

$V_u = 1.5 \times 1375.45 = 2063.2$ kN

$M_u = 1.5 \times 31595.25 = 47392.9$ kN

Flexural strength, we know, $f_{ck} = 25$ N/mm².

∴ $f_y = 415$ N/mm². $E_s = 2 \times 10^5$ MPa.

$$\therefore \phi = \frac{0.87 f_y}{f_{ck}} \cdot e = 0.03611$$

$$\lambda = \frac{P_u}{f_{ck} \times f_w \cdot l_w} = 0.15$$

$$\beta = \frac{0.87 f_y}{0.0035 \cdot E_s} = 0.5158.$$

$$\frac{M_u}{l_w} = \frac{\phi + \lambda}{2\phi + 0.36} = 0.4306$$

$$\frac{x_u}{l_w} = \frac{0.0035}{0.0035 + \frac{0.87 \cdot f_y}{E_s}} = 0.6597$$

$$\frac{x_u}{l_w} < \frac{x_u^*}{l_w}$$

$$\therefore M_u = f_{ck} \cdot l_w \cdot t_w^2 \, \phi \left\{ \left(1 + \frac{\lambda}{\phi}\right)\left(\frac{1}{2} - 0.416 \cdot \frac{x_u}{l_w}\right) - \left(\frac{x_u}{l_w}\right)^2 \right.$$

$(0.763/8)$

$\therefore M_u = 37777.48$ kN·m $<$ 47392.9 kN-m

Balance moment $= 47392.9 - 37777.48$

$= 9615.42$ kN-m

$d_w = 0.9 \cdot l_w = 10260$ mm

$$A_{st} = \frac{M_u}{0.87 \cdot f_y \cdot d_w} = 2595.69 \text{ mm}^2$$

Provide 10 Nos. 20 mm ϕ bars in 2 layers in wall at each end

$\therefore A_{st}$ provided $= 314.15 \times 10$ mm^2

$\therefore$ min^m $A_{st} = 0.0025 \times 11400 \times 200 = 5700$ mm^2.

$\therefore 0.8 \times l_w = 9120$ mm.

Area of min^m reinforcement of wall $= 0.0025 \times 1000 \times 200$

$= 500$ mm^2

Max^m permissible spacing $= 5$ or $3 t_w$ or 450 $= 450$ mm

∴ provide 10 mm ϕ bars at 300 mm c/c in verticle direction in 2 layers.

– check for shear

$V_u = 2063.2 kN$

$\therefore \tau_v = \frac{V_u}{t_w . d_w} = \frac{2063.2 \times 1000}{200 \times 10260} = 1.0 N/mm^2 < 0.25 \sqrt{f_{ck}}$

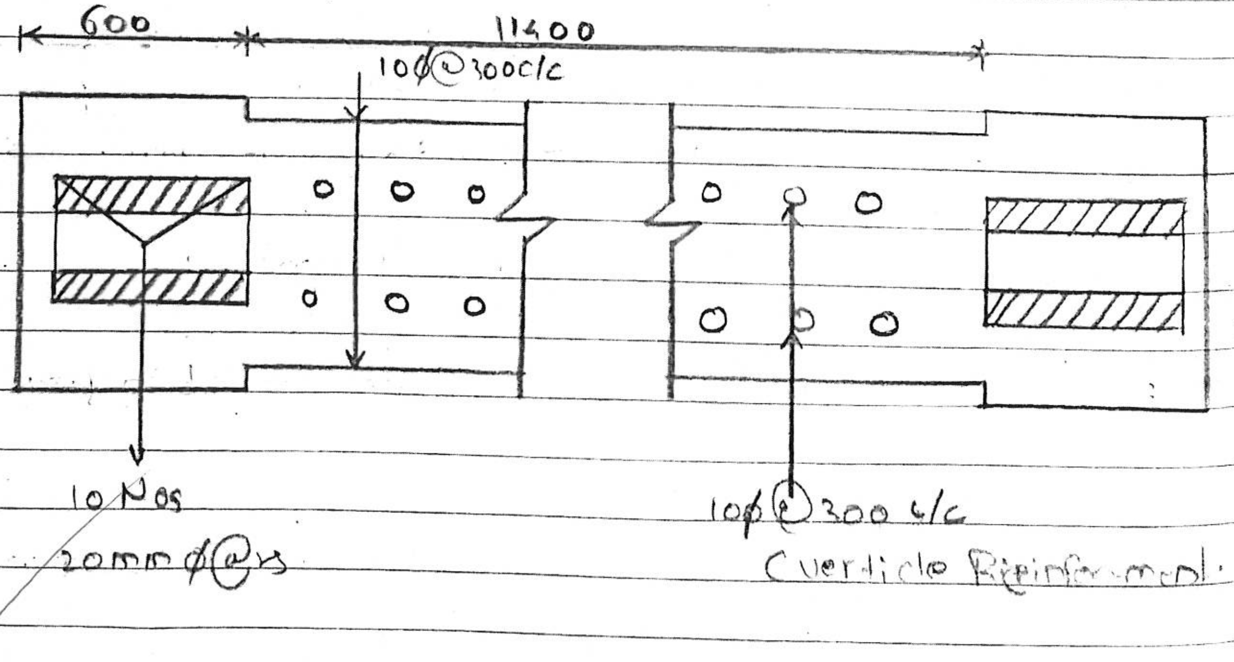
$\therefore 0.25 \sqrt{25} = 1.25 N/mm^2$.

$\therefore S_v = \frac{0.87 \times 415 \times 78.5 \times 2 \times 10260}{2063200 - 0.36 \times 10260 \times 200} = 439 mm c/c$

Reinforcement in horizontal direction $= \frac{78.5 \times 2 \times 1000}{439}$

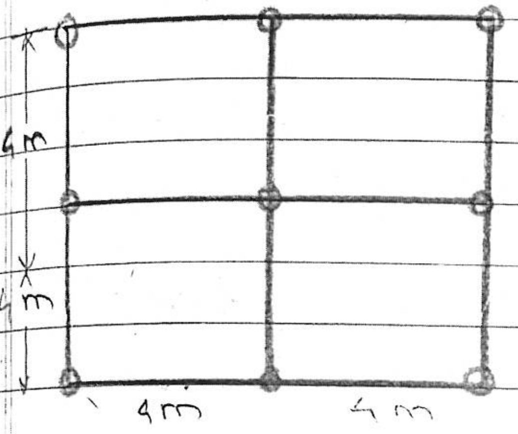
$= 358 mm^2$

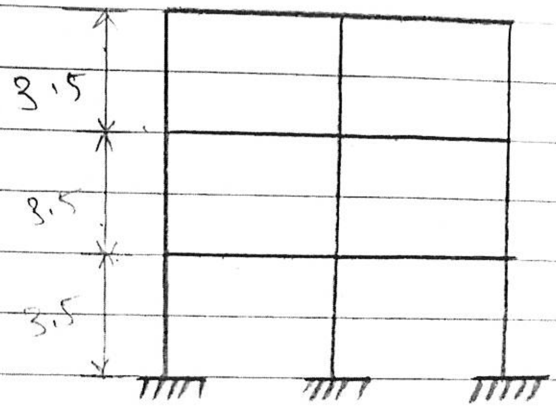
provide 10 ϕ at 300 mm c/c on both the faces & in full length of wall.



plan :- Reinforcement Detailing in Shear wall

Q.2] Determine the design seismic forces for the following using dynamic analysis and show distribution of lateral forces with building height. Also determine the maximum moment and axial load in bottom storey columns due to seismic forces. The building is symmetrical in the x & y direction and its properties in both the directions are same.





Plan.

Elevation.

1] Dynamic properties

Storey level.	Natural period	Mode 1	Mode 2	Mode 3
3	0.134	1	1	1
2	0.191	-2.038	-0.439	0.81
1	0.533	1.611	-1.223	0.45

=> To calculate Mode Shapes.

Table on draw mode shapes for each storey in the building

→ P.T.O.

Storey level	W_i (kW)	Mode 1 ϕ_{ik}	Mode 1 $W_i\phi_{ik}$	Mode 1 $W_i\phi_{ik}^2$	Mode 2 ϕ_{ik}	Mode 2 $W_i\phi_{ik}$	Mode 2 $W_i\phi_{ik}^2$	Mode 3 ϕ_{ik}	Mode 3 $W_i\phi_{ik}$	Mode 3 $W_i\phi_{ik}^2$
3	640	1	640	640	1	640	640	1	640	640
2	688	-2.308	-1402.14	2829.6	0.489	-3.364	164.51	-0.81	537.3	457.40
1	688	1.611	1108.37	1785.58	1.223	841.23	1029.06	0.45	309.6	139.30
Σ	2016		346.23	5255.18		537.085	1833.57		1506.99	1230.7.
$M_k = \frac{(\Sigma W_i \phi_{ik})^2}{g \Sigma W_i \phi_{ik}^2}$		$\frac{346.23^2}{9.81 \times 5255.18}$ = 2.33 kg			$\frac{537.85^2}{1833.57 \times 981}$ = 16.08 kg.			$\frac{1508.90^2}{9.81 \times 1230.7}$ = 188.08 kg		
% of total weight		1.13 %			7.79 %			91.03 %		
$P_k = \frac{\Sigma W_i \phi_{ik}}{\Sigma W_i \phi_{ik}^2}$		0.66			0.29			1.220.		

$Q_{ik} = A_{hk} \cdot \phi_{ik} \cdot P_k W_i$

The values of A_{hk} for different modes are as given.

Mode 1	Mode-2	Mode-3
$T_1 = 0.0134$ $S_a/g = 1 + 15T = 3.01$ $A_1 = Z I (S_a/g) / 2R$ $= \frac{0.36 \times 1.5 \times 3.01}{2 \times 3}$ $\therefore A_1 = 0.271$	$T_2 = 0.191$ $S_a/g = 3.365$ $A_2 = 0.3484$	$T_3 = 0.533$ $S_a/g = 8.993$ $A_3 = 0.809$
$\phi_{1k} = \phi_{1k} \times W_i$ $= 0.271 \times 0.066.$	$Q_{2k} = 0.3484 \times 0.29$	$Q_{3k} = 0.809 \times 1.22$

floor levels (i)	weight (kN)	Mode 1			Mode 2			Mode 3		
		ϕ_{i1}	ϕ_{i1}	V_{i1}	ϕ_{i2}	ϕ_{i2}	V_{i2}	ϕ_{i3}	ϕ_{i3}	V_{i3}
3	640	1	11.45	11.45	1	64.59	64.59	1	631.6	631.6
2	688	-2.083	-25.08	-13.65	-0.48	-0.48 -33.95	-30.64	0.81	550.02	1181.6
1	688	1.611	-19.82	6.19	-1.273	-84.95	-34.22	0.45	305.5	1487.2

$V_3 = (11.45^2 + 64.59^2 + 631.67^2)^{1/2} = \underline{635.06 \text{ kN}}$

Similar, $V_2 = 1182.16$ kN

$V_1 = 1488.26$ kN.

$Q_3 = V_3 = 635.06$ kN

$Q_2 = V_2 - V_3 = 1182.16 - 635.06 = 547.10$ kN.

$Q_1 = V_1 - V_2 = 1488.2 - 1182.16 = 306.10$ kN.

for top floor

$635.06 \times \frac{3.5}{2} = F_1 \times 4 + F_2 \times 0 + F_3 \times 4$

$F_1 = F_3$ due to symmetry.

$F_1 = 138.92$ kN

$F_1 \times 2 = H_1 \times 3.5/2$

$H_1 = 158.78 \text{ kN} = H_3 ;\ H_2 = 2H_1 = 317.53$ kN.

for 1st floor

taking moment about A_2

$635.06 \times 5.25 + 547.10 \times 1.75 = (F_1 + F_3)\,4$

$\therefore F_1 = \underline{1072.97 \text{ kN}}$

Taking moment ~~about A~~ at hinge as

$10728.87 \times 2 - 547.10 \times 3.5/2 - 138.92 \times 2 = 1.75 H_1$

$\therefore H_1 = 520.27 \text{ kN} = H_3.$

$\therefore H_2 = 2H_1 = 1040.54$ kN

for ground floor

Taking moment about A 3.

$635.06 \times 8.75 + 547.10 \times 5.25 + 306.10 \times 1.75 = (F_1 + F_3) \times 4$, $= F_1 = 2241.18\,kN = F_3$ — symmetry

∴ taking moment @ hinge as:

$2241.18 \times 2 - 1072.87 \times 2 - 520.27 \times 1.75 = H_1 \times 1.75$

$\therefore H_1 = 814.94\,kN = H_3$

$H_2 = 1629.88\,kN$

∴ Max^m base shear would also occurs at middle column = 1629.28 kN

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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Assignment No- 6

Q.1 Explain code provision for water tank given in IS: 3370. Write design procedure for water tank.

Q.2 A RC circular water container of $50m^3$ capacity has a internal diameter of 4.65m and height of 3.3m (Including free board of 0.3m). it is supported on RC staging consisting of 4 columns of 450mm dia with horizontal bracing of 300mm x 450mm at 4 levels. The supply level is 12m above ground staging to ductile detailing as per IS 13920. Staging columns have isolated rectangular footing at a depth of 2m from ground level. Tank is located on soft soil in seismic zone II. Grade of staging concrete and steel are M20 & Fe415, density of concrete is $25kN/m^3$.Analyse the tank for seismic loads up to base moment.

Subject Incharge

HOD, Civil Engg Dept

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70/4

Assignment No :- 6

Q.1) State IS 3370 code provisions for water with units. write design procedure for water tanks.

→ IS 3370 part 2 specifically gives importance to construction measures for storage structure (for water) liquid holding. The recommendations however may generally be applicable to the storage at normal temperature for aqueous liquid & solutions which have no detrimental actions on concrete & steel or where sufficient precautions are taken to ensure protection of concrete & steel from damage due to action of such liquid as in case of sewage code states that provisions shall be made in accordance with principle of mechanics, recognised methods of design & second engineering practise. Also adequate considerations shall be given to the effect of monolithic construction is assessment of axial force, bending moment & shear.

- Loads acting on liquid storage structures are given. All structures are required to be designed for both the full & empty conditions & the assumps regarding the arrangements of loading should be such as to ensure the most critical effects for load combinations, water load shall be treated as dead load.

- The code gives two Alternative methods for design of water tank i) limit state method ii) working stress design. Though more inclination is made on working stress method owing to the fact that the members are designed to not crack which is essential for storing liquids

The provisions to Calc. the permissible stresses in concrete & steel are given.

- Further provisions for floor of tanks resting on ground or resting on support are given.
- Design of roof in matter of movement joints, water tightness is given.
- Detailing of water tank, provision for spacing min reinforcement, crack spacing, Thick sections are given.

Design steps for water tank

Step 1 :- Determine design contacts like σ_{cbc}, σ_{st}, m, σ_t

where σ_{cbc} → Permissible Compressive stress in concrete

σ_{ct} → Permissible tensile stress in Concrete.

m → Modulus ratio

σ_{st} → Permissible Compressive stress

Step 2 :- Determine

i) ~~Determine~~ Diamension of the tank.

ii) Volume of tank

iii) Area of tank.

Step 3 Find :-

i) Hoop tension $H_t = d \times h \times D/2$

ii) Area of steel, $A_{st} = A \times h \times D/2\ \sigma_{st}$

Step 4 Thickness of wall of watertank

$A_{st} = [100 D t + (m-1) A_{st}] \times \sigma_{st}$

Step 5 :- Reduction in Hoop style. The steel calculated in step 3 is for 1m height from the bottom of the watertank. The pressure of water decreases at the the top. Hence, Steel can be reduced by keeping the same thickness of wall.

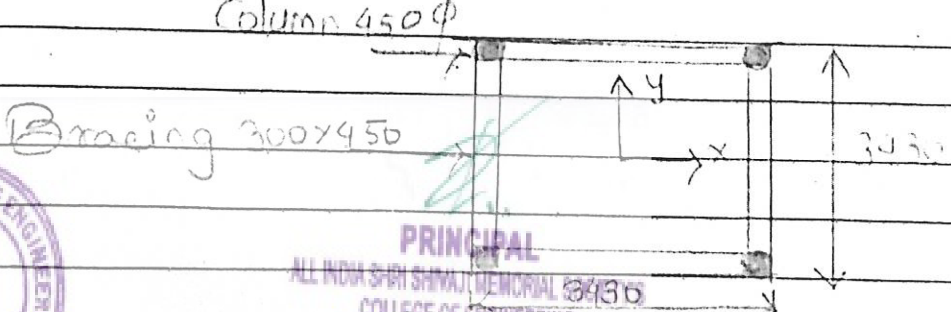
Step 6:- Distribution steel (vertically placed)

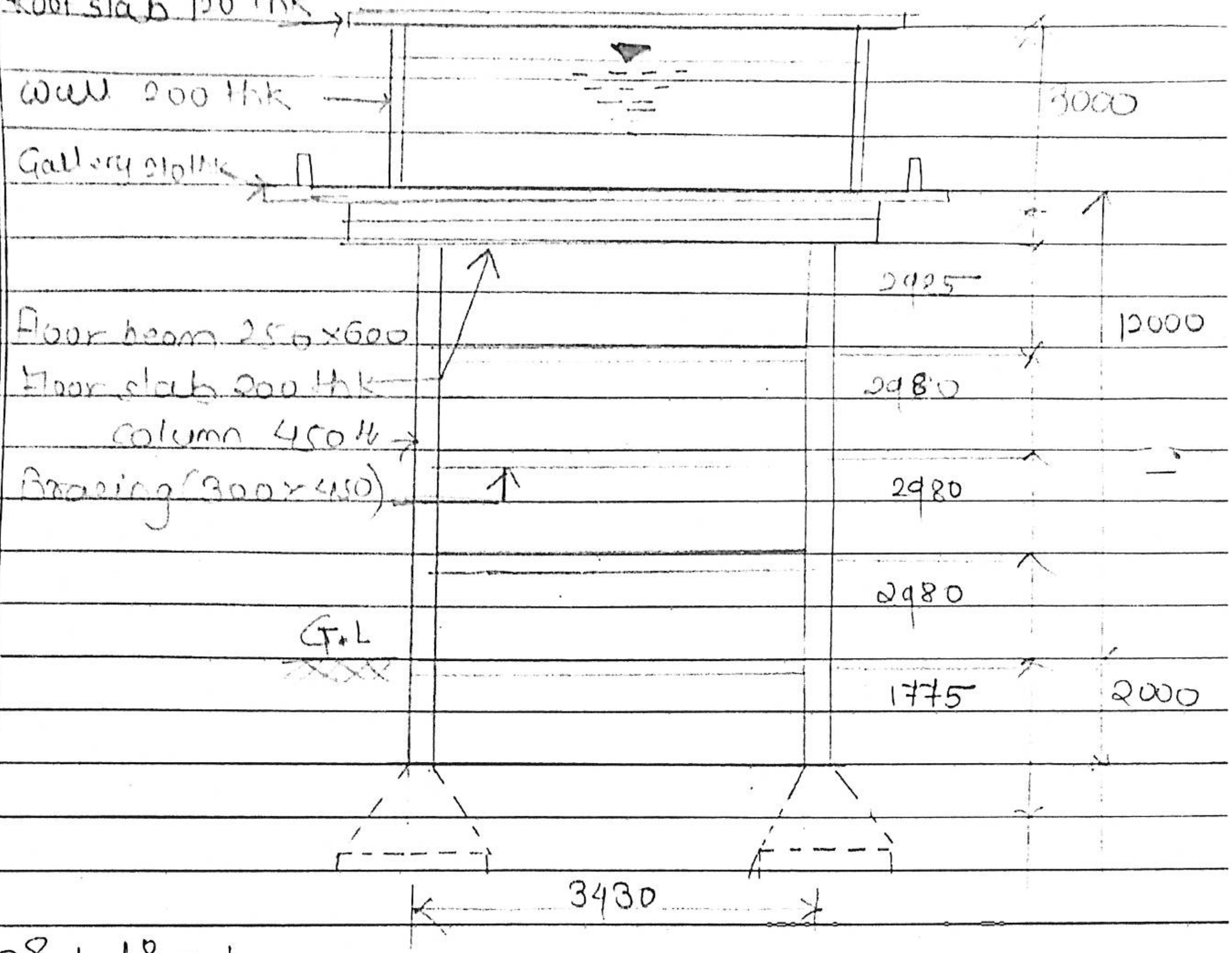
$$A_{st} = 0.3\% \text{ of } A_g.$$

Step 7:- Floor of the tank

∴ provide 0.3% of Ag both ways.

Q.2) A RC circular water container of $50\,m^3$ capacity has internal diameter of 4.65m & Hgt of 3.3 m (including 0.3 m of freeboard). It is ~~happen~~ supported on RC staging consisting of 450 dia with Horizontal bracings of 300 x 450 mm dia ~~with~~ at ~~floor~~ level. The lower supply level is 12m above ground level. Staging Conforms to ductile as per IS 13920. Staging conforms columns have isolated rectangular footings at a depth of 2.m from ground level. Tank is located on safe soil is seismic zone II. Grade of staging criteria of concrete & steel are M20 & Fe 415 resp. Density of concrete is $25\,kN/m^2$. Analyse the tank for seismic loads upto base moment. $(K_s = 178 \times 10^5\, N/m)$.





Solution :-

1) wt of tank ⇒ vol × ρ

a) volume of wall = (External diam of tank − Internal diam of tank) × ht of tank

$= (\pi/4 \times 5.05^2 - \pi/4 \times 4.65^2) \times 3.3 = 10.056 m^3$

b) volume of roof $= \pi/4 \times 5.05^2 \times 0.12 = 2.4 m^3$

c) Volume of base $= \pi/4 \times 5.05^2 \times 0.2 = 4 m^3$

d) Volume of beam supports $= \pi/4 \times 0.25 \times 0.6 \times 5.05$

$= 3.03 m^3$.

∴ Total Volume $= 19.486 m^3$.

wt of tank $= 19.486 \times 25 = 487.15$ KN.

volume of bracing $= 4 \times 4 \times 0.3 \times 0.45 \times 3.43 = 7.4088\ m^3$

volume $= 16.18948\ m^3$

cot $= 404.699$ KN

iii) Volume of water $= 50.94\ m^3$

iv) Mass of water $= 50946.81$ kg

v) CG. height from bottom of tank $= 1.65$ m

Step 2 Hydrodynamic & spring mass model for parameter for fluid.

Eq. water High 'h' in circular & coeffnt tank is to be obtained from given water value & inner diam of tank.

$$\text{Vol. of water} = \frac{\pi D^2}{4} = h_{eqn}\ h$$

$$h_{eqn}\ h = \frac{50.94}{\frac{\pi}{4} \times 4.65^2} = 2.99$$

$$h/d = 2.99/4.65 = 0.643$$

The parameter of spring mass. Refer table of fig. C

$$\frac{m_i}{C} = \frac{(\tanh)(0.866\ D/h)}{0.866 D/h} = \frac{\tan(3)(0.866 \times 4.65/2.99)}{0.866 \times 4.65/2.99}$$

$$m_i/m = 0.0524$$

$$m_i = 0.0524 \times 50946 = 2670.009\ kg$$

$$\frac{m_c}{m} = 0.23 \frac{\tanh}{h/D}\left(3.68 \times \frac{h}{D}\right) = 0.04435$$

$$m_c = 0.04435 \times 50946.81 = 2259.89\ kg$$

5.12) Dynamic response of concrete flat slab

for $h/D \leq 0.75$

$hi/h = 0.375$

for $hi = 0.375 \times 3 = 1.125\,m$

for $h/D \leq 1.33$

$$hi^*/h = \frac{0.866 \times D/h}{2\tanh(0.866 \times D/h)} \times 0.125$$

$$= \frac{0.866 \times 4.65/2.99}{2\tan 3(0.866 \times 4.65/2.99)} \times 0.125$$

$hi^*/h = 1.19$

$hi^* = 1.19 \times 3 = 3.578\,m$

$$\frac{hc}{h} = \frac{1-\cosh(3.68 \times h/D)}{3.68 \times h/D \times \sinh(3.68 \times h/D)} = \frac{1-\cos(3.68 \times 3/4.65)}{3.68 \times 3/4.65 \times \sin 3(3.68 \times 3/4.65)} - 1$$

$= hc/h = 1.00$

$hc = 1 \times 3 = 3\,m$

$$hc^*/h = \frac{1-\cosh(3.68 \times h/D)\,2.01}{3.68 \times h/D \times \sinh(3.68 \times h/D)} = 0.78$$

$hc^* = 0.78 \times 3 = 2.34$

$$Kc = 0.836 \times \frac{m}{h} \times g \times \tanh^2\left(3.68 \times 0.643\frac{h}{D}\right)$$

$= 905.13\,kN.$

step 3 :- Dynamic properties of structure as per clause 4.2.2.3

at M_s = Mass of Empty tank + $\frac{1}{3}$ mass of staging + Bracing

$$M_s = \left(487.15 + \frac{904.699}{3}\right) \times \frac{1000}{9.81} = 63409.75$$

$$K_s = \frac{3EI}{L^3}$$

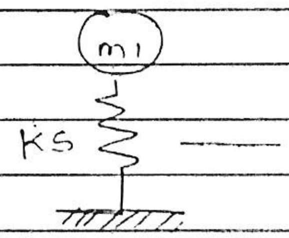
$E = 5000\sqrt{20} = 22360.68$ mpa

$I = \pi/64 \times D^4 = 2.0128 \times 10^{-3} m^4$

$l = 13.8$

$K_s \rightarrow$ lateral stiffness of staging

$K_s = 178 \times 10^5$ N/m



Impulsive mode (T_i) = (1.4.3.13)

$$T_i = 2\pi\sqrt{\frac{m_i + m_s}{K_s}}$$

$$= 2 \times \pi\sqrt{\frac{2670.009 + 63409.75}{178 \times 10^3}}$$

$$E = 2\pi \cdot \sqrt{\frac{m_c}{K_c}} = 2\pi\sqrt{\frac{2269.89}{905.13}} = 9.93 \text{ sec}$$

Step 4 :- Base shear, base moments tank full condition.

Flat slab

Tank Full Condition.

A) $A_{hi} = \frac{Z}{2} \times \frac{I}{R} \times \frac{Sa}{g}$

$I = 1$

$R = 5$

$Sa/g = 1$

$Z = 0.10$

$A_{hi} = \frac{0.1}{2} \times \frac{1}{5} \times 2 = 0.02$

B) Convective mode (In this mode 5% damping considered)

$A_c = \frac{Z}{2} \times \frac{I}{R} \times \frac{Sa}{g}$

$= \frac{0.1}{2} \times \frac{1}{5} \times (2 \times 1.75)$

$= 0.0355$

Base shear

Impulsive mode

$V_i = A_{hi} \times (M_i + M_s) \times g$

$= 0.02 \times (2970.009 + 63409.75) \times 9.81$

$= 13023.70$ KN

$= 13.02$ KN.

Convective mode

$V_c = A_{hc} \times M_c \times g$

$= 0.035 \times 2259.89 \times 9.81$

$= 775.93$ N

$= 0.8$ KN

// wt of staging + bracing $= \omega \times 8$

Volume of staging $= 4 \times \pi/4 \times 0.45^2 \times 13.825 = 8.78 m^3$

By SRSS Rule

$V_{total} = \sqrt{V_i^2 + V_c^2} = 13.04$ kN.

Base moment

Impulsive mode:-

$M_i^* = (A_{hi})[M_i(h_i^* + h_{staging}) + m_c \times h_{cg}] \times g$

$= 0.02[2670.009(3.578+13.8) + 63409.75 \times 15.95] \times 9.81$

$= 201316.9066$ N.m

$= 201.31$ kN.m

Convective mode

$M_c = (A_{hc}) \times M_c(h_c^* + h_s) g$

$= 0.035 \times 2259.89(2.34+13.8) \times 9.81$

$= 12.52$ kN.m

$M^* = \sqrt{M_i^* + M_c}$

$= 201.698$ kN.m.

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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Test- 1 **Date: 4th Dec 2020**

1. Earthquakes are produced during:

(a) plastic failure within the mantle,

(b) brittle failure during faulting,

(c) mushrooming during folding

(d) none of the above

2. Seismic waves are waves of energy that:

(a) plastically distort the material that they pass through,

(b) permanently distort the material that they pass through,

(c) break the material that they pass through

(d) elastically distort the material that they pass through

3. The region of initiation of seismic energy within the Earth is called the:

(a) epicenter,

(b) hypocenter,

(c) area of greatest building damage

(d) area of least building damage

4. As rupture along a fault initiates, waves of energy travel outward from the hypocenter in a:

(a) linear fashion,

(b) a straight line path,

(c) a spherical fashion,

(d) none of the above

5. Body waves emanate spherically from the focus traveling:

(a) entirely within the interior of the Earth,

(b) along the surface of the Earth,

(c) within the worlds oceans

(d) into space dude!

6. P-waves produce a series of:

(a) shearing motions that are at right angles to the direction of wave propagation,

(b) contractions and expansions that are in the direction of wave propagation,

(c) circular motions like an ocean wave

(d) snake-like motions parallel to the Earth's surface

7. S-waves produce a series of:

(a) contractions and expansions that are in the direction of wave propagation,

(b) snake-like motions parallel to the Earth's surface,

(c) circular motions like an ocean wave

(d) shearing motions that are at right angles to the direction of wave propagation

8. Rayleigh waves move along the surface of the Earth forming a wave that is much like:

(a) a skier moving down a mountain hill,

(b) a car traveling through the sand dunes,

(c) an ocean wave

(d) a whale gliding along the ocean's surface

9. A seismograph is a device used to:

(a) sound an alarm,

(b) prevent earthquakes from occurring,

(c) record the vibrations produced during an earthquake

(d) calm the seismologist during an earthquake

10. Which of the following classes represent earthquakes with magnitudes between 4 and 4.9?

(a) moderate

(b) great

(c) strong

(d) light

11. Which of the following classes represent earthquakes with magnitudes between 6 and 6.9? (a) moderate

(b) great

(c) strong

(d) light

12. On a global scale, on average, over 900,000 earthquakes a year occur with magnitudes below

(a) 6.0

(b) 7.0

(c) 2.5

(d) 5.0

13. Great earthquakes, on average, occur

(a) 30,000 times annually

(b) 500 times annually

(c) 100 times annually

(d) once every 5 to 10 years

14. Mercalli indices of VI or lower measure the effects of an earthquake on

(a) cows

(b) dogs

(c) horses

(d) people

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15. Mercalli indices of VII or higher measure the effects of an earthquake on

(a) cows

(b) dogs

(c) horses

(d) buildings

16. If the parental material is rock characteristic of a given region, then the resulting soil is referred to as

(a) transported

(b) elevated

(c) superposed

(d) residual

17. The climatic conditions that are most conducive for the formation of calcite and/or halite in a soil are

(a) high precipitation – low temperature

(b) high precipitation – high temperature

(c) high precipitation – moderate temperature

(d) low precipitation – high temperature

18. **The soils most susceptible to liquefaction are :**

[A]. saturated dense sands

[B]. **saturated fine and medium sands of uniform particle size**

[C]. saturated clays of uniform size

[D]. saturated gravels and cobbles

Subject Incharge

HOD, Civil Engg Dept

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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Test- 2 **Date: 4th Dec 2020**

1. Mass is best given by ________
   a) Product of volume and density
   b) Ratio of mass to density
   c) Addition of mass and density
   d) Subtraction of mass and density
2. We use sometimes the measures to know the direction of moment in the calculations of the centre of mass. It is done by right handed coordinate system. Which is right about it(consider the mentioned axis to be positive)?
   a) Thumb is z-axis, fingers curled from x-axis to y-axis
   b) Thumb is x-axis, fingers curled from z-axis to y-axis
   c) Thumb is y-axis, fingers curled from x-axis to z-axis
   d) Thumb is z-axis, fingers curled from y-axis to x-axis
3. The total of all the masses of small particles adds up to give the total body mass. This mass lies along with gravity gives a force vector which is being passed by ________
   a) Axis of rotation
   b) Axis of rolling
   c) Centre of Gravity
   d) Centre of mass
4. A material's resistance to elastic deflection is known as ___
   a) stiffness
   b) toughness
   c) hardness
   d) elasticity
5. How can stiffness of material be improved?
   a) By increasing the cross-sectional area
   b) By decreasing the cross-sectional area
   c) By increasing temperature
   d) By increasing the length of spring

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6. While considering the design of R.C. buildings for providing ductility, the minimum grade of concrete limited by the Indian Code is _________
a) M 10
b) M 20
c) M 35
d) M 50

7. According to the recommendations of IS 13920: 1993, the thickness of any part of the wall should not be less than __________
a) 50 mm
b) 100 mm
c) 150 mm
d) 200 mm

8. The four-storeyed building of Bhuj Hospital was built after the __________
a) 2001 Bhuj earthquake
b) 1996 Bhuj earthquake
c) 2006 Bhuj earthquake
d) 1893 Bhuj earthquake

9. While considering the design of R.C. buildings for providing ductility, IS codes prohibit the steel grade greater than _________
a) Fe 250
b) Fe 320
c) Fe 415
d) Fe 550

10. Inertia forces generated by the earthquake shakings primarily develop at the floor of the building.
a) True
b) False

11. Structures built on which land have to withstand greater risk during earthquakes?
a) Solid mass
b) Loose soil
c) Strong rocks
d) Unfractured mass

12. What should be maintained in cross walls?
a) Continuity
b) Discontinuity
c) Intersections
d) Gaps

13. Which of the following need not be avoided for construction of quake resistant buildings?
a) Uniform height

b) Chimneys

c) Heavy weight walls

d) Discontinuous foundations

14. A dam is subjected to simpler system of forces during an earthquake compared to the other buildings.

a) True

b) False

15. wood is good for earthquakes?

a) true

b) False

16. What is the strongest part of the building?

a) Foundation

b) Beam

c) Column

d) Slab

17. Which of the following would be most appropriate for a high-rise building in a high-risk seismic zone?

a) A building on stilts

b) A building with an L-shaped plan

c) A building with a symmetrical T-shaped plan

d) A building with a symmetrical square plan

18. Which of the following primary structural systems are used to resist lateral loads? Check the four that apply. (Check the four that apply)

a) Shear walls

b) Braced frames

c) Hinged frames

d) Moment-resisting frames

e) Horizontal diaphragms

f) Precast systems

19. To perform well in an earthquake, a building should posses

(a) regular configuration and adequate strength

(b) adequate stiffness and ductility

(c) regular configuration, adequate strength, stiffness, and ductility

(d) adequate strength and ductility

20. Which shape of plan is better in earthquake zone?

(a) L

(b) O

(c) H

(d) Y

Subject Incharge

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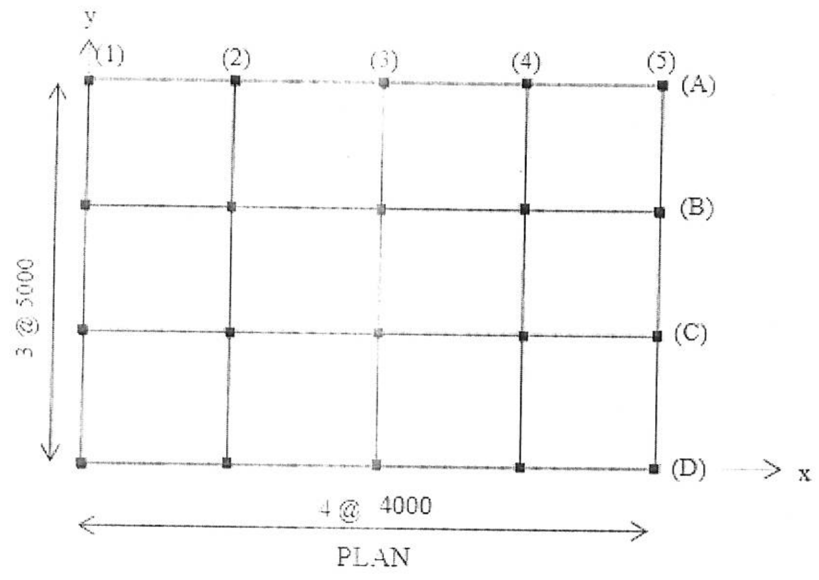
DEPARTMENT OF CIVIL ENINEERING

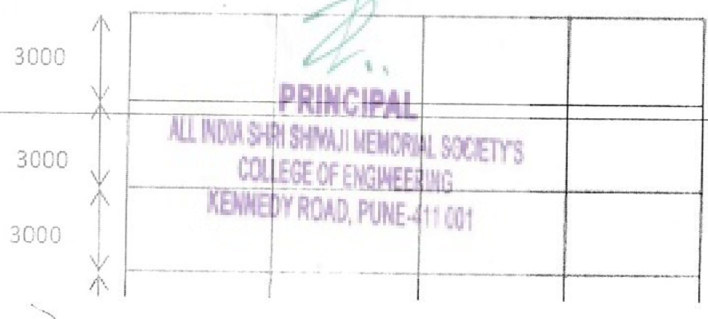
Analysis and Design of Earthquake Resistant Structures

<u>Test- 3</u>

Date: 23 Nov 2020

Q.1	Explain Code Based Procedure for Seismic Analysis	(5 Marks)
Q.2	Consider a four storey Reinforced concrete office building as shown in fig. The building is located in zone V. The soil conditions are medium stiff and the entire building is supported on raft foundation. The RC frames are infilled with brick-masonry. The lumped weight due to dead loads is 10 kN/m^2 on floors and 8 kN/m^2 on the roof. The floors are to cater for a live load of 3 kN/m^2 on floors and 1 kN/m2 on the roof. Determine design seismic load on the structure as per new code.	(15 Marks)





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Anagh Suresh Ghule 19ST007
ADERS

18/20 ~~9~~

Test 3

Q1) Explain code based procedure for seismic analysis.

A) As per IS code 1893 2002, three methods have been mentioned for seismic analysis, namely:
i) Equivalent lateral force method
ii) Response spectrum method
iii) Dynamic time history analysis

i) Equivalent lateral force method: It is the simplest way of analysis and requires less computational effort because the forces depend on the code based fundamental period of structures with some empirical modifier. The design base shear based fundamental period of structure with some emepirical modifier obtained at each floor level shall then be distributed along the height of the building based on simple formulas appropriate for buildings with regular distribution of mass and stiffness. The design lateral force obtained at each floor level shall then be distributed ~~for~~ to individual lateral load resisting elements depending upon floor diaphragm action.

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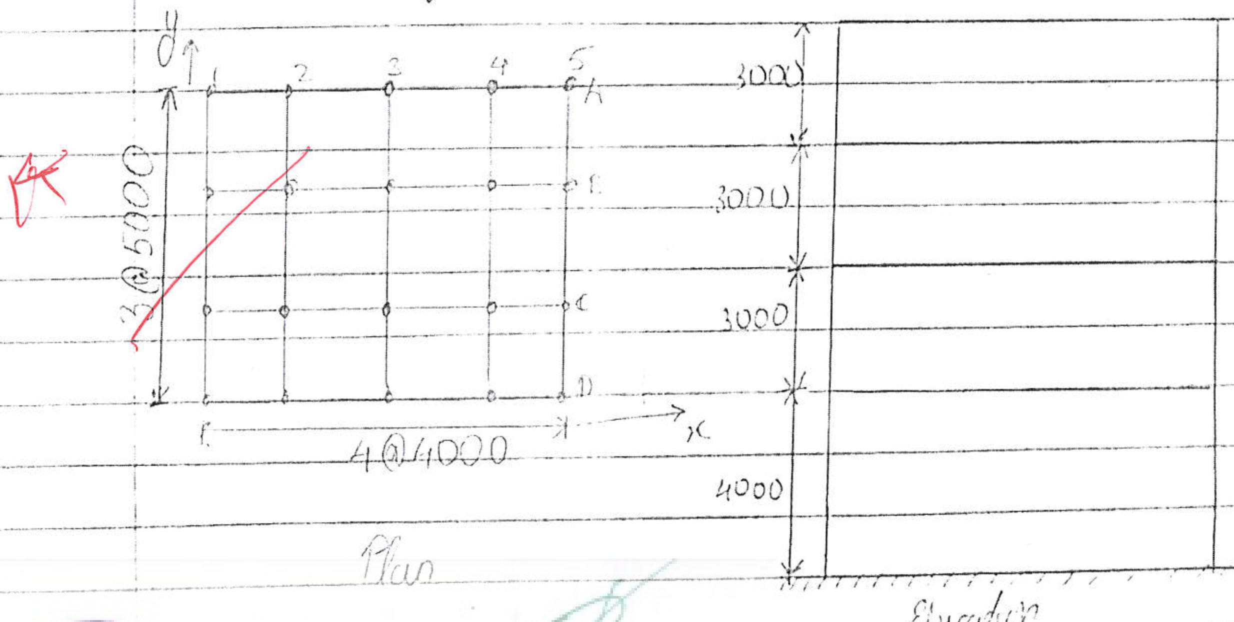
Response Spectrum Analysis:
Response spectrum analysis is a method to estimate the structural response to short, non-determinate, transient dynamic events. The response spectrum method is based on a special type of mode superposition. The idea is to provide an ~~input~~ input that gives a limit to how much an eigen mode having a certain natural frequency and damping can be excited by an event of this type.

Dynamic Time History analysis:

Time history analysis provides for linear or non-linear evaluation of dynamic structural response under loading which may vary according to the specified time function. It is an important technique for structural seismic analysis especially when the evaluated structural response is non linear. To perform such analysis a representative earthquake, time history is required for a structure being evaluated. The Time history analysis is a step by step analysis of the dynamic response of a structure to a specified loading that may vary with time.

Q2) Consider a four storey building located in zone V, the soil are medium stiff. Type of foundation is raft. Brick masonary for partition wall. D.L. on floor = 10 KN/m^2 and roof = 8 KN/m^2, L.L. for floor = 3 KN/m^2 and roof 1 KN/m^2. Determine design seismic.



i) Zone V = Zone factor = 0.36
Importance factor = 1
Response reduction factor = 5

ii) Calculating seismic weight:
floor area = $(3\times5)\times(4\times4) = 15\times16 = 240\,m^2$
Since the ~~table~~ live load class is $4\,kN/m^2$ only 50% of the L.L. is on the floor.
At roof the L.L. is to be lumped.

Loading for floor : $W_1 = W_2 = W_3$

D.L. = 240×10 = $2400\,kN/m^2$
L.L. = 240×3 = $720\,kN/m^2$
$2760\,kN/m^2$

Loading for roof = $240\times D.L. = 240\times8 = 1920\,kN/m^2$

Seismic wt. of structure $W = (3\times2760) + 1920 = 10200\,kN/m^2$

iii) Determination of fundamental natural period

$$T_a = \frac{0.09\times h}{\sqrt{d}}$$

for x-direction = $\frac{0.09\times13}{\sqrt{16}} = 0.2925$

$Sa/g = 2.50$

for y-direction $= \frac{0.09 \times 13}{\sqrt{15}} = 0.3020$

$Sa/g = 2.50$

iv) Determining design base shear in x-direction

$V_B = A_h \times W$

$A_{h(x)} = \frac{Z}{2} \times \frac{I}{R} \times \frac{Sa}{g} = \frac{0.36}{2} \times \frac{1}{5} \times 2.50 = 0.09$

$V_{B(x)} = 0.09 \times 10200 = 918 kN$

Determining design base shear in y-direction :

$V_B = A_h \times W$

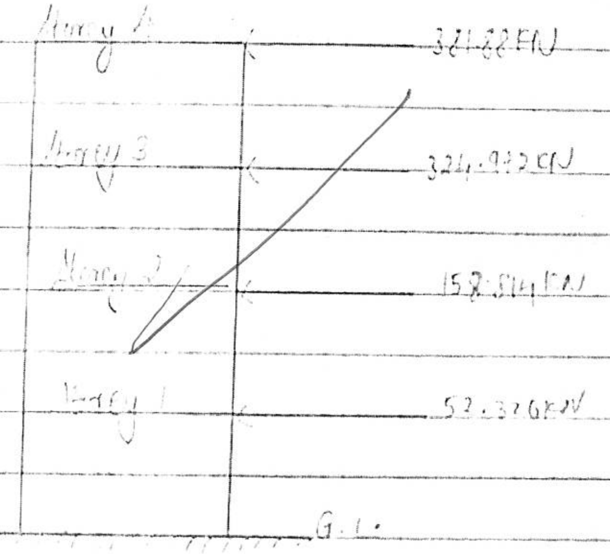
$A_h(y) = \frac{Z}{2} \times \frac{I}{R} \times \frac{Sa}{g} = \frac{0.36}{2} \times \frac{1}{5} \times 2.50 = 0.09$

$V_B(y) = 0.09 \times 10200 = 918 kN$

Vertical distribution of base shear

$$Q_i = \frac{W_i h_i^2}{\sum_{i=j}^{n} W_i h_i^2}$$

Storey level	W_i	h_i	$\frac{W_i h_i^2}{1000}$	$\frac{W_i h_i^2}{\Sigma W_i h_i^2}$	Lateral force that floor level for earthquake load x	y
4	1920	13	324.48	0.4161	381.88	381.88
3	2760	10	276	0.354	324.972	324.972
2	2760	7	135.24	0.173	158.814	158.814
1	2760	4	44.16	0.057	52.326	52.326



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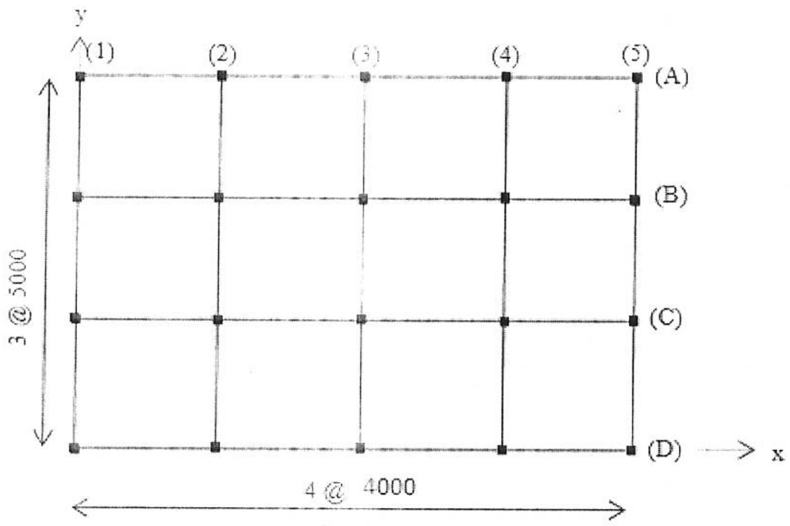
DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Test- 4 **Date: 27 Nov 2020**

Q.1	Explain Behaviour of concentric and Eccentric Braced frames	(5 Marks)
Q.2	Consider a four storey Steel office building as shown in fig. The building is located in zone V on hard soil. The framing system of the building is moment resisting frames with brick masonry infill panels design bracing system for the building for the following data. **Column Section:** Ground Floor:-ISHB 450@872N/m with 10mm thick and 300mm wide cover plate on each flange Remaining Floor:-ISHB 450@ 872N/m **Beam Section:** Along 1500mm intermediate beam (L1): ISMB 400@616N/m All other Beams(L2): ISMB 225@ 312 N/m **Slab:** 120mm thick RCC slab for all Floors **Walls:** 230mm thick (Unit wt 18 kN/m^3) Bracing Concentric	(15 Marks)



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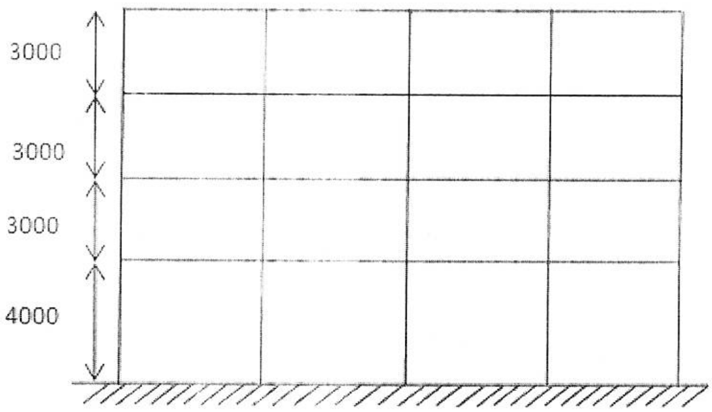

ELEVATION

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20/18 4

Class Test - 4   ADERS   D- 27-11-2020

Name- Siddharth Sunil Bhavsar

Roll No. 19ST002

Q.1] Explain Behaviour of Concentric and Eccentric Braced Frames.

=) Behaviours of Concentric Braced Frames and eccentric braced frames:

A Braced Frames are structural system which is design primarily to resist wind and earthquake forces. Members in a braced frames are design to work in tension and compression.

Concentric braced frames in which Centre line of the member that meets at points intersects at a point to form a verticle truss system that resist lateral forces.

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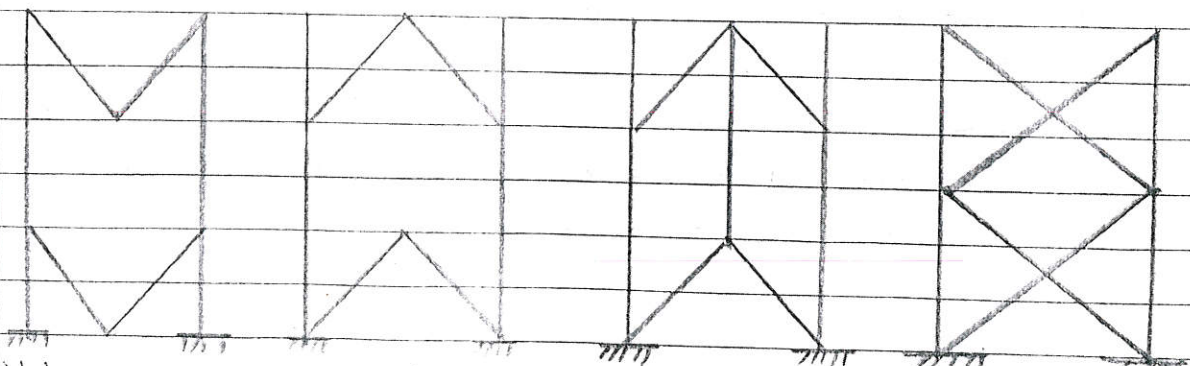
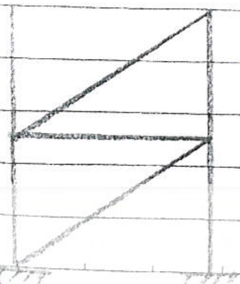


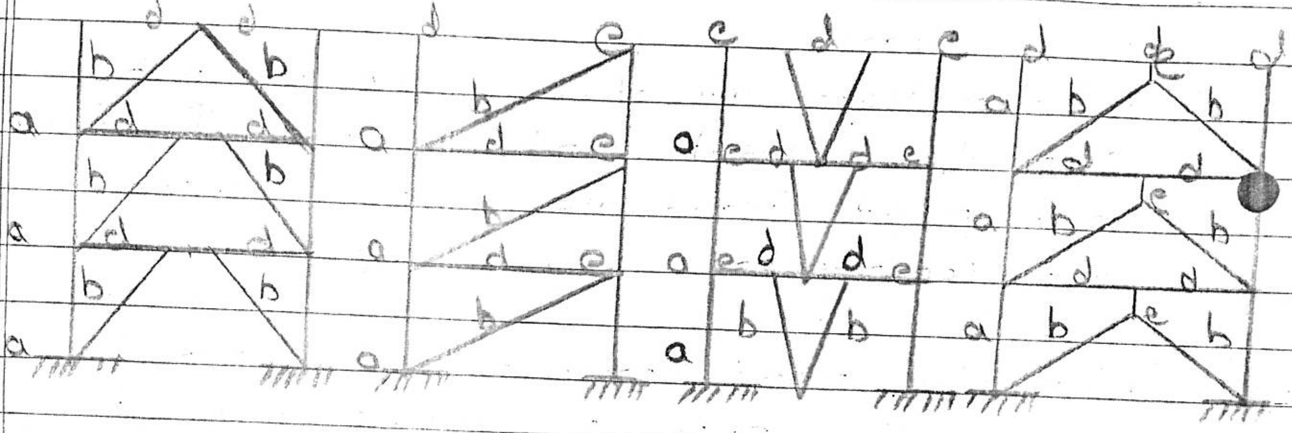
V-bracing   Inverted Bracing   Zipper Bracing.   X-bracing.



Diagonal Bracing

Both v-braced and Inverted v-braced frames perform poor because of buckling of brace, & excessive flexure of beam at midspan where the brace interact the beam.

ii] Ecentric Braced frames:-



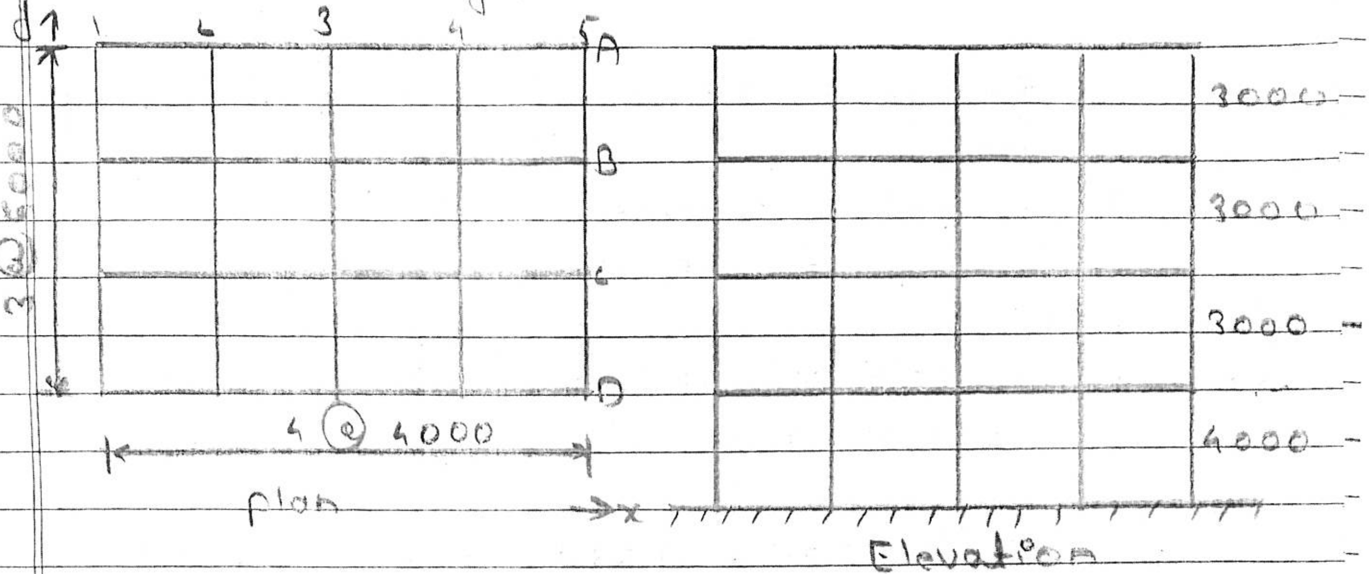
a - column   b - base   e - link
d - portion of beam outside of link.

Eccentricity braced framed is a framing system in which the forces induced in the braces are transfered either to column or to another base through shear & bending in a small segment of Beam called the link.

The link is segment of a beam that is

By selecting suitable frame stiffness & yeild level that is possible to resist moderate earthquake elastically with only moderate displacement and to resist major earthquake elastically.

Q.2) Design Bracing system for the building for the following data.



Zone factor for zone V = 0.36.

Importance factor = 1

Response Reduction = 4

Load - F.F = 1 kN/m² —— assume.

assume load from roof = 1 kN/m²

L.L = 2.5 kN/m² for all floor except roof - 1.5 kN/m²

Seismic wt =

Dead loads = SF of slab = 0.12 × 25 = 3 kN/m².

F.F = 1 kN/m²

4 kN/m²

Beam = ISMB 400 = 15 × 4 × 0.616 = 36.96 kN.

ISMB 225 = [(15×2) + (16×4)] × 0.312 = 29.33 kN.

Load of column = ISHB 450 = 4 × 14 × 0.872

= 48.83 kN.

Total load on wall = 15.63 × (16×2 + 15×2)

= 968.97 kN.

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Floor load = 16 × 15 × 4 = 960 kN.

Live load calculations.

∵ live load is 2.5 kN/m² < 3 kN/m² only 25% load considered

at roof = 1.5 × 0.25 × 16 × 15 = 90 kN.

at other floor = 2.5 × 0.25 × 16 × 15 = 150 kN

W_1 = 36.96 + 29.33 + 48.83 + 968.97 + 960 + 150
= 2194.09 kN

$W_2 = W_3$ = 36.96 + 29.33 + 36.624 + 712.287 + 960 + 150
= 1925.21 kN

W_4 = 36.96 + 29.33 + 18.31 + 960 + 90 = 1134.6 kN

Equivalent lateral force method,

i) Natural period = $T_a = 0.09\, h/\sqrt{d}$

$\therefore T_{ax} = 0.09 \times 13/\sqrt{16} = 0.293$

$\therefore T_{ay} = 0.09 \times 13/\sqrt{15} = 0.302$

$S_a/g_x = 2.5$ $S_a/g_y = 2.5$

$V_B = A_h \cdot W$

$\therefore A_{hx} = \dfrac{Z \cdot I \cdot S_a}{2 \cdot R \cdot g} = \dfrac{0.36 \times 1 \times 2.5}{2 \times 4} = 0.1125$

W = 7179.11

V_x = 7179.11 × 0.1125 = 807.24

V_{oy} = 7179.11 × 0.1125 = 807.64.

Calculation of lateral loads:

storey	w_i	h_i	$w_i h_i^2$	$\frac{w_i h_i^2}{\Sigma w_i h_i^2}$	Q_i	V_B
4	1186.4	13	191747.2	0.373	301.24	301.24
3	1925.21	10	192521	0.375	302.86	604.12
2	1925.21	7	94335.29	0.184	148.61	752.73
1	2194.09	4	35105.44	0.068	54.92	807.63

Design of Bracing system.

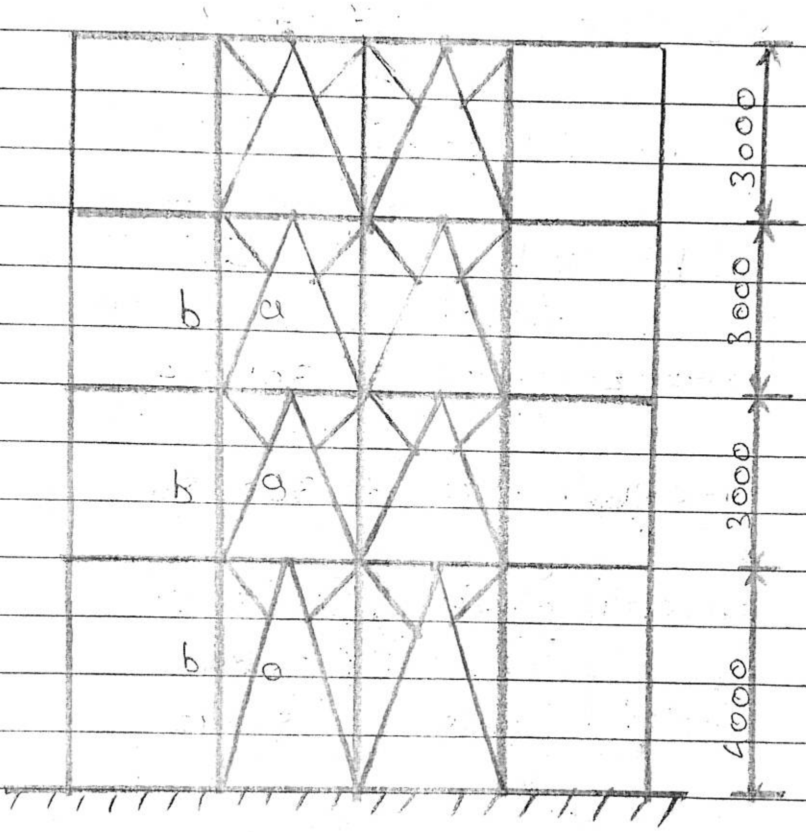
Lateral force to be resisted = $\frac{807.65}{2}$ = 403.82

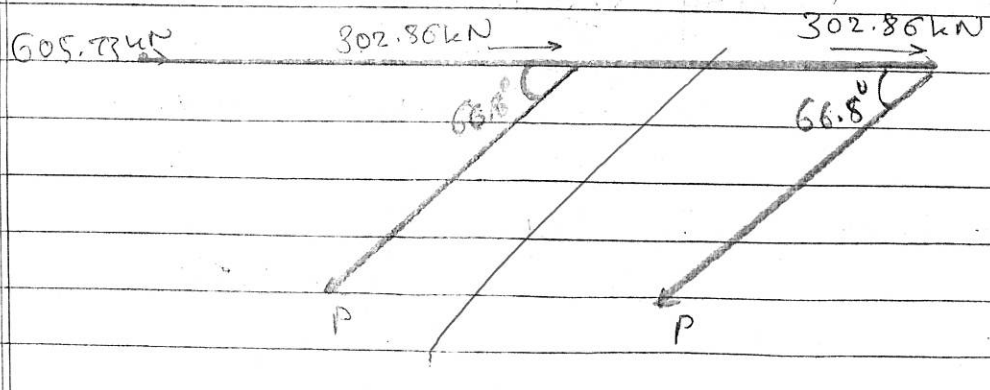
Design force of bracing
partial safety factor = γ_f = 1.5.
Lateral load = 1.5 × 403.82 = 605.73.

Bracing has been provided on both faces.
Lateral loads for each brace = 605.73/2
= 302.86 kN.

∴ design force in each brace = $\frac{302.86}{\cos 66.8}$

= 768.81 kN.





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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Test- 5 **Date: 3 Dec 2020**

Q.1	Explain types of lateral load resisting systems.	(10 Marks)
Q.2	Explain steps for computation of design lateral forces on RC shear walls.	(10 Marks)

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Name : Prathamesh Dhole
SUB : ADREC
Roll No: 19ST004

15/20

Test No 05

Q.1) Explain types of lateral load resisting systems.

1) Moment Resisting frames

This types of LFR's is made up of columns of beams that resist lateral loads by having the members of the structure flex under pressure and via the stiffness of joints connecting the columns and beams.

Advantage
- It can be modified for various types of architectural design and/or layouts.

Disadvantage
- Can drift and deflect more when compared to other types of LFR's.
- Joints can become points of accumulated stress.
- Precise construction of the frame is essential to resist lateral loads effectively can be expensive.

2) Braced frames

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- This types of LFR's uses a combination of truss made up of steel beams/members. Due to the nature of construction of truss - diagonal beams connecting parallel beams.
- lateral loads get transferred into axial stress via compression or tension. Those two basic types of braced frames

a) Concentric frames
Concentric frames have beams connecting diagonally at the end of elements. This develops truss action creating stiffness that can resist lateral loads.

b) Eccentric frames.
Eccentrically braced frames are used to support axial beams especially. This essentially creates a frame with increased flexibility

→ Advantages
- Can be located internally or externally to provide flexibility to architectural design
- Accomodates service penetrations.
- Can be located within portion walls
- No need for moment connections.

→ Disadvantages:
- Produces problems for layout of windows and doors due to obstruction by bracings
- Requires fireproofing materials for steel members which takes up spaces.
- Need for large gusset plates for bracing connections between the beams and columns.

3) Shear Walls
- Shear walls resist lateral forces due to cantilever action principle shear walls must be symmetrically placed in any design.
- This type of LFR's is usally constructed using concrete or stonework, supporting beams can provide vertical reinforcement of reduce flexure, conversly gaps space and holes in shear walls

Advantage
1) Shear walls can be used for other purpose apart from load bearing - they can be used as stairs or walls in compartment areas for fire, sanitation or maintainence or even in lifts shafts
2) They are stiff and are inherently resilient structures when placed under heavy loads.

classmate
Date
Page

Shear walls can be considered relatively cost-effectively as there are usually fewer a required to be constructed for a safe design.

Disadvantages
- Considering: shear walls are used to support entire sections of building, stress can be pronounced in the LFRS.
- The presence of gaps, openings and spaces can result in lower levels of strength and stiffness
- shear walls themselves can weigh a lot. This weight can put pressure on foundation of the buildings.

Q.2
Steps for computation of lateral forces on RC shear walls are given below

Steps 1) Computation of seismic weight of building as per the codal provisions the percentage of design live load to be considered for the calculation of earthquake forces is 25% for the floors & live load for the roof is not to be accounted for
- Calculate effective weight of each floors and roof due to dead load and live load.
- Calculate effective weight of each floors beams on all floors and roof
- Calculate weight of columns on each floors and roof.

08

weight of columns on roof = ½ wt. of columns on floors

Step 2 Finding Basic Shear

- fundamental time period of vibration (T)

(IS1893 P1 Clause 7.6
$T_a = 0.075 h^{0.75}$ → for RC frame structures } Moment resisting frames
$T_a = 0.085 h^{0.75}$ → for steel frame structures } buildings with brick infill panel

h = height of building
d = Base (direction) of building dimension.

- Zone factor = Z (IS 1893 P1) clause 6.4.2
- Importance factor = I (IS 1893 P-1) table 7.6
- Responce reduction factor (R) = (IS 1893 P1) table 7
- Sa/g (avg response acceleration coeff) depends upon soil type & time period (T)
  (IS 1893 P-1) clause 6.4.5.

- Design horizontal seismic coefficient (Ah) = $\frac{Z}{I} \times \frac{I}{R} \times \frac{Sa}{g}$

Base shear (V_B) = Ah·w.

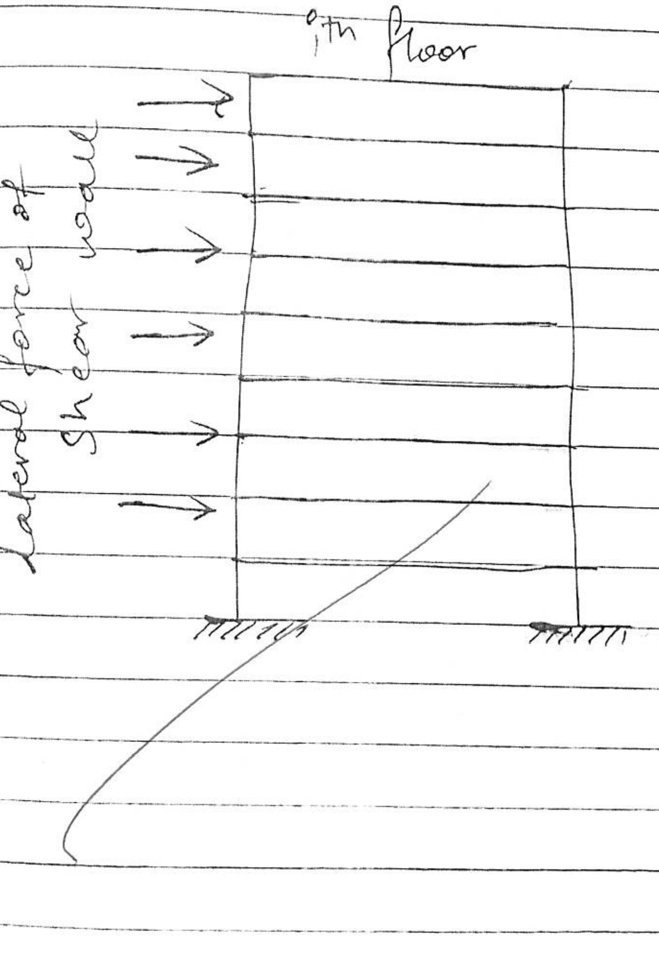
Step 3 Computational of lateral forces & shear wall forces at various floor levels

Design lateral forces at floors $Q_i = \frac{V_B}{\sum_{j=1}^{n} w_j h_j^2} \times w_i h_i^2$

Table for calculation of lateral forces and shear forces

Mass No. / floor No.	w_i KN	h_i KN	$w_i h_i^2$	$\frac{w_i h_i^2}{\Sigma w_j h_j^2}$	Q_i KN	V_i KN

w_i → weight of floor
h_i → height of floor from G.L.
Q_i → Lateral force on shear wall
V_i → shear force



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DEPARTMENT OF CIVIL ENINEERING

Analysis and Design of Earthquake Resistant Structures

Test- 6 **Date: 4th Dec 2020**

Q.1	Explain Spring mass model for seismic analysis	(05 Marks)
Q.2	An Intze shape watertank of 300 m^3 capacity is supported on RC staging of 6 columns tied with horizontal bracing at 4 level sizes of column and bracing 350 x 650mm. Staging confirms to ductile detailing as per IS 13920 grade of concrete M20 and steel Fe 415. Tank is located on hard soil in zone IV analyse tank for seismic loads Ks = 185 x 10^5 N/m (Consider tank full conditiononly)	(15 Marks)

Subject Incharge

HOD, Civil Engg Dept

18/20

Test-6 (ADERS)

Name: Siddharth Sunil Bhavsar

Q.1] Explain spring mass model for seismic analysis.

=> When tank containing liquid with a free surface is subjected to horizontal earthquake ground motion, tank wall and liquid are subjected to horizontal acceleration. The liquid in the lower region of tank behaves like a mass that is rigidly connected to tank wall. This mass is termed as impulsive liquid mass which accelerates along with the wall and induces impulsive hydrodynamic pressure on tank wall and base. Thus, total liquid mass ~~which~~ accelerates gets devided into two parts; i) Impulsive mass and ii) Convective mass.

In spring mass model of tank liquid system, these two liquid masses are to be suitably represented. A qualitative description of impulsive and convective hydrodynamic pressure distribution on tank wall and base is given. Sometimes, verticle columns and shaft are present inside the tank. This elements causes obstruction to sloshing motion of liquid. In the presense of such obstructions, Impulsive and convective pressure distributions are likely to change. However, it is reasonable to expect that due to presense of such obstructions impulsive and will in increase and convective pressure will decrease.

Derivation for single mass

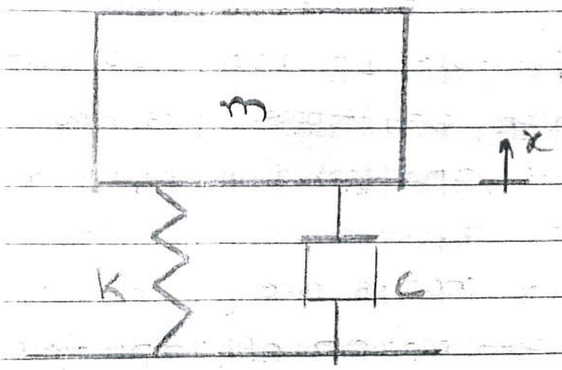
Deriving the equation of motion for this model is usually done by examining the sum of forces on the mass

$\Sigma F = -kx - c\dot{x} + \omega_n^2 x = u$ where

$\omega_n = \sqrt{\frac{k}{m}}$, $\xi = \frac{c}{2m \cdot \omega_n}$ $u = \frac{F_{external}}{m}$

ω_n is the undamped natural frequency

ξ is the damping Ratio.



Q.2) An Intze shape watertank of 300m² capacity is supported on RC staging of 6 columns tied with horizontal bracing at 4 level sizes of column and bracing 350 x 650mm staging confirms to ductile detailing as per IS: 13920 grade of Concrete M20 and steel Fe415. Tank is located on hard soil zone IV analyse tank for seismic loads $K_s = 1.15 \times 10^5$ N/m (consider tank full conditionally).

=> Given:

wt. of empty water tank = 1576 kN.

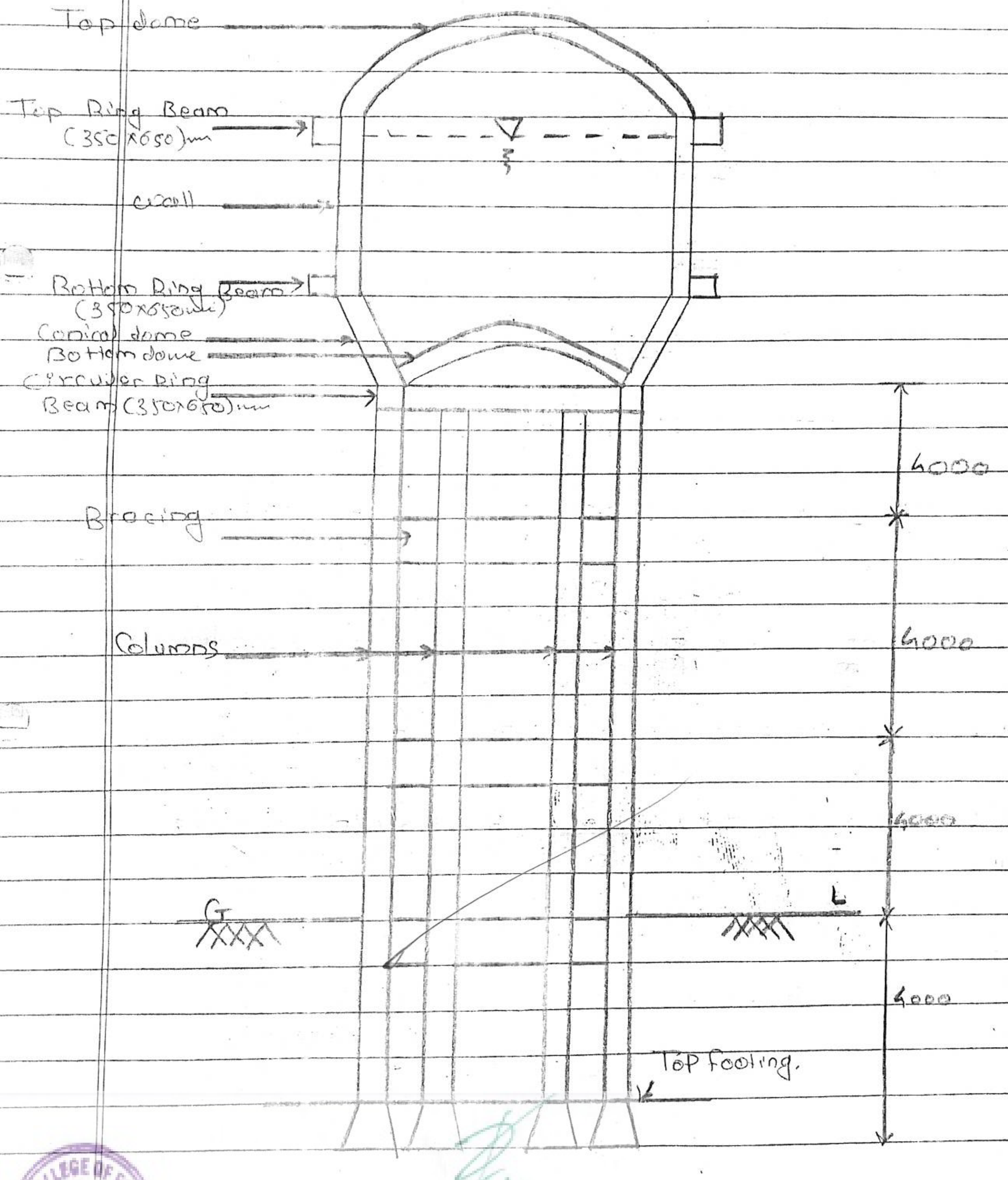
wt. of staging plus bracing = 1036 kN

Vol. of water = 255.658 m^3

14

Mass of water = 255658 kg

C.G. of height from bottom of tank = 2.88 m



Step 17 → Hydrodynamics and spring mass model parameter for fluid.

∴ Vol. of water = $\frac{\pi D^2}{4} \times h$

∴ $h = \frac{255.658}{\frac{\pi}{4} \times 8.6^2}$

= 4.4 m

$h/d = 4.4/8.6 = 0.51$

For parameters of spring mass

i) $\frac{m_i}{m} = \frac{\tanh(0.866 \frac{D}{h})}{0.866\ D/h} = \frac{\tan(0.866 \times 8.6/4.4)}{0.866 \times 8.6/4.4}$

∴ $\frac{m_i}{m} = 0.55$

∴ $m_i = 0.55 \times 255658 = 140.612$ kg

ii) ∴ $m_c/m = 0.23 \frac{\tanh}{h/D} (3.68 \times h/D) = 0.43$

∴ $m_c/m = 0.43$

∴ $m_c = 0.43 \times 255.658 = 10933$ kg for h/D < 0.75

$\therefore h_i/h = 0.375$

for $h_i = 0.375 \times 4.4 = 1.65 m$

for h/D < 1.33

$\therefore \frac{h_i}{h} = \frac{0.866 \times D/h}{2 \tanh\left(\frac{0.866 D}{h}\right)} \times 0.125$

$h_i^* = 0.78 \times 4.4 = 3.43 m$

$\frac{h_c}{h} = \frac{1 - \cosh(3.68\ h/D)}{3.68 \times h/D \sinh(3.68 h/D)}$

$h_c^* = 0.78 \times 4.4 = 3.43 m$

$\therefore k_c = 0.836\ mg/h . \tanh^2\left(3.68 \frac{h}{D}\right)$

$= \frac{0.836 \times 255658 \times 9.81}{4.4} . \tanh^2\left(3.68 \frac{4.4}{8.6}\right)$

$\therefore k_c = 4397.32 N$

Step 2) ⇒ Dynamic parameters of structure

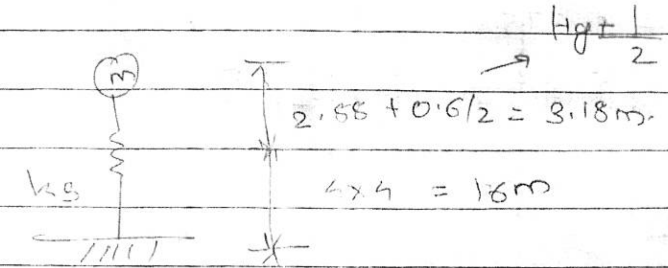
a) as per clause 4.2.2.3

m_s = Mass of empty tank + 1/3 mass of staging

$= \left(1576 + \frac{1063}{3}\right) \times 1000/9.81 = 195821 kg$

ks = lateral stiffness of staging

ks = 178 × 10^5 N/m



Time period of for tank full condition the tank full and staging of DOF system.

∴ Impulsive mode (T_i) = CJ = 43.13

$$\therefore T_i = 2\pi \sqrt{\frac{140612 + 195821}{178 \times 10^5}}$$

$\therefore T_i$ = 0.80 sec

∴ convective mode (T_v)

$$\therefore T_v = 2\pi \sqrt{\frac{107933}{439732}}$$

= 3.14 sec

Step 3] ⇒ Base shear moments tank full condition (check for tank empty).

I] tank full condition

A] Impulsive mode

$$(A_h)_i = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$

I = Importance factor given in table I = 1.5
R = 2.5 for SMRF

Sa/g — Damping is 5%
T_i = 0.5116
∴ $(Ah)_i = \frac{0.24}{2} \times \frac{1.5}{2.5}$ (1/6)

∴ $(Ah)_i$ = 0.084

B] Convective mode
$(Ah)_c = \frac{Z}{2} \times \frac{I}{R} \times \frac{Sa}{g}$

$(Ah)_c = \frac{0.24}{2} \times \frac{1.5}{2.5} \left(\frac{1}{3.14} \times 1.75 \right)$

∴ $(Ah)_c$ = 0.04

Base shear
Impulsive mode
$V_i = (Ah)_i \times (m_i \times m_s) \times f$
= 0.084 × (140812 + 195821) × 9.81
= 277 kN

Convective Mode
$V_c = (Ah_c) \times (m_c) \times g$

= 0.04 × 109933 × 9.81
= 431 kN

By SRSS Rule

$V_{total} = \sqrt{V_i^2 + V_c^2} = \underline{280 kN}$

Base Moment

Impulsive mode

$M_i^* = (Ah)_i [m_i (h_i^* + h_s) + m_s \times h_{cg}] \times g.$

$= 0.084 [140612 (3.43 + (6.3) + 195821 \times 9.81] \times 9.81$

$= \underline{5381 kN.m}$

Convective mode

$M_c^* = (Ah)_c \cdot m_c (h_c^* + h_s) \times g$

$= 0.04 \times 19933 \times (3.43 + 16.3] \times 9.81$

$= \underline{85 kN.m}$

$\therefore M^* = \sqrt{M_i^{*2} + M_c^{*2}} = \underline{5448 kN.m}$