

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 6, Issue 10, October 2017

Method of Analysis and Design of RC High Rise building

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ABSTRACT: Generally engineers, man of science and call manufacturers have determined the behavior of structures victimisation linear static elastic finite component analysis together with summations of vertical column masses. whereas building height will increase in construction section, the structural responses, i.e. axial masses, bending moments and displacements, of such typical analysis could more and more diverge from actual behavior. Time-dependent, long-term, deformations in response to construction sequence will cause distribution of responses that may not be computed and thought of by standard ways. This analysis was complicated in nature then several parameters ought to be taken under consideration throughout analysis. however currently advancement of finite component modeling and simulation has created nonlinear analysis simple, well managed and common among engineers, researchers and call manufacturers that accelerate correct style of structures particularly high-rise. A high rise building is defined as a building 35 meters or greater in height, which is divided at regular intervals. High rise buildings are generally preferred because it saves the cost of land in the restricted places and where the place is limited. Due to the increased demand of high rises and decreased availability of space, high rises are now mushrooming especially in cities. Generally, in the major cities, the cost of the land will be very high.

I. INTRODUCTION

Structural design can be defined as a mixture of Art and Science, combining the Engineer's feeling for the behavior of structure with the sound data of the principle of data point, dynamics, mechanics of materials, and structural analysis, to supply safe economical structure which will serve its supposed purpose. Any structure is made up of structural elements (load carrying, such as slabs, beams and columns) and non-structural elements (such as partitions, ceilings, doors). The structural elements put together, constitute the 'structural system'. Its perform is to resist effectively the action of gravitative and environmental masses, and to transmit the ensuing forces to the supporting ground, while not considerably worrisome the pure mathematics, integrity and usability of the structure. A sturdy structure is one, which might safely carry the forces and might serve the due perform satisfactorily throughout its expected service lifetime.

An engineering structure is an assembly of members or elements transferring the load (or resisting external actions) and providing a form, space, an enclosure and/or a cover to serve the desired function.

The structural style is Associate in Nursing art and science of planning, with economy and magnificence, a safe, serviceable, and a sturdy structure. A sturdy structure is one, which might safely carry the forces and might serve the required operate satisfactorily throughout its service life. the whole method of structural coming up with and style needs not solely imagination and abstract thinking (which kind art of designing) however additionally sound information of science of structural engineering besides information of sensible aspects, adore relevant style codes and bye-laws, secured by ample expertise, intuition and judgment.

The objective of structural design is to plan a structure, which meets the basic requirements of structural design. The objectives are as follows:

- ✓ Serviceability

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- ✓ Safety
- ✓ Durability
- ✓ Economy
- ✓ Aesthetic value
- ✓ Feasibility, practicability and acceptability

II. DESIGN ASSINING

Beams

The DXF file after it was imported is used now, the beams are assigned their designated sections as per plan



Fig 1: Beam Sections Assigned

Columns:

Columns are placed just by one click at the position to the required positions. Columns which have the ratio of the longer side to shorter side greater than four can be assigned as walls.

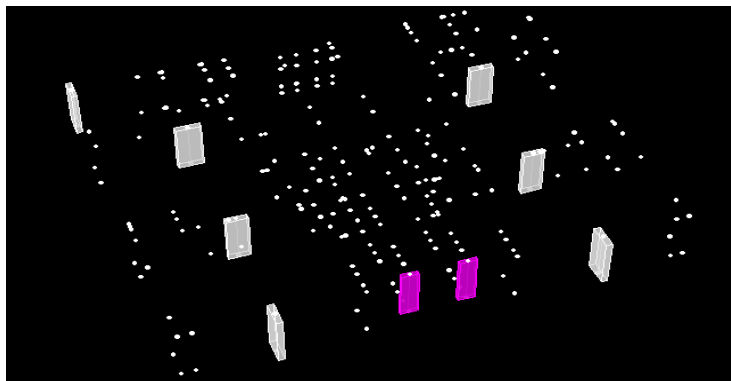


Fig 2: Coloumn Posistion Assigned (3D View)

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Walls:

Columns which have the ratio of the longer side to shorter side greater than four can be assigned as walls.

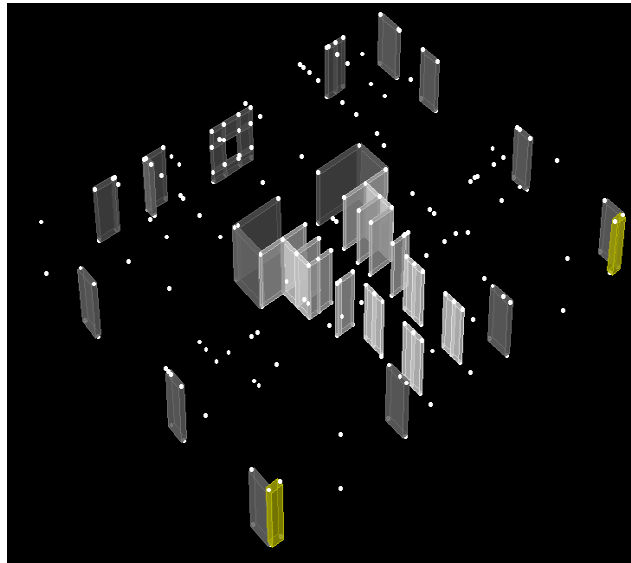


Fig 3: Wall Sections Assigned (3D View)

Slabs:

Slabs are created by create slabs command. It should be made sure that the slab is placed by clicking on all the nodes at its periphery for load distribution to take place at the required joints.

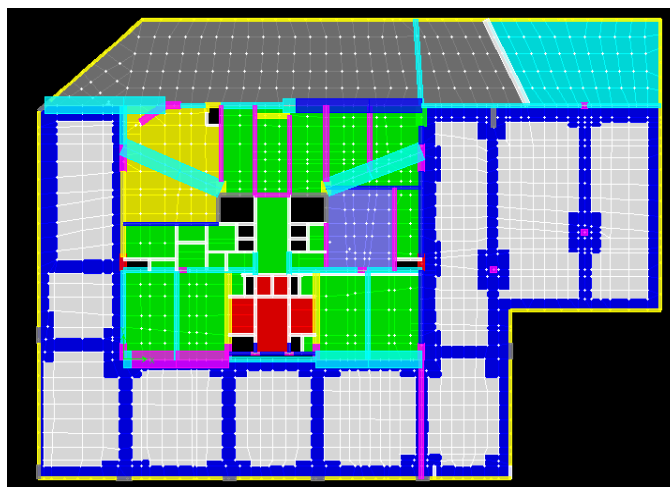


Fig 4 : Slabs Assigned.

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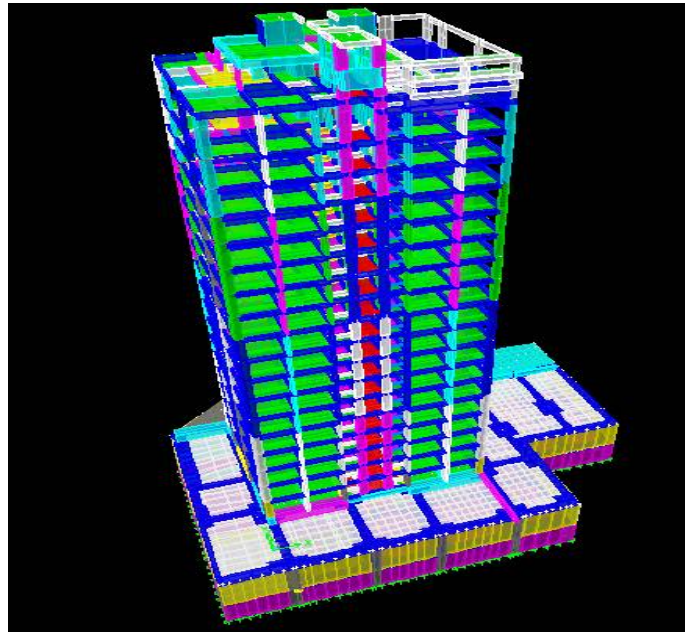


Fig 5: ETABS 3D model

Comparison between sequential analysis and linear static analysis results for a Girder beam. (Dead and dead sequential case).

Table 1: Comparison of sequential analysis results and linear static analysis

MOMENTS:

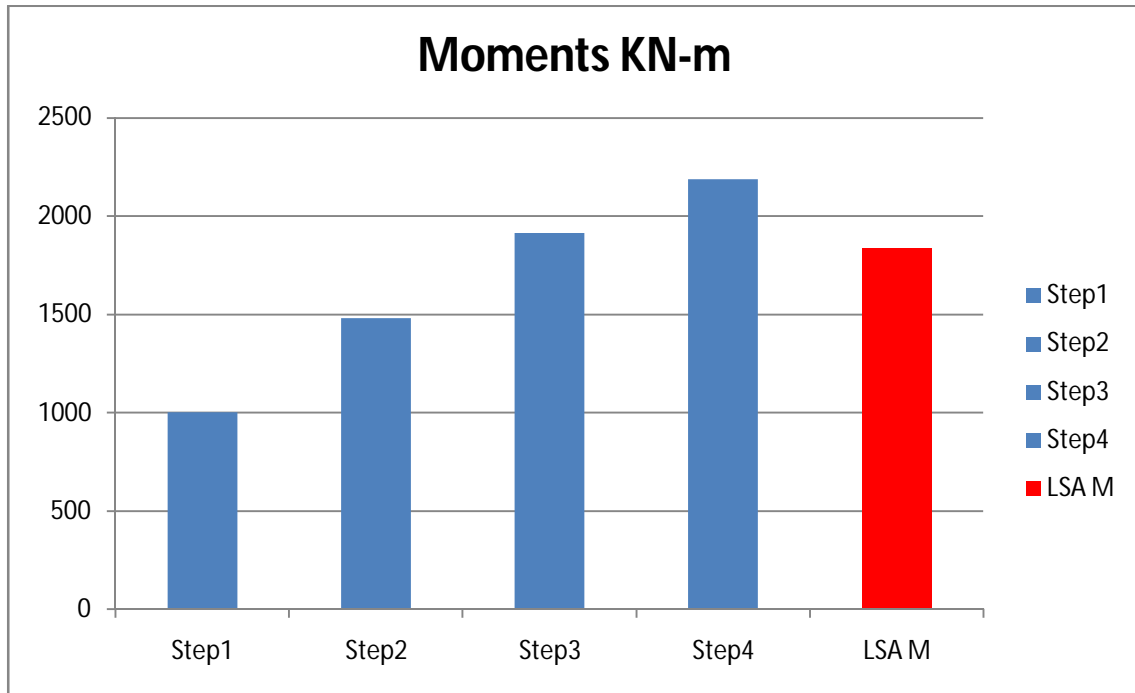
	Material	Construction sequential analysis				Linear static analysis
		Step1	Step2	Step3	Step4	
Moment KN-M	RCC	1003.20	1481.82	1912.655	2189.01	1837.23
Shear KN	RCC	323.20	436.13	549.28	624.38	533.01
Displacement	RCC	1.59	2.259	2.89	3.30	3.30

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MOMENTS:

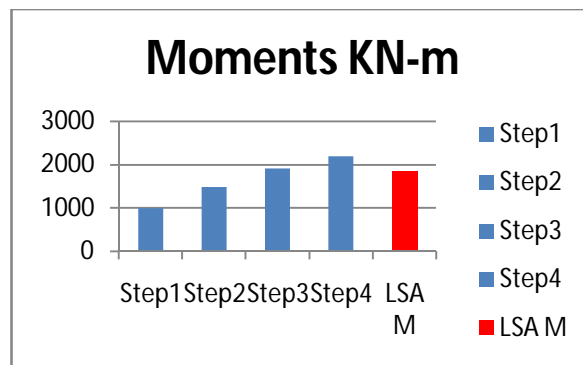


Fig 6: CSA vs LSA moments

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SHEAR FORCE:

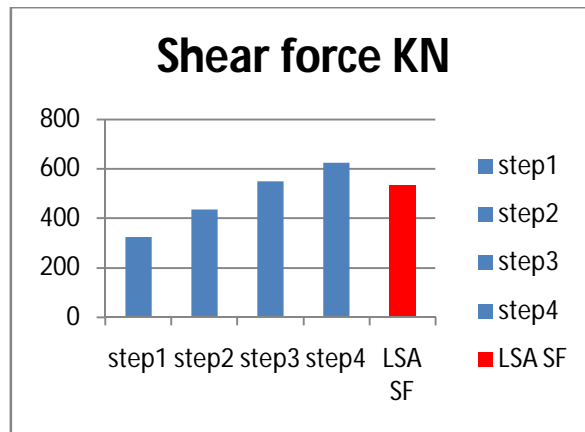


Fig 7: CSA vs LSA shear force

DEFLECTION:

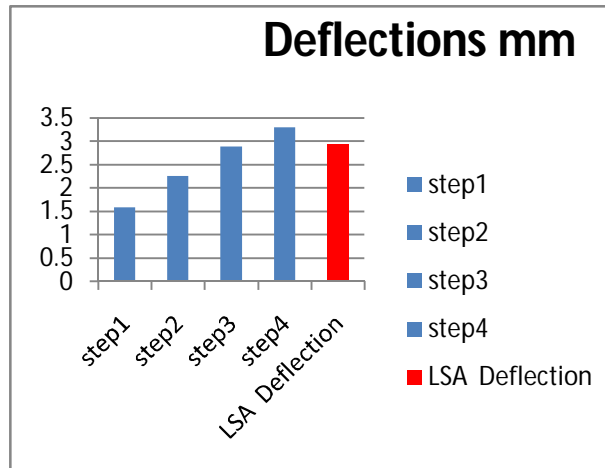


Fig 8: CSA vs LSA Deflection

TYPICAL DESIGN OF BEAM

Beams size 200 x 650mm
Assume $F_{CK} = 25 \text{ N/mm}^2$
 $F_y = 500 \text{ N/mm}^2$

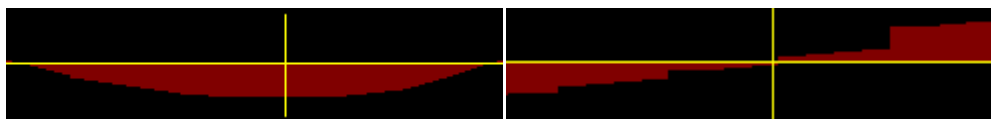


Fig 34: Beam results from ETABS

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Bending moment shear force

From ETABS, analysis

$$M_u = 135.779 \text{ KN-m}$$

$$T_u = 10.91 \text{ KN-m}$$

$$V_u = 162.91 \text{ KN}$$

$$d = 850 \text{ mm}$$

$$M_t = (T_u/1.7) \{1 + (D/b)\}$$

$$M_t = (10.91/1.7) \{1 + (800/200)\} = 35.29 \text{ KNm}$$

$$M_{el} = M_u + M_t$$

$$M_{el} = 135.779 + 35.29 = 171.077 \text{ KNm}$$

$$D_{\text{required}} = \sqrt{((171.077 \times 10^6) / (0.1336 \times 25 \times 200))}$$

$$= 506.066 < d_{\text{provided}}$$

Therefore, hence design as singly reinforced beam.

$$M_{el}/bd^2 = (171.077 \times 10^6) / (200 \times 850 \times 850) = 1.18$$

From Table 3 of SP-16, corresponding to $M_u/bd^2 = 1.18$, we have

$$p_t = 0.2878. \text{ So,}$$

$$A_{st} = 0.2878(200)(850)/100 = 491.07 \text{ mm}^2.$$

Provide 3-10mm in tension and 2-10mm in compression

$$V_e = V_u + 1.6(T_u/b)$$

$$= 162.90 + 1.6(10.91/0.20) = 249.28 \text{ kN}$$

The equivalent shear stress,

$$\tau_{ve} = (V_e / bd) = (249.28 \times 10^3) / (200 \times 850) = 1.466 \text{ N/mm}^2$$

From (Table 20 of IS 456), $\tau_{c \text{ max}} = 3.1 \text{ N/mm}^2$. Hence, the section does not need any revision.

$$\tau_{ve} < \tau_{c \text{ max}}$$

From Table 19, for value of

$$p_t = 1.18, f_{ck} = 25$$

$$\tau_c = 0.37 \text{ N/mm}^2$$

$$\tau_c < \tau_{ve}$$

SHEAR REINFORCEMENT REQUIRED

Assuming 2L stirrups of 10mm dia

$$V_{us} = (\tau_{ve} - \tau_c) * b * d$$

$$= (1.466 - 0.37) * 200 * 850$$

$$= 186.32 \text{ KN}$$

$$S_v = (0.87 * f_y * A_{sv} * d) / V_{us}$$

$$= (0.87 \times 415 \times 2 \times 50.2 \times 850) / (249.27 \times 10^3)$$

$$= 123 \text{ mm (Minimum} = 120 \text{ mm)}$$

PROVIDE 8mm DIA 2L @120mm C/C

DESIGN OF SLAB:

1. DATA

$$L_x = 4.05 \text{ m}$$

$$(L_y/L_x) = (4.60 / 4.05) = 1.13 < 2$$

$$L_y = 4.60 \text{ m}$$

$$F_{ck} = 25 \text{ N/mm}^2$$

$$F_Y = 500 \text{ N/mm}^2$$

Since the ratio of long to short span is less than 2, the slab is designed as two way slabs.

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2. DEPTH OF SLAB

Assume overall depth $D = 150$ mm
Along shorter direction, $d = 121$ mm
Along longer direction, $d = 113$ mm
Clear Cover = 25 mm
Dia of Bar = 8 mm

3. LOADS

Self weight of the slab = $(0.15 \times 25) = 3.75 \text{ kN/m}^2$
Floor finish = 1.33 kN/m^2
Live load = 2 kN/m^2
Total service load = 7.75 kN/m^2
Ultimate load = $w_u = (1.5 \times 7.75) = 11.63 \text{ kN/m}^2$

4. CALCULATION OF BENDING MOMENT COEFFICIENTS:

From IS: 456-2000, table 26, pg 91, bending moment coefficients at different span edges. Two Adjacent edges discontinuous

C o e f f i c i e n t	Continuous edge (-VE)	Mid span (+VE)
α_x	0 . 0 5 6	0 . 0 4 2
α_y	0 . 0 4 7	0 . 0 3 5

$$M_x = \alpha_x w l_x^2$$

$$M_y = \alpha_y w l_x^2$$

5. CALCULATION OF BENDING MOMENTS:

Short Span Moments

At Continuous Edge:

$$M_x = 0.056 \times 11.63 \times 4.05^2 = -10.68 \text{ KN-m}$$

At Mid Span:

$$M_x = 0.042 \times 11.63 \times 4.05^2 = +8.011 \text{ KN-m}$$

Long Span Moments

At Continuous Edge:

$$M_x = 0.047 \times 11.63 \times 4.05^2 = -8.96 \text{ KN-m}$$

At Mid Span:

$$M_x = 0.035 \times 11.63 \times 4.05^2 = +6.68 \text{ KN-m}$$

Check for effective depth required:

$$M_u = 10.68 \text{ KN-m}$$

$$d_{\text{req}} = \sqrt{\frac{M_u}{0.138 f_{ck} b}}$$

$$d_{\text{req}} = 55.63 \text{ mm} < \text{Provided } 150 \text{ mm}$$

(Safe)

Calculation of Reinforcements:

$$M_{ux} - ve = -10.68 \text{ KN-m}$$

$$M_{ux} + ve = +8.011 \text{ KN-m}$$

$$M_{uy} - ve = -8.96 \text{ KN-m}$$

$$M_{uy} + ve = +6.68 \text{ KN-m}$$

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At Continuous Edge of short span

$$\frac{M_u}{bd^2} = 0.73$$

From SP 16, $P_t = 0.178\%$

$$A_{st} = 215.38 \text{ mm}^2$$

Assuming #8 mm Bars

$$c/c \text{ spacing} = (50.26 \times 1000 / 215.38) = 233.35 \text{ mm}$$

Spacing should exceed:

- $3d = 3 \times 125 = 375 \text{ mm}$
- 300 mm

∴ Provide #8 @ 220 mm c/c

At mid span of Short span

$$\frac{M_u}{bd^2} = 0.55$$

From SP 16, $P_t = 0.13 \%$

$$A_{st} = 157 \text{ mm}^2$$

Min. % of Main reinforcement required = 0.12%

$$A_{st \text{ min.}} = 0.12 \times 1000 \times 150 / 100 = 180 \text{ mm}^2$$

Assuming #8 mm Bars

∴ Provide #8 @ 275 mm c/c

At Continuous Edge of long span

$$\frac{M_u}{bd^2} = 0.7$$

From SP 16, $P_t = 0.167 \%$

$$A_{st} = 202.07 \text{ mm}^2$$

∴ Provide #8 @ 225mm c/c

At mid span of long span

$$\frac{M_u}{bd^2} = 0.52$$

From SP 16, $P_t = 0.11 \%$,

$$A_{st} = 133 \text{ mm}^2$$

Min. % of Main reinforcement required = 0.12%

$$A_{st \text{ min.}} = 0.12 \times 1000 \times 150 / 100 = 180 \text{ mm}^2$$

$$A_{st} = 180 \text{ mm}^2$$

∴ Provide #8 @ 275 mm c/c

Check for shear:

$$M_{ux} = w_u l^2 / 8$$

$$10.8 = w_u * (4.05^2) / 8$$

$$w_u = 5.26 \text{ KN}$$

Therefore, $V_{ux} = w_u l / 2$

$$= 5.26 * 4.05 / 2$$

$$= 10.65 \text{ KN}$$

$$\tau_u = V_{ux} / bd$$

$$= 10.65 * 10^3 / (1000 * 121)$$

$$= 0.088 \text{ N/mm}^2$$

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From IS: 456 – 2000, table 19

$$P_t = 215.38 * 100 / (1000 * 121)$$

$$= 0.178\%$$

$$\tau_c = 0.78 \text{ N/mm}^2$$

Here $\tau_u < \tau_c$ * ok

Hence safe in shear.

6. CHECK FOR DEFLECTION:

$$P_t = 0.12\%$$

$$F_s = 0.58 \times F_y \times \frac{\text{Area of c/s steel required}}{\text{Area of c/s of steel provided}}$$

$$F_s = 0.58 \times 500 \times \frac{180}{415} = 242$$

$$(L/D)_{\text{max}} = 26 \times K_t = 20 \times 1.769 = 45 \text{ mm}$$

$$(L/D)_{\text{provided}} = 4050 / 150 = 27 \text{ mm}$$

$(L/D)_{\text{provided}} < (L/D)_{\text{max}}$, Safe in deflection.

Typical Design of Stair case:

Staircase room = 2.6x 4.75m

Floor height = 3.05m

Live load = 3 KN/m²

Treads = 300 mm

Rise = 145.2mm

Height of each flight = 3.05 / 2 = 1.525m

No of rises in each flight = 1500 / 145.2 = 11

No of treads in each flight = 11 - 1 = 10

Width of landing = 1.2m

$$\begin{aligned} \text{Effective span} &= \text{Going} + \text{landing} + \text{bearing} / 2 \\ &= (0.3 \times 10) + (1.2) + (0.15 / 2) = 4.3 \text{ m} \end{aligned}$$

Assuming the waist slab thickness = 150mm

To meet durability of concrete in moderate condition and 2 hrs fire resistance [from table 16 and 16 A of IS 456-2000 pg 47] nominal cover required 30mm.

Taking clear cover = 30 mm

Assuming bar diameter for main reinforcement as 10mm

Effective depth $d = 150 - 30 - 10 / 2 = 115 \text{ mm}$

Loads on-going:

$$\text{Self weight of slab} = 0.150 \times 25 = 3.75 \text{ KN/m}^2$$

Equivalent of this load in plan (on Horizontal plane)

$$\begin{aligned} &= \text{load on slope} \times \frac{\sqrt{R^2 + T^2}}{T} \\ &= 3.75 \times \sqrt{(300^2 + 145.2^2)} / 300 = 4.166 \text{ KN/m}^2 \end{aligned}$$

$$\text{Self weight of steps} = \text{average rise} \times \text{density} = (0.145.2 / 2) \times 25 = 1.815 \text{ KN/m}^2$$

Live load = 3 KN/m²

$$\text{Floor finish (50mm thick)} = 0.05 \times 25 = 1 \text{ KN/m}^2$$

$$\text{Total load on stair} = 4.166 + 1.815 + 1 + 3 = 9.99 \text{ KN/m}^2$$

$$\text{Factored load } w_1 = 1.5 * 10 = 15 = 20$$

Calculations for landing:

Provide landing slab thickness = waist slab thickness

$$\text{Dead load of landing} = 0.15 * 25 = 3.75 \text{ KN}$$

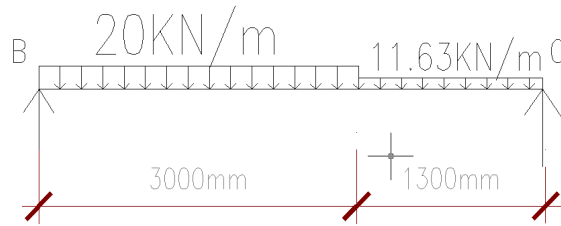
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Floor finishes = 1 KN
Live load = 3KN
Ultimate load $w_2 = 11.625$



$$R_a = w_1 a(2l - a) + w_2 c^2 / 2L = 41.2 \text{ KN}$$

$$R_b = w_2 c(2l - c) + w_1 a^2 / 2L = 33.76 \text{ KN}$$

M max at $X = R_1 / W_1$ when $R_1 < w_1 a = R_1^2 / 2w$
 $X = 2.1$
M max = $R_1^2 / 2w_1 = 42.43 \text{ KN-m}$

Check for effective depth:

For balanced section, $M_U = M_{U,lim} = 0.133 f_{ck} b d^2$

From SP-16, $P_t = 0.478 \%$

$$A_{st} = 717 \text{ mm}^2$$

Main steel; provide 12 # @ 115 mm c/c

Distribution steel: 0.15% of gross area

Provide 8 # @ 200 mm c/c.

Check for shear:

$$V_u = \text{reaction} = 41.2 \text{ KN}$$

$$\tau_u = V_u / b d = 41200 / (1000 * 125)$$

$$= 0.3296$$

$$\text{Min \% of steel } 100 A_{st} / b d = 0.478$$

$$\tau_c = 0.49$$

Here $\tau_u < \tau_c$ * ok

$$d = \sqrt{\frac{M_u}{0.133 f_{ck} b}} =$$

$$\sqrt{\left(\frac{42.43 \times 10^6}{0.133 \times 25 \times 1000}\right)} = 112.9 \text{ mm} < 150 \text{ mm}$$

Hence it is safe.

Reinforcement:

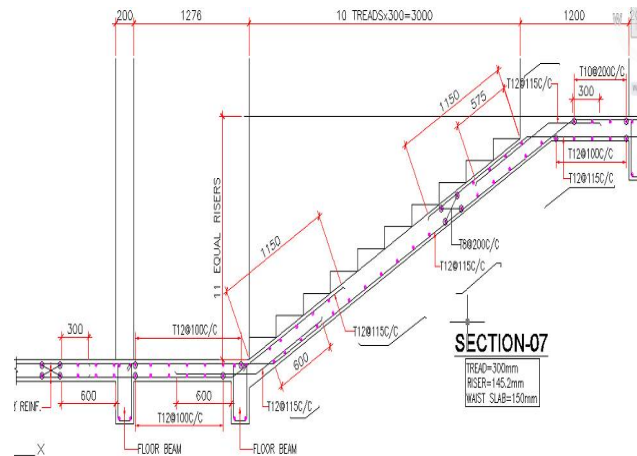
$$\frac{M_u}{b d^2} = 1.88$$

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III. CONCLUSION

The study presented an experimental and analytical study on The study reveals the necessity of performing nonlinear static analysis becomes important with increasing slenderness while the each additional floor creates a significant load upon the columns. With increasing slenderness the necessity to perform sequential analysis considering P-Delta effects, material characteristics and nonlinear of behavior of the structures become a significant issue. Construction sequence analysis in structures of both Steel and RCC is necessary to improve the analysis accuracy in terms of displacement, axial, moment and shear force in supporting beam and column near of it and also for the whole the structure overall. Moments and shear in supporting beam are higher in sequential analysis which must be considered during manual or computer aided design in the design phase for avoiding cracking of beam and column due to sequence effects.

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