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Design and Analysis of Residential Building

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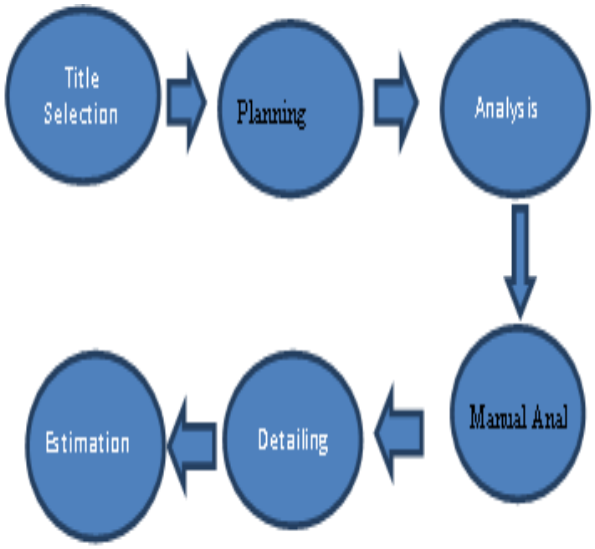
Abstract:
The Project has been taken as the design of a Residential Building. The project deals with the planning, analysis, design, detailing, and estimation of a Residential Building. The purpose of our project is to gain knowledge in the field of design and applying the design principles in a practical way. The structure has been designed by using STAAD.Pro and detailing using AutoCAD.
The plan has been drawn on AutoCAD with reference of National Building Code (NBC) The structure has been analyzed in STAAD.Pro software. The load acting on the structure has been calculated using IS : 875- 1987 (Part- 2[2],[3]).The elements of the structure has been designed in detail by limit state method of design using IS:456:2000[1].The column of the structure designed with reference to SP 16.Finally,the reinforcement details for the structural elements have been drawn with reference of SP 34(S &T):1987[6].

INTRODUCTION

The Problem of growing population and increasing urbanization prompted us to plan a residential flat which can be ideally constructed in a rapidly growing city like Erode.The building plan is 5000 sqft. The total plinth area is 4600 Sq.ftvilla of S+2 floors with a basement for vehicle parking is proposed to be constructed. Vasthu-sastra details will also be taken into consideration during planning of the building. The earth excavation shall be carried out to the hard dense soil which is available at 1.6 m depth; the safe bearing capacity of soil is 250 kN/m^2. A concrete of mix PCC 1:2:4 shall be used for foundation.Reinforced cement concrete members like column footing, column, slab and beam shall be carried out using M30concrete and Fe 500 steel. The main walls to super structure shall be of brick work in C.M 1:6 mix using best quality first class bricks.Entire walls and all exposed RCC shall be plastered with C.M 1:5 of 12mm thick.Smooth finish for inner walls with putty and Primer from Asian paint. External walls will be Asian Paint weather coat.

METHODOLOGY



BASIC DATA

Type of building is Residential building. We have designed S+2 building. The floor to floor height is 3.28 m. The external wall width is 230 mm including plaster and internal wall width is 150 mm including plaster.Bearing capacity of Soil is 200 kN/m^2

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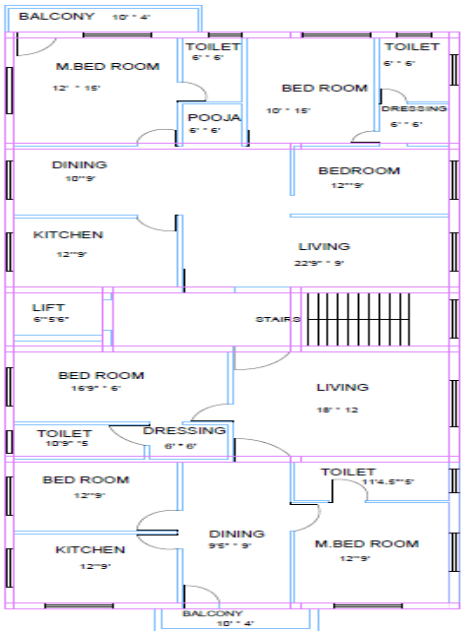
PLAN OF RESIDENTIAL BUILDING



DESIGN OF STRUCTURAL ELEMENTS

SLAB :

- Our slab dimension is 4.21 x 6.37m. we use Concrete grade of M30 and Steel grade of Fe500.To find whether the slab is one way or two way slab.we use the code book IS 456 : 2000. The ratio between effective length of major and minor axis we deduct our slab is a two way slab.
- Assume the effective depth of our slab as135 mm and we take overall depth as 175mm including cover thickness.
- Effective Span is calculated by sum of clear span and effective depth. By using code book IS 456: 2000 we take the value of clear span. By using the case as sum of clear span the effective depth results as 4.34 m and by using another case i.e. centre to centre distance of supports clear span resultsas 6.50 m.Thus we take the least value as effective span.Hence effective span is 4.34m
- Self weight of the slab is calculated by product of unit weight of concrete, breadth and depth of the slab which gives self-weightas4.37 kN/m^2. From IS 875(Part-2) the live load istaken as3kN/$m^2$and Floor Finishas 1kN/m^2.Thus total Load is 8.37 kN/$m^2$and factored load is 12.50kN/m.
- Our slab belongs to interior panel,(From IS 456[1])clause D-1.1 and 24.4.1 because our slab was completely fixed at a end of each panel,the division would be as in a fixed end beam, two third negative and one third positive as below:
- Along shorter direction, negative moment at continuous edge is taken as αx = 0.049 and positive moment at midspanas α_x = 0.036. Along longer direction negative moment at continuous edgeasα_x = 0.035 and positive moment at midspan α_y = 0.024.
- For factored bending moment we take clause D-1.1. By using this clause we get M_{ux} positive is 11.53 kNmandM_{ux} negative is 8.47kNm. M_{uy}positive is 8.24 kNm and M_{uy} negative is 5.65 kNm.
- For checking required depth, As per Is456: 2000 (clause 38.1, ANNEXG-1.1). Muis 52.77 mm.which is less than 135 mm ,therefore the adopted depth is sufficient.
- By substituting the adopted depth. M_u value is 11.53 kNm, the valve of steel i.e.,Ast is equal to 201.34 mm^2 and Ast_{min} is 210 mm^2. Using 10mm bar, spacing is 154 mm therefore we provide # 10 bars at 160 mm c/c spacing along both shorter and longer span.
- We calculate as per IS 456: 2000$(l/d)_{provided}$i.e., effective span divided by effective depth is 32.14 and $(l/d)_{basic}$=32,$(l/d)_{max}$ is equal to 59.2(From IS 456 : 2000,24.1).Percentageof reinforcement is equal to 0.14%i.e.Pt =0.14% and kt = 1.85 ; kc =1 ; kf =1 therefore the value of $(l/d)_{max}$ is equal to 59.2here $(l/d)_{max}$ is greater than $(l/d)_{provided}$.Hence the section is safe.
- For edge strip we are providing minimum area of steel i.e. Ast_{min} which is equal to162 mm^2.Using # 8 bars, spacing of bar is 220 mm, therefore Provide # 8 bars at 200mm c/c as edge strip reinforcement.

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BEAM:

- Beams are members that are subjected to bending the critical beam is beam no. 110.
- The size of beam is 230mmx450mm
- The bending moment of beam is 158.510kNm, shear force is 144.972kNandclear Span is 6.97 m.
- Taking the overall depth of beam as 450mm and clear cover as 50mm the effective depth is 400mm.
- The ultimate bending moment 'Mu' is taken as factor of safety i.e., 1.5 multiplied by moment which results as 237.77 kNm similarly the ultimate shear force 'Vu' is equal to 144.972 thus we get 217.458 kNm.
- For checking the beam as under reinforced or over reinforced we are using (clause 38.1) ANNEXG1.1 of IS 456:2000 by which we calculate our beam is doubly reinforced becauseMu.limit is less then Mu.
- From IS 456 :2000 (clause 38.1) ANNEX G1.2 we are calculating compression reinforcement also the design stress in compression reinforcement can be calculated by using same clause herefsc calculated is greater than fsc provided 435 <535, Hence safe.
- Compression reinforcement A_{sc}comes out as561.05mm^2.
- Using 16 mm diameter bars. Area of one bar is equal to 201mm^2 therefore no.of bars is equal to3 therefore Provide 3# 16mm bars on the top face of the beam.
- A_{st} can be calculated as $A_{st} = A_{st1} + A_{st2}$for calculating Ast_1 we are using (clause 38.1) ANNEX G1.1 of IS 456:2000 and for Ast_2 we are using (ANNEX G1.2) of same clause from which we get $Ast_1$and Ast_2 as 1091.33mm^2and561.05mm^2respectively.Therefore total Ast.isequal to 1652.38 mm^2 ,by using # 16 mm bars the bars required are 8.
- Therefore provide 8 No's of 16 mm diameter bars.
- To calculate nominal shear stress from IS 456:2000 we use (Clause 40.1) for uniform depth, the nominal shear stress comes out as2.35 N/mm^2. percentage of reinforcement, i.e. Pt.is taken from the (Table 19) of IS 456:2000which is equal to 0.48 %
- From IS 456:2000 (Table 20) maximum shear stress = 0.82 N/mm^2here the nominal shear stress is grater then maximum shear stress (therefore it is unsafe). Hence shear reinforcement has to be provided.
- For the design of shear reinforcement we use (Clause 40.4) of IS 456:2000 from which we calculated shear Vus as 142.018kN.Using two legged #8mm stirrups, spacing of stirrups can be calculated as per the guide lines given in the IS 456:2000.
- Provide 2 legged # stirrups @ 300mm c/c.
- For checking deflection we have to calculate$(l/d)_{basic}$and $(l/d)_{max.}$,$(l/d)_{basic}$ is17.425 , Percentage of tensile steel provided Pt is 2.4%. Fsis0.58&fy is 290 N/mm^2. From IS 456 2000[1],kc is 1; kt is 1 $(l/d)_{max}$ is30,$(l/d)_{actual}$ is 17.4 . $(l/d)_{actual}$ is less than $(l/d)_{max}$
- Hence the section is safe in deflection.

COLUMN

- From STAAD.Prothe critical column of our building is column No: 53 length of the column is 3200 mm, breadth of the column is 230mm,depth of the column, D is 450 mm. The grade of concrete is M30 and grade of steel is Fe 500.
- The factored shear force taken from staadpro.is 1592.33kNand factored bending moment is 22.21kNm and factored bending moment is 11.65 kNm. Unit weight of concrete is 25kN/m^3.
- From Table 28 of IS 456:2000 we take the value of effective length of column as, Le is 0.8 L which is equal to 2560 mm.
- For checking the short column or long column we are using (Clause 25.1.2) of IS 456:2000

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in our case the column is short because both the slenderness ratios are less than 12 i.e. 11.13 and 5.68respectively for both the axis .

- Effective cover,d' = 40 mm the ratio of effective depth to overall depth is equal to 0.089~0.1. For calculating moment we are using equation i.e. root of square of moment about X-axis and square of moment about Y-axis, here Mux is 22.21 and Muy.is11.65 therefore ,Mu = 25.08 kNm.
- For the two non-dimensional parameters i.e. Pu/fckbD and Mu/fckbD the values are 0.00113 and 0.017 respectively.From chart 48 of SP 16[8]the value of P/fck is 0.02 and Percentage of reinforcement, pt is 0.6therefore Area of reinforcement, $A_{sc,req}$ = 0.6 % ofcross sectional area which is equal to 2456 mm^2. Hence provide 8 no. of 20 mm diameter bars as longitudinal reinforcement. Therefore area of reinforcement provided, $A_{sc,prov.}$ = 2512 mm^2.
- For the designof biaxial bending we are using equation of (Clause 3.3) of SP16 code book and for calculating the value of P_{uz} we are using chart 63 of the same code book.
- For our design the equation is satisfied i.e. the value is less than 1.Hence the design is safe under specified loads.
- Take diameter of tie, $\phi_t$as$\phi_{m.max}$ or 8mm whichever is maximum therefore take diameter as 8 mm. Pitch is breadth or 16 $\phi_{m.max}$ or 300mm therefore pitch is 190 mm.
- Hence, provide 8 mm diameter bars @ 190 mm c/c as lateral reinforcement.
- Total depth of beam is 450mm and effective depth is 410 mm. provide longitudinal reinforcement as 8 no's of 20 mm diameter bar and lateral reinforcement as 8mm diameter bars @ 190 mm c/c.

FOOTING

- The Size ofour columnis 230mm x 450mm grade of concrete is 30 $N/mm^2$and grade of steel is 500 N/mm^2, from STAAD.Pro analysis.
- Factored axial load $P_u$is 1592.33kN, M_{uxis} 22.21$kN/m^2$and $M_{uy}$is 11.65kN/m^2.Safe bearing capacityof soil is 300kN/m^2,d is equal to 75 mm.
- Axial load on column is calculated as design load divided by factor of safety which is equal to 1061.55kN.
- Assume self weight of footing as 10% of axial load. Therefore total load on footing is equal to 1167.705kN.Area of footing is total load / SBC of soil which is equal to 3.89 m^2.The size of footing should be proportionate to the size of the column.The size of footing can be calculated as follow ratio of column is calculated as 450 / 230 as 1.96.
- The size of our footing is 3mx1.5m.
- To calculate depth of footing we have to determine the shear force (one way shear) at distance of'd' from the column face across section X-X which is equal to 414.27kN/m^2.
- $M_{u.max}$ is equal to 1852.52 kNm therefore depth required is calculated as per the (Clause 38.1) ANNEX G1.1 equation (c) of IS 456:2000 which comes as 540 mm therefore overall depth is equal to 600mm and effective depth = 550 mm(Cover 50mm).

- Net upward soil reaction (q) is equal to factored axial load/Area which is equal to 409.43KN/mm^2.

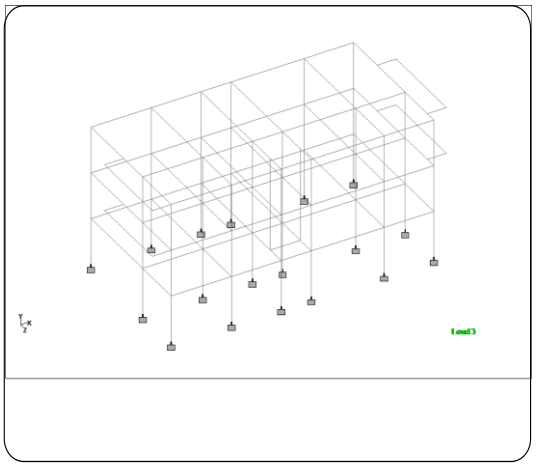

Fig.1.STAAD.Pro Modelling

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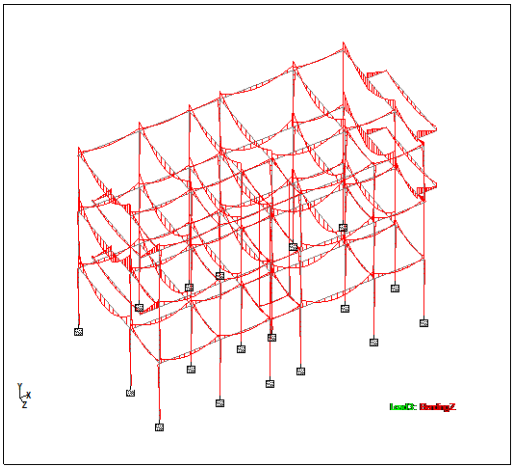

Fig.2 Bending MomentDiagram

CONCLUSION

- The Residential Building was planned using AUTOCAD software and analyzed by STAAD.Pro.
- All the RCC structural elements were designed manually by Limit state design using IS 456:2000[1] and compared with software values.
- Detailing was done in accordance with SP 34[6] code.

REFERENCE

[1] Balaji G and Dineshkumar R (2020), 'Experimental Investigation on High Performance Concrete with Silica Fume and Combination of Coconut Shell and Egg Shell Ash as Mineral Admixture', ADALYA JOURNAL, Volume 9, Issue 1, January 2020, PP 403-407.

[2] Dineshkumar R and Balaji G (2020), 'Behavior of Concrete with Poly Ethylene Terephthalate Fibres', ADALYA JOURNAL, Volume 9, Issue 1, January 2020, PP 306-309.

[3] Balaji G and Vetturayasudharsanan R (2019), 'Experimental investigation on flexural behaviour of RC hollow beams', Materials Today Proceedings,https://doi.org/10.1016/j.matpr.2019.05.461.

[4] Vetturayasudharsanan R and Balaji G (2019), 'Feasibility study on triangular perfobond rib shear connectors in composite slab, Materials Today Proceedings. DOI: 10.1016/j.matpr.2019.06.080.

[5] Balaji .G, Venkatesh .A, Ragul .S and Pradeep R (2019), 'Experimental Investigation of E-Waste based Concrete', SSRG International Journal of Civil Engineering (SSRG-IJCE), Special Issue ICTER, Mar 2019, ISSN: 2348 - 8352, pp 20-23.

[6] Balaji G and Vetturayasudharsanan R (2018), 'Experimental Study on Fly Ash Based slurry Infiltrated Fiber Concrete Beam Incorporate with Lathe Waste', International Journal of Emerging Trends in Science and Technology, Volume 4, Issue 2, pp 5-8.

[7] Balaji G and Mukesh P (2017), 'Traffic Characteristics in Urban Areas', International Journal of Emerging Trends in Science and Technology, Volume 3, Issue 1, pp 6-9.

[8] Balaji G, Arivu Thiravida Selvan V and Maniarasan S.K (2016), 'Study on Structural Behaviour of RC Hollow Beams', International Journal of Innovative Research in Engineering Science and Technology, Special Issue March 2016, pp 38-43.

[9] Arivu Thiravida Selvan V, Balaji G and Venkatachalam S (2016), 'A Study on Performance of Fly ash based Bacterial concrete for sustainable solutions', International Journal of Innovative Research in Engineering Science and Technology, Special Issue March 2016, pp 32-37.

[10] Dineshkumar, R., & Suchithra, S. (2017, August). Properties of concrete with partial replacement of steel slag with fine aggregate. In *2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS)* (pp. 3850-3852). IEEE.

[11] Dineshkumar, R., & Ramkumar, S. (2020). Review paper on fatigue behavior of reinforced concrete beams. *Materials Today: Proceedings*, *21*, 19-23.

[12] Ramkumar, S., & Dineshkumar, R. (2020). Experimental study on impact on fineness of sand and M-sand in M20 grade of concrete. *Materials Today: Proceedings*, *21*, 36-40.

[13] Dineshkumar R and Balaji G (2020), 'Behavior of Concrete with Poly Ethylene Terephthalate Fibres', ADALYA JOURNAL, Volume 9, Issue 1, January 2020, PP 306-309.

[14] Mukesh P, Balamurugan P 2020, Experimental investigation of buckling characteristics of FRP hollow circular section, Adalya Journal, 9(1), 398-402.

[15] R.Vetturayasudarsanan, P.Balamurugan 2020, Utilization of magnesite soil in manufacturing of bricks, Adalya Journal, 9(1), 310-315.

May – June 2020
ISSN: 0193-4120 Page No. 1837 - 1842

[16] M.Renumathi, P.Mukesh & P.Balamurugan 2020, A State of art on geopolymer concrete, Adalya Journal, 9(1), 372- 378.
[17] IS456: 2000 – Indian Standard Plain and Reinforced Concrete Codeof Practice.
[18] IS875: Part I – Code of Practice for design loads (other than earthquake) for buildings and structures (dead load unit weight of building material and stored material).
[19] IS875: Part II – Code of Practice for design loads (other than earthquake) for buildings and structures (imposed loads)
[20] KrishnaRaju .N and Pranesh. R.N (2012) "Reinforced Concrete Design" New Age International (P) Limited, Publishers, New Delhi
[21] SP 7 - National Building Code of India 2005 – Bureau of Indian Standards.
[22] SP 34 – Concrete Reinforcementand Detailing.
[23] Schedule of Rates (PWD) – Code of Practice for the cost estimation.
[24] SP 16 - Design Aids for ReinforcedConcrete.