Rcc building design example pdf

CAPSTONE PROJECT REPORT (Project Term January-April, 2014) (DESIGN OF SINGLE STOREY MUNICIPAL BUILDING) Department of Civil engineering Submitted by:Mysum Shabir Yavar Ahad Mohd. Tajamul Jaspreet Kaur Amol Kumar Registration Number: 11007722 Registration Number: 11011945 Registration Number: 11012119 Registration Number: 11001586 Registration Number: 11008366 Project Group Number:Under the Guidance of Miss Damanpreet Kaur Discipline of Civil Lovely Professional University, Phagwara January to April, 2014 i|Page Declaration:We hereby declare that the project work entitled "DESIGN OF SINGLE STOREY MUNICIPAL BUILDING" is an authentic record of our own work carried out as requirements of Capstone Project for the award of degree of B.Tech in Civil engineering from Lovely Professional University, Phagwara, under the guidance of Miss Damanpreet Kaur during January to April 2014. Mysum Shabir Registration Number: 11007722 Yavar Ahad Registration Number: 11011945 Mohd. Tajamul Islam Registration Number: 11012119 Jaspreet Kaur Registration Number: 11001586 Amol Kumar Registration Number: 11008366 ii | P a g e CERTIFICATE This is to certify that the declaration statement made by this group of students is correct to the best of my knowledge and belief. The Capstone Project Proposal based on the technology / tool learnt is fit for the submission and partial fulfillment of the conditions for the award of B.Tech in Civil Engineering from Lovely Professional University, Phagwara. Name: Damanpreet Kaur U.ID: 17418 Designation: Assistant Professor Signature of Faculty Mentor iii | P a g e Table of contents Abstract...v LIST OF FIGURES.......................................vii LIST OF TABLES...viii 1.0 Introduction.. 1-5 1.1 General Introduction.................................1-3 1.2 Proposals...4 1.3 Statement of project...................................4 1.4 Elements of RCC Framed Building...............4-5 2.0 Basic codes for design.....................................5-6 3.0 Aim of design.. 7 4.0 Method of design...7 5.0 Requirement of reinforcement for structural member.......................... .... 8-16 5.1 Beams...8-9 5.2 Slabs..10 5.3 Columns...10-11 5.4 Shear...11-14 5.5 Development length of bars..........................14-16 6.0 Structural design (Manual Method Of Design).........17- 76 6.1 Study of architectural drawing.......................17 6.2 Finalization of structural configuration..............18 6.3 Design of slabs..18-43 6.4 Design of beams...44-53 6.5 Design of columns..53-66 6.6 Design of foundation.......................................67-76 7.0 Conclusion...77 8.0 References...78 iv | P a g e Abstract Structural design is the primary aspect of civil engineering. The very basis of construction of any building, residential house or dams, bridges, culverts, canals etc. is designing. Structural engineering has existed since humans first started to construct their own structures. The foremost basic in structural engineering is the design of simple basic components and members of a building viz., Slabs, Beams, Columns and Footings. In order to design them, it is important to first obtain the plan of the particular building that is, positioning of the particular rooms (Drawing room, bed room, kitchen toilet etc.) such that they serve their respective purpose and also suiting to the requirement and comfort of the inhabitants. Thereby depending on the suitability; plan layout of beams and the position of columns are fixed. Thereafter, the loads are calculated namely the dead loads, which depend on the unit weight of the materials used (concrete, brick) and the live loads, which according to the code IS:875-1987 is around 2kN/m2. Once the loads are obtained, the component takes the load first i.e. the slabs can be designed. Designing of slabs depends upon whether it is a one-way or a two-way slab, the end conditions and the loading. From the slabs, the loads are transferred to the beam. The loads coming from the slabs onto the beam may be trapezoidal or triangular. Depending on this, the beam may be designed. Thereafter, the loads (mainly shear) from the beams are taken by the columns. For designing columns, it is necessary to know the moments they are subjected to. For this purpose, frame analysis is done by Moment Distribution Method. After this, the designing of columns is taken up depending on end conditions, moments, eccentricity and if it is a short or slender column. Most of the columns designed in this mini project were considered to be axially loaded with biaxial bending. Finally, the footings are designed based on the loading from the column and also the soil bearing capacity value for that particular area. Most importantly, the sections must be checked for all the four components with regard to strength and serviceability. Overall, the concepts and procedures of designing the basic components of a single storey building are described. Apart from that, the planning of the building with regard to appropriate directions for the respective rooms, choosing position of beams and columns are also properly explained. The future of structure engineering mainly depends on better and more effective methods of designing the structures so that they serve better and are also economical. v|Page LIST OF FIGURES S.No. FIGURE NAME PAGE NO. 1 Load bearing masonry building 2 2 Framed Structure 3 3 Elements of RCC framed building 5 4 Architectural plan of building 17 5 Load distribution in one way slab for slab S9 22 6 Two way slab load distribution and action for slab S3 27 7 Two slab load distribution for slab S1 32 8 Two way slab load distribution and action for slab S4 37 9 Cross section of beams 52,53 10 Layout of beams and columns 63 11 Sectional and cross sectional view of column (C1) 64 12 Cross sectional view of column (C2) 64 13 Sectional view of column (C2) 65 14 Cross sectional view of column (C3) 65 15 Sectional view of column (C3) 66 vi | P a g e List of tables TABLE NO. NAME OF TABLE PAGE NO. 1 Values of partial safety factor for loads (IS 456:2000, TABLE 18) 7 2 Maximum shear stress, τcmax , N/mm2 (Table 20 of IS 456:2000) 12 3 Design shear strength of concrete τc, N/mm2 (table 13 19 of IS 456:2000) 4 Development length for fully stressed deformed 15 bars shear reinforcement (stirrups) 5 Live loads on floors as per IS-875(Part-2)-1987 16 6 Live loads on roofs as per IS-875(Part-2)-1987 16 7 Beam design data 51 8 Beam design data 51 9 column design data 62 10 Foundation design data 76 vii | P a g e Acknowledgement:We have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals. We would like to extend my sincere thanks to all of them. We are highly indebted to Dept. of Civil Engineering for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project. We would like to take this opportunity to express our gratitude towards all those people who have helped us in the successful completion of this capstone project, directly or indirectly. We would also like to express our sincere gratitude towards Miss Damanpreet Kaur for her guidance and help which she willingly provided at every step of the project. viii | P a g e 1.0 INTRODUCTION 1.1 General Introduction The procedure for analysis and design of a given building will depend on the type of building, its complexity, the number of stories etc. First the architectural drawings of the building are studied, structural system is finalized sizes of structural members are decided and brought to the knowledge of the concerned architect. The procedure f or structural design will involve some steps which will depend on the type of building and also its complexity and the time available for structural design. Often, the work is required to start soon, so the steps in design are to be arranged in such a way the foundation drawings can be taken up in hand within a reasonable period of time. Further, before starting the structural design, the following information of data is required: (i) A set of architectural drawings; (ii) Soil Investigation report (SIR) of soil data in lieu thereof; (iii) Location of the place or city in or der to decide on wind and seismic loadings; (iv) Data for lifts, water tank capacities on top, special roof features or loadings, etc. Choice of an appropriate structural system for a given building is vital for its economy and safety. There are two types of buildings systems: (a) Load Bearing Masonry Buildings. (b) Framed Buildings. (a) Load Bearing Masonry Buildings:- Small buildings like houses with small spans of beams, slabs generally constructed as load bearing brick walls with reinforced concrete slab beams. This system is suitable for building up to four or less stories.(as shown in fig. below). In such buildings crushing strength of bricks shall be 100 kg/cm2 minimum for four stories. This system is adequate for vertical loads it also serves to resist horizontal loads like wind & earthquake by box action. The design of Load Bearing Masonry Buildings are done as per IS: 1905 - 1980 (Indian Standards Code of Practice f or Structural Safety of Buildings: Masonry Walls(Second Revision) . 1|P a g e Fig 1. Load bearing masonry building (b) Framed Buildings: -In these types of buildings reinforced concrete frames are provided in both principal directions to resist vertical loads and the vertical loads are transmitted to vertical framing system i.e. columns and Foundations. This type of system is effective in resisting both vertical & horizontal loads. The brick walls are to be regarded as non load bearing filler walls only. This system is suitable for multi - storied building which is also effective in resisting horizontal loads due to earthquake. In this system the floor slabs, generally 100 - 150 mm thick with spans ranging from 3.0 m to 7.0 m. In certain earthquake prone areas, even single or double storey buildings are made framed structures for safety reasons. Also the single storey buildings of large storey heights (5.0m or more) ,like electric substation etc. are made framed structure as brick walls of large heights are slender and load carrying capacity of such walls reduces due to slenderness. 2|P a g e Fig 2. Framed Structural system 3|P a g e 1.2 proposals The municipal building housed in a single storey shall have following accommodation:Bed room = 4 No. 3.2m x 3.15 m Kitchen = 4 No. 3.25m x 2.40 m Bathroom = 4 No. 2.15m x 1.25 m Dressing room = 4 No. 1.25m x 0.95m Living room = 4 No. 3.050m x 4.25m Balcony = 4 No. 3.00m x 1.475m Lobby = 1 No. 4.4m x 2.2m 1.3 statement of the project Utility of the building------ Residential building. No.of storeys----------------Single storey (G). Shape of the building-------- Rectangular. No. of staircases-------------- 1 No. Type of foundation----------isolated footing. Type of building-----------RCC Framed Building. 1.4 Elements of RCC Framed Building:1. Slab: - The flat ceiling of a storey is called a 'Slab'. 2. Beams:- The peripheral horizontal member supporting the slab is called 'Beam'. 3. Plinth Beam:-The beam at ground level or plinth level is called 'Plinth Beam'. 4|P a g e 4. Column:-The vertical member supporting the beam is called 'Column'. 5. Foundation: - The system below ground transferring the entire load of the structure to the soil is called 'Foundation'. • slab • Beams •Plinth beam •Columns •Foundation Fig 3. Elements of RCC framed building 2.0 Basic Codes for Design :The design should be carried so as to conform to the following Indian code for reinforced concrete design, published by the Bureau of Indian Standards, New Delhi. Purpose of Codes:- National building codes have been formulated in different countries to lay down guidelines for the design and construction of structure. The codes have evolved from the collective wisdom of expert structural engineers, gained over the years. These codes are periodically revised to bring them in line with current research, and often, current trends. Firstly, they ensure adequate structural safety, by specifying certain essential minimum requirement for design. 5|P a g e Secondly, they r ender the task of the designer relatively simple; often, the result of sophisticated analyses is made available in the form of a simple formula or chart. Thirdly, the codes ensure a measure of consistency among different designers. Finally, they have some legal validity in that they protect the structural designer from any liability due to structural failures that are caused by inadequate supervision and/or faulty material and construction. (i) IS 456 : 2000 – Plain and reinforced concrete – code of practice (fourth revision) (ii) Loading Standards These loads to be considered for structural design are specified in the following loading standards: IS 875 (Part 1 - 3) : 1987 – Code of practice f or design loads (other than earthquake) f or buildings and structures (second revision) Part 1: Dead loads Part 2: Imposed (live) loads Part 3: Wind loads IS 13920: 1993 – Ductile detailing of reinforced concrete structure subject to seismic forces. Design Handbooks The Bureau of Indian standards has also published the following handbooks, which serve as useful supplement to the 1978 version of the codes. Although the handbooks need to be updated to bring them in line with the recently revised (2000 version) of the Code, many of the provisions continue to be valid (especially with regard to structural design provisions). SP 16 : 1980 - Design Aids (for Reinforced Concrete) to IS 456 : 2000 6|P a g e 3.0 AIM OF DESIGN:The aim of design is achievement of an acceptable probability that structures being designed shall, with an appropriate degree of safety – Perform satisfactorily during their intended life. Sustain all loads and deformations of normal construction & use Have adequate durability Have adequate resistance to the effects of misuse and fire. 4.0 METHOD OF DESIGN:- Structure and structural elements shall normally be designed by Limit State Method. DESIGN LOAD:- Design load is the load to be taken for use in appropriate method of design. It is Characteristic load with appropriate partial safety factors for limit state design. Table 1:- values of partial safety factor for loads (IS 456:2000, TABLE 18) 7|P a g e 5 REQUIREMENT OF REINFORCEMENT FOR STRUCTURAL MEMBER 5.1 Beams 5.1.1 Tension reinforcement (a) Minimum reinforcement:- The minimum area of tension reinforcement shall not be less than that given by the following:As/bd = 0.85/fy where As = minimum area of tension reinforcement. b = breadth of beam or the breadth of the web of T-beam. d = effective depth, and fy = characteristic strength of reinforcement in M/mm2 (b) Maximum reinforcement:- the maximum area of tension reinforcement shall not exceed 0.04bD. 5.1.2 Compression reinforcement The maximum area of compression reinforcement shall not exceed 0.04 bd. Compression reinforcement in beams shall be enclosed by stirrups for effective lateral restraint. 5.1.3 Maximum spacing of shear reinforcement Maximum spacing of shear reinforcement means long by axis of the member shall not exceed 0.75 d for vertical stirrups and d for inclined stirrups at 45] where d is the effective depth on the section under consideration. In no case shall be spacing exceed 300mm. 8|P a g e 5.1.4 Minimum shear reinforcement Minimum shear reinforcement in the form of stirrups shall be provided such that: Asv / bsv > 0.4/0.87 fy Where Asv = total cross-sectional area of stirrups legs effective in shear. Sv= stirrups spacing along the length of the member b = breadth of the beam or breadth of the web of flange beam, and fy = characteristic strength of the stirrups reinforcement in N/mm2which shall not taken greater than 415 N/mm2 5.1.5 Minimum Distance between Individual Bars (a) The horizontal distance between two parallel main reinforcing bars shall usually be not-less than the greatest of the following: (i) Dia of larger bar and (ii) 5 mm more than nominal maximum size of coarse aggregate. (b) When needle vibrators are used it may be reduced to 2/3rdof nominal maximum size of coarse aggregate,Sufficient space must be left between bars to enable vibrator to be immersed. (c) Where there are two or more rows of bars, bars shall be vertically in line and the minimum vertical distance between bars shall be 15 mm, 2/3rd of nominal maximum size of aggregate or the maximum size of bars, whichever is greater. 9|P a g e 5.2. Slabs:5.2.1 Minimum reinforcement:- The mild steel reinforcement in either direction in slabs shall not be less than 0.15 percent of the total cross-sectional area. However, this value can be reduced to 0.12 percent when high strength deformed bars or welded wire fabric are used. 5.2.2 Maximum diameter. The diameter of reinforcing bars shall not exceed one eight of the total thickness ofslab. 5.2.3 Maximum distance between bars - Slabs 1) The horizontal distance between parallel main reinforcement bars shall not be more than three times the effective depth of solid slab or 300 mm whichever is smaller. 2) The horizontal distance between parallel reinforcement bars provided againstshrinkage and temperature shall not be more than five times the effective depth of a solid slab or 300 mm whichever is smaller. 5.2.4 Torsion reinforcement - Slab Torsion reinforcement is to be provided at any corner where the slab is simply supported on both edges meeting at that corner. It shall consist of top and bottom reinforcement, each with layers of bars placed parallel to the sides of the slab and extending from the edges a minimum distance of one-fifth of the shorter span. The area of reinforcement in each of these four layers shall be three-quarters of the area required for the maximum mid-span moment in the slab. 5.3. Columns 5.3.1 Longitudinal Reinforcement a. The cross sectional area of longitudinal reinforcement shall be not less than 0.8% nor more than 6% of the gross sectional area of the column. Although it is recommended that the maximum area of steel should not exceed 4% to avoid practical difficulties in placing & compacting concrete. 10 | P a g e b. In any column that has a larger cross sectional area than that required to support the load, the minimum percentage steel must be based on the area of concrete resist the direct stress & not on the actual area. c. The bar should not be less than 12 mm in diameter so that it is sufficiently rigid to stand up straight in the column forms during fixing and concreting. d. The minimum member of longitudinal bars provided in a column shall be four in rectangular columns & six in circular columns. e. A reinforced concrete column having helical reinforcement must have at least six bars of longitudinal reinforcement with the helical reinforcement. These bars must be in contact with the helical reinforcement & equidistance around its inner circumference. f. Spacing of longitudinal should not exceed 300 mm along periphery of acolumn. g. In case of pedestals, in which the longitudinal reinforcement is not taken into account in strength calculations, nominal reinforcement should be not be less than 0.15% of cross sectional area. 5.3.2 Transverse Reinforcement a. The diameter of lateral ties should not be less than ¼ of the diameter of the largest longitudinal bar in no case should not be less than 6 mm. b. Spacing of lateral ties should not exceed least of the following: Least lateral dimension of the column 16 times the smallest diameter of longitudinal bars to be tied. 300mm. 5.4 SHEAR 5.4.1 Nominal Shear Stress The nominal shear stress in beams of uniform depth shall be obtained by the following equation: 11 | P a g e τv =Vu/ b.d where Vu = shear force due to design loads; b = breadth of the member, which for flanged section shall be taken as the breadth ofthe web, bw; and d = effective depth. With Shear Reinforcement Under no circumstances, even with shear reinforcement, shall the nominal shear stress in beams should not exceed given in Table 20 of IS 456:2000. For solid slabs, the nominal shear stress shall not exceed half the appropriate values given in Table 20 of IS 456:2000. CONCRETE M15 M20 M25 M30 M35 M40 & above 2.5 2.8 3.1 3.5 3.7 4.0 GRADE Tc max , N/mm2 TABLE 2:- MAXIMUM SHEAR STRESS, τcmax , N/mm2 (Table 20 of IS 456:2000) 5.4.2 Minimum Shear Reinforcement When τv, is less than τc given in Table 19 of IS 456:2000 , minimum shear reinforcement shall be provided in accordance with clause 26.5.1.6 of IS 456:2000. 12 | P a g e 100 Ast / bd Concrete grade M15 M20 M25 M30 M35 M40 & above Xu,max/d = 0.479 and Ru =2.761 Fck = 20 N/mm2 Step 2: Computation of design B.M. and S.F. : Assume,L/d = 20 for simply supported slab (from the point of deflection) Pt = 20% for under reinforced section ft (Modification factor) = 1.5 Taking c/c dis. L = 3.2m => L/d = 20×1.5 { L=4100mm} 4100/d = 20×1.5 d = 136.66 mm. 140mm. Providing 20mm. nominal cover and 8mm. Ø bars D = 140+20+4 = 164 165mm. Design load (Wu) :For, depth (D) = 165mm. = 0.165m. 18 | P a g e DL (wt. of slab/m2) = vol. × density = (0.165m.×1m.×1m.)×(25 KN/m2) LL+FF (imposed loads) = 1.5 KN/m2 + 1.5 KN/m2 = 4.125 KN/m2 = 3 KN/m2 So, Total load = 4.125 + 3 = 7.125 KN/m2 Design load (Wu) = 1.5 × 7.125 = 10.687 KN/m2 Design shear force (Vu) :Vu = Wu × l/2 = 10.687 × 3.2 / 2 = 17.09 KN Design bending moment (Mu):Mu = Wu ×l2/8 = (10.687 × 3.22) / 8 = 13.68 KN-m Step 3: Computation of effective depth :For, b(width) = 1m. =1000mm d = √Mu / (Ru×b) = √(13.68×106) / (2.761×1000) = 70.38mm dassumed = D-20-4 = 165-20-4 = 141mm => So.provide d = 141mm Step 4:- Steel reinforcement :Main reinforcement : Astreq. = 0.5fck/fy {1-√1- 4.6Mu/ / fck×b×d2 }×bd = 0.5 × 20/415 {1-√1 - 4.6(13.68×106)/(20×1000×1412)} ×1000×141 = 280.42 Spacing (S) = (1000 × 50.3) / 300 = 167 300 mm2 160mm c/c , which is < 3d =423mm and 300mm Astactual = (1000×50.3)/160 = 314.3mm2 Pt = 100Ast/bd = (100×314.3)/(1000×141) =0.22 = 20% (Page no.-73) 19 | P a g e Note :- Bend alternate bars of main reinforcement up at a dis. of l/7 = 4100/7 = 585.7mm from the face of support. Distribution reinforcement:Astmini. = 0.12% × bD = (0.12/100)×1000×165 =198mm2 Spacing (S) = (1000×50.3)/198 = 254mm. ,which is ft (modification factor) =1.68 From the deflection pt. of view, L/dreq. = 20×ft 4100/dreq. = 20×1.68 =122 => dreq. =125mm But,available dprovided = 141mm Hence ,safe. Step 6:- Check for shear :Nominal shear stress (ţv) : (page no. 72) ţv = VuD/ bd =(15.58×103)/(1000×141) =0.110 N/mm2 { VuD = S.F. due to design loads = Vu – Wu(0.141) = 17.09 -(10.687×0.141) =15.58 KN} 20 | P a g e Design shear strength of concrete (ţc.k): * Page no.72:- 40.2.11 => k= for D=165mm. *Page no.73:table19 => ţc =0.28 for M20 ,Pt = 10% (at supports =1/2×20%) So, k.ţc = ×0.28 = Now, ţv Xu,max/d = 0.479 and Ru =2.761 Fck = 20 N/mm2 Step 2: Computation of design load and B.M. : (Page no. 35):Assume,L/d = 35 for simply supported slab L/d=35×0.8 (If HYSD bars are used then L/d must be multiplied with 0.8, but if mild steel is used then no need to multiply) Pt = 20% for under reinforced section (can be taken upto 30% for HYSD bars and 40-50% for mild steel and these values are generally taken byexperience) ft (Modification factor) = 1.68 Now,L/d =35×0.8×1.68 (*page no.-380) (for slabs spanning in two directions, => 2500/d= 35×0.8×1.68 L=shorter of two spans(3.4×2.5) should => be used for calculating L/d ratio) d = 53.14 60mm. Providing nominal cover of 20mm. and 8mmØ bars D= 60+20+4=84mm 100mm 23 | P a g e Design load(Wu) : for D=100mm =0.1m DL(wt. of slab/m2) = vol.×density =(0.1m×1m×1m)×25KN/m2 =2.5KN/m2 LL+FF(imposed loads) =1.5+1.5 =3KN/m2 So,total load =2.5+3 = 5.5KN/m2 Design load(Wu) =1.5 ×5.5 =8.25KN/m2 Design moment(Mu) : Taking d=60mm: ly = 3.4+0.06 =3.46mm {page no.91 table:27 :- for ly/lx =3.46/2.56= 1.4 , lx =2.5+0.06 =2.56mm => αx =0.099,αy =0.051 } Mux = αx..Wu..lx2 = 0.099×8.25×2.562 =5.353KN-m Muy = αy.Wu.ly2 = 0.051×8.25×3.462 = 5.037 KN-m (Page no. 90) :For long span(ly), width of middle strip =3/4 ly = ¾(3.46) =2.6m width of edge strip =½(3.46-2.6) = 0.43m For short span ,width of middle strip =3/4 lx= ¾(2.56) =1.92m Width of edge strip = ½(2.56-1.92) =0.32m Step 3: Computation of effective depth : For, b(width) = 1m. =1000mm d = √Mu/(Ru×b) = √(5.35×106) / (2.761×1000) = 44.01mm but,,from point of deflection,Dassumed =100mm with nominl cover=20mm and 8mmØ bars 24 | P a g e So,dshort span =100-20-4 =76mm dlong span = 100-20-4-8 = 68mm Step 4: Computaion of steel reinforcement for short span (lx =2.56m): Astx =0.5fck/fy{1-√1-4.6Mux/fck.b.d2}.b.d. =0.5×20/415 {1-√1 – (4.6×5.35×106)/(20×1000×762)}×1000×76 = 206.9 207mm2 Providing 8mmØ bars, Spacing(Sx) =1000×50.3/207 =242.99mm 200mmc/c Hence,providing 8mmØ bars @200mmc/c for middle strip of short span = ¾(lx) =1.92m Edge strip of lx =0.32m Reinforcement in edge strip =1.2D = 1.2(100) =120mm2 Spacing(S) = 1000×50.3/120 = 419mm c/c Note: Bend half the bars up at a distance of 0.15lx =0.15(2.56) = 0.384m =384mm from centre of support. Step 5 :Reinforcement for long span (ly=3.46m): Asty=0.5×20/415{1-√1- (4.6×5.037×106)/(20×1000×682)} =220mm2 Providing 8mmØ bars, Spacing (Sy) =1000×50.3/220 =229mm 220mm c/c Hence,providing 8mmØ /c in middle strip of ¾(ly) = ¾(3.46) =2.6m Edge strip of ly =0.43m Reinforcement in edge strip =1.2D =120mm2 25 | P a g e Spacing(S) =1000×50.3/120 =419mm c/c Step 6: Torsional reinforcement at corners: Size of torsional mesh = lx/5 = 2.56/5 =0.512m from the centre of support Area of torsional reinforcement =¾Astx =¾(207) =155.25mm2 Spacing (S) =1000×50.3/155.25 =323mm c/c Step 7 :Check for shear and development length in short span(lx) :Shear force at long edges(Vu) =Wu×lx×r/(2+r) =8250×2.56×1.4/(2+1.4) =8696.4 N Page no.72 :- ţv =Vu/b.dx =8696.4/(1000×76) =0.114 N/mm2 Page no.44:- At simply supports, Ø of bars should be so restricted that following requirement is satisfied *Mu1 = 0.87fyAst1/(d - 0.416xu) :- (1.3Mu1/Vu)+ LO > Ld {*Ast1 at supports of short span=½(1000×50.3/200) =125.75mm2 = 0.87×415×125.75 / (100-0.416×6.3) = Nmm *Xu = 0.87 fy.Ast1/(0.36 fck.b) =6.3mm } *Assuming that width of support ls =160mm and a side cover(x′) of 20mm Provinding no hooks ; Lo = ls/2 – x′ =160/2 -20 =60mm *Ld (Development length of bars: page no.42):Ld = Øσs / 4 ţbd = 60 % of 0.87fyØ / (4ţbd) {page no.43:- ţbd for M20 =1.2 and this value should be increased by 60%} 26 | P a g e = 0.6 ×{0.87×415×8 / 4×1.2 } =376 mm So, (1.3Mu1/Vu) + LO > Ld (1.3×3.3×106/8696.6) + 60 >Ld => 553 >376 Hence,satisfied. Step 8 :- Distribution of loading in two way slab :- (page no. 41) Fig 6 two way slab load distribution and action for slab S3 27 | P a g e Two way slab (S1) :- (BEDROOOM: 3.15 ×3.4m2 c/c) Step 1: Design constants and limiting depth of neutral axis :For, Fy = 415 N/mm2 => Xu,max/d = 0.479 and Ru =2.761 Fck = 20 N/mm2 Step 2: Computation of design load and B.M. : Assume,L/d = 35 for simply supported slab L/d=35×0.8 (If HYSD bars are used then L/d must be multiplied with 0.8, but if mild steel is used then no need to multiply) Pt = 20% for under reinforced section (can be taken upto 30% for HYSD bars and 40-50% for mild steel and these values are generally taken byexperience) ft (Modification factor) = 1.68 Now,L/d =35×0.8×1.68 (*page no.-380) (for slabs spanning in two directions, => 3150/d= 35×0.8×1.68 L=shorter of two spans(3.15×3.4) should => be used for calculating L/d ratio) d = 66.9 70mm. Providing nominal cover of 20mm. and 8mmØ bars D= 70+20+4=94mm 100mm Design load(Wu) : 28 | P a g e for D=100mm =0.1m DL(wt. of slab/m2) = vol.×density =(0.1m×1m×1m)×25KN/m2 =2.5KN/m2 LL+FF(imposed loads) =1.5+1.5 =3KN/m2 So,total load =2.5+3 = 5.5KN/m2 Design load(Wu) =1.5 ×5.5 =8.25KN/m2 Design moment(Mu) : Taking d=70mm { page no.91 table:27 long span: ly = 3.4+0.07 =3.47mm for ly/lx =3.46/3.26= 1.06 short span:-lx =3.15+0.07 =3.22mm => αx =0.074,αy =0.061 } Mux = αx..Wu..lx2 = 0.074×8.25×3.222 =6.329KN-m Muy = αy.Wu.ly2 = 0.061×8.25×3.472 = 6.059 KN-m (Page no. 90) :For long span(ly), width of middle strip =3/4 ly = ¾(3.47) =2.60m width of edge strip =½(3.47-2.6) = 0.435m For short span(lx) ,width of middle strip =3/4 lx= ¾(3.22) =2.415m width of edge strip = ½(3.22-2.415) =0.402m Step 3: Computation of effective depth : For, b(width) = 1m. =1000mm d = √Mux/(Ru×b) = √(6.329×106) / (2.761×1000) = 47.87mm 29 | P a g e but,,from point of deflection,Dassumed =100mm with nominal cover=20mm and 8mmØ bars So,dshort span(x) =100-20-4 =76mm dlong span(y) = 100-20-4-8 = 68mm Step 4: Computaion of steel reinforcement for short span (lx =3.22m): Astx =0.5fck/fy{1-√1-4.6Mux/fck.b.d2}.b.dx. =0.5×20/415 {1-√1 – (4.6×6.327×106)/(20×1000×762)}×1000×76 = 247.40 250mm2 Providing 8mmØ bars, Spacing(Sx) =1000×50.3/250 =201.2mm 200mmc/c Hence,providing 8mmØ bars @200mmc/c for middle strip of short span = ¾(lx) =2.415m Edge strip of lx =0.402m Reinforcement in edge strip =1.2D = 1.2(100) =120mm2 Spacing(S) = 1000×50.3/120 = 419mm c/c Note: Bend half the bars up at a distance of 0.15lx =0.15(3.22) = 0.483m =483mm from centre of support . Step 5 :Reinforcement for long span (ly=3.47m): Asty=0.5×20/415{1-√1- (4.6×6.059×106)/(20×1000×682)}×1000×68 =268.9mm2 Providing 8mmØ bars, 270mm2 Spacing (Sy) =1000×50.3/270 =186mm 180mm c/c Hence,providing 8mmØ /c in middle strip of ¾(ly) = ¾(3.47) =2.6m 30 | P a g e Edge strip of ly =0.435m Reinforcement in edge strip =1.2D =120mm2 Spacing(S) =1000×50.3/120 =419mm c/c Note: Bend half the bars up at a distance of 0.15ly =0.15(3.47) = 0.52m =520mm from centre of support. Step 6: Torsional reinforcement at corners: Size of torsional mesh = lx/5 =3.22/5 =0.644m from the centre of support Area of torsional reinforcement =¾Astx =¾(250) =187.5mm2 Spacing (S) =1000×50.3/187.5 =268mm c/c Step 7 :Check for shear and development length in short span(lx) :Shear force at long edges(Vu) =Wu×lx×r/(2+r) =8250×3.22×1.4 /(2+1.4) = 10938N Page no.72 :- ţv =Vu/b.dx = 10938 /(1000×76) =0.413 N/mm2 Page no.44:- At long edges, Ø of bars should be so restricted that following requirement is satisfied :- (1.3Mu1/Vu)+ LO > Ld *Mu1 = 0.87fyAst1/(dx - 0.416xu) {*Ast1 at supports of short span=½(1000×50.3/250) =100.6mm2 = 0.87×415×100.6/(76-0.416×5.04) = 491.47 Nmm *Xu = 0.87 fy.Ast1/(0.36 fck.b) =5.04mm } *Assuming that width of support ls =160mm and a side cover(x′) of 20mm 31 | P a g e Provinding no hooks ; Lo= ls/2 – x′ =160/2 -20 =60mm *Ld (Development length of bars: page no.42):Ld = Øσs / 4 ţbd = 60 % of 0.87fyØ / (4ţbd) {page no.43:- ţbd for M20 =1.2 and this value should be increased by 60%} = 0.6 ×{0.87×415×8 / 4×1.2 } =376 mm So, (1.3Mu1/Vu) + LO > Ld (1.3× /10938) + 60 >Ld => >376 Hence,satisfied. Step 8 :-Distribution of loading in two way slab :- (page no. 41) Fig 7 two slab load distribution for slab S1 32 | P a g e Two way slab (S4) : (LIVING ROOM:3.2*4.4mm c/c) Step 1: Design constants and limiting depth of neutral axis :For, Fy = 415 N/mm2 => Xu,max/d = 0.479 and Ru =2.761 Fck = 20 N/mm2 Step 2: Computation of design load and B.M. : (Page no. 35):Assume,L/d = 35 for simply supported slab L/d=35×0.8 (If HYSD bars are used then L/d must be multiplied with 0.8, but if mild steel is used then no need to multiply) Pt = 20% for under reinforced section (can be taken upto 30% for HYSD bars and 40-50% for mild steel and these values are generally taken byexperience) ft (Modification factor) = 1.68 Now,L/d =35×0.8×1.68 (*page no.-380 (for slabs spanning in two directions, => 2500/d= 35×0.8×1.68 L=shorter of two spans(3.4×2.5) should => be used for calculating L/d ratio) d = 53.14 60mm. Providing nominal cover of 20mm. and 8mmØ bars D= 60+20+4=84mm 100mm Design load(Wu) : 33 | P a g e for D=100mm =0.1m DL(wt. of slab/m2) = vol.×density =(0.1m×1m×1m)×25KN/m2 =2.5KN/m2 LL+FF(imposed loads) =1.5+1.5 =3KN/m2 So,total load =2.5+3 = 5.5KN/m2 Design load(Wu) =1.5 ×5.5 =8.25KN/m2 Design moment(Mu) : Taking d=60mm: ly = 3.4+0.06 =3.46mm {page no.91 table:27 :- for ly/lx =3.46/2.56= 1.4 lx =2.5+0.06 =2.56mm => αx =0.099,αy =0.051 } Mux = αx..Wu..lx2 = 0.099×8.25×2.562 =5.353KN-m Muy = αy.Wu.ly2 = 0.051×8.25×3.462 = 5.037 KN-m (Page no. 90) :For long span(ly), width of middle strip =3/4 ly = ¾(3.46) =2.6m width of edge strip =½(3.46-2.6) = 0.43m For short span(lx),width of middle strip =3/4 lx= ¾(2.56) =1.92m Width of edge strip = ½(2.56-1.92) =0.32m Step 3: Computation of effective depth : For, b(width) = 1m. =1000mm d = √Mu/(Ru×b) = √(5.35×106) / (2.761×1000) = 44.01mm but,,from point of deflection,Dassumed =100mm with nominl cover=20mm and 8mmØ bars 34 | P a g e So,dshort span =100-20-4 =76mm dlong span = 100-20-4-8 = 68mm Step 4: Computaion of steel reinforcement for short span (lx =2.56m): Astx =0.5fck/fy{1-√1-4.6Mux/fck.b.d2}.b.d. =0.5×20/415 {1-√1 – (4.6×5.35×106)/(20×1000×762)}×1000×76 = 206.9 207mm2 Providing 8mmØ bars, Spacing(Sx) =1000×50.3/207 =242.99mm 200mmc/c Hence,providing 8mmØ bars @200mmc/c for middle strip of short span = ¾(lx) =1.92m Edge strip of lx =0.32m Reinforcement in edge strip =1.2D = 1.2(100) =120mm2 Spacing(S) = 1000×50.3/120 = 419mm c/c Note: Bend half the bars up at a distance of 0.15lx =0.15(2.56) = 0.384m =384mm from centre of support. Step 5 :Reinforcement for long span (ly=3.46m): Asty=0.5×20/415{1-√1- (4.6×5.037×106)/(20×1000×682)} =220mm2 Providing 8mmØ bars, Spacing (Sy) =1000×50.3/220 =229mm 220mm c/c Hence,providing 8mmØ /c in middle strip of ¾(ly) = ¾(3.46) =2.6m Edge strip of ly =0.43m Reinforcement in edge strip =1.2D =120mm2 35 | P a g e Spacing(S) =1000×50.3/120 =419mm c/c Step 6: Torsional reinforcement at corners: Size of torsional mesh = lx/5 =2.56/5 =0.512m from the centre of support Area of torsional reinforcement =¾Astx =¾(207) =155.25mm2 Spacing (S) =1000×50.3/155.25 =323mm c/c Step 7 :Check for shear and development length in short span :Shear force at long edges(Vu) =Wu×lx×r/(2+r) =8250×2.56×1.4/(2+1.4) =8696.4KN Page no.72 :- ţv =Vu/b.dx =8696.4/(1000×76) =0.114 N/mm2 Page no.44:- At simply supports, Ø of bars should be so restricted that following requirement is satisfied :- (1.3Mu1/Vu)+ LO > Ld *Mu1 = 0.87fyAst1/(d - 0.416xu) {*Ast1 at supports of short span=1000×50.3/400 =125.75mm2 = 0.87×415×125.75 / (100-0.416×6.3) = 466.23 Nmm *Xu = 0.87 fy.Ast1/(0.36 fck.b) =6.3mm } *Assuming that width of support ls =160mm and a side cover(x′) of 20mm Provinding no hooks ; Lo= ls/2 – x′ =160/2 -20 =60mm *Ld (Development length of bars: page no.42):Ld = Øσs / 4 ţbd = 60 % of 0.87fyØ / (4ţbd) {page no.43:- ţbd for M20 =1.2 and this value should be increased by 60%} 36 | P a g e = 0.6 ×{0.87×415×8 / 4×1.2 } =376 mm So, (1.3Mu1/Vu) + LO > Ld (1.3×3.3×106/8696.6) + 60 >Ld => 553 >376 Hence,satisfied. Step 8 :-Distribution of loading in two way slab :- (page no. 41) Fig 8 two way slab load distribution and action 37 | P a g e One way slab (S9,Staircase): Step 1 :General arrangement of stairs:Height of each flight =3/2 =1.5m. No. of Rises required=1.5/0.15 =10 in each flight. No. of treads reqired in each flight = 10-1 =9 Space occupied by treads = 9×230 = 2070mm. Landing =1m Space for Passage =0.55m Step 2 :Computation of design constants : For , fy = 415N/mm2 => Xumax / d =0.479 and Ru = 2.761 Step 3: Computation of Loading and Bending moment : Let the bearing of landing slab in the wall to be 160mm Effective span = 2.07+1m+(0.16/2) =3.15m Let thickness of waist slab =200mm. Weight of slab w′ on slope =200/1000×1×1×25000 =5000 N/m2 Dead wt. on horizontal area (W1) = (w′√R2 + T2) / T = 5000√1502 + 2302 /230 =5969 N/mm2 Dead wt. of steps (W2) = R / (2×1000) ×25000 = 150 /2000 ×25000 = 1875 N/m2 38 | P a g e Total dead wt/mm = 5969+1875 =7844 N Weight of finishing =100 N (assumed) LL =2500 N Total (LL +finishing) =10444 N Wu =1.5×1044 =1566 N/m Mu =15666×3.152 /8 = 19.93×106 N-mm Step 4 :Design of waist slab : d = √Mu / Ru×b =√19.43×106 / 2.761×1000 =83.88mm Adopt overall depth (D) of 150mm ,using 20mm nominal cover and 10mmØ bars d= 150-20-5 = 125mm Step 5 : Computation of reinforcement :Ast = (0.5×20 /415) ×1000×125×{1-√1-(4.6×19.43×106 / 2.761×1000×1252)} = 1390 mm2 No. of bars for 1.05 width =1.05×1390/ 78.54 =19 bars Spacing , S = 1050 /19 =55mm c/c Asd = 0.12 ×150×1000 /100 =180 mm2 Spacing of 8mmØ bars = 1000×50.3 /180 =279 mm c/c 39 | P a g e CANTILEVER SLAB ,S2 : (BATHROOM 1.475 overhang) Step 1: Design constants and limiting depth of neutral axis :For, Fy = 415 N/mm2 => Xu,max/d = 0.479 and Ru =2.761 Fck = 20 N/mm2 Step 2: Computation of design B.M. and S.F. : Assume,L/d = 7 Pt = 20% for cantilever slab (from the point of deflection) for under reinforced section ft (Modification factor) = 1.68 Taking c/c dis. L = 1.535m => L/d = 7×1.68 {Leffective =1.475+(.12/2) =1.535 mm} 1535/d = 7×1.68 d = 130 mm. Provide D=146mm at fixed end and 110mm at free end Averagw thickness = (146+110)/2 =128 mm Design load (Wu) :For, depth (D) = 128mm. = 0.128m. DL (wt. of slab/m2) = vol. × density = (0.128m.×1m.×1m.)×(25 KN/m2) LL+FF (imposed loads) = 1.5 KN/m2 + 1.5 KN/m2 = 3.2 KN/m2 = 3 KN/m2 So, Total load = 3.2 + 3 = 6.2 KN/m2 Design load (Wu) = 1.5 × 6.2 = 9.3 KN/m2 40 | P a g e Design shear force (Vu) :Vu = Wu × l = 9.3×1.475 = 13.717 KN {for cantilever Vu =Wu×l} Design bending moment (Mu):Mu = Wu ×l2/2 = (13.71×1.4752) /2 = 10.116 KN-m {for cantilever Mu =Wu×l2/2} Step 3: Computation of effective depth :For, b(width) = 1m. =1000mm d = √Mu / (Ru×b) = √(10.116×106) / (2.761×1000) = 60.53mm providing nominal cover of 15mm and using 8mmØ bars dassumed = D-15-4 = 146-15-4 = 127mm {D=146mm} Reducing D =100mm at free end Step 4:- Steel reinforcement :Main reinforcement : Astreq. = 0.5fck/fy {1-√1- 4.6Mu/ / fck×b×d2 }×bd = 0.5 × 20/415 {1-√1 - 4.6(10.116×106)/(20×1000×1272)} ×1000×127 239 mm2 = 239 Spacing (S) = (1000 × 50.3) / 300 = 167 160mm c/c , which is < 3d and 300mm Distribution reinforcement:Astmini. = 0.12% × bD = (0.12/100)×1000×146 = 175.2mm2 Spacing (S) = (1000×50.3)/175.2 = 287 Pt =100Ast /bd = 100×186/1000×127 270mm c/c , which is k= 1.3 *Page no.73:table19 => ţc =0.28 for D=146mm. for M20 ,Pt = 10% So, k.ţc = 1.3×0.28 = 0.364 N/mm2 Now, ţv Ld . Hence O.K. DESIGN OF LOBBYBEAM (beam-10,11) Span of beam (L) = 2.2 m Width of beam = 230 mm Take Depth of beam= 350 mm Concrete mix=M20 Characteristic strength= 415N/mm2 COMPUTATION OF DESIGN BENDING MOMENT:staircase load = 10.44/2.2 = 4.74 KN/m Self-weight of beam= 0.23x0.35x1x25 = 2.0125 KN/m Total design load (WD) = 1.5x (4.74+2.0125) = 10.13 KN/m Factored resisting moment (MR) = WDxL2/8= 10.13x2.22/8 = 6.13 KN-m 47 | P a g e COMPUTATION OF EFFECTIVE DEPTH (d):Mu=.36 x Xu, max/d [1 - .42 x Xu,max/d] fck bd2 Xu, max/d = 700/ [1100 + .87fy] = .479 . .. Mu= 2.761 bd2 And from above equation d=√Mu/2.761 bd2 = √6.13x106/2.761x230 = 98.25mm ≈ 93mm Provide 25mm clear cover and using 20mm dia. bars with 8mm stirrups Overall beam Depth (D) = 93+25+8+16/2 = 134 mm However keep beam Depth= 350mm Therefore, effective depth of beam (d) = 350-25-8-16/2 = 309 mm STEEL REINFORCEMENT:Ast = 0.5 fck/fy [1 - √1-(4.6 Mu/fck bd2)] bd= 55.88mm2 No. of 16mm dia. Bars = 55.88/π/4x102 = 0.71≈2bars of 10mm dia. Horizontal Spacing should be lesser of greatest of the following:a) Diameter of the bar b) 5mm more than the nominal size of aggregate Hence provide horizontal spacing of 12 mm between the bars [IS 456:2000 Clause 26.3.2 (a)] Actual Ast = 2x(π/4x102) = 157 mm2 Moment of resistance at mid span is :MR = 6.13 KN-m (evaluated above). Mu,lim = 2.761 bd2 = 60.63 KN-m 48 | P a g e Since Mu < Mu,lim. The design is ok. SHEAR REINFORCEMENT:The critical section for shear is at a distance of d=(0.309 m) from face of support. Note that distance of theoretical centre of support from face = d/2=0.309/2=0.16 Therefore, VuD = Wu L/2 – Wu (d/2 + d)=(10.13x2.2)/2 – 10.13x(0.309+0.16) = 6.40 KN τv = VuD/bd= 6.40x103/(230x309) = 0.09N/mm2 100Ast/bd (at the support) = 100x157/(230x309) = 0.22% From table 19 of IS 456:2000 τc = 0.336N/mm2 Since τv < τc , min. shear reinforcement is given according to clause 26.5.1.6 of IS456:2000. As per IS 456:2000, nominal shear reinforcement is given by the expression:Asv/b.sv > 0.4/0.87 fy or sv = 2.175 Asv . fy/b Using 2 legged 8mm dia. Stirrups, Asv = 2 x π/4 (8)2 = 100.5 mm2 Sv= 2.175x100.65x415/230 = 335.66 mm Max. spacing is least of:(i) 0.75 d= 0.75x307 = 230.25 mm Or (ii) 300 mm Hence provide 8 mm dia. 2-legged stirrups @230 mm c/c throughout the length of the beam. Provide 2-10 mm dia. holding bars at the top. 49 | P a g e CHECK FOR DEVELOPMENT LENGTH:Ld ≤ 1.3 M1/V + Lo Xu = 0.87 fy Ast1/0.36 fck b = 0.87x415x157/0.36x20x230 = 34.22 mm ≈ 35mm M1 = 0.87 fy Ast1 (d – 0.42 Xu) = 0.87x415x157 (309 – 0.42x35) = 16.68x106 KN-m Vu = Wu L /2 = 10.13x2.2 /2 = 11.143 KN Ld = 0.87 fy x diameter of bar / 4τb (clause 26.2.1 of IS456:2000) Ld = 0.87x415x10/4x1.2x1.6 = 471 mm Lo = sum of anchorage beyond centerline of support and anchorage hook value. If no hook is provided, then Lo = Ls/2 – x′ Where Ls = wall thickness x′ = side cover which is assumed to be 40 mm Therefore, Lo = 200/2 -40 = 60 mm Ld/3 = 471/3 = 157 mm Available distance beyond face of support = Lo + Ls/2 = 60+ 200/2 = 160 mm < Ld/3. Hence hook is required. According to codal provision, Anchorage Value of standard U-type hook shall be equal to 16 times the diameter of bar(clause 26.2.2.1, IS456:2000). Hence, Lo = 16x diameter of bar = 16x10 = 160 mm Therefore, 1.3 M1/V + Lo = 1.3 x (16.68x106 /11.143x103) +160 = 2105.97 mm > Ld Hence O.K. 50 | P a g e Other beams are similarly designed and the all values are tabulated below:S.NO BEAM NO. Span Width Depth Design Design moment (m) (mm) (mm) load(KN) (KN-m) 1 Beam-1 3.40 230 350 11.11 16.05 2 Beam-2 3.15 250 400 10.39 12.88 3 Beam-3 5.00 250 400 14.06 47.52 4 Beam-4 &5 2.50 250 400 16.875 24.25 5 Beam-6 2.50 250 400 19.11 30.96 6 Beam-7 3.20 230 350 14.013 17.94 7 Beam-8 &12 4.40 250 400 24.36 58.96 8 Beam-9 3.20 250 400 19.95 25.54 9 Beam-10 & 11 2.20 230 350 10.13 6.13 10 Beam-13 3.65 230 350 11.56 19.25 Table 7:- beam design data BEAM NO. Ast 2 Required(mm) Dia of No.of Actual Dia of shear Spacing of bars bars(Ast/ Ast reinforcement shear (mm2) (mm) reinforcement (Φmm) Φ 2) c/c (mm) Beam-1 151.62 12 2 226.2 8 225 Beam-2 102.41 10 2 157 8 260 Beam-3 407.45 10 6 471 8 260 Beam-4 &5 197.28 12 2 226.2 8 260 Beam-6 253.87 12 3 339.3 8 260 Beam-7 169.24 12 2 226.2 8 225 Beam-8 &12 520.68 10 5 565.5 8 260 Beam-9 208.33 12 2 226.2 8 260 Beam-10 & 55.88 10 2 157 8 225 183.67 12 2 226.2 8 225 11 Beam-13 Table 8 :- beam design data 51 | P a g e 52 | P a g e Fig 9. X-Section of beams V:-DESIGN OF COLUMNS:There are usually three types of columns that are usually encountered while designing. These are as follows along with their nomenclature used . 1. Axially loaded columns (C1) 2. Columns with axial load and uniaxial bending (C2) 3. Columns with axial load and biaxial bending (C3) Design of column C1: Using fck=20N/mm2 ,fy=415N/mm2 Unsupported length= 3-0.4=2.6m Leff =1*2.6= 2.6m (Cl:25.13) (Annex E) 53 | P a g e Load calculations: Load from beam 9=(19.95*3.20)/2=31.92KN Load from beam 8=(4.4*24.36)*2/2=107.184KN Load from beam4= (3.4*16.875)/2=28.6875KN Self weight= 1.5(25*B2*3*10-6) KN =112.5*10-6B2 KN (Assuming a square column) Total axial force due to D.L+L.L=(167.79+112.5*10-6B2)KN 1)Size of Column: Assuming P=0.01 Ag= [p/{(0.4fck)(1-p/100)+(p/100)(0.67fy)}] Ag = [(167.79*1000+0.1125Ag)/{(0.4*20)(1-1/100)+(1/100)(0.67*20)}] Ag =[(167790+0.1125Ag)/8.054] Ag= 21128.25 mm2 So B=D= 145.35 mm Let us provide a column size of 300*300 2) Slenderness ratio of a column Effective length (l)= 2.6m=2600mm l/D=2600/300=5.60.005D, the column needs to be redesigned 54 | P a g e Lets provide a column section of 400x400 emin=[(2600/500)+(400/30)]=18.53~20mm 0.05(400)=20mm 4) Longitudinal Reinforcement:[cl 26.5.3.1] Asc =(1/100)(21142.10)=211.42mm2 Providing 12mm bars, so the no. of bars =211.42/(0.785x144)=1.87 However providing a minimum of 4 bars of HYSD grade (415),with a clear cover of 40mm So actual Asc provided =4x0.785x144=452.16mm2 5) Transverse reinforcement: [cl 26.5.3.2] Providing 8mm dia ties as 8>(12/4) Pitch of lateral ties= Least of lateral dimension=400 16(Dia of longitudinal rein.)=16*12=192 300 So provide 8mm /c c/c distance between main bars=400-2 x 40-2x6=308mm

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