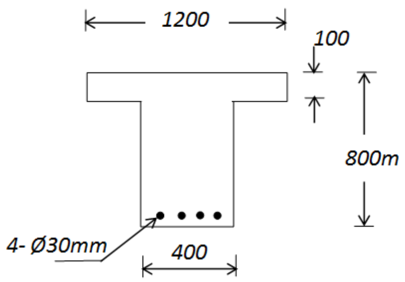
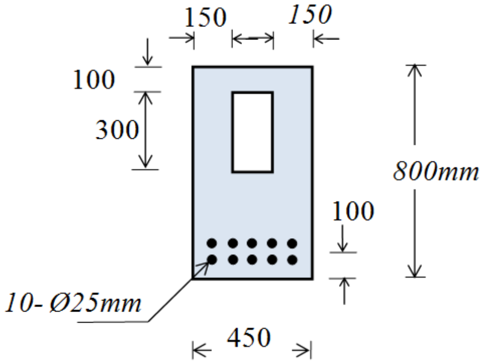
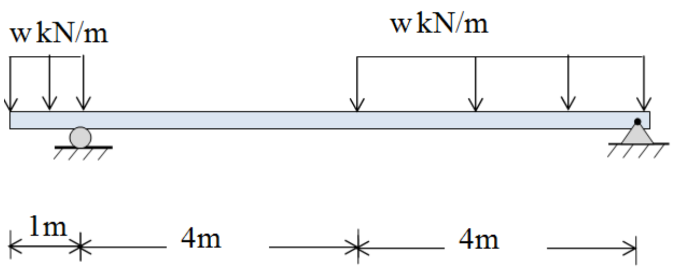
80 Problems in Reinforced Concrete

1. How the engineer test the tensile strength of concrete.
2. Explain the shrinkage in the concrete, and how the engineer can minimize the shrinkage of it.
3. Define high strength concrete, what is the benefit of high strength concrete. Draw relationship between stress and strain for different strength of concrete.
4. What is the compatibility between steel and concrete that make steel used instead of another metals (materials) to reinforced concrete?
5. What is modulus of elasticity, how many methods used to find it, which of them used to find modulus of elasticity of concrete and which of them for Steel. Clear your answer with figures.
6. What s the main points that make steel used in RC instead of other materials.
7. What are the advantages of RC as a structural material?
8. What are the disadvantages of RC as a structural material?
9. What is creep, what factors influences the creep of concrete.
10. Explain the shrinkage in the concrete, and how the engineer can minimize the shrinkage of it.
11. Who take patent on inventing cement and when? How make it?
12. Draw stress-strain curve for different strength of concrete starting from 31MPa to 120MPa, and write the main similar and difference between them.
13. Who got patent on inventing cement and when? How make it?
14. Draw stress-strain curve for different strength of steel bars (for reinforcement) starting from 420MPa (60ksi) to 1860MPa (270ksi), and write the main similar and difference between them.
15. How invented cement (found), at about which year, how he made it (produced) and what is the event that leads to popularized the use (widespread).
16. What is the difference between normal strength concrete and high strength concrete?
17. How many methods to test tensile strength of concrete, explain briefly, then draw each one.
18. A reinforced concrete beam loaded gradually until ultimate load (i.e., loaded from zero to failure). What are the stages passing through loading? Then draw the stress distribution and strain distribution at each stage.
19. Show the advantages of elastic method of analysis of beam (i.e., its useful to be familiar with WSD), and advantages of ultimate method (strength method) of analysis of beam.
20. Determine the cracking moment of inertia for the section shown by the transformed area method. Use fc`=28MPa and fy=420MPa , n=10, Es=200GPa, cover =70mm.

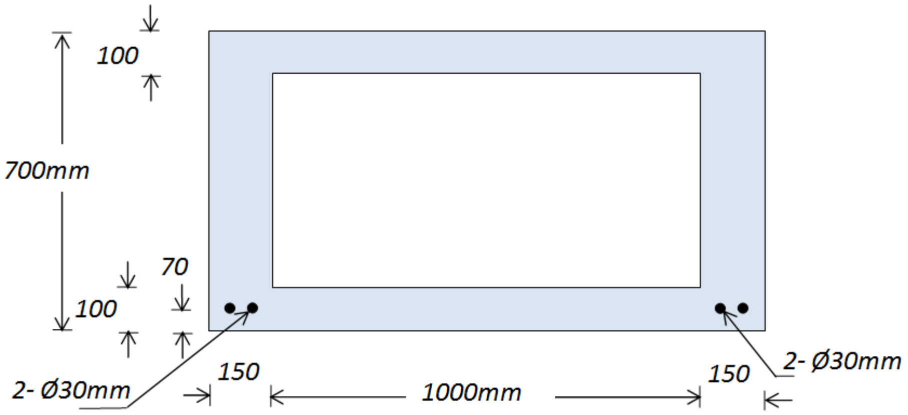


21. What the allowable uniform w kN/m load that is distributed over the beam for maximum positive moment of the beam shown. Use a transformed area, and the beam is cracked section. Take fc=0.4 fc` and fs=0.6 fy . If fc`=35MPa and fy=420MPa.

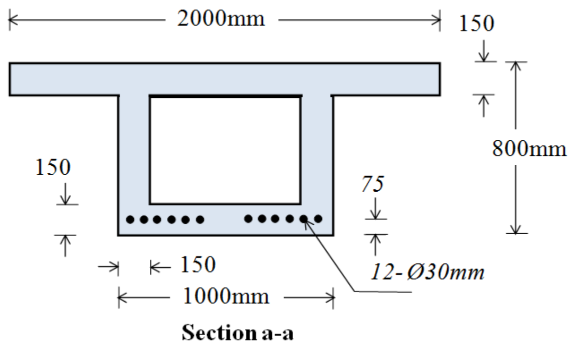




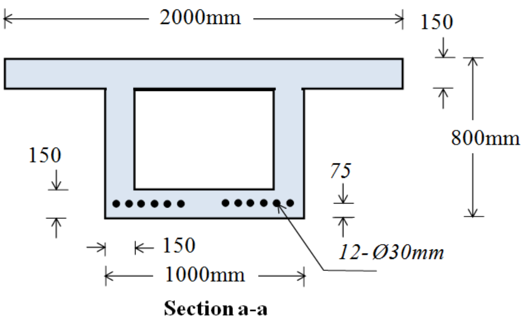
22. Check the bending stresses in the steel and concrete for the beam shown (section) subjected to a moment of 450kN.m. Use working stress design method - cracked section. Allowable bending stress in the concrete is fc=0.45fc`, and allowable bending stress in the steel bars is fs=0.6fy . Take n=9 ; fc`=28MPa ; fy= 420MPa ; INA=7268.5x10 6mm4; and cover=70mm.

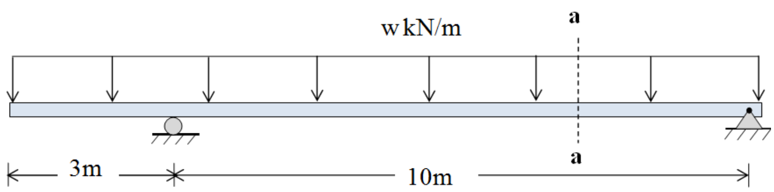


23. Using transformed area method to compute the cracked moment of inertia (Icr) of section a-a shown.

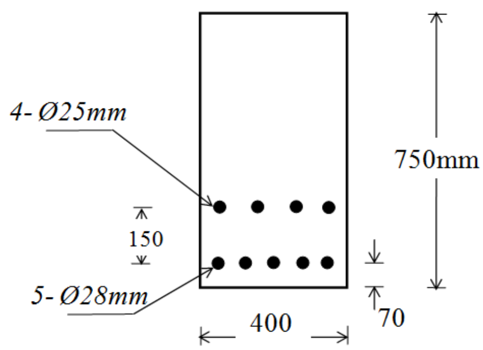


24. Determine the allowable uniform load w that can be applied on the beam shown for a maximum positive moment. Use working stress design- cracked section. Allowable bending stress in the concrete is fc= 0.4f`c and in the steel is fs=0.6fy, n=9, Icr=26270x106mm4 and kd=yt=205mm.

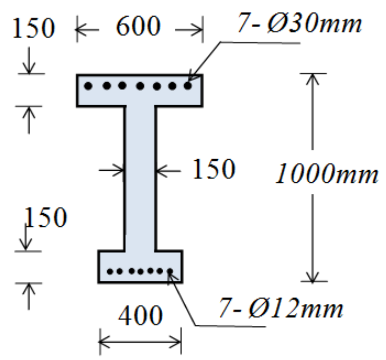




25. Use working stress design method - cracked section to check the bending stresses in the steel and concrete for a beam section shown, subjected to a moment of 360kN.m. Allowable bending stress in the concrete is fc=0.45fc`, and allowable bending stress in the steel bars is fs=0.6fy . Take n=10.

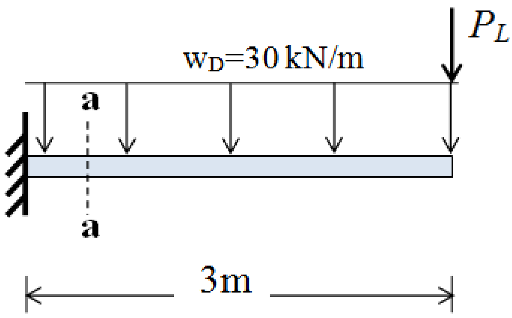


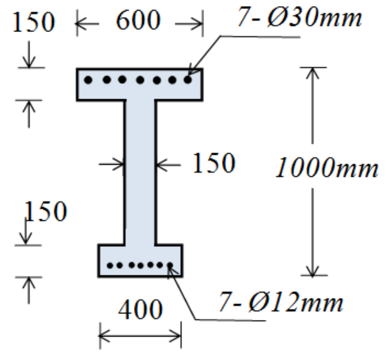
26. Use transformed area method for cracked section, accurate method, to compute the depth of neutral axis (kd) of the I beam section a-a shown. Then determine the cracked moment of inertia(Icr).



Section a-a

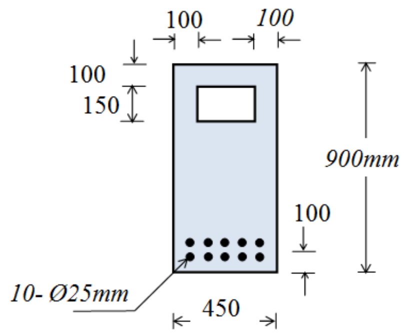
27. Determine the maximum point load PL can be applied for the loaded beam shown. If the applied uniform dead load is wD= 30kN/m. Take n=8 , fc=0.45 fc` ; fs=0.6 fy ; kd=390 mm ; Icr=20000x106 mm^2.





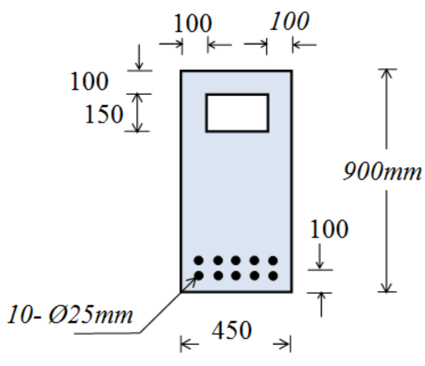
Section a-a

28. Use transformed area method for cracked section, accurate method, to compute the depth of neutral axis (kd) of the beam section a-a shown. Then determine the cracked moment of inertia (Icr). The main bars are 10-Ø25mm (for Ø25 Ab=490mm^2).

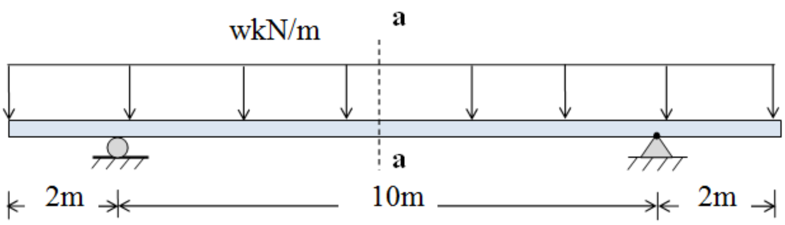


Section a-a

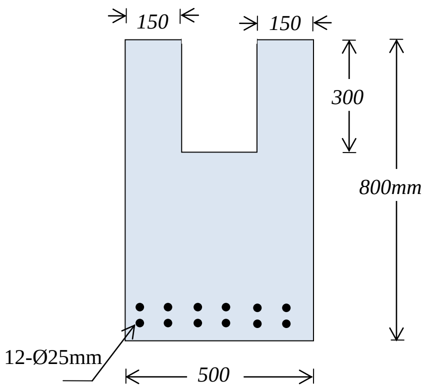
29. Determine the maximum uniform load (w) that can be applied for the beam shown (working method). Take fc=0.45 fc`; fs=0.6 fy; kd=360 mm; Icr=14000x106 mm^4.



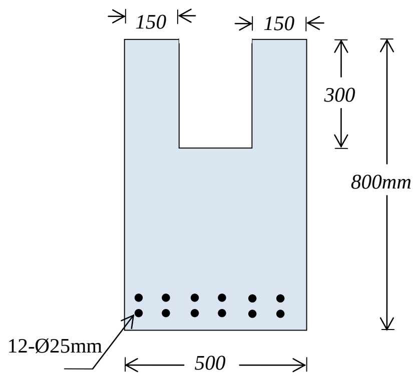
Section a-a



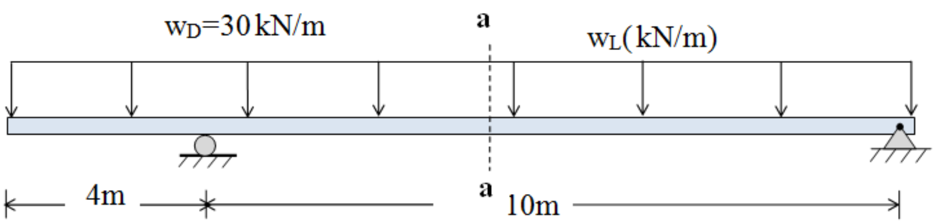
30. Use transformed area method for cracked section, , to compute depth of neutral axis (kd) of the beam section shown. Then determine the cracked moment of inertia (Icr). Main bars are 12-Ø25mm. Cover=100mm.

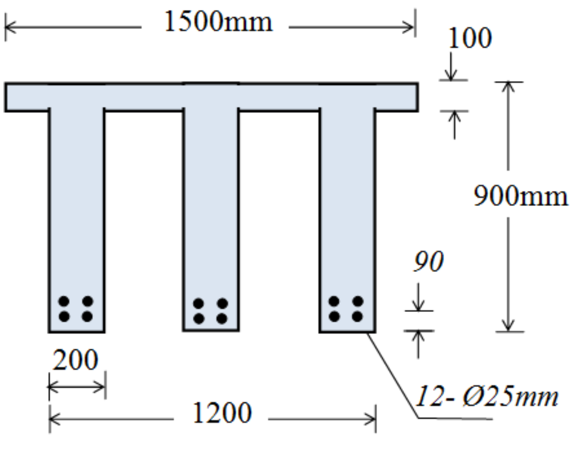


31. Determine the allowable bending moment that can be applied on the beam shown for maximum positive moment. Apply working stress design- cracked section. Use minimum factor of safety 2.0, n=9, kd=380mm , Icr=12000 x106mm^4.



32. The loaded beam has a section a-a shown, is subjected to uniform distributed dead load wD=30kN/m and uniform live load wL . take Allowable bending stress in the concrete is fc= 0.45f`c and in the steel is fs=0.6fy,
   A) Using transformed area method to compute cracked moment of inertia (Icr) of section a-a shown.
   B) Determine the maximum allowable uniform live load wL, that can be applied on the beam shown. Use working stress design- cracked section, Icr=25000x106mm4 and kd=yt=250mm.

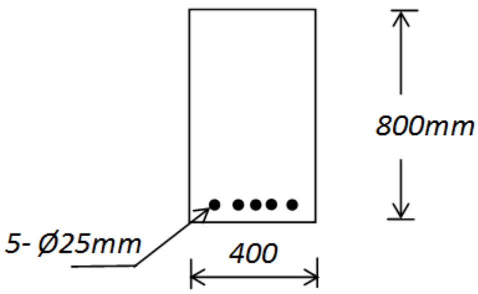




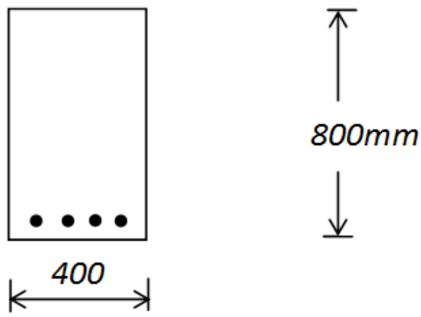
Section a-a

33. Write the assumptions that the strength design method (ultimate) for beam design is based on.

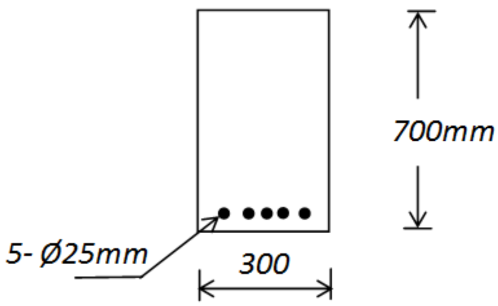
34. Determine the ACI moment capacity of beam shown, and then check the beamwidth. Use fc`=28MPa fy=420MPa, Ø10mm for stirrup.



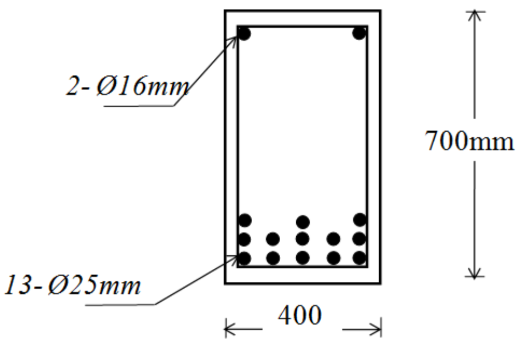
35. Design the beam shown for a moment Mu= 800 kN.m. Use Ø25mm , fc`=28MPa fy=420MPa , Es=200GPa, Ø10mm for stirrup.



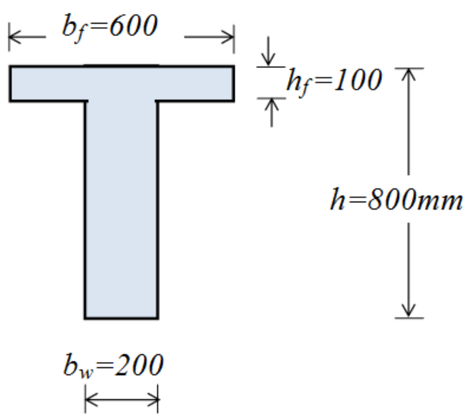
36. Determine the ACI moment capacity of the beam shown for different concrete strength, fc`=28MPa, fc`=100MPa, then compare between the results, use fy=420MPa, and Ø10mm for stirrup.



37. Determine d and d` for the beam shown, then check the width of the beam. Take stirrups Ø10mm and dagg.=20mm.



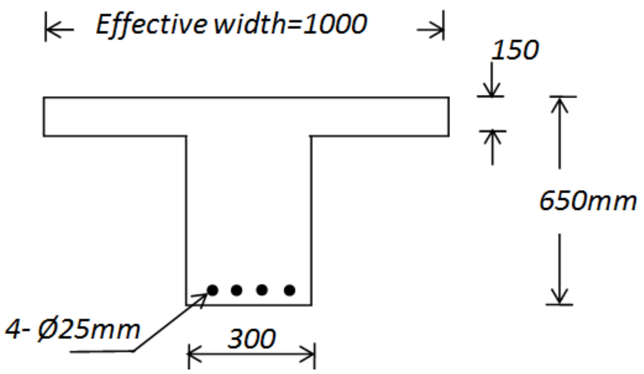
38. Determine the maximum steel ratio(i.e., As,max, and ρmax.) for the T-beam section shown (i.e., this ratio is maximum permissible to design the beam as single reinforcement).



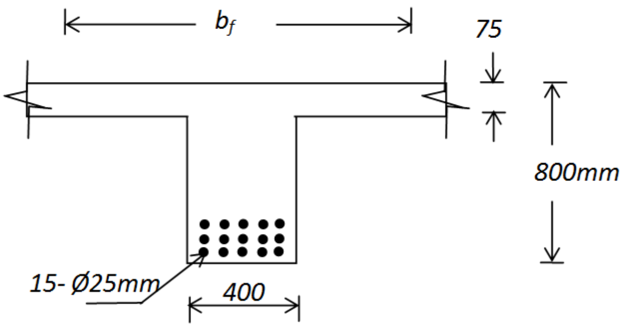
39. How the safety can be achieved (satisfy) in ACI-318 code (2019). Explain each item briefly.

40. What is the advantage of compression reinforcements in the beam?

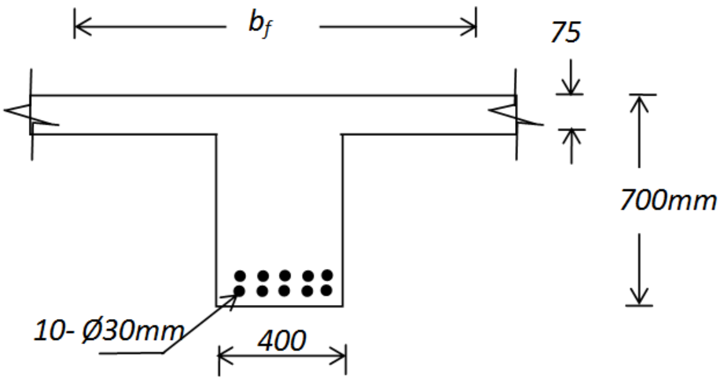
41. Determine the design strength of T-beam shown. *Use* f_c`=28MPa f_y=420MPa, and *Ø10mm for stirrup.*



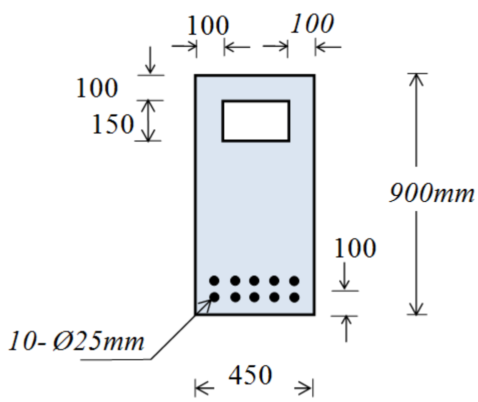
42. Determine the design strength of T-beam shown. The beam has span of 8m and the clear distance between the adjacent webs is 800mm. *Use* f_c'=28MPa f_y=420MPa, cover =100mm and Ø10mm for stirrup.



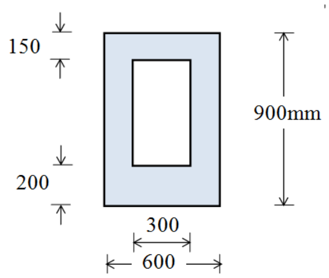
43. Determine the design strength of T-beam shown. The beam has span of 7m and the clear distance between the adjacent webs is 1000mm. *Use* f_c'=28MPa f_y=420MPa, cover =100mm and Ø10mm for stirrup.



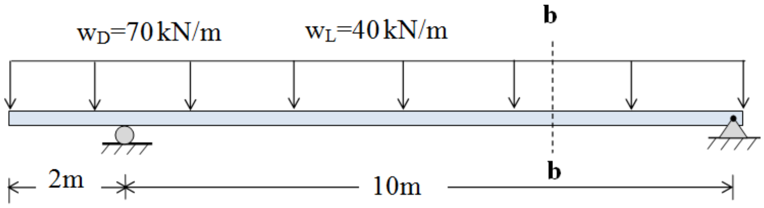
44. Determine the design moment strength ($ØM_n$) of the hollow section shown. *Use* f_c'`=28MPa f_y=420MPa



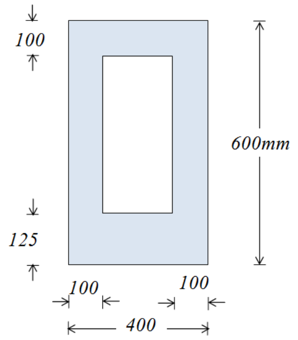
45. Design the hollow beam shown at maximum positive moment. Use Ø25mm (A_b=490mm^2). *Use* $f_c'=35MPa$ $f_y=490MPa$



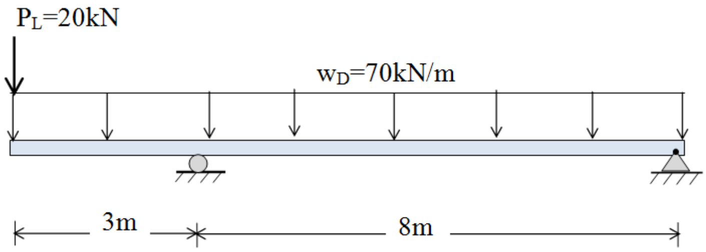
Section b-b



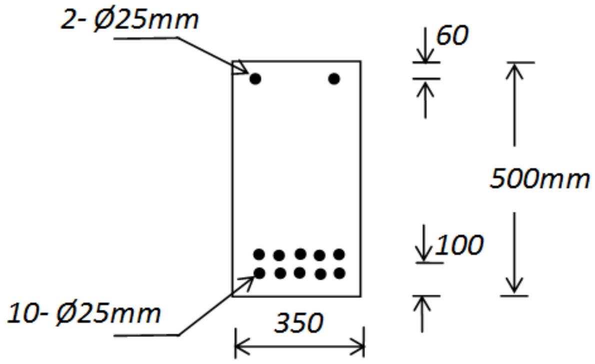
46. Determine the steel area required for the un-factored loaded beam shown at maximum positive moment. Take the main bars *Ø25mm* and for stirrups *Ø10mm*. *Use* $f_c'=28MPa$ $f_y=420MPa$



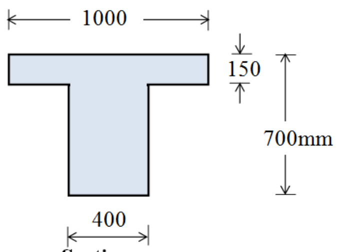
Section a-a



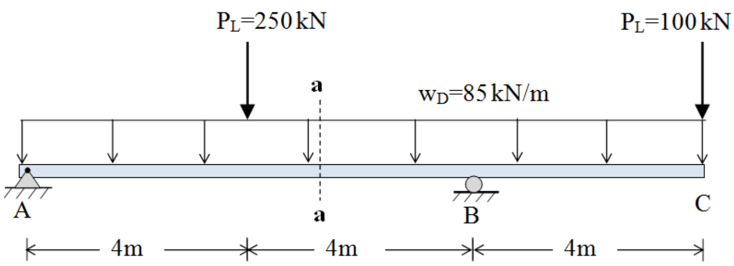
47. Determine the design strength of double reinforced beam shown. *Use* $f_c'=28MPa$ $f_y=420MPa$, and *Ø10mm for stirrup.*



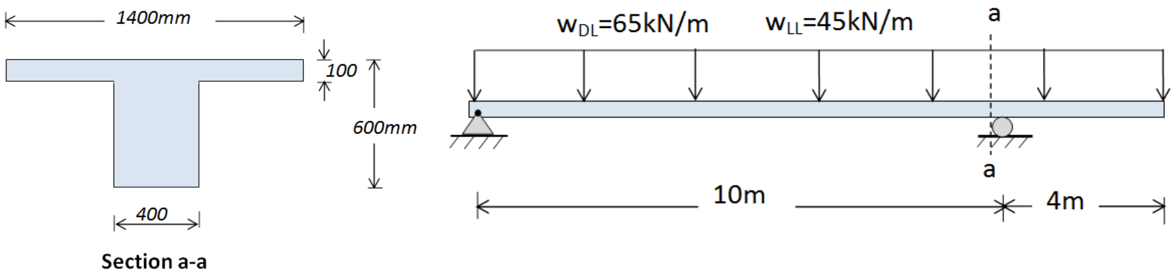
48. The beam shown is limited to the dimensions shown. Determine the maximum positive moment and maximum negative moment in the beam, then design the beam for maximum negative moment(at support B). Also, check values of ϵ_t and Ø. Take diameter of main bars Ø30mm (A_b=706mm^2). *Use* $f_c'=35MPa$ $f_y=420MPa$



Section a-a

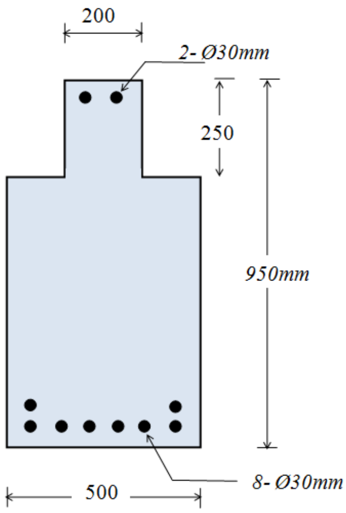


49. Determine the steel area required for the loaded beam shown at section a-a (for the maximum negative moment). The dimensions of the section are limited to the values shown. Use: $f_c'=35MPa$; $fy= 490MPa$; w_{DL}=65kN/m (neglect self weight) ; w_{LL}=45kN/m ; and diam. of the bars are 30mm (A_b=706mm^2).

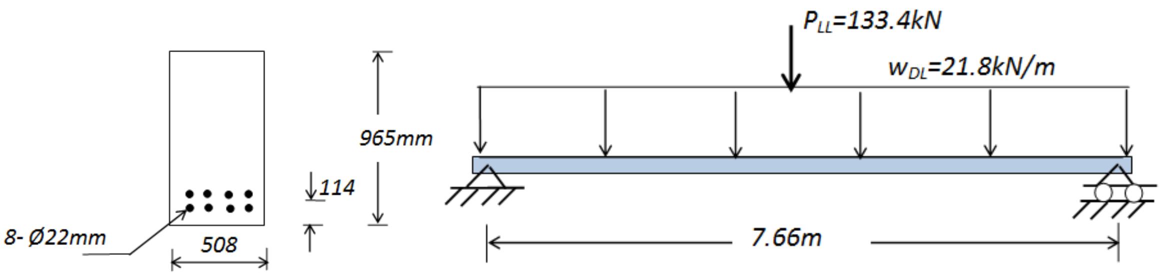


(Ans. Use 9-Ø 30 at

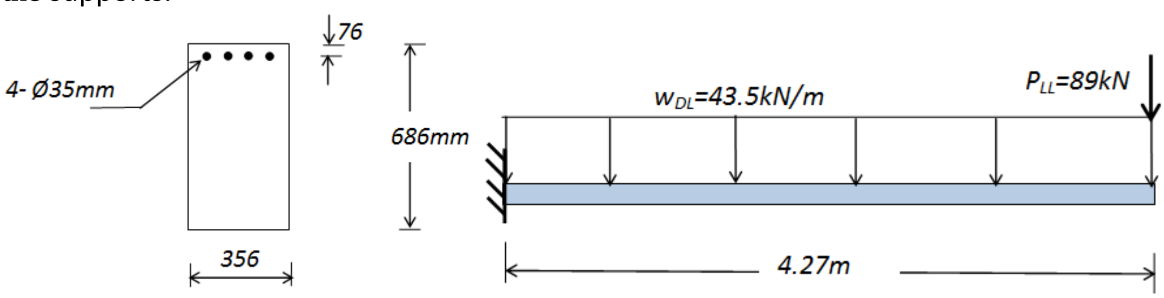
50. Determine the ultimate moment strength of the double reinforced concrete section shown. *Use* $f_c'=28MPa$ $f_y=420MPa$



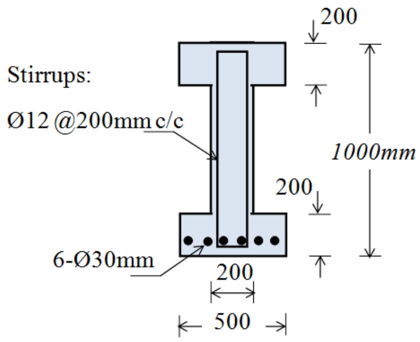
51. Determine the required spacing for *Ø10mm* stirrups *(Av=78mm2)* at maximum shear of the loaded beam shown. *Use fc`=27.6MPa* and *fy=414MPa.* Note: assume that the span is given from faces of the supports.



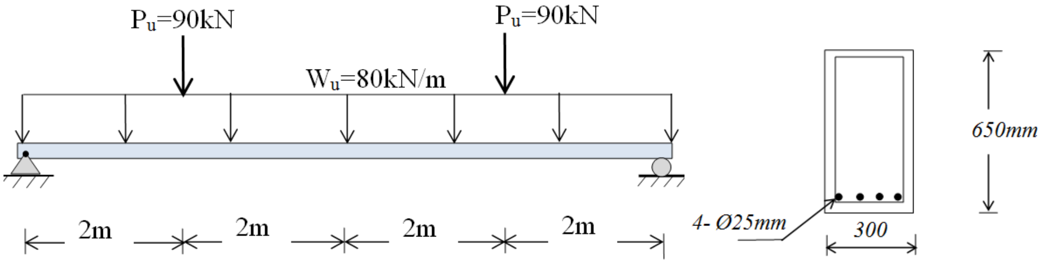
52. Determine the required spacing for *Ø10mm stirrups (Av=78mm2)* at maximum shear of the loaded beam shown. *Use fc`=27.6MPa* and *fy=414MPa.* Note: assume that the span is given from faces of the supports.



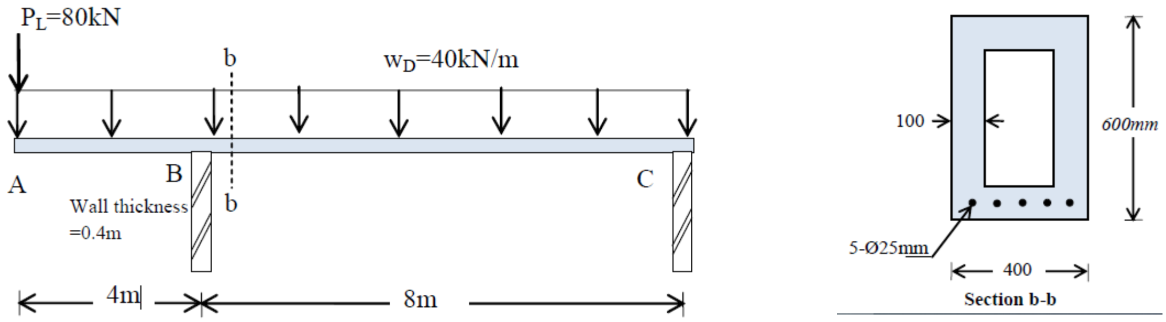
53. Determine the ***Vn*** for the section shown, if *fc`=100MPa*.



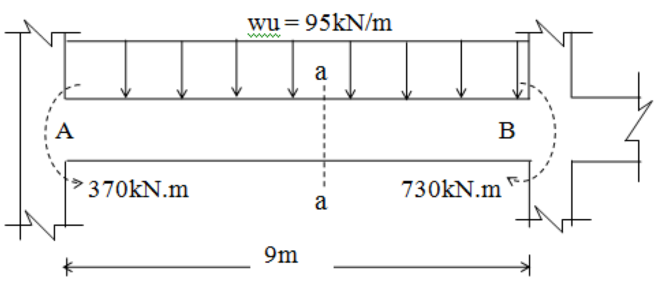
54. Select spacing for Ø10mm (take Ab=78mm2) stirrups for a beam with bw=300, h=650 mm for the loaded beam shown, with *fc'*=28MPa and *fy*=420MPa.

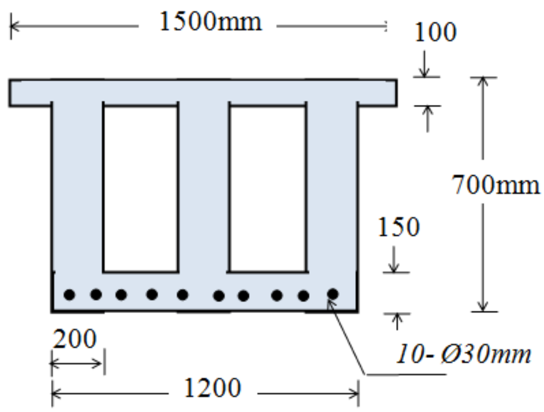


55. For the loaded beam and hollow section shown, determine the required spacing of stirrups at right of support B (at critical section), then check all requirements for shear. Use *Ø12mm stirrups* with *fc'* =28MPa and *fy*=420MPa.



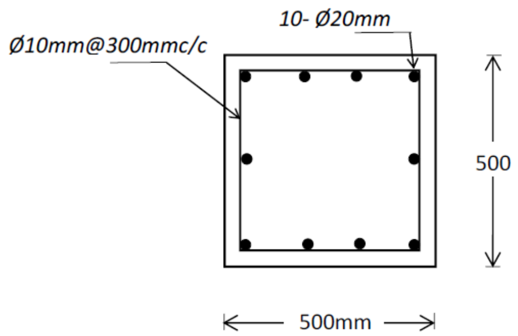
56. The loaded beam and hollow section are shown. Use *fc'=28MPa; fy= 420MPa* column dimensions are 600x600mm. Determine the required spacing of stirrups at left of support B (at critical section), then check all requirements for shear. Use 3-legs stirrups, Ø10mm (Ab=78mm2).



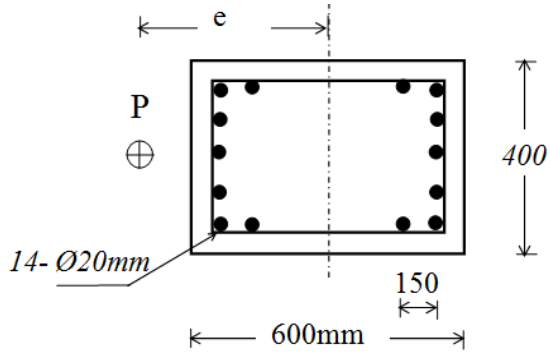


Section a-a

57. Design the round **tied** column for axially loaded. PD=650kN and PL=425kN. Then check ACI-318 Code-2014 requirements for columns. fc'=28MPa and fy=420MPa.
58. Design the round **spiral** column for axially loaded. PD=1150kN and PL=525kN. Then check ACI-318 Code-2014 requirements for columns. fc'=28MPa and fy=420MPa.
59. Check the ACI-318 code requirements for the column shown. Maximum aggregate size 25mm.

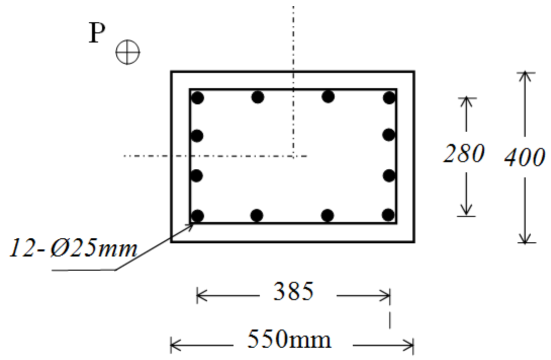


60. A 600x400mm column is reinforced with 14-Ø20mm as shown. Determine the P_n and M_n on the interaction curve at a point has c=500mm (depth of compression zone). Use f_c\`=28MPa ; f_y= 490MPa and A_b=314mm^2 for Ø20mm.

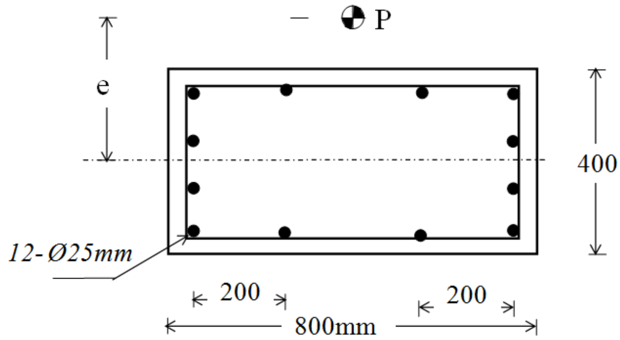


61. Determine the design capacity strength $ØP_n$ values for the short tied column which is subjected to biaxial bending as shown. Use f_c\`=28MPa ; f_y= 420MPa e_x=150mm , e_y=300mm. use Bresler formula: .

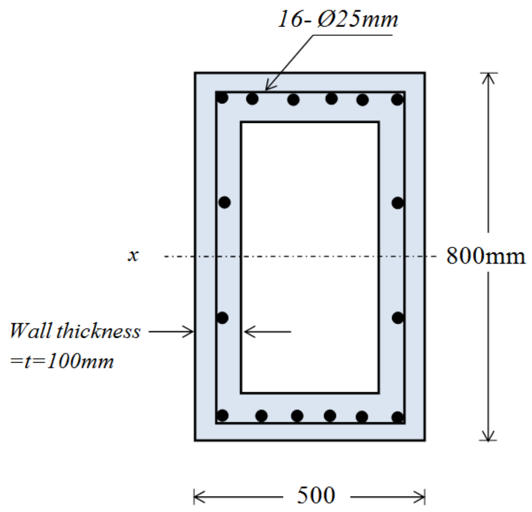
$$\frac{1}{P_{ni}} = \frac{1}{P_{nx}} + \frac{1}{P_{ny}} - \frac{1}{P_o}$$



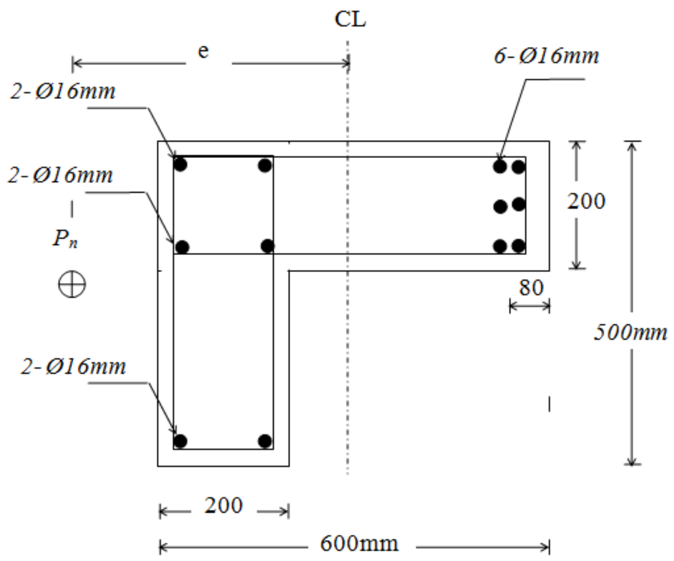
62. A column 400x800mm is reinforced with 12-Ø25mm as shown. Determine the P_n and M_n on the interaction curve at a point has c=150mm (depth of compression zone).Also, find Ø (reduction factor). Use f_y= 550MPa .



63. Analyze the hollow column shown for case of pure moment (P_n=0) about x-axis. Find the tensile stress in each bar. Use f_c`=28MPa ; f_y= 420MPa



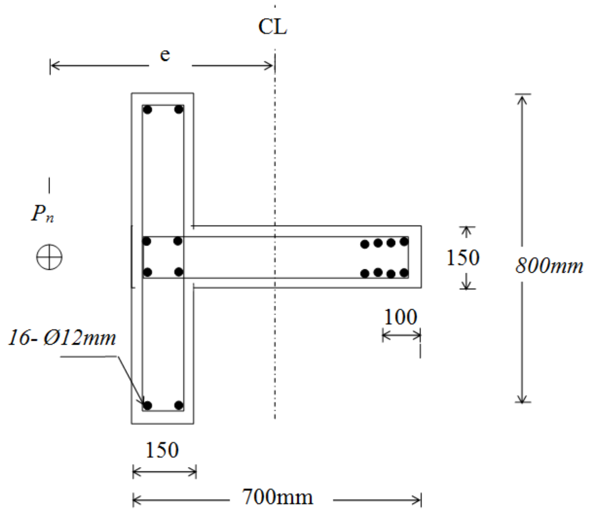
64. L-column shown is reinforced with 12-Ø16mm. Determine the P_n and M_n on the interaction curve at a point has c=300mm (depth of compression zone). Use f_c'=35MPa ; f_y= 420MPa and A_b=200mm^2 *for* Ø16mm. ties Ø10mm at 200mmc\c.



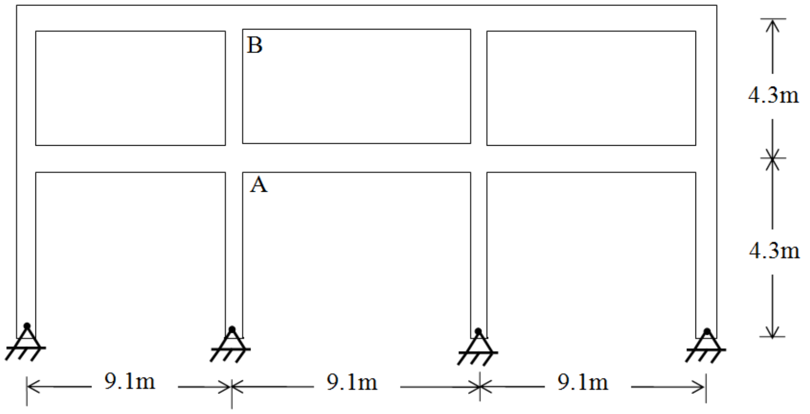
65. T-column shown is reinforced with 16-Ø12mm. Use f_c'=28MPa ; f_y= 490MPa and A_b=113mm^2 *for* Ø12mm and ties Ø10mm at 200mmc\c.

a) Determine the P_n and M_n on the interaction curve at a point has c=350mm (depth of compression zone).

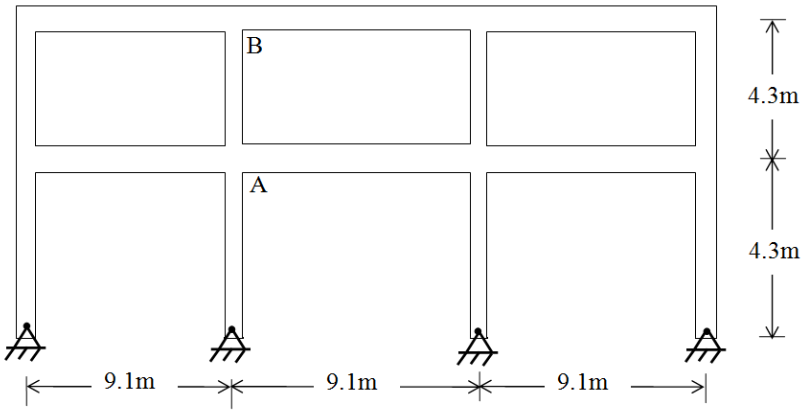
b) Find eccentricity and strength reduction factor (i.e., Ø).



66. Using the alignment charts for the unbraced (Sway) frame shown, determine the effective length factors for column AB. Take dimensions for all beams are 300x500 mm and for all columns are 300x400 mm, f_c`$=27.6MPa$, $f_y=414MPa$ *and for pinned supports* $\psi_A=10$.



67. Using the alignment charts for the braced (Non-sway) frame shown, determine the effective length factors for column AB. Take dimensions for all beams are 300x500 mm and for all columns are 300x400 mm, f_c`$=27.6MPa$, $f_y=414MPa$ and for pinned supports $\psi_A=10$.

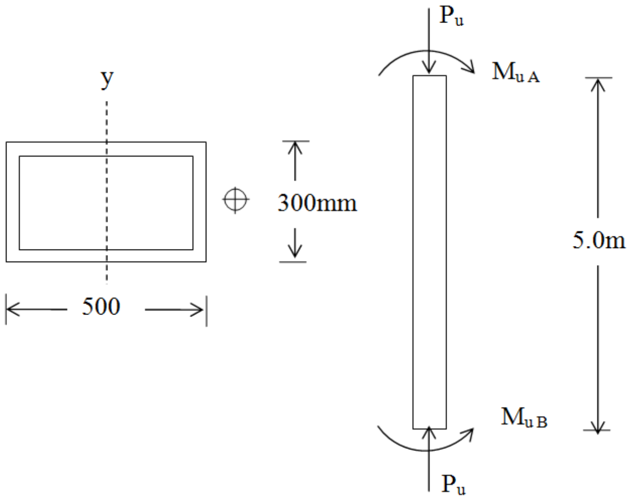


68. Determine the design axial load and design moment for the tied column shown. The moment about y-axis. f_c`$=28MPa$, $f_y=420MPa$, $k=1.0$.

$P_D=500kN$, $P_L=300kN$

at top $M_D=50kN.m$, $M_L=40kN.m$

at bottom $M_D=60kN.m$, $M_L=55kN.m$

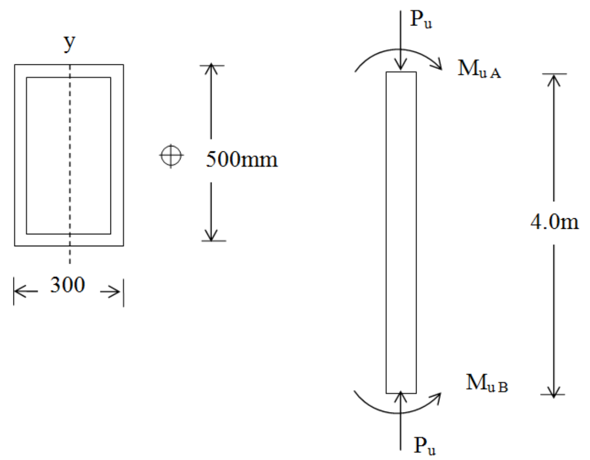


69. Determine the design axial load and design moment for the tied column shown. The moment about y-axis. f_c`$=28MPa$, $f_y=420MPa$, $k=1.0$.

P_D=600kN , P_L=400kN

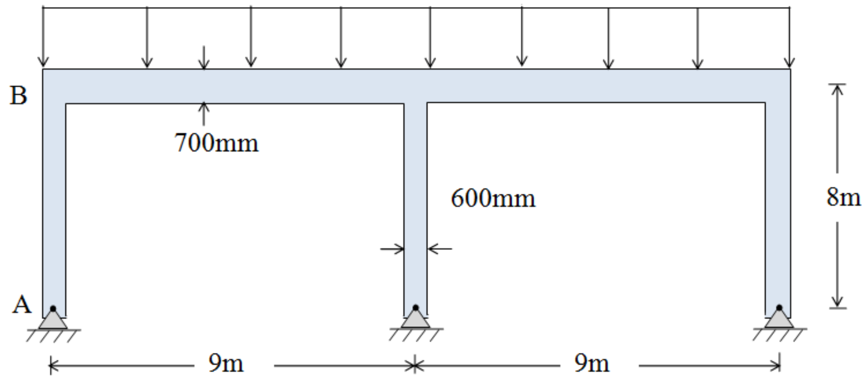
at top: M_D=50kN.m , M_L=40kN.m

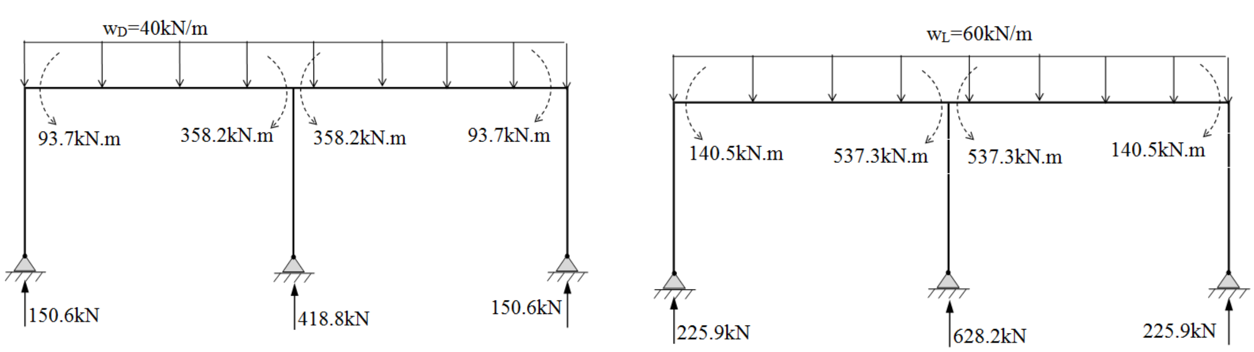
at bottom: M_D=60kN.m , M_L=55kN.m



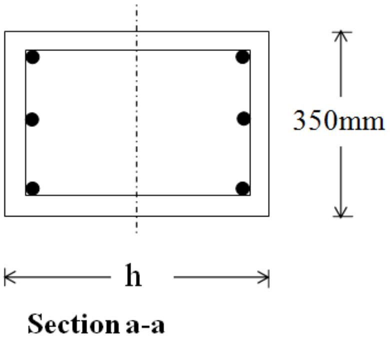
70. For braced frame (Non-sway) shown, determine δ_{ns} (moment magnification factor), and the axial force and moment that must be used in the design of the column AB, just for load case U=1.2D+1.6L. Consider only bending in the plan of the frame. The unfactored applied loads are $w_D=40kN/m$; $w_L=60kN/m$. The dimensions of all columns are 300x600mm and for all beams are 300x700mm.

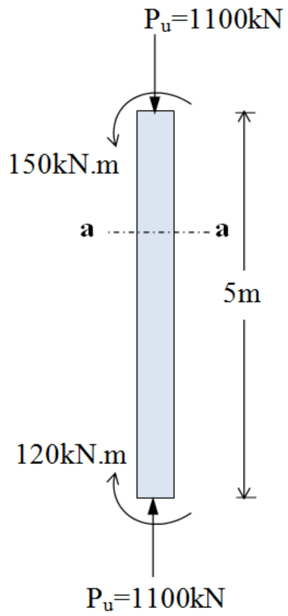
. Analysis results are:





71. A braced column is subjected to the loading shown. Determine the minimum value h so as the column can be design as a short column (i.e., avoid the slender column). Take effective length factor, k=1.0



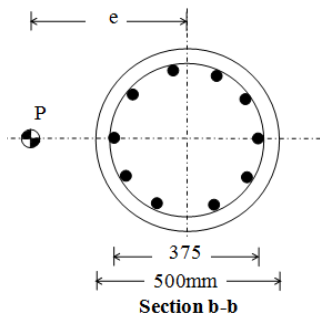


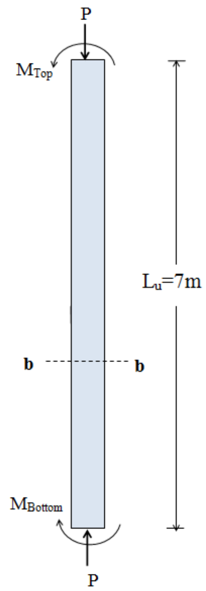
72. Design the tied braced circular columns with diameter D=500mm and height L_u=7m as shown. Use Ø25mm , k=0.9 , $I_{circle} = \pi D^4/64$

At Top: M_D=50kN.m ; M_L=40kN.m

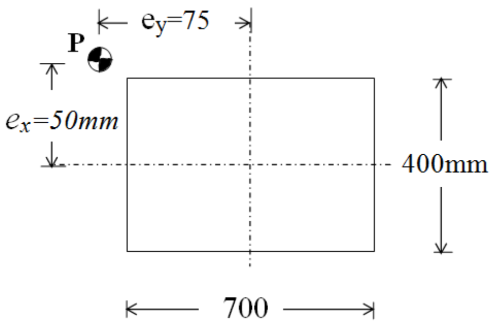
At Bottom: M_D=80kN.m ; M_L=50kN.m

P_D=500kN ; P_L =400kN

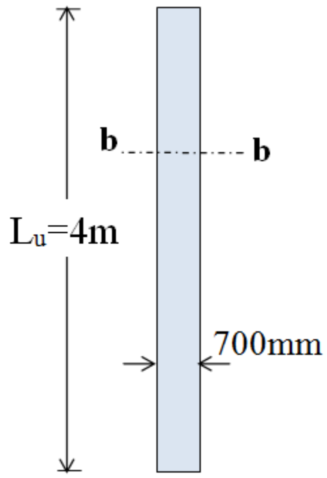




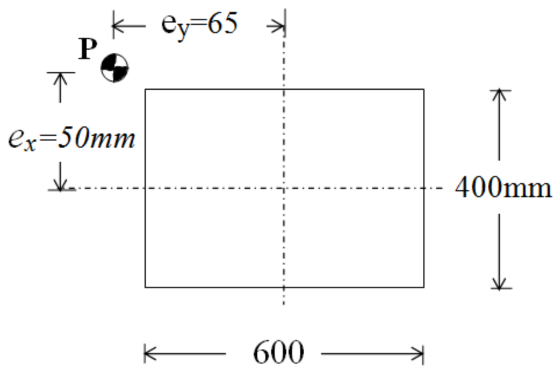
73. Design a braced column subjected to axial load (P_D=1500kN, P_L=1000kN) and biaxial bending moments shown. The column dimensions 400x700mm, the moments at top and bottom of the column are equal and induced single curvatures. Use k=1.0 and Ø25mm(A_b=490mm^2) for main bars.



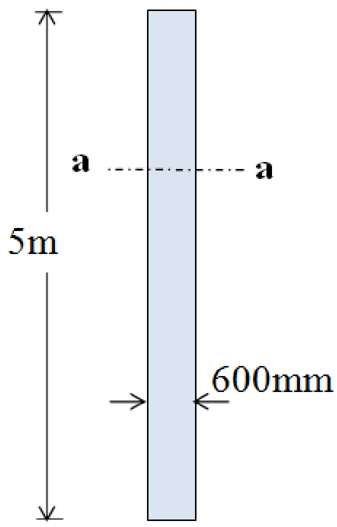
Section b-b



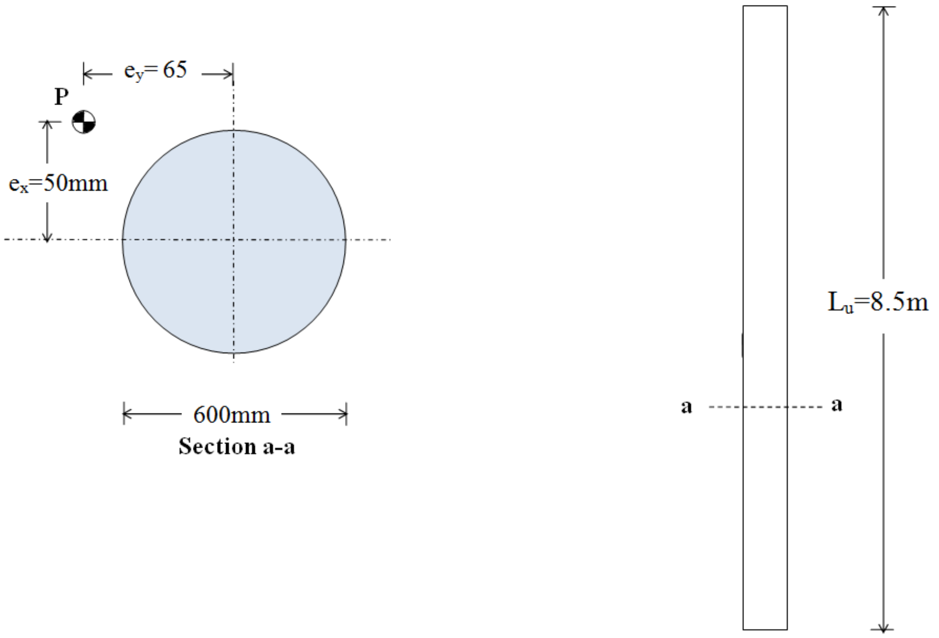
74. Design a braced column subjected to axial load (P_D=1250kN, P_L=1000kN) and biaxial bending moments shown. The column dimensions 400x600mm, the moments at top and bottom of the column are equal and induced single curvatures. Use k=0.7 and Ø20mm(A_b=314mm^2) for main bars, f_c`=28MPa ; f_y= 420MPa , ties are Ø10mm(A_b=78mm^2) and γ=(h_c / h) =0.7.



Section a-a



75. Design the spiral braced column (longitudinal reinforcements), subjected to axial load (P_D=1750kN and P_L=1250kN) and biaxial bending moments shown. The column height is 8.5m. The moments at top and bottom are equal and induced double curvatures, use k=0.9 and $\gamma = (h_c/h) = 0.8$, $I_{circle} = \pi r^4 / 64$.

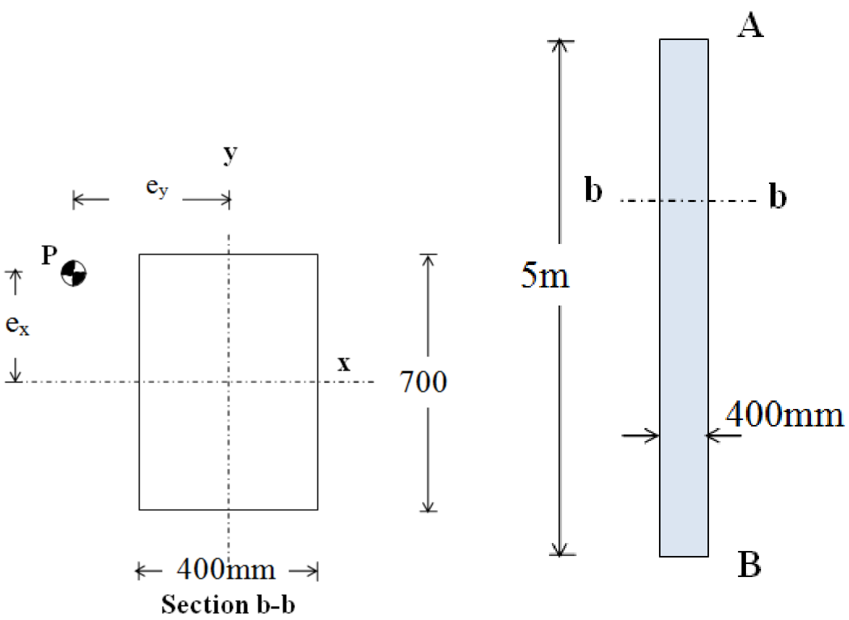


76. Design the sway column shown (for longitudinal reinforcement only) for load case: U=1.2D+L+W. The column subjected to axial loads and biaxial bending moments as follows: P_D = 1000kN ; P_L = 750kN ; P_W = 120kN ,

moment about x-axis are: M_D = 120kN.m ; M_L = 80kN.m ; M_W =110kN.m ,

and moment about y-axis are : M_D = 100kN.m ; M_L = 70kN.m ; M_W =90kN.m

The moments at top and bottoms are equal, induced single curvature. Take $\Sigma P_u = P_u$ for column AB and $\Sigma P_{cr} = P_{cr}$ for column AB, effective length factor k=1.3, $\gamma = h_c / h = 0.7$.



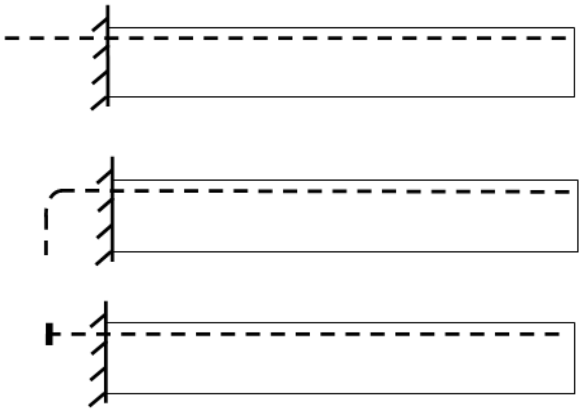
77. Determine the development length required for 4-25mm of the cantilever shown for :

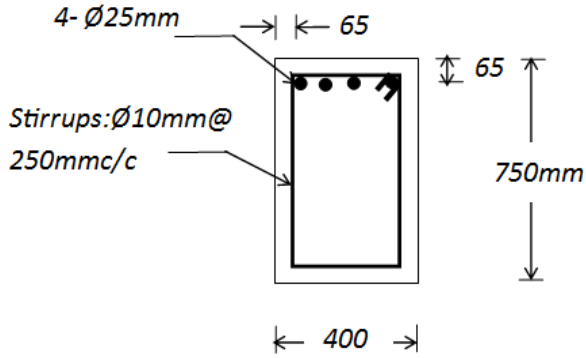
a. Use full ACI equation.

b. Use hooked end development length

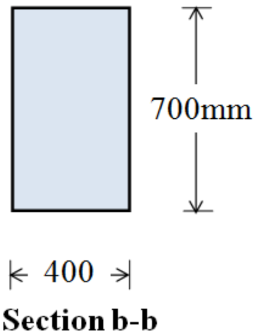
c. Use mechanical headed end development length.

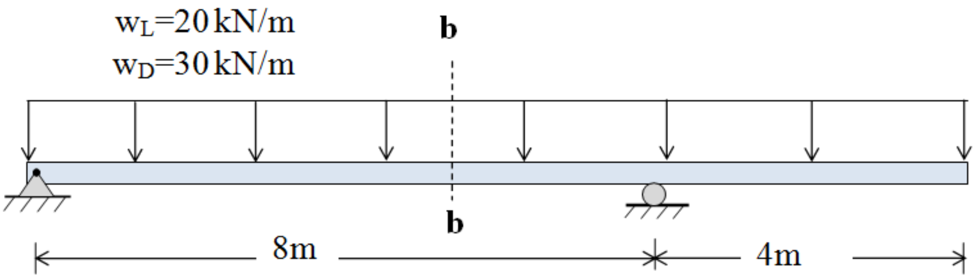
Take f_c\`=35MPa and f_y=420MPa.



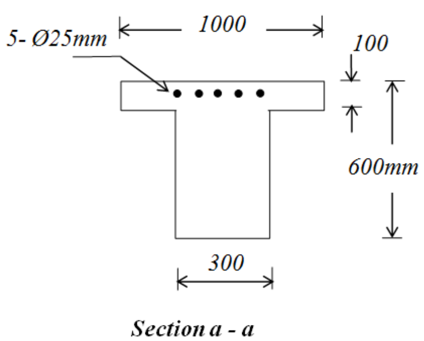


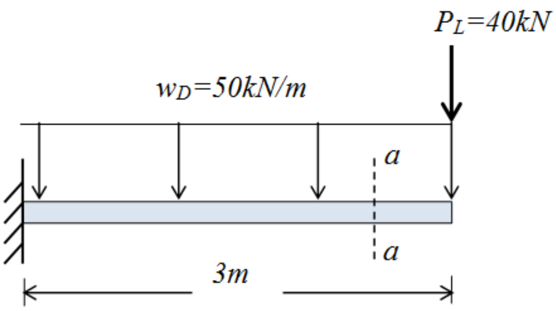
78. Design the beam shown for maximum negative moment (Use Ø25mm, A_b=490mm^2), then determine the accurate cut-off points for the top bars, use full ACI-318 code equations for development length. Take just two of the top bars as continues bars along the beam length. Also, show (draw) the details of the top bars. Use stirrups Ø10mm at 150mm c/c. Columns (supports) dimensions are 400x400mm.Use reduction factor Ø=0.9. *Take* f_c\`=35MPa and f_y=420MPa.



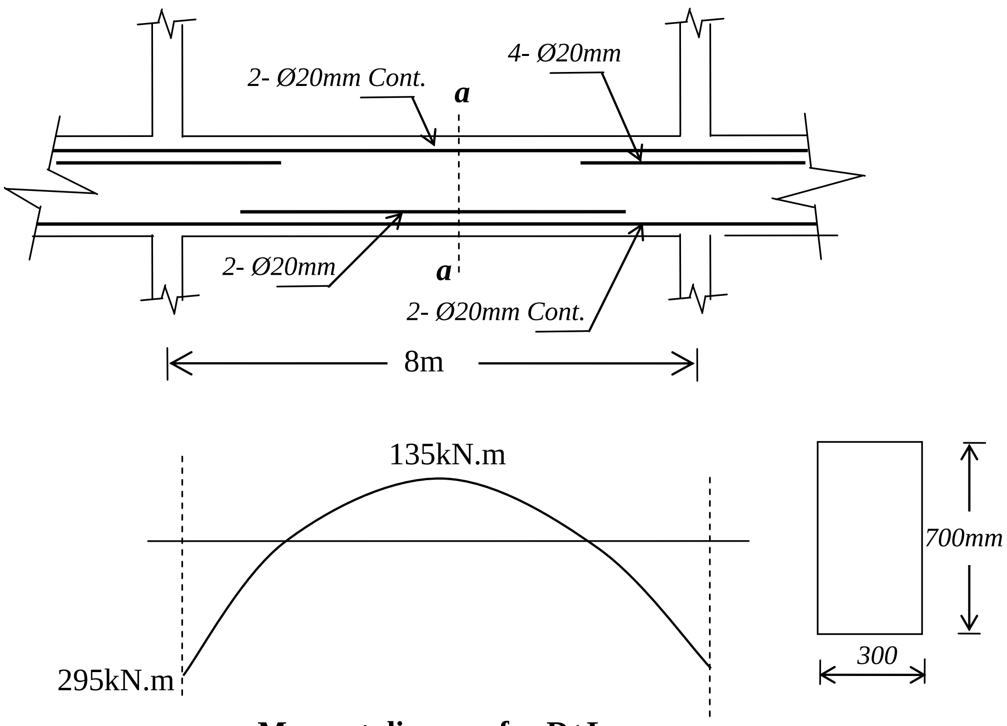


79. Determine the instantaneous deflection for dead and live load applied as shown. *Use* f_c\`=28MPa *and* f_y=420MPa , n=8, E_s=200GPa, Stirrups Ø10mm, $I_g=8600x10^6 mm^4$.





80. Determine the instantaneous deflection due to live load (δ_L) at mid span of the beam shown, if the deflection due to dead load (δ_D) is 2mm, then check it with ACI. The member supports a dead load including its own weight of 43kN/m and live load of 10kN/m. The moment diagram for full dead and live loads was shown below. Use n=8. f_c`=28MPa ; f_y= 420MPa , stirrups are Ø10mm(A_b=78mm^2) .



Moment diagram for D+L

Section a-a