DESIGN OF JOINTS

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1. The beam-column joint is calculated accordance with Clause 6.8 of CP-2013.

2. The load combinations and values of partial safety factors:

Load Combination	Dead Load Adverse	Dead Load Beneficial	Imposed Load Adverse	Imposed Load Beneficial	Earth & Water	Wind
D.L.+L.L.+EARTH	1.40	1.00	1.60	0.00	1.40	----
D.L.+EARTH+WIND	1.40	1.00	----	----	1.40	1.40
D.L.+L.L.+EARTH+WIND	1.20	1.00	1.20	0.00	1.20	1.20

   The partial safety factors for ultimate limit state:

For concrete (flexure)	1.500
For concrete (shear)	1.250
For steel bars	1.150

3. The load combinations and values of partial safety factors for FLS:
   The load combination factors for fire limit state:

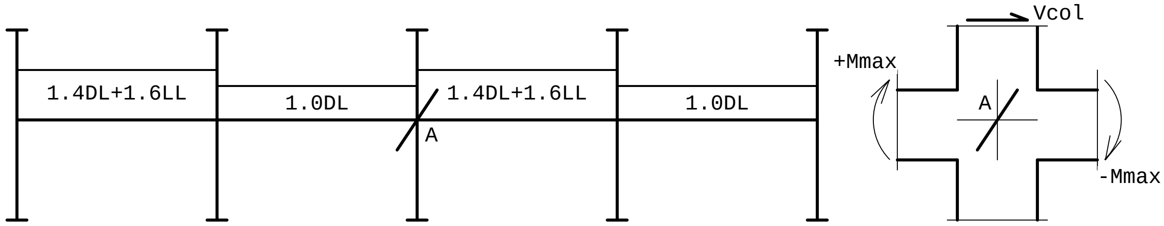
Dead load	1.00
Permanent live load, escape stairs and lobbies	1.00
Non-ermanent live load in other area	0.80
Lateral soil load	0.80
Lateral wind load	0.33

   The partial safety factors for fire limit state:

For concrete (flexure)	1.100
For concrete (shear)	1.100
For steel bars	1.000

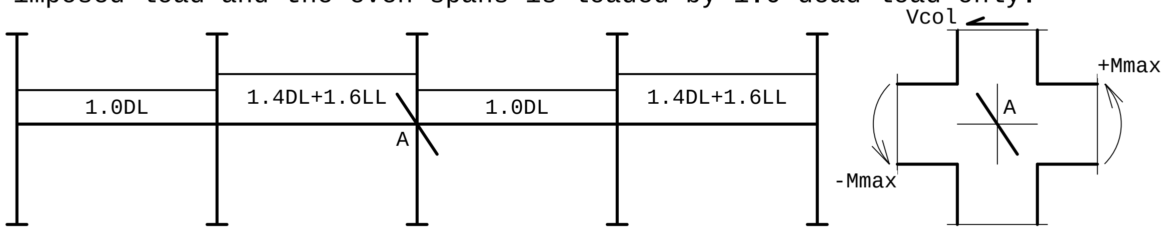
4. There are 2 cases to calculate design forces on beam-column joints.
   (a) The load case has lateral load and this side has larger hogging moment or has sagging moment. The design forces T_a is calculated based on the provided area of reinforced bars.
      $T_a = 1.0A_sf_y$
      where:
         A_s is the area of longitudinal bars of beam,
         f_y is the characteristic yield strength of reinforced bars.
   (b) In all other cases, the design force T_m is calculated based on the bending moment on the connected beam.
      If K <= K',
         $T_m = M/z$
         $z = [0.5+\sqrt{}(0.25-K/0.9)]d$
      If K > K',
         $T_m = M_c/z+(M-M_c)/(d-d')$
         $z = [0.5\sqrt{}(0.25-K'/0.9]d$
      where:
         M is bending moment on connected beam,
         $M_c = K'bd^2f_{cu}$
         $K = M/(bd^2f_{cu})$
         K' = 0.156 for f_{cu} <= 40 N/mm^2
         K' = 0.120 for 40 < f_{cu} <= 70 N/mm^2
         K' = 0.094 for 700 < f_{cu} <= 100 N/mm^2

5. The design moments of BC joints are taken from 2 load patterns.
   1: The odd spans of continuous beam is loaded by 1.4 dead load plus 1.6 imposed load and the even spans is loaded by 1.0 dead load only.



The joints at odd supports (e.g. A) has maximum clockwise rotation.

2: The even spans of continuous beam is loaded by 1.4 dead load plus 1.6 imposed load and the even spans is loaded by 1.0 dead load only.



The joints at odd supports (e.g. A) has maximum anti-clockwise rotation.

The load combination shown above is Dead Load + Imposed Load. For other load combinations, SADS takes the appropriate load combination factors in item #2 automatically. Also, for Fire Limit State, SADS takes the load combination facters from item #3.

6. The total horizontal shear force across a joint V_{jh}.
   SADS considers 2 cases, maximum clockwise rotation and anti-clockwise rotation.
   Maximum clockwise rotation: SADS takes the maximum hogging moment at right hand side of joint. The shear forces can be calculated in following cases.
   (a) The load case has no lateral load but no reverse to sagging moment at right:
   $V_{jh} = T_{mL} - T_{mR}$
   (b) The load case has no lateral load but with reverseto sagging moment at right:
   $V_{jh} = T_{mL} + T_{mR}$
   (c) The load case has lateral load but no reverseto sagging moment at right:
   $V_{jh} = T_{aL} - T_{mR}$
   (d) The load case has lateral load with reverseto sagging moment at right:
   $V_{jh} = T_{aL} + T_{aR}$
   Maximum anti-clockwise rotation: Then SADS takes the maximum hogging moment at left hand side of joint. The shear forces can be calculated by reversing the left and right design force on joint.
   The reinforcement of joint listed at following sections is calculated by 2 sets of shear forces and select the larger reinforcement printed on the design report.

7. The joint stress is calculated by following equation.
   $v_{jh} = V_{jh}/b_j/h_c <= 0.2f_{jcu}$
   where:
   V_{jh} is the total horizontal shear force across a joint.
   h_c is the overall depth of column in the direction of the horizontal shear being considered.
   b_j is the effective joint width, which shall be taken as.
   for $b_c>=b_w$, $b_j=b_c$ or $b_w+0.5h_c$ whichever is the smaller, and
   for $b_c<b_w$, $b_j=b_w$ or $b_c+0.5h_c$ whichever is the smaller.
   b_w is the width of beam.

8. The area of total horizontal joint shear reinforcement is calculated by following equation.

$A_{jh} = [V_{jhx}/(0.87f_{yh})]x[0.5-C_jN/(0.8A_gf_{cu})]$

where:

A_g is the gross area of column section in mm^2,

C_j is the ratio: $V_{jh}/(V_{jx}+V_{jy})$,

V_{jh} is the total horizontal shear force across a joint,

V_{jx} is the total horizontal joint shear force in X direction,

V_{jy} is the total horizontal joint shear force in Y direction,

N is the minimum design axial column load at ultimate limit state taken positive when causing compression occurring with V_{jh},

F_{yh} is the characteristic yield strength of horizontal joint shear reinforcement.

9. The area of total vertical joint reinforcement corresponding with each direction of horizontal joint shear force shall be:

$A_{jv} = (0.4V_{jvx}-C_jN)/(0.87f_{yv})$

where:

V_{jvx} is the total vertical joint shear force: $(h_b/h_c)V_{jh}$

h_b is the overall depth of the beam,

f_{yv} is the characteristic yield strength of vertical joint shear reinforcement.

10. The calculation option is listed as below.
The position of all design moments is set to the edge of support.

11. The notations in program output are described as below:

Joint data:

b_c - The section size of column along X-X direction, unit: mm.

h_c - The section size of column along X-X direction, unit: mm.

Design Temperature : The temperature for designing Fire Limit State.

Reduction : Strength reduction factors for concrete and steel bars taken from Table 3.5 and 3.6 in Clause 3.6 of CoP 2013.

Vertical load:

DL - The axial dead load in column above the joint, unit: kN.

LL(N) - The axial non-permanent impose load in column above the joint, unit: M.

LL(P) - The axial permanent impose load in column above the joint, unit: M.

Load Case : The load case that the load combunation factors is used.

DL+LL: All moments are applied with ULS dead and imposed load combination factors.

D+L(W): All moments are applied with ULS dead, imposed and wind load combination factors.

DL ONLY: All moments are applied with ULS dead load only combination factors.

D+L(FLS): All moments are applied with FLS dead and imposed load combination factors.

D ONLY(FLS): All moments are applied with FLS dead load only combination factors.

Dir : The direction of moments and shears.

Mlmin: The maximum hogging moment at LHS of joint, unit: kN-M.

Vcl : The column shear in anti-clockwise case, unit: kN.

Mrmax: The maximum sagging or minimum hogging moment at RHS of joint, unit: kN-M.

Mlmax: The maximum sagging or minimum sagging moment at LHS of joint, unit: kN-M.

Vcl : The column shear in clockwise case, unit: kN.

Mrmin: The maximum hogging moment at right end of beam, unit: kN-M.

(\) : The joint is in anti-clockwise case.
(/) : The joint is in clockwise case.

Lateral load:

Msxl - the LHS moment of soil load in X direction, unit: kN-M.
Vsx - the shear force of soil load in X direction, unit: kN-M.
Msxr - the RHS moment of soil load in X direction, unit: kN-M.
Msyl - the LHS moment of soil load in Y direction, unit: kN-M.
Vsy - the shear force of soil load in Y direction, unit: kN-M.
Msyr - the RHS moment of soil load in Y direction, unit: kN-M.
Ns - the axial load of soil load above the joint, unit: kN.
Mwxl - the LHS moment of wind load in X direction, unit: kN-M.
Vwx - the shear force of wind load in X direction, unit: kN-M.
Mwxr - the RHS moment of wind load in X direction, unit: kN-M.
Mwyl - the LHS moment of wind load in Y direction, unit: kN-M.
Vwy - the shear force of wind load in Y direction, unit: kN-M.
Mwyr - the RHS moment of wind load in Y direction, unit: kN-M.
Nw - the axial load of wind load above the joint, unit: kN.
Mnxl - the LHS moment of dynamic load in X direction, unit: kN-M.
Vnx - the shear force of dynamic load in X direction, unit: kN-M.
Mnxr - the RHS moment of dynamic load in X direction, unit: kN-M.
Mnyl - the LHS moment of dynamic load in Y direction, unit: kN-M.
Vny - the shear force of dynamic load in Y direction, unit: kN-M.
Mnyr - the RHS moment of dynamic load in Y direction, unit: kN-M.
Nn - the axial load of dynamic load above the joint, unit: kN.

Calculation direction, Load combination and Larger hogging moment position:

(1) Calculation direction:
  (a) ALONG X-X: The calculation is performed for joint in X direction.
  (b) ALONG Y-Y: The calculation is performed for joint in Y direction.
(2) Load combination: e.g. D+L+S+Wi(/) or D+L+S+Ni(\)
  (a) D - Dead load.
  (b) L - Live (imposed) load.
  (c) S - Lateral soil load.
  (d) W - Lateral wind load.
  (e) N - Lateral dynamic load.
  (f) i - The direction of wind or dynamic load. The valid characters are a to z (26 chracters).
(3) Rotation direction of joint:
  (a) / - It denotes the joint is in maximum clockwise rotation case.
  (b) \ - It denotes the joint is in maximum anti-clockwise rotation case.

Design axial load N:

1. The axial load is taken from column above the joint.
2. The value of N is calculated as below.
   DL+LL: Nc = 1.0DL+0.0LL
   DL Only: Nc = 1.0DL
   DL+LL+Wind: Nc = 1.0DL+0.0LL+1.2Nw
   DL+Wind: Nc = 1.0DL+0.0LL+1.4Nw

Notes:

If the section is controlled by Ultimate Limit State, the direction and load case are printed by regular font.
If the section is controlled by Fire Limit State, the direction and load case is printed by bold font.