26	A (Slenderness)	=	Constant
27	A_c	=	Cross Sectional Area of Concrete in mm^2
28	A_{ceff}	=	Effective Cross Sectional Area of Concrete used for shear in mm^2
29	Ash	=	Volume of confining hoops in mm^3
30	As est	=	Estimated area of longitudinal reinforcement for slenderness check in mm^2
31	Asw/s	=	Area of Shear reinforcement required in sqmm/m
32	Aswmax/s	=	Maximum Area of Shear Reinforcement in sqmm/m
33	b	=	Effective Width of Column in mm
34	bj	=	Effective joint width along Column direction considered in mm
35	B (General Data)	=	Width / Smaller Dimension of Column in mm
36	B (Slenderness)	=	Constant
37	bwo	=	Thickness of web of a wall in mm
38	C (Slenderness)	=	Constant
39	c	=	Factor depending on the curvature distribution
40	D	=	Depth / Larger Dimension of Column OR Diameter of Circular Column in mm
41	d	=	Effective Depth of Column in mm
42	Dk	=	Diameter Of core measured to the outside of circular link in mm
43	Ec	=	Modulus of elasticity of concrete in N/sqmm
44	Es	=	Modulus of elasticity of Reinforcement in N/sqmm
45	e2	=	Deflection to calculate second order moment in mm
46	e0	=	Minimum eccentricity in mm
47	fck	=	Characteristic Cylindrical strength of Concrete N/sqmm
48	FcPerm	=	Permissible Stress in Concrete required in N/sqmm
49	fctm	=	Mean value of axial tensile strength of Concrete in N/sqmm
50	Fst	=	Stress in Reinforcement in N/sqmm
51	FstPerm	=	Permissible Stress in Reinforcement required in N/sqmm
52	Fyd	=	Design value of Reinforcement yield strength in N/sqmm
53	fyd, h	=	Design value Of yield strength Of the horizontal web reinforcement in N/sqmm
54	fctd	=	Tensile Strength of Concrete in N/sqmm
55	fywd	=	Design yield stress for shear reinforcement in N/sqmm
56	hcr	=	Height Of critical region above base Or basement story in m
57	hjc	=	Distance between extreme layer of column reinforcement along Column direction considered in mm

58	hjw	=	Distance between top and bottom reinforcement of Beam along Column direction considered in mm
59	i	=	Radius of Gyration of uncracked section in mm
60	K_1	=	Crack width co-efficient For high bond bars (value = 0.8)
61	K_2	=	Crack width co-efficient For bending (value =0.5)
62	K_3	=	Crack width constant (value =3.4)
63	K_4	=	Crack width constant (value =0.5)
64	Kr	=	Correction factor depending On the axial load
65	kw	=	Factor reflecting the prevailing failure node In structural systems With walls
66	lo	=	Effective length Of column in mm
67	lw	=	Length Of cross-section Of wall in mm
68	Med	=	Design bending moment from the analysis For the seismic design situation in kN-m
69	mgeoD	=	Moment due To geometric imperfections along D in kN-m
70	mgeoB	=	Moment due To geometric imperfections along B in kN-m
71	Mux	=	Factored moment Along D (Momemt About Major Axis) in kN-m
72	Muy	=	Factored moment Along B (Momemt About Minor Axis) in kN-m
73	MCap	=	Moment capacity Of section For NA angle at design Pu in kN
74	MRes	=	Resultant design moment at angle To local major axis in kN-m
75	M2B	=	Additional moment due To slenderness about minor axis (Along B) in kN-m
76	M2D	=	Additional moment due To slenderness about major axis (Along D) in kN-m
77	M2	=	Nominal second order moment in kN-m
78	M01	=	First order End moments in kN-m
79	M02	=	First order End moments in kN-m
80	n	=	Relative axial force in kN
81	nbal	=	Value Of n at maximum moment Of resistance in kN
82	Ned	=	Design axial force from the analysis For the seismic design situation in kN
83	q	=	Behavior factor
84	qo	=	Basic value Of the behavior factor
85	rm	=	Moment Ratio, M01 / M02
86	sl,max	=	Maximum Longitudinal Spacing of stirrups in mm
87	T1	=	Fundamental period Of the building In the horizontal direction Of interest in sec
88	Tc	=	Corner period at the upper limit Of the constant acceleration region Of the elastic Spectrum in sec

89	$V_{Rd,max}$	=	Maximum Shear resistance of Section in kN
90	Vd	=	Normalized axial force in column above joint in kN
91	VEd x	=	Design shear force at the ULS Long B in kN
92	VEd y	=	Design shear force at the ULS Long D in kN
93	v'ed	=	Shear force in a wall from the analysis for the seismic design situation in kN
94	Vur	=	Factored resultant shear force acting on the column in kN
95	Vjhd	=	Compressive strength of Concrete in the presence of transverse tensile strain in kN
96	Wcr	=	Surface Crack Width in mm
97	WcrPerm	=	Permissible Crack Width required in mm
98	Xu	=	Neural axis Depth in mm
99	z	=	Internal lever arm in mm

Code References:

EN 1992 - 1 - 1 - 2004 Base

	ELEMENT		CLAUSE / table
1	Max area of reinforcement	:	Cl. 9.5.2 (3)
2	Min area of reinforcement	:	Cl. 9.5.2 (2)
3	Minimum Eccentricity Calc	:	6.1 (4)
4	Slenderness Moments	:	5.8.8.2
5	Design of horizontal links	:	6.2.3
6	Determine shear capacity without shear reinforcement	:	6.2.2
7	Crack width calculation	:	7.3.4

BS EN 1998-1:2004 (E)

	ELEMENT		CLAUSE / table
1	Spacing of special confining reinforcement	:	Cl.5.4.3.2.2 (8)
2	C/s area of special confining reinforcement	:	Cl.5.2.3.4 (3)
3	Shear resistance of ductile wall	:	Cl.5.5.2.4.1
4	Ductile wall (Bending and Shear)	:	Cl.5.4.3.4
5	Special provisions for ductile walls	:	Cl.5.4.2.4 and Cl.5.4.2.5
6	Design for DCM	:	Cl.5.4
7	Design for DCH	:	Cl.5.5

General Data

Column No.	:	C1
Level	:	0 m To 5.25 m

Design Code	=	EN 1992 - 1 - 1 - 2004 Base	
Type of Frame	=	Non Ductile	
Grade Of Concrete (f_{ck}) (Cylindrical)	=	C25/30	N/sqmm
Partial Factor for concrete, γ_c (Persistent and Transient)	=	1.5	
Partial Factor for concrete, $\gamma_{c\ acc}$ (Accidental)	=	1.2	
Grade Of Steel (f_{yk})	=	Fy500	N/sqmm
Partial Factor for reinforcing steel, γ_s (Persistent and Transient)	=	1.15	
Partial Factor for reinforcing steel, $\gamma_{s\ acc}$ (Accidental)	=	1	
Column B	=	300	mm
Column D	=	300	mm
A_c	=	90000	sqmm
Clear Cover	=	35	mm
Clear Floor Height @ B,loB	=	5250	mm
Clear Floor Height @ D,loD	=	5250	mm
No Of Floors	=	1	
No Of Columns In Group	=	1	
Column Type Along D	=	UnBraced	
Column Type Along B	=	UnBraced	
Minimum eccentricity check	=	Simultaneously (Both Axis)	
Effective Length Along D	=	1.2	
Effective Length Along B	=	1.2	

Load Data

Analysis Reference No.	=	1	
Critical Analysis Load Combination	:	2	
Load Combination	=	[1] : (LOAD 1: LOAD CASE 1)	
Critical Location	=	Mid Joint	
Ned(top joint)	=	420.17	kN
Mux(top joint)	=	0	kNm
Muy(top joint)	=	0	kNm
Vux(top joint)	=	0	kN
Vuy(top joint)	=	0	kN
Ned(bottom joint)	=	420.17	kN
Mux (bottom joint)	=	0	kNm
Muy (bottom joint)	=	0	kNm
Vux (bottom joint)	=	0	kN
Vuy(bottom joint)	=	0	kN

Minimum Eccentricity,

Since Axial Force is compressive, Min. Eccentricity check to be performed

Check,e0

Minimum Eccentricity Along D:	=	D / 30	
Minecc (e0D)	=	10	mm
	=	20	MM,Since < 20
Mmind	=	Ned x Minimum Eccentricity	
	=	8.4	kNm
Minimum Eccentricity Along B:	=	B / 30	
Minecc (e0B)	=	10	mm
	=	20	MM,Since < 20
Mminb	=	Ned x Minimum Eccentricity	
	=	8.4	kNm

Geometric imperfection, ei

θ0	=	0.005	
αn	=	0.873	
αm	=	1	
θ1	=	0.00436	Radian
Eccentricity ,(ei) (along both the directions)	=	13.75	mm
MgeoD	=	5.78	kNm
MgeoB	=	5.78	kNm

Slenderness Check

Ast Prv		2060.88	sqmm
ω	=	Ast prv x fyd / (B x D x fcd)	
	=	0.7	

Calculation of SLENDERNESS CHECK

	Along D	Along B
Crtical Load Combination	[1] : (LOAD 1: LOAD CASE 1)	[1] : (LOAD 1: LOAD CASE 1)
Ned (kN)	420.17	420.17
Mo1 (kNm)	0	0
Mo2 (kNm)	0	0
Radius of Gyration (i) (mm)	86.71	86.71
Φef	2.14	2.14
A = 1 / (1 + 0.2 x Φ ef)	0.7	0.7

B = Sqrt (1 + 2 ω)	1.55	1.55
rm = Mo1 / Mo2	0	0
C = 1.7 - rm	1.7	1.7
n = Ned / (B x D x fcd)	0.3295	0.3295
Slenderness ratio (λ) = lo / i	72.66	72.66
Permissible Limits (λ lim) = A x B x C / sqrt (n)	64.26	64.26
	Hence, Column is Slender	Hence, Column is Slender

Calculation of Slenderness Moment

	Along D	**Along B**
nu = 1 + ω	1.7	1.7
nbal	0.4	0.4
Kr = Min ((nu - n)/(nu - nbal), 1)	1	1
c (Constant)	10	10
Is (mm)	86.71	86.71
deff, slenderness = (D' / 2) + Is (mm)	134.08	134.08
β = 0.35 + fck / 200 - λ / 150	-0.009	-0.009
1 / ro = fyd / Es x (0.45 x deff, slenderness) x 10 ^ - 5	3.6	3.6
K φ = Max ((1 + β x Φ ef) , 1)	1	1
1 / r = Kr x k φ x (1 / ro) x 10 ^ - 5	3.6	3.6
e2 = (1 / r) x (lo ^ 2 / c) (mm)	143	143
Moe = 0.4 x Min (top, bottom) + 0.6 x Max (top, bottom) (kNm)	3.36	3.36
M2 = e2 x Ned (kNm)	60.08	60.08
Mid Moment = Moe + M2 (kNm)	63.45	63.45

Note:

deff, slenderness = Effective Depth of the section along the direction considered.

D' = Depth of the section along the direction considered.

Calculation of Design Moment

Direction	**Manalysis**	**Mmin**	**Mgeo**	**Mdesign**	**M2**	**Mdesign-final**
	A	B	C	D	E	F
Major Axis - Mux (top)	0	8.4	5.78	8.4	60.08	38.45
Major Axis Mux (bottom)	0	8.4	5.78	8.4	60.08	38.45
Major Axis Mux (mid)	---	---	---	---	---	63.45
Minor Axis Muy (top)	0	8.4	5.78	8.4	60.08	38.45
Minor Axis Muy (bottom)	0	8.4	5.78	8.4	60.08	38.45
Minor Axis Muy (mid)	---	---	---	---	---	63.45

Where

A	= Moments directly from analysis
B	= Moments due to minimum eccentricity
C	= Moments due to geometrical imperfection
D	= Max of (Manalysis+MGeo) , Mmin
E	= Moment due to slenderness effect
F Top.Bottom	= Mdesign+ M2 /2
F Mid	= Moe+M2

Final Critical Design Forces

Critical Case - Axial Load & BiAxial Bending

Pu	=	420.17	kN
Mux	=	63.45	kNm
Muy	=	63.45	kNm

Resultant Moment (Combined Action)

Moment Capacity Check

Pt Calculated	=	2.29	
Reinforcement Provided	=	4-T20 + 4-T16	
Load Angle	=	Tan^{-1}(Muy/Mux)	
	=	45	deg
MRes	=	89.73	kNm
MCap	=	95.4	kNm
Capacity Ratio	=	MRes/ MCap	
	=	0.94 < 1	

Biaxial Bending Check

λD/λB	=	1	
λB/λD	=	1	
eD(top)	=	91.501	mm
eD(bot)	=	91.501	mm
eB(top)	=	91.501	mm
eB(bot)	=	91.501	mm
(eD top/D)/(eB top/B)	=	1	mm
(eB top/B)/(eD top/D)	=	1	mm
(eD bot/D)/(eB bot/B)	=	1	mm
(eB bot/B)/(eD bot/D)	=	1	mm

Check for Bi-axial bending — Consider Biaxial

Check For Minimum Vertical Reinforcement

Minimum pt-1(User Defined)	=	0.2	%

As,min-1(as per user defined pt-1)	=	Minimum pt-1 x Ac / 100	
	=	180	sqmm
Load Combination	=	[1] : (LOAD 1: LOAD CASE 1)	
Ned	=	420.17	kN
fyd	=	434.78	N/sqmm
Minimum pt-2 (as per Ned)	=	0.1 x Ned / (fyd x Ac)	
	=	0.1074	%
As,min-2 (as per Ned)	=	Minimum pt-2 x Ac / 100	
	=	96.64	sqmm
As,min	=	Max (As,min-1 , As,min-2)	
	=	180	sqmm
As provided	=	2060.88	sqmm
As provided	>	As,min Hence, OK	

Design Of Shear

Along D

Critical Analysis Load Combination	:	2	
Critical Load Combination	=	[1] : (LOAD 1: LOAD CASE 1)	
Design shear force, Vuy	=	0	kN
N_{Ed}	=	420.17	kN
Design shear stress ,V_{Ed}	=	0	N/mm^2
Calculation for Concrete Strut Capacity V_{Rdmax}			
lever arm, z	=	255	mm
v1	=	0.54	
$v_{Rd,max \cot \theta = 2.5}$	=	2.37	N/mm^2
$v_{Rd,max \cot \theta = 1}$	=	3.44	N/mm^2
$V_{Rd,max}$	=	181.61	kN
Check		$V_{Rd,max} > V_{uy}$ Hence, OK	
VRD,c	=	88.41	kN
As tension(50%)	=	1030.44	sqmm
CRdc	=	0.18/γc	
	=	0.12	
A_{ceff}	=	76500	sqmm
deff	=	255	mm
k	=	MIN(1 + SQRT(200 / deff),2)	
	=	1.8856	
ρ1	=	Asmain / A_{ceff}	
	=	0.0135	%
k1		0.15	

σcp	=	NEd / (B x D)	
	=	2.8333	N/mm^2
Shear check		No Shear Reinforcement Required Since VRD,C > Vuy	

Along B

Critical Analysis Load Combination	:	2	
Critical Load Combination	=	[1] : (LOAD 1: LOAD CASE 1)	
Design shear force, Vux	=	0	kN
N_{Ed}	=	420.17	kN
Design shear stress ,v_{Ed}	=	0	N/mm^2
Calculation for Concrete Strut Capacity $V_{Rd,max}$			
lever arm, z	=	255	mm
v1	=	0.54	
$v_{Rd,max \cot\theta = 2.5}$	=	2.37	N/mm^2
$v_{Rd,max \cot\theta = 1}$	=	3.44	N/mm^2
$V_{Rd,max}$	=	181.61	kN
Check		$V_{Rd,max} > V_{ux}$ Hence, OK	
VRD,c	=	88.41	kN
As tension(50%)	=	1030.44	sqmm
CRdc	=	0.18/γc	
	=	0.12	
A_{ceff}	=	76500	sqmm
beff	=	255	mm
k	=	MIN((1 + SQRT(200 / beff)),2)	
	=	1.8856	
ρ1	=	Asmain / A_{ceff}	
	=	0.0135	%
k1	=	0.15	
σcp	=	NEd / (B x D)	
	=	2.8333	N/mm^2
Shear check		No Shear Reinforcement Required Since VRD,C > Vux	

Design Of Links

Length of End Zone:

Maximum dimension of column	=	300	mm

Links in the zone where special confining links are not required or End Zone

Normal Links			
Diameter of link Provided	=	8	mm
Check for minimum diameter of link			
Main Reinforcement (Bundled / Single)	=	Single	
Number of Rebars in Bundled	=	1	
Maximum diameter of Vertical Reinforcement	=	20	mm
Effective diameter of Vertical Reinforcement	=	20	mm
Minimum dia-1 (6mm)	=	6	mm
Minimum dia-2	=	Effective diameter / 4	
	=	5	mm
Minimum dia	=	Max (Minimum dia-1, Minimum dia-2)	
	=	6	mm
Diameter of link Provided	>	Minimum dia Hence, OK	
Criterion for spacing of normal links			
Min. Longitudinal Bar dia X 20	=	320	mm
Min. dimension of column	=	300	mm
Max. Permissible	=	400	mm
Max. Permissible (User Input)	=	300	mm
Provided spacing	=	300	mm

Links at End Zone			
Criterion for spacing of End Zone links			
0.6 x Min. Longitudinal Bar dia X 20	=	192	mm
0.6 x Min. dimension of column	=	180	mm
0.6 x Max. Permissible	=	240	mm
Max. Permissible (User Input)	=	300	mm
Provided spacing	=	175	mm

Table For Links

	Required			Provided	
	Normal Design	**Shear Design**	**Ductile/End Zone**	**Normal Zone**	**Ductile/End Zone**
Link Dia.	8	---	8	8	8
Spacing	300	---	175	300	175