[Company name - fill on Project tab]				PRELIMINARY		
				JOB NO.		
PROJECT				CALC NO. / REV	Rev 0	
SUBJECT	Beam-Column Design (Combined Forces) - C1 - NPB 400x180x66.31			MADE / DATE		
CLIENT				CHKD / APPD		

Item	Calculation	Symbol	Ref. IS 800	Result	Unit	Note
1 Section properties						
1.1	Position of the section in the database			87		
1.2	Section designation			NPB 400x180x66.31		
1.3	Database		*Database*	IS 808:2021		
1.4	Section type			I-Section		
1.5	Family			NPB		
1.6	Mass			66.31	kg/m	
1.7	Depth h (long leg)			400.0	mm	
1.8	Width b (short leg)			180.0	mm	
1.9	Web thickness t_w			8.6	mm	
1.10	Flange thickness t_f			13.5	mm	
1.11	Root / corner radius			21.0	mm	
1.12	Area A			84.40	cm²	
1.13	Moment of inertia I_z			23,100.0	cm⁴	
1.14	Moment of inertia I_y			1,310.0	cm⁴	
1.15	Radius of gyration r_z			16.50	cm	
1.16	Radius of gyration r_y			3.95	cm	
1.17	Elastic modulus Z_ez			1,150.0	cm³	
1.18	Elastic modulus Z_ey			146.0	cm³	
1.19	Plastic modulus Z_pz			1,300.0	cm³	
1.20	Plastic modulus Z_py			229.0	cm³	
1.21	Torsion constant I_t			51.30	cm⁴	
1.22	Warping constant I_w			4,90,000	cm⁶	
1.23	Min. radius of gyration r_vv			3.95	cm	
1.24	Manufacture			Hot rolled		
2 Material						
2.1	Steel grade (Auto: E250 rolled / YSt 310 hollow)		*IS 2062 / IS 4923*	E250		
2.2	Governing element thickness	*t_max*		13.5	mm	
2.3	Yield stress (thickness dependent)	*f_y*	*IS 2062 / IS 4923*	250	MPa	
2.4	Ultimate tensile stress	*f_u*	*IS 2062 / IS 4923*	410	MPa	
2.5	Yield stress ratio ε = √(250/fy)	*ε*	*Table 2, Note 2*	1.000		
3 Design forces						
3.1	Design compression P (from signed input)	*P*		450.0	kN	
3.2	Design tension T (from signed input)	*T*		0.0	kN	
3.3	Design moment M_z	*M_z*		80.0	kNm	
3.4	Design moment M_y	*M_y*		5.0	kNm	
3.5	Design shear V_z (major)	*V_z*		60.0	kN	
3.6	Design shear V_y (minor)	*V_y*		3.0	kN	
4 Geometry						
4.1	Gross area	*A_g*		8,440	mm²	
4.2	Moment of inertia, major	*I_z*		2.310E+08	mm⁴	
4.3	Moment of inertia, minor	*I_y*		1.310E+07	mm⁴	
4.4	Elastic modulus, major	*Z_ez*		11,50,000	mm³	
4.5	Elastic modulus, minor	*Z_ey*		1,46,000	mm³	
4.6	Plastic modulus, major	*Z_pz*		13,00,000	mm³	
4.7	Plastic modulus, minor	*Z_py*		2,29,000	mm³	
4.8	Clear depth of web (I, C: h−2tf−2r ; RHS: h−3t)	*d*	*Fig. 2A*	331.0	mm	
5 Classification						
5.1	Flange ratio (I: (b/2)/tf ; C: b/tf ; RHS: (b−3t)/t ; CHS: D/t ; L: b/t)	*b/t_f*	*Table 2*	6.67		
5.2	Web ratio (I, C: d/tw ; RHS: (h−3t)/t ; L: d/t)	*d/t_w*	*Table 2*	38.49		
5.3	Design squash load of web(s)	*N_w*	*Table 2, Note 5*	647.0	kN	
5.4	Stress ratio r1 = depth in compression / web depth (plastic)	*r1*	*Table 2, Note 5*	0.848		
5.5	Stress ratio r2 = min/max web stress (elastic, tension −ve)	*r2*	*Table 2, Note 5*	-0.036		
5.6	Flange limit – Class 1 (I,C: 8.7ε ; RHS: 27ε ; CHS: 48ε²)		*Table 2*	8.70		

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5.7	Flange limit – Class 2 (I,C: 9.7ε ; RHS: 33ε ; CHS: 68ε²)		*Table 2*	9.70		
5.8	Flange limit – Class 3 (I,C: 13.6ε ; RHS: 37ε ; CHS: 87ε² ; L: 14.5ε)		*Table 2*	13.60		
5.9	Flange class (angle: Table 2 row iv – all three criteria)		*Table 2*	1		
5.10	Web limit – Class 1: r1>0.5 → 122ε/(5.5r1−1) ; else 35ε/r1		*Table 2 row ii*	33.31		
5.11	Web limit – Class 2: r1>0.5 → 182ε/(6.53r1−1) ; else 40ε/r1		*Table 2 row ii*	40.12		
5.12	Web limit – Class 3: r2>−1 → 37ε/(0.608+0.343r2+0.049r2²) ; else 59ε(1−r2)		*Table 2 row ii*	62.12		
5.13	Web class (under applied N + Mz)		*Table 2*	2		
5.14	SECTION CLASS (most critical element) – used for bending & interaction		*10.8.2*	**2**		
5.15	Section class description		*10.8.2*	Compact		
5.16	Class under pure axial compression (3 = not slender, 4 = slender)		*Table 2*	4		
6 Effective area						
6.1	Flange area in excess of semi-compact limit	*ΔA_f*	*10.8.2(d), Fig. 2C*	0	mm²	
6.2	Web area in excess of semi-compact limit (37ε)	*ΔA_w*	*10.8.2(d), Fig. 2C*	110	mm²	
6.3	Effective area for compression	*A_e*	*14.3.2*	8,330	mm²	
7 Compression						
7.1	Effective length factor K_z (end conditions, z-z)	*K_z*	*Table 11*	1.00		
7.2	Effective length factor K_y (end conditions, y-y)	*K_y*	*Table 11*	1.00		
7.3	Effective length, major axis KL_z = K_z·L_z	*KL_z*	*14.2, Table 11*	4,000	mm	
7.4	Effective length, minor axis (angle: I_vv) KL_y = K_y·L_y	*KL_y*	*14.2, Table 11*	4,000	mm	
7.5	Slenderness ratio, major KL_z/r_z	*KL/r*		24.2		
7.6	Slenderness ratio, minor KL_y/r_y (angle: I_vv/r_vv)	*KL/r*		101.3		
7.7	Non-dimensional slenderness λ_z = √(fy/fcr,z)	*λ_z*	*14.1.2.1*	0.273		
7.8	Non-dimensional slenderness λ_y = √(fy/fcr,y) (angle: λ_vv, 14.5.1.1)	*λ_y*	*14.1.2.1 / 14.5.1.1*	1.140		
7.9	Buckling class about z-z		*Table 10*	a		
7.10	Buckling class about y-y		*Table 10*	b		
7.11	Imperfection factor α_z	*α*	*Table 7*	0.21		
7.12	Imperfection factor α_y	*α*	*Table 7*	0.34		
7.13	φ_z = 0.5[1+α(λ−0.2)+λ²]	*φ_z*	*14.1.2.1*	0.545		
7.14	Stress reduction factor χ_z = 1/[φ+√(φ²−λ²)] ≤ 1	*χ_z*	*14.1.2.1*	0.984		
7.15	φ_y = 0.5[1+α(λ−0.2)+λ²]	*φ_y*	*14.1.2.1*	1.309		
7.16	Stress reduction factor χ_y	*χ_y*	*14.1.2.1*	0.512		
7.17	Design compressive stress f_cd,z = χ_z·fy/γm0	*f_cd,z*	*14.1.2*	223.6	MPa	
7.18	Design compressive stress f_cd,y = χ_y·fy/γm0	*f_cd,y*	*14.1.2*	116.3	MPa	
7.19	Design compressive strength, z-z buckling P_dz = A_e·f_cd,z	*P_dz*	*14.1.2*	1,862.4	kN	
7.20	Design compressive strength, y-y buckling P_dy = A_e·f_cd,y	*P_dy*	*14.1.2*	969.2	kN	
7.21	DESIGN COMPRESSIVE STRENGTH P_d = min(P_dz, P_dy)	*P_d*	*14.1.2*	**969.2**	kN	
7.22	Maximum slenderness ratio	*KL/r*	*10.9, Table 3*	101.3		
7.23	Maximum permitted KL/r		*Table 3*	180		
8 Tension						
8.1	Yielding of gross section T_dg = A_g·fy/γm0	*T_dg*	*13.2*	1,918.2	kN	
8.2	Rupture of net section T_dn = 0.9·A_n·fu/γm1 (A_n = ratio × A_g)	*T_dn*	*13.3*	2,491.5	kN	
8.3	DESIGN TENSILE STRENGTH T_d = min(T_dg, T_dn)	*T_d*	*13.1*	**1,918.2**	kN	
9 Shear						
9.1	Shear area, major-axis shear (I,C: h·tw ; RHS: A·h/(b+h) ; CHS: 2A/π)	*A_v*	*15.4.1.1*	3,440	mm²	
9.2	Shear area, minor-axis shear (I,C: 2·b·tf ; RHS: A·b/(b+h) ; CHS: 2A/π)	*A_v*	*15.4.1.1*	4,860	mm²	
9.3	Web shear buckling check required? (d/tw > 67ε)		*15.4.2.1*	No		
9.4	Elastic critical shear stress τ_cr,e (K_v = 5.35)	*τ_cr,e*	*15.4.2.2(a)*	652.8	MPa	
9.5	Web slenderness for shear λ_w = √(fy/(√3·τ_cr,e))	*λ_w*	*15.4.2.2(a)*	0.470		

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9.6	Shear buckling stress τ_b	*τ_b*	*15.4.2.2(a)*	144.3	MPa	
9.7	DESIGN SHEAR STRENGTH, major V_d = V_n/γm0	*V_dz*	*15.4.1 / 15.4.2*	**451.4**	kN	
9.8	DESIGN SHEAR STRENGTH, minor V_d = A_v·fy/(√3·γm0)	*V_dy*	*15.4.1*	**637.7**	kN	
10	**Bending (major)**					
10.1	Limit factor on Z_e (1.2 simply supported / cantilever, else 1.5)		*15.2.1.2*	1.2		
10.2	Compression-flange area in excess of semi-compact limit	*ΔA_c*	*10.8.2(d)*	0	mm²	
10.3	Shift of neutral axis due to ΔA_c	*e*		0.00	mm	
10.4	Effective elastic modulus (Class 4; slender web → flanges only)	*Z_eff*	*10.8.2(d), 15.2.1.1*	11,55,000	mm³	
10.5	β_b (1.0 Class 1/2 ; Z_e/Z_p Class 3 ; Z_eff/Z_p Class 4)	*β_b*	*15.2.1.2*	1.000		
10.6	Section bending strength β_b·Z_p·fy/γm0 ≤ k·Z_e·fy/γm0	*M_d*	*15.2.1.2*	295.5	kNm	
10.7	Plastic strength of flanges only	*M_fd*	*16.2.2*	213.5	kNm	
10.8	High-shear factor β = (2V/V_d − 1)² (only if V > 0.6V_d)	*β*	*16.2.2*	0.000		*low shear*
10.9	Section strength incl. high shear M_dv = M_d − β(M_d − M_fd) ≤ 1.2Z_e·fy/γm0	*M_dv*	*15.2.1.3 / 16.2.2*	295.5	kNm	
11	**Lateral torsional buckling**					
11.1	Moment gradient parameter f_m (from moment diagram)	*f_m*	*Table 14*	1.250		
11.2	Elastic critical moment M_cr = √[(π²EI_y/L_LT²)(GI_t + π²EI_w/L_LT²)]	*M_cr*	*15.2.2.1*	401.8	kNm	
11.3	λ_LT = √(β_b·Z_p·fy/M_cr) ≤ √(1.2·Z_e·fy/M_cr)	*λ_LT*	*15.2.2*	0.899		
11.4	Imperfection parameter α_LT	*α_LT*	*Table 13*	0.337		
11.5	λ_y = √(fy/f_cr,y) over L_LT	*λ_y*	*15.2.2*	1.140		
11.6	φ_LT = 0.5[1 + f_m((λ_LT/λ_y)²·α_LT(λ_y−0.2) + λ_LT²)]	*φ_LT*	*15.2.2*	1.129		
11.7	χ_LT = f_m/{φ_LT + [φ_LT² − f_m·λ_LT²]^0.5} ≤ 1 (=1 if λ_LT < 0.4)	*χ_LT*	*15.2.2*	0.762		
12	**Bending (major) – design strength**					
12.1	DESIGN BENDING STRENGTH, major M_dz = min(β_b·Z_p·χ_LT·fy/γm0 , M_dv)	*M_dz*	*15.2.2*	**225.0**	kNm	
13	**Bending (minor)**					
13.1	Class for minor-axis bending		*Table 2*	2		
13.2	β_b for minor axis	*β_b*	*15.2.1.2*	1.000		
13.3	DESIGN BENDING STRENGTH, minor M_dy = β_b·Z_py·fy/γm0 ≤ k·Z_ey·fy/γm0	*M_dy*	*15.2.1.2*	**39.8**	kNm	
14	**Combined – section**					
14.1	Axial design strength (yielding) N_d = A·fy/γm0 (A_e if slender in compression)	*N_d*	*16.3.1.1*	1,893.2	kN	
14.2	n = N/N_d (N = larger of compression / tension)	*n*	*16.3.1.1*	0.238		
14.3	Reduced major-axis strength M_ndz	*M_ndz*	*16.3.1.2*	250.0	kNm	
14.4	Reduced minor-axis strength M_ndy	*M_ndy*	*16.3.1.2*	39.7	kNm	
14.5	Exponent α1 (on M_y)	*α1*	*Table 17*	1.188		
14.6	Exponent α2 (on M_z)	*α2*	*Table 17*	2.000		
14.7	Section check: Class 1/2 (M_y/M_ndy)^α1 + (M_z/M_ndz)^α2 [reported ≥ M/M_nd] ; Class 3/4 N/N_d + M_y/M_dy + M_z/M_dz	*UR*	*16.3.1.1 / 16.3.1.3*	**0.320**		
15	**Combined – member**					
15.1	Equivalent uniform moment factor C_mz (z-z bending, braced in y)	*C_mz*	*Table 19*	0.600		
15.2	Equivalent uniform moment factor C_my (y-y bending)	*C_my*	*Table 19*	0.600		
15.3	Equivalent uniform moment factor C_mLT (LTB)	*C_mLT*	*Table 19*	0.600		
15.4	n_y = P/P_dy	*n_y*	*16.3.2.2*	0.464		
15.5	n_z = P/P_dz	*n_z*	*16.3.2.2*	0.242		
15.6	K_zz	*K_zz*	*Table 18 (i)*	0.611		
15.7	K_yy (I sections row ii ; hollow row iii)	*K_yy*	*Table 18 (ii)/(iii)*	0.990		
15.8	K_zy (0.66·K_yy plastic ; K_yy elastic)	*K_zy*	*Table 18 (iv)*	0.653		
15.9	K_yz (LTB-susceptible: row vi ; otherwise row v)	*K_yz*	*Table 18 (v)/(vi)*	0.867		*LTB-susceptible (row vi)*
15.10	P/P_dy + K_yy·M_y/M_dy + K_yz·M_z/M_dz	*UR*	*16.3.2.2*	**0.897**		
15.11	P/P_dz + K_zy·M_y/M_dy + K_zz·M_z/M_dz	*UR*	*16.3.2.2*	**0.541**		
15.12	Tension + bending: M_eff = M − ψ·T·Z_ec/A (ψ = 0.8)	*M_eff*	*16.3.2.1*	80.0	kNm	

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16	**Utilisation**					
16.1	Tension T/T_d	*UR*	*13.1*	0.000		
16.2	Compression P/P_d	*UR*	*14.1.2*	0.464		
16.3	Bending major M_z/M_dz	*UR*	*15.2*	0.356		
16.4	Bending minor M_y/M_dy	*UR*	*15.2*	0.126		
16.5	Shear major V/V_dz	*UR*	*15.4*	0.133		
16.6	Shear minor V/V_dy	*UR*	*15.4*	0.005		
16.7	Section strength, N + M	*UR*	*16.3.1*	0.320		
16.8	Member buckling, N + M (max of two equations)	*UR*	*16.3.2.2*	0.897		
16.9	Tension + bending (M_eff / M_dz)	*UR*	*16.3.2.1*	0.000		
16.10	Slenderness (KL/r)/limit	*UR*	*10.9, Table 3*	0.563		
16.11	GOVERNING UTILISATION RATIO	*UR*		**0.897**		
16.12	Governing check			**Member buckling N+M**		

End of calculation.

Design as per IS 800:2026 (Fourth Revision), limit state method. Axes: z-z major, y-y minor. Forces are factored design values.

Section properties from the selected database; confirm availability with the supplier before specifying.

Section interaction reported as the larger of the Table 17 interaction value and the individual M/M_nd ratios.