SECTION 2. DESIGN OF WALLS FOR AXIAL COMPRESSION

The tables in this section can be used to directly establish the compression load capacity of 200 ***mortarless*** masonry walls of a wide range of heights and lengths constructed with masonry units of Grade 15 or 20, and grouted with M20 or M25 concrete.

Mortarless masonry units are essentially permanent formwork for concrete walls however the masonry units contribute to the strength of the wall just a little. Only the portion that is filled with concrete is considered in the design thickness of the wall and this means that only 61% of the face shell thickness is considered in the calculation of compressive strength. The other 39% is ignored.

Walls are designed assuming thickness t = 174mm which ignores any contribution that the outer 39% of the face shell thickness might have to the stiffness of the wall.

This approach to the design of the wall is validated in IS 456:2000 by Clause 30.6 which states in the case of slabs that:

"*Blocks and formers may be of any suitable material……. When required to contribute to the structural strength of the slab they shall be made of concrete…….. and have a crushing strength of at least 14 N/mm^2 measured on the net section when axially loaded in the direction of the compressive stress in the slab.*"

Mortarless masonry units are manufactured with compressive strengths of 15Mpa and 20Mpa and thus they comply with Clause 30.6. It is recommended however that 15Mpa masonry units be coupled with M20 grout and that 20Mpa masonry units be coupled with M25 grout. While higher strength grouts may be used the load tables are based on these combinations.

When designing walls for compression using the empirical design method it is necessary to first calculate the eccentricity of the design compression load (P_u) applied to the top of the particular storey height of wall. IS 456:2000 Clause 32.2.2 describes how the eccentricity is to be calculated and this is shown in the in details on pages 4 and 5 of this Section. When using this method to calculate the effective eccentricity it is permissible to assume that the effective eccentricity at the base of any storey height of the wall is zero as indicated in the diagram on page 4.

Tables are provided for the two effective length factors but designers should note that the effective length factor may be applied to the length of the wall rather than the height.

IS 456:2000 Clause 32.2.4 defines the effective height (H_{ew}) of a wall panel as the lesser of the clear height (H_w) multiplied by an effective length factor, or the center to center distance between intersecting walls that provide lateral restraint (L_1) multiplied by an effective length factor. In both cases the effective length factor is 0.75 when there is rotational restraint at both ends in addition to lateral restraint, and 1.0 when there is just lateral restraint at both ends with no rotational restraint.

A formula for the design axial strength of a wall panel is given in Clause 32.2.5 and this has been used in the generation of all values in the following design tables. The formula provides for the effects of eccentricity of the load at the top of the wall panel, and it also provides for the additional eccentricity at mid height due to deformation resulting from slenderness. The formula for this additional eccentricity is incorrectly stated in the July 2000 edition of the code but the appropriate correction has been made when generating the values given in the following tables.

DESIGN PROCEDURE: AXIAL COMPRESSION

Step 1: Calculate ultimate limit state design load on the wall.

Step 2: Select a ***mortarless*** block size and strength (grade) based on local availability and price, and any other requirements (architect's requirements, fire rating, sound rating, thermal rating etc).

Step 3: Calculate the design eccentricity at the top of the wall panel. (refer pages 3and 4)

Step 4: Use the applicable table of Tables W1-200U to W4-200U to check that the wall panel has an axial load capacity greater than or equal to the design axial load. Note that the tables include allowance for all partial safety factors and design eccentricities.

Step 5: If the load capacity is not adequate, make the necessary adjustments to block strength, grout strength and/or wall thickness etc and check again.

Step 6: If the wall is subject to in-plane lateral load check the adequacy of the wall for shear – refer to Section 5

Step 7: If the wall is subjected to substantial out-of-plane lateral load check the out-of-plane shear stress – refer to Section 5

Fire, sound attenuation etc:

Step 8: Check that the wall satisfies all other requirements in terms of durability, slenderness, thickness etc.

Note that the tables in this Section can only be used to determine the compression load capacity of walls in a structure that is fully braced in both directions (refer IS 456:2000 Clause 32.2.1 for the criteria). The walls themselves can be utilized for bracing the structure when designed to act as shear walls and detailed accordingly. The tables cannot be used for walls subject to combined axial compression and out-of-plane bending.

An alternative to the design of walls using the empirical design method is to carry out a structural analysis to determine more accurately the design bending moments and to design the walls as compression members. The interaction diagrams in Section 4 have been prepared for this purpose and wall panels designed using this method can have a maximum slenderness ratio of 60.

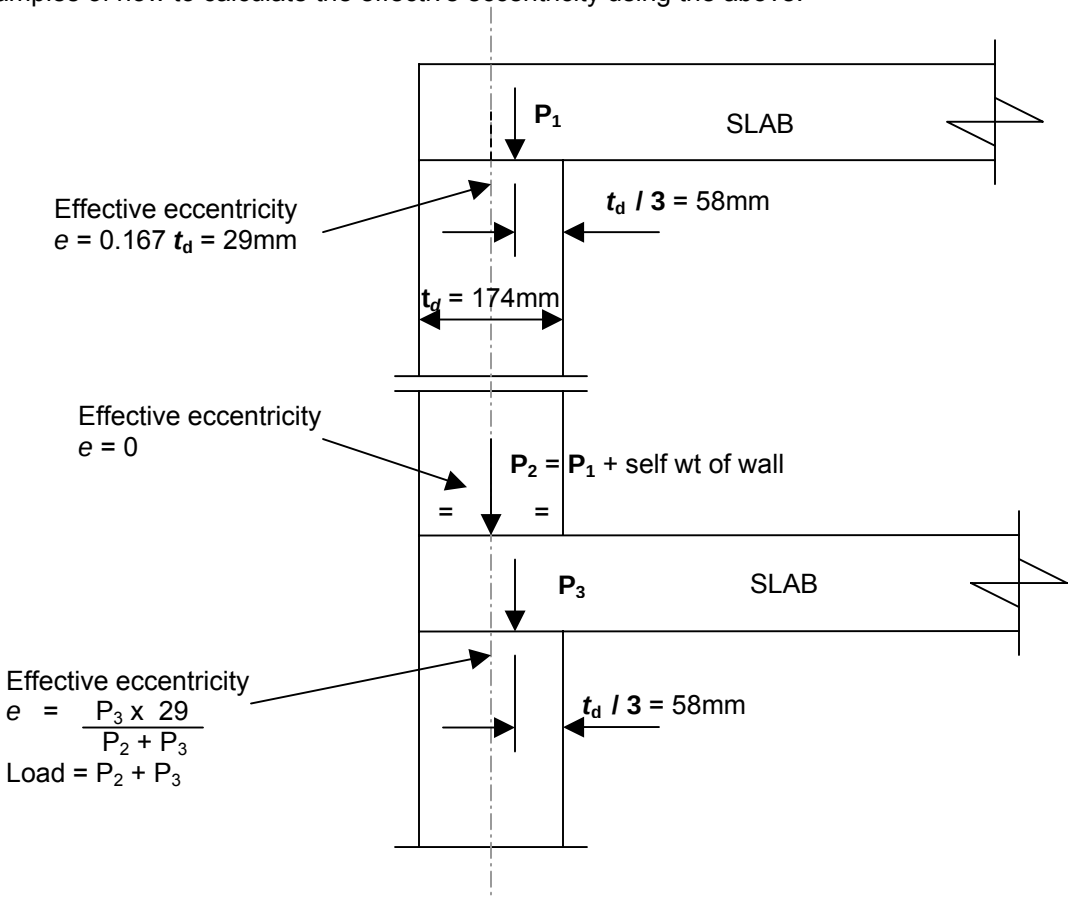
If a wall is subject to axial compression plus out-of-plane lateral load then it must be designed for combined compression and bending using the method outlined in Section 4.

Calculation of effective eccentricity when designing for compression:

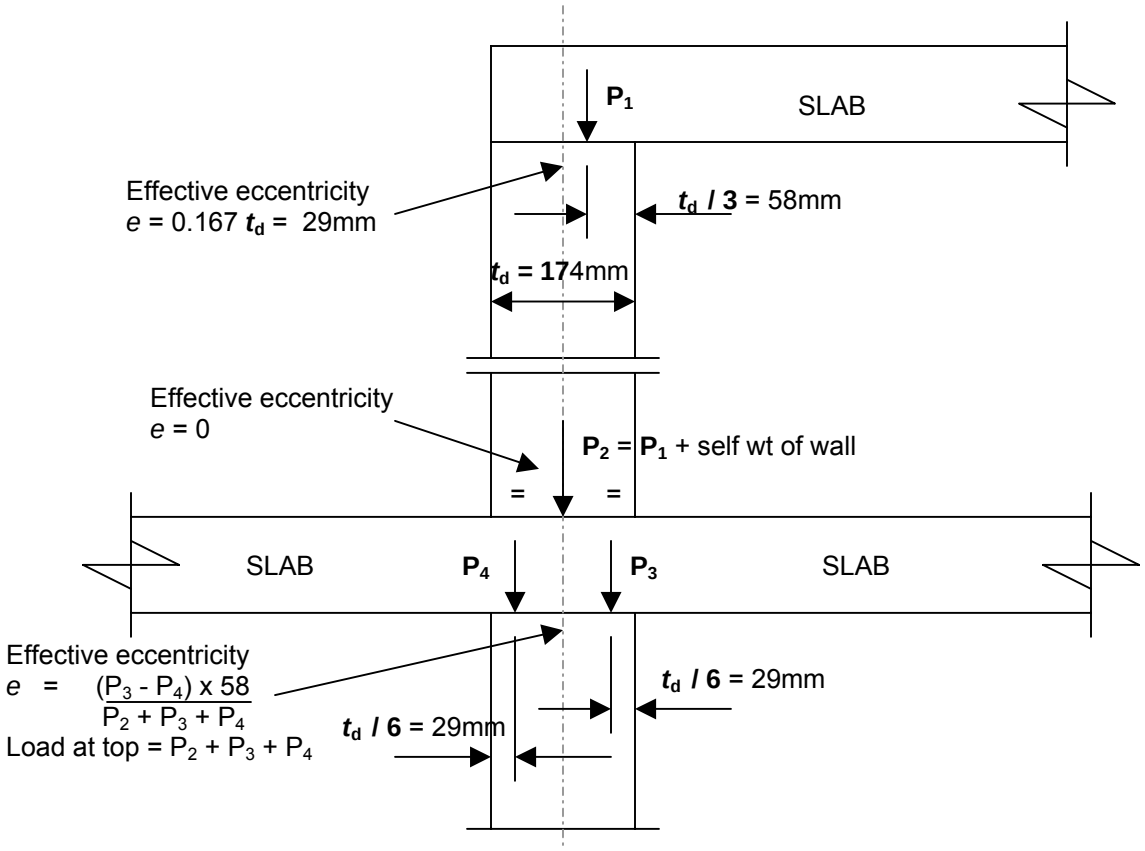
It is necessary to take into account the relative stiffnesses of interconnected structural members (walls, slabs, piers etc) and their interaction. IS 456 Clause 32.2.2 permits the following approach to calculating eccentricity of the compression load on a wall:

- The minimum eccentricity shall be 0.05*t*
- The vertical load transmitted to a wall by a discontinuous concrete floor or roof shall be assumed to act at ⅓ rd of the bearing depth measured from the span face of the wall.
- Where there is an insitu concrete floor or roof continuous over the wall, the load shall be assumed to act at the center of the wall.
- It is recommended by the author that if the continuous slab has different spans on each side of the wall then each side of the floor or roof shall be taken as being individually supported on ½ the total bearing area.
- The resulting eccentricity *e* at any level shall be calculated on the assumption that the total vertical load on the wall above the plane under consideration is axial immediately above the joint under consideration.

Examples of how to calculate the effective eccentricity using the above:



Alternatively, for walls with a minimum compressive stress above the joint of 0.25MPa or with reinforcement that can resist the design moment, a rigid frame analysis may be used.



Alternatively, for walls with a minimum compressive stress above the joint of 0.25MPa or with reinforcement that can resist the design moment, a rigid frame analysis may be used.

TABLE W1-200U **Effective height factor = 0.75**

15MPa Blocks
M20 Core fill (f_{ck} = 20Mpa)
Rotational restraint both ends of wall panel

200 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	1500	8.6	5.2	919	910	874	838	802	773
2200	1650	9.5	6.3	906	897	861	825	789	760
2400	1800	10.3	7.4	892	883	847	811	775	746
2600	1950	11.2	8.7	876	867	831	795	759	730
2800	2100	12.1	10.1	860	850	814	778	742	714
3000	2250	12.9	11.6	842	832	796	760	724	696
3200	2400	13.8	13.2	822	813	777	741	705	676
3400	2550	14.7	14.9	802	793	757	721	685	656
3600	2700	15.5	16.8	780	771	735	699	663	634
3800	2850	16.4	18.7	757	748	712	676	640	611
4000	3000	17.2	20.7	733	724	688	652	616	587
4200	3150	18.1	22.8	708	698	662	626	590	561
4400	3300	19.0	25.0	681	672	636	600	564	535
4600	3450	19.8	27.4	653	644	608	572	536	507
4800	3600	20.7	29.8	624	614	578	542	506	478
5000	3750	21.6	32.3	593	584	548	512	476	447
5200	3900	22.4	35.0	562	552	516	480	444	416
5400	4050	23.3	37.7	529	520	484	448	412	383
5600	4200	24.1	40.6	495	485	449	413	377	349
5800	4350	25.0	43.5	459	450	414	378	342	313
6000	4500	25.9	46.6	423	413	377	341	305	277
6200	4650	26.7	49.7	385	376	340	304	268	239
6400	4800	27.6	53.0	346	336	300	264	228	200
6600	4950	28.4	56.3	305	296	260	224	188	159
6800	5100	29.3	59.8	264	254	218	182	146	118

Notes:
Use this table to determine the design axial strength (P_{uw}) for a wall of any clear height or length that does not exceed the slenderness ratio limit set in IS 456:2000. Note that the slenderness ratio limit for walls is 30 (refer Clause 32.2.3) and this table is curtailed at that slenderness ratio.

8.7mm is the minimum design eccentricity for any unchamfered 200 ***mortarless*** wall. Linear interpolation may be used for any intermediate values of design eccentricity.

When using this table ensure that the ends of the wall panel (the top and bottom end if using H_w, or the left and right end if using L_1) are restrained rotationally. Insitu slabs at the top and bottom of the wall panel are considered to provide rotational restraint. If using length rather than height to determine P_{uw} then the intersecting walls must be adequately tied with anchored horizontal reinforcement.

The tabulated values of P_{uw} account for the reduction in axial load resulting from the additional eccentricity e_a due to slenderness effects. The value of e_a for each wall height is tabulated.

TABLE W2-200U Effective height factor = 0.75

20MPa Blocks
M25 Core fill (f_{ck} = 25Mpa)
Rotational restraint both ends of wall panel

200 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	1500	8.6	5.2	1149	1137	1092	1047	1002	930
2200	1650	9.5	6.3	1133	1121	1076	1031	986	914
2400	1800	10.3	7.4	1115	1103	1058	1013	968	896
2600	1950	11.2	8.7	1096	1084	1039	994	949	877
2800	2100	12.1	10.1	1075	1063	1018	973	928	856
3000	2250	12.9	11.6	1052	1040	995	950	905	833
3200	2400	13.8	13.2	1028	1016	971	926	881	809
3400	2550	14.7	14.9	1002	991	946	901	856	784
3600	2700	15.5	16.8	975	964	919	874	829	757
3800	2850	16.4	18.7	947	935	890	845	800	728
4000	3000	17.2	20.7	916	905	860	815	770	698
4200	3150	18.1	22.8	885	873	828	783	738	666
4400	3300	19.0	25.0	851	839	794	749	704	632
4600	3450	19.8	27.4	816	805	760	715	670	598
4800	3600	20.7	29.8	780	768	723	678	633	561
5000	3750	21.6	32.3	742	730	685	640	595	523
5200	3900	22.4	35.0	702	691	646	601	556	484
5400	4050	23.3	37.7	661	649	604	559	514	442
5600	4200	24.1	40.6	618	607	562	517	472	400
5800	4350	25.0	43.5	574	563	518	473	428	356
6000	4500	25.9	46.6	528	517	472	427	382	310
6200	4650	26.7	49.7	481	469	424	379	334	262
6400	4800	27.6	53.0	432	421	376	331	286	214
6600	4950	28.4	56.3	382	370	325	280	235	163
6800	5100	29.3	59.8	330	318	273	228	183	111

Notes:
Use this table to determine the design axial strength (P_{uw}) for a wall of any clear height or length that does not exceed the slenderness ratio limit set in IS 456:2000. Note that the slenderness ratio limit for walls is 30 (refer Clause 32.2.3) and this table is curtailed at that slenderness ratio.

8.7mm is the minimum design eccentricity for any unchamfered 200 ***mortarless*** wall. Linear interpolation may be used for any intermediate values of design eccentricity.

When using this table ensure that the ends of the wall panel (the top and bottom end if using H_w, or the left and right end if using L_1) are restrained rotationally. Insitu slabs at the top and bottom of the wall panel are considered to provide rotational restraint. If using length rather than height to determine P_{uw} then the intersecting walls must be adequately tied with anchored horizontal reinforcement.

The tabulated values of P_{uw} account for the reduction in axial load resulting from the additional eccentricity e_a due to slenderness effects. The value of e_a for each wall height is tabulated.

TABLE W3-200U Effective height factor = 1.0

15MPa Blocks

M20 Core fill (f_{ck} = 20Mpa)

No rotational restraint both ends of wall panel (just lateral restraint)

200 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	2000	11.5	9.2	871	862	826	790	754	696
2200	2200	12.6	11.1	848	838	802	766	730	673
2400	2400	13.8	13.2	822	813	777	741	705	648
2600	2600	14.9	15.5	795	786	750	714	678	620
2800	2800	16.1	18.0	765	756	720	684	648	590
3000	3000	17.2	20.7	733	724	688	652	616	558
3200	3200	18.4	23.5	699	690	654	618	582	524
3400	3400	19.5	26.6	662	653	617	581	545	488
3600	3600	20.7	29.8	624	614	578	542	506	449
3800	3800	21.8	33.2	583	574	538	502	466	408
4000	4000	23.0	36.8	540	531	495	459	423	365
4200	4200	24.1	40.6	495	485	449	413	377	320
4400	4400	25.3	44.5	447	438	402	366	330	272
4600	4600	26.4	48.6	398	388	352	316	280	223
4800	4800	27.6	53.0	346	336	300	264	228	171
5000	5000	28.7	57.5	292	282	246	210	174	117
5200	5200	29.9	62.2	235	226	190	154	118	60

Notes:

Use this table to determine the design axial strength (P_{uw}) for a wall of any clear height or length that does not exceed the slenderness ratio limit set in IS 456:2000. Note that the slenderness ratio limit for walls is 30 (refer Clause 32.2.3) and this table is curtailed at that slenderness ratio.

8.7mm is the minimum design eccentricity for any unchamfered 200 ***mortarless*** wall. Linear interpolation may be used for any intermediate values of design eccentricity.

This table is for walls in which the ends are restrained laterally but not rotationally. Ensure always that there is adequate connection between the walls and the roof or floor slabs to provide such restraint (refer Clause 32.2.1 d))

The tabulated values of P_{uw} account for the reduction in axial load resulting from the additional eccentricity e_a due to slenderness effects. The value of e_a for each wall height is given in column 4 of the table.

TABLE W4-200U Effective height factor = 1.0

20MPa Blocks
M25 Core fill (f_{ck} = 25Mpa)
No rotational restraint both ends of wall panel (just lateral restraint)

200 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	2000	11.5	9.2	1089	1077	1032	987	942	870
2200	2200	12.6	11.1	1060	1048	1003	958	913	841
2400	2400	13.8	13.2	1028	1016	971	926	881	809
2600	2600	14.9	15.5	994	982	937	892	847	775
2800	2800	16.1	18.0	956	945	900	855	810	738
3000	3000	17.2	20.7	916	905	860	815	770	698
3200	3200	18.4	23.5	874	862	817	772	727	655
3400	3400	19.5	26.6	828	816	771	726	681	609
3600	3600	20.7	29.8	780	768	723	678	633	561
3800	3800	21.8	33.2	729	717	672	627	582	510
4000	4000	23.0	36.8	675	663	618	573	528	456
4200	4200	24.1	40.6	618	607	562	517	472	400
4400	4400	25.3	44.5	559	547	502	457	412	340
4600	4600	26.4	48.6	497	485	440	395	350	278
4800	4800	27.6	53.0	432	421	376	331	286	214
5000	5000	28.7	57.5	365	353	308	263	218	146
5200	5200	29.9	62.2	294	283	238	193	148	76

Notes:

Use this table to determine the design axial strength (P_{uw}) for a wall of any clear height or length that does not exceed the slenderness ratio limit set in IS 456:2000. Note that the slenderness ratio limit for walls is 30 (refer Clause 32.2.3) and this table is curtailed at that slenderness ratio.

8.7mm is the minimum design eccentricity for any unchamfered 200 ***mortarless*** wall. Linear interpolation may be used for any intermediate values of design eccentricity.

This table is for walls in which the ends are restrained laterally but not rotationally. Ensure always that there is adequate connection between the walls and the roof or floor slabs to provide such restraint (refer Clause 32.2.1 d))

The tabulated values of P_{uw} account for the reduction in axial load resulting from the additional eccentricity e_a due to slenderness effects. The value of e_a for each wall height is given in column 4 of the table.