SECTION 2. DESIGN OF WALLS FOR AXIAL COMPRESSION

The tables in this section can be used to directly establish the compression load capacity of 140 ***mortarless*** 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 55% of the face shell thickness is considered in the calculation of compressive strength. The other 45% is ignored.

Walls are designed assuming thickness t = 114mm which ignores any contribution that the outer 45% 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 ion 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.

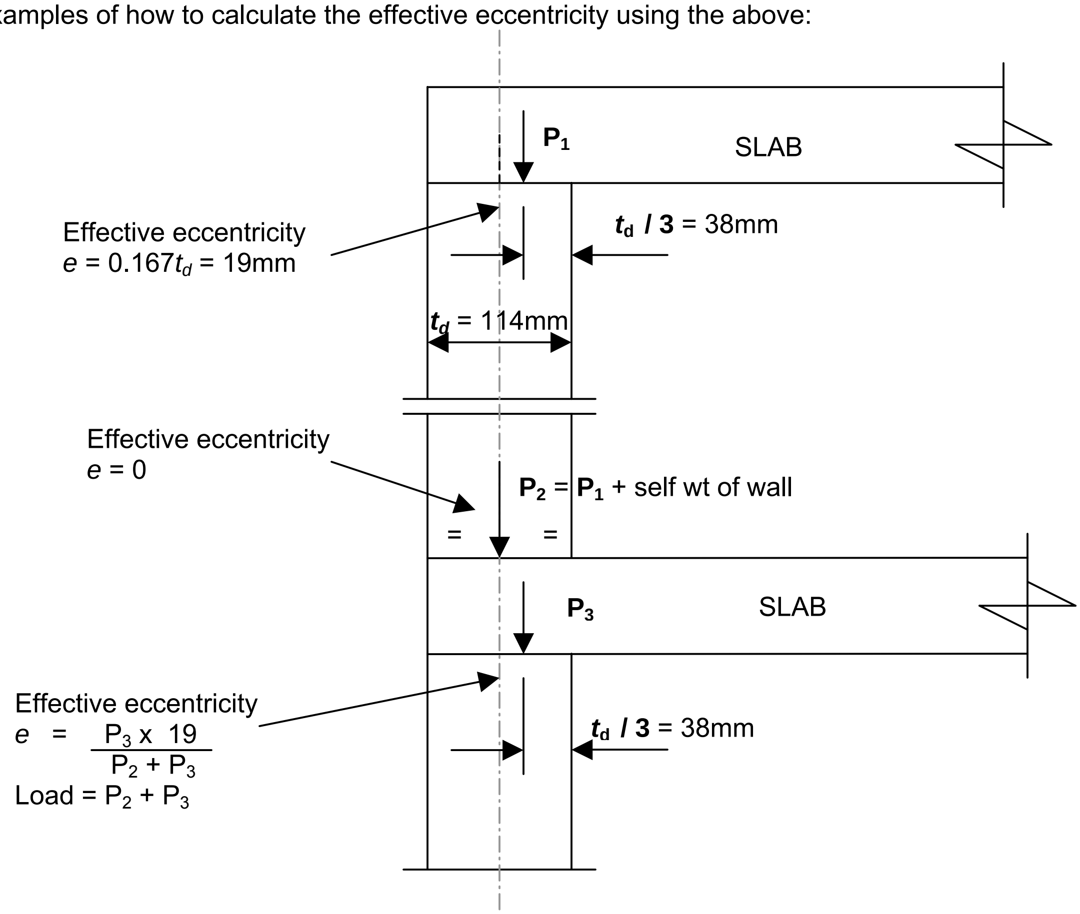
If a wall is subject to axial compression plus out-of-plane lateral load then it must be designed for combined compression and bending using the method outlined in Section 4.

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:

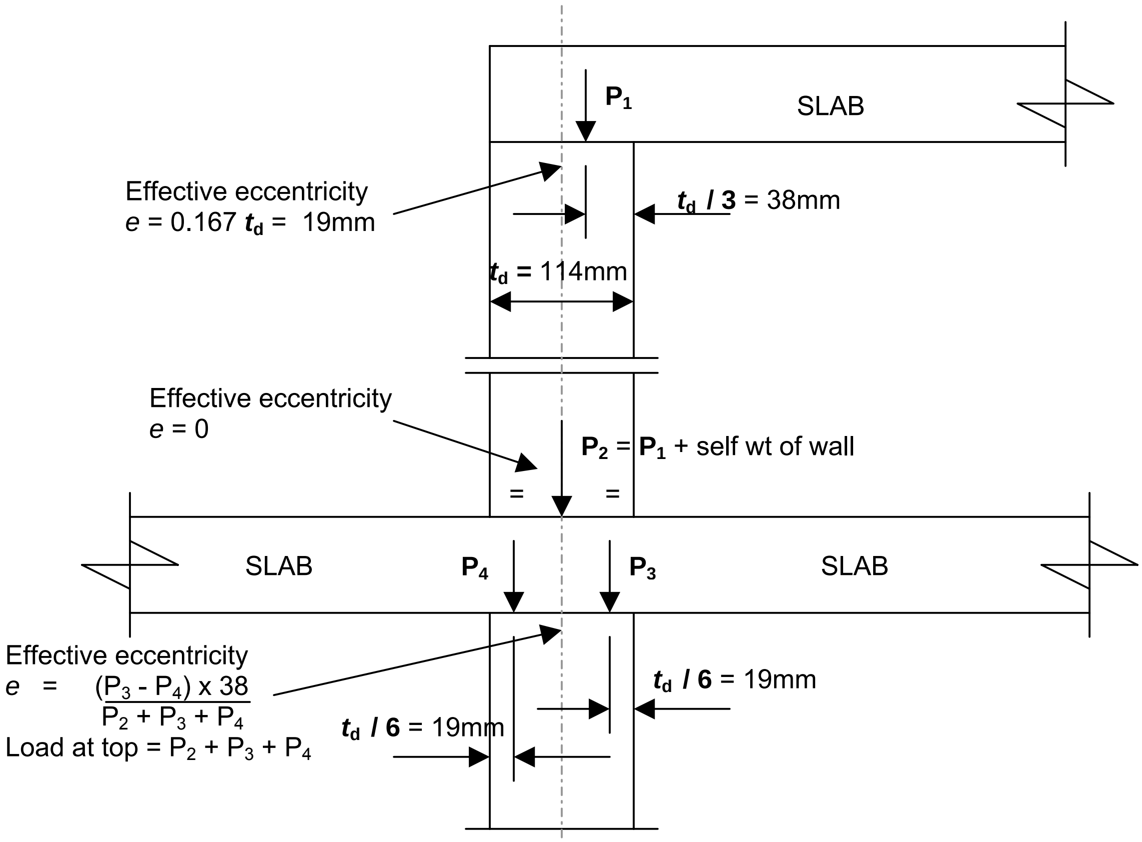
- The minimum eccentricity shall be 0.05t
- The vertical load transmitted to a wall by a discontinuous concrete floor or roof shall be assumed to act at ⅓ rd of the bearing depth measured from the span face of the wall.
- Where there is an insitu concrete floor or roof continuous over the wall, the load 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.

Note that total thickness of the masonry unit has been used for the calculation of eccentricity as this is the width that insitu slabs will bear on unless isolation strips are installed.



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.

Note that total thickness of the masonry unit has been used for the calculation of eccentricity as this is the width that insitu slabs will bear on unless isolation strips are installed.

TABLE W1-140U **Effective height factor = 0.75**

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

140 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
2000	1500	13.2	7.9	548	532	517	481	445	424
2200	1650	14.5	9.6	528	512	497	461	425	404
2400	1800	15.8	11.4	507	490	476	440	404	382
2600	1950	17.1	13.3	483	466	452	416	380	358
2800	2100	18.4	15.5	457	441	426	390	354	333
3000	2250	19.7	17.8	430	413	399	363	327	305
3200	2400	21.1	20.2	400	384	369	333	297	276
3400	2550	22.4	22.8	369	353	338	302	266	245
3600	2700	23.7	25.6	336	319	305	269	233	211
3800	2850	25.0	28.5	301	284	270	234	198	176
4000	3000	26.3	31.6	264	247	233	197	161	139
4200	3150	27.6	34.8	225	209	194	158	122	101
4400	3300	28.9	38.2	184	168	153	117	81	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.

5.7mm is the minimum design eccentricity for any unchamfered 140 ***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 W2-140U Effective height factor = 0.75

20MPa Blocks
M25 Core fill (f_{ck} = 25Mpa)

Rotational restraint both ends of wall panel

140 Mortarless (unchamfered)

H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
2000	1500	13.2	7.9	685	665	647	602	557	530
2200	1650	14.5	9.6	660	640	622	577	532	505
2400	1800	15.8	11.4	633	612	594	549	504	477
2600	1950	17.1	13.3	604	583	565	520	475	448
2800	2100	18.4	15.5	572	551	533	488	443	416
3000	2250	19.7	17.8	537	517	499	454	409	382
3200	2400	21.1	20.2	501	480	462	417	372	345
3400	2550	22.4	22.8	461	441	423	378	333	306
3600	2700	23.7	25.6	420	399	381	336	291	264
3800	2850	25.0	28.5	376	356	338	293	248	221
4000	3000	26.3	31.6	330	309	291	246	201	174
4200	3150	27.6	34.8	281	261	243	198	153	126
4400	3300	28.9	38.2	231	210	192	147	102	75

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.

5.7mm is the minimum design eccentricity for any unchamfered 140 ***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 W3-140U **Effective height factor = 1.0**

15MPa Blocks

M20 Core fill (f$_{ck}$ = 20Mpa)

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

140 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
2000	2000	17.5	14.0	475	458	444	408	372	350
2200	2200	19.3	17.0	439	423	408	372	336	315
2400	2400	21.1	20.2	400	384	369	333	297	276
2600	2600	22.8	23.7	358	342	327	291	255	234
2800	2800	24.6	27.5	313	296	282	246	210	188
3000	3000	26.3	31.6	264	247	233	197	161	139
3200	3200	28.1	35.9	212	195	181	145	109	87
3400	3400	29.8	40.6	156	140	125	89	53	32

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.

5.7mm is the minimum design eccentricity for any unchamfered 140 ***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 W4-140U Effective height factor = 1.0

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

140 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design axial strength P_{uw} (kN/m)					
				e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
2000	2000	17.5	14.0	593	572	554	509	464	437
2200	2200	19.3	17.0	549	528	510	465	420	393
2400	2400	21.1	20.2	501	480	462	417	372	345
2600	2600	22.8	23.7	448	427	409	364	319	292
2800	2800	24.6	27.5	391	370	352	307	262	235
3000	3000	26.3	31.6	330	309	291	246	201	174
3200	3200	28.1	35.9	265	244	226	181	136	109
3400	3400	29.8	40.6	195	175	157	112	67	40

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.

5.7mm is the minimum design eccentricity for any unchamfered 140 ***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.