SECTION 2. DESIGN OF WALLS FOR AXIAL COMPRESSION USING SIMPLIFIED DESIGN METHOD

Many walls are designed using the simplified design method of AS 3600 Clause 11.5 and this Section 2 of the design manual is dedicated to that approach. When using this method a simplified approach is taken to the calculation of the eccentricity of the applied axial compression load on any wall panel. When using this method however a conservative approach is also taken to calculation of the compression load capacity of a wall panel.

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

Mortarless masonry units are essentially permanent formwork for concrete walls however the masonry units do contribute to the strength of the wall. 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.

Mortarless masonry units are manufactured with compressive strengths of 15Mpa and 20Mpa and it is recommended that the minimum grout strength be 20MPa. This is despite the fact that when calculating the load capacity of a wall a 28 day compressive strength equal to the unconfined compressive strength of the masonry units is assumed and this is considered to be somewhat conservative.

When designing walls for compression it is necessary to first calculate the eccentricity of the design compression load (N^*) applied to the top of the particular storey height of wall. It is permissible to use simplified methods to calculate the effective eccentricity as outlined in AS 3600 Clause 11.5 provided the slenderness ratio (H_{we}/t_w) does not exceed 30.

The simplified method of calculating the effective eccentricity is outlined on the following page. 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 2. (refer Clause 11.5.2)

After calculating the effective eccentricity for a particular wall panel it is then necessary to determine the effective height of the wall. Clause 11.4 contains the provisions for calculating effective height and these take into account the possibility of either one-way or two-way buckling.

The simple approach is to assume one-way buckling in which case the effective height factor is either 0.75 or 1.0 depending on the end restraint conditions. If the wall panel is restrained against rotation at both ends then the effective height factor k = 0.75. If there is no restraint against rotation at one or both ends then the effective height factor k = 1. Note that this is for walls in structures that are laterally braced in both directions meaning that all wall panels are laterally restrained at both ends.

Clause 11.4 also provides a means of calculating the effective height factor for wall panels in which two-way buckling can govern the design and this can be significantly less than 0.75. Diagram 2-1 in this Section can be used to determine the effective height factor for a wall panel laterally restrained on three or four sides and subject to two-way buckling. Table W5-200U and Table W6-200U are provided for use with Diagram 2-1.

If walls are designed for two-way buckling then it is necessary to install the reinforcement in both faces.

Note: An alternative approach is to carry out a structural analysis to determine more accurately the design bending moments and to then use the interaction diagrams in Section 4 to check the adequacy of any wall panel. Wall panels with a slenderness ratio greater than 30 can be designed if a proper analysis is carried out.

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: If the wall is subject to one-way buckling determine the design axial strength of the wall from the applicable table of Tables W1-200U to W4-200U and check that it is greater than or equal to the design axial load. Note that the tables include allowance for all partial safety factors.

If the wall is subject to two-way buckling rather than one-way buckling, determine the effective height factor (k) from Diagram 2-1 and use this to calculate the design slenderness ratio (SR) for the wall panel ($SR=kH_w/t_d$). Then use either Table W5-200U or Table W6-200U to determine the design ultimate strength of the wall and check that it is greater than or equal to the design axial load. Note that the tables include allowance for all partial safety factors. Ensure that all cross walls are adequately tied when using this approach – refer Clauses 11.3 and 11.4. Refer to Section 1 of this manual for the value of t_d.

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 also subject to out-of-plane lateral loads check the adequacy of the selected wall for combined action – refer to Section 4

Step 7: If the wall is subject to in-plane lateral load check the adequacy of the wall for shear – refer to Section 5

Step 8: 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 9: Check that the wall satisfies all other requirements in terms of durability, slenderness, thickness etc.

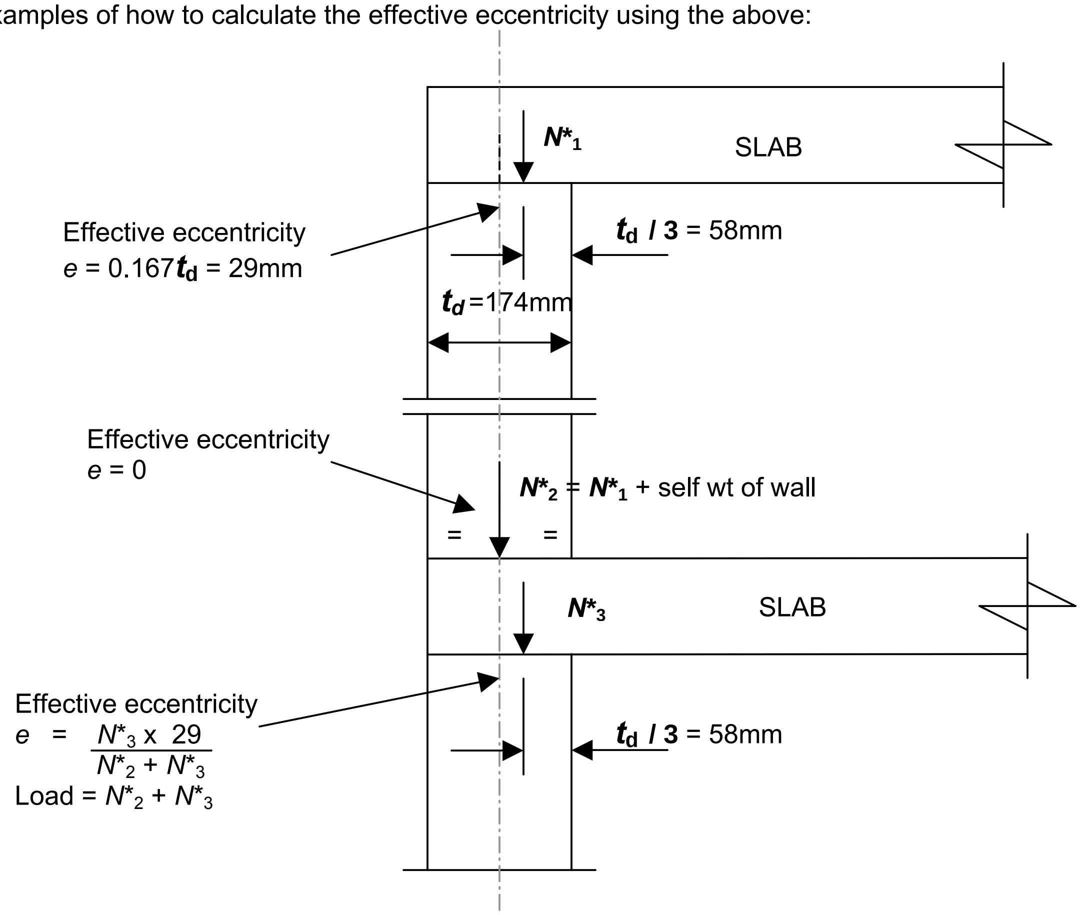
Calculation of effective eccentricity when designing for compression using simplified method:

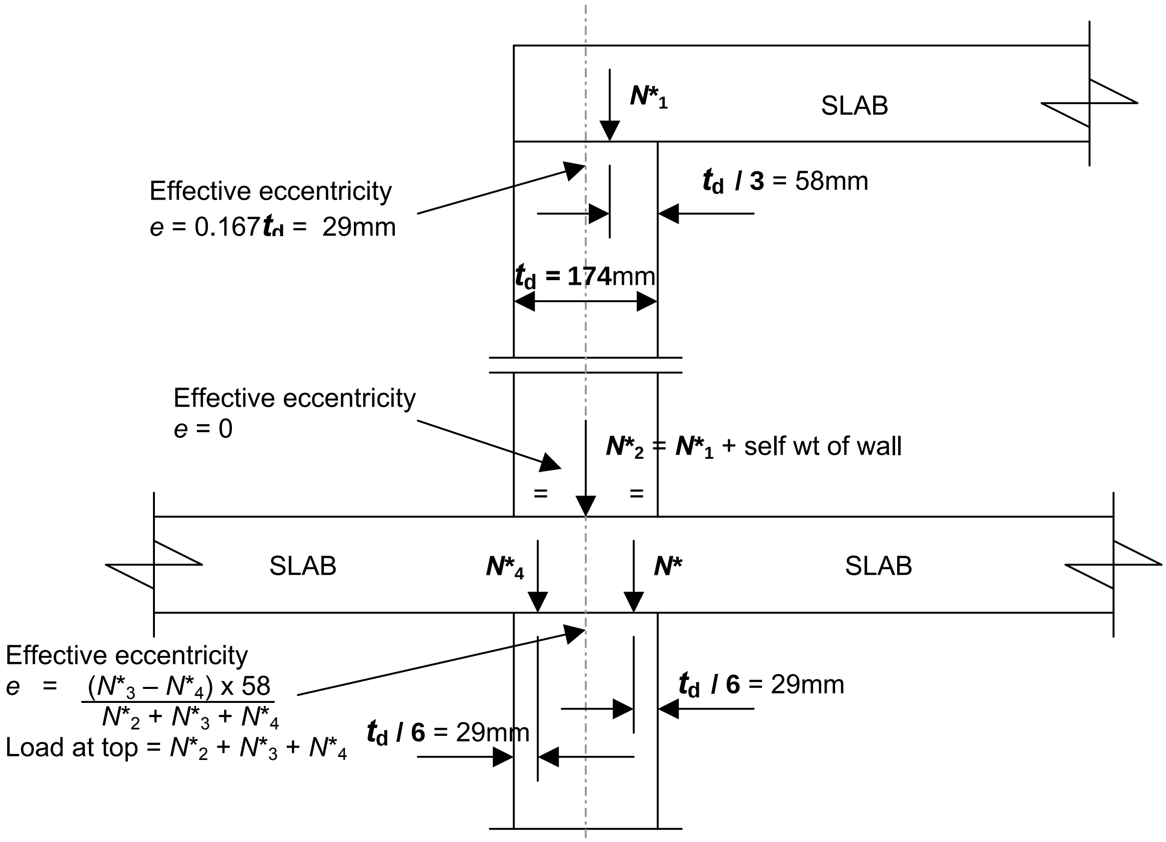
AS 3600 Clause 11.5.2 permits the calculation of eccentricity of applied vertical loads at the top of walls as follows:

- The minimum eccentricity shall be $0.05t_d$
- 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.

It also permits the assumption that the eccentricity of aggregated load from all floors above the floor at the top of the wall being designed is zero.

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





N*1
SLAB
Effective eccentricity
e = 0.167td = 29mm
td / 3 = 58mm
td = 174mm
Effective eccentricity
e = 0
N*2 = N*1 + self wt of wall
=
=
SLAB
N*4
N*
SLAB
Effective eccentricity
e = (N*3 – N*4) x 58 / N*2 + N*3 + N*4
Load at top = N*2 + N*3 + N*4
td / 6 = 29mm
td / 6 = 29mm

TABLE W1-200U Effective height factor k = 0.75

15MPa Blocks
20MPa Core fill (*f'*$_c$ = 20Mpa)
Rotational restraint both ends of wall panel

200 Mortarless (unchamfered)

H_w	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 8.7mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 25mm	*e* = 33mm
2000	1500	8.6	5.2	827	819	787	754	722	670
2200	1650	9.5	6.3	816	807	775	742	710	658
2400	1800	10.3	7.4	803	794	762	730	697	645
2600	1950	11.2	8.7	789	780	748	716	683	631
2800	2100	12.1	10.1	774	765	733	701	668	616
3000	2250	12.9	11.6	758	749	717	684	652	600
3200	2400	13.8	13.2	740	732	699	667	635	583
3400	2550	14.7	14.9	722	713	681	649	616	564
3600	2700	15.5	16.8	702	694	661	629	597	545
3800	2850	16.4	18.7	682	673	641	608	576	524
4000	3000	17.2	20.7	660	651	619	587	554	502
4200	3150	18.1	22.8	637	628	596	564	531	479
4400	3300	19.0	25.0	613	604	572	540	507	455
4600	3450	19.8	27.4	588	579	547	514	482	430
4800	3600	20.7	29.8	561	553	521	488	456	404
5000	3750	21.6	32.3	534	526	493	461	428	377
5200	3900	22.4	35.0	506	497	465	432	400	348
5400	4050	23.3	37.7	476	468	435	403	370	319
5600	4200	24.1	40.6	445	437	404	372	340	288
5800	4350	25.0	43.5	413	405	373	340	308	256
6000	4500	25.9	46.6	380	372	340	307	275	223
6200	4650	26.7	49.7	346	338	306	273	241	189
6400	4800	27.6	53.0	311	303	270	238	206	154
6600	4950	28.4	56.3	275	266	234	202	169	117
6800	5100	29.3	59.8	237	229	197	164	132	80

Notes:

Use this table to determine the design axial strength (ΦN_u) for a wall of any clear height that does not exceed the slenderness ratio limit set in AS 3600:2009. Note that the slenderness ratio limit for walls is 30 (refer Clause 11.5) 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) are restrained rotationally. Insitu slabs at top and bottom are considered to provide rotational restraint.
The tabulated values of ΦN_u 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.
A capacity reduction factor (Φ) of 0.6 has been used when calculating the tabulated strengths.

TABLE W2-200U **Effective height factor k = 0.75**

20MPa Blocks
20MPa Core fill (*f'*$_c$ = 20Mpa)
Rotational restraint both ends of wall panel

200 Mortarless (unchamfered)

H_w	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	1500	8.6	5.2	1103	1092	1049	1006	962	893
2200	1650	9.5	6.3	1088	1076	1033	990	947	878
2400	1800	10.3	7.4	1070	1059	1016	973	930	860
2600	1950	11.2	8.7	1052	1041	997	954	911	842
2800	2100	12.1	10.1	1032	1020	977	934	891	822
3000	2250	12.9	11.6	1010	999	956	912	869	800
3200	2400	13.8	13.2	987	976	933	889	846	777
3400	2550	14.7	14.9	962	951	908	865	822	752
3600	2700	15.5	16.8	936	925	882	839	795	726
3800	2850	16.4	18.7	909	898	854	811	768	699
4000	3000	17.2	20.7	880	868	825	782	739	670
4200	3150	18.1	22.8	849	838	795	752	708	639
4400	3300	19.0	25.0	817	806	763	720	676	607
4600	3450	19.8	27.4	784	772	729	686	643	574
4800	3600	20.7	29.8	749	737	694	651	608	539
5000	3750	21.6	32.3	712	701	658	614	571	502
5200	3900	22.4	35.0	674	663	620	576	533	464
5400	4050	23.3	37.7	635	623	580	537	494	425
5600	4200	24.1	40.6	594	582	539	496	453	384
5800	4350	25.0	43.5	551	540	497	454	410	341
6000	4500	25.9	46.6	507	496	453	410	366	297
6200	4650	26.7	49.7	462	451	407	364	321	252
6400	4800	27.6	53.0	415	404	360	317	274	205
6600	4950	28.4	56.3	367	355	312	269	226	157
6800	5100	29.3	59.8	317	305	262	219	176	107

Notes:

Use this table to determine the design axial strength (ΦN_u) for a wall of any clear height that does not exceed the slenderness ratio limit set in AS 3600:2009. Note that the slenderness ratio limit for walls is 30 (refer Clause 11.5) 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) are restrained rotationally. Insitu slabs at top and bottom are considered to provide rotational restraint.
The tabulated values of ΦN_u 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.
A capacity reduction factor (Φ) of 0.6 has been used when calculating the tabulated strengths.

TABLE W3-200U Effective height factor k = 1.0

15MPa Blocks
20MPa Core fill (**f'_c = 20Mpa**)

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

200 Mortarless (unchamfered)									
				Design ultimate strength ΦN_u (kN/m)					
H_w	H_{we}	SR	e_a	e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 20mm	e = 29mm
2000	2000	11.5	9.2	784	775	743	711	678	626
2200	2200	12.6	11.1	763	755	722	690	657	606
2400	2400	13.8	13.2	740	732	699	667	635	583
2600	2600	14.9	15.5	715	707	675	642	610	558
2800	2800	16.1	18.0	689	680	648	615	583	531
3000	3000	17.2	20.7	660	651	619	587	554	502
3200	3200	18.4	23.5	629	621	588	556	523	472
3400	3400	19.5	26.6	596	588	555	523	491	439
3600	3600	20.7	29.8	561	553	521	488	456	404
3800	3800	21.8	33.2	525	516	484	451	419	367
4000	4000	23.0	36.8	486	478	445	413	380	329
4200	4200	24.1	40.6	445	437	404	372	340	288
4400	4400	25.3	44.5	403	394	362	329	297	245
4600	4600	26.4	48.6	358	349	317	285	252	200
4800	4800	27.6	53.0	311	303	270	238	206	154
5000	5000	28.7	57.5	263	254	222	189	157	105
5200	5200	29.9	62.2	212	203	171	139	106	54

Notes:

Use this table to determine the design axial strength (ΦN_u) for a wall of any clear height that does not exceed the slenderness ratio limit set in AS 3600:2009. Note that the slenderness ratio limit for walls is 30 (refer Clause 11.5) 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 only restrained laterally and not rotationally. Ensure always that there is adequate connection between the walls and the roof or floor slabs to provide such restraint (refer Clause 11.3)
The tabulated values of ΦN_u 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.
A capacity reduction factor (Φ) of 0.6 has been used when calculating the tabulated strengths.

TABLE W4-200U Effective height factor *k* = 1.0

20MPa Blocks
20MPa Core fill (*f'*$_c$ = 20Mpa)

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

200 Mortarless (unchamfered)									
				Design ultimate strength ΦN_u (kN/m)					
H_w	H_{we}	SR	e_a	e = 8.7mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	2000	11.5	9.2	1045	1034	991	948	904	835
2200	2200	12.6	11.1	1017	1006	963	920	877	807
2400	2400	13.8	13.2	987	976	933	889	846	777
2600	2600	14.9	15.5	954	943	899	856	813	744
2800	2800	16.1	18.0	918	907	864	820	777	708
3000	3000	17.2	20.7	880	868	825	782	739	670
3200	3200	18.4	23.5	839	827	784	741	698	629
3400	3400	19.5	26.6	795	784	741	697	654	585
3600	3600	20.7	29.8	749	737	694	651	608	539
3800	3800	21.8	33.2	700	688	645	602	559	490
4000	4000	23.0	36.8	648	637	594	550	507	438
4200	4200	24.1	40.6	594	582	539	496	453	384
4400	4400	25.3	44.5	537	526	482	439	396	327
4600	4600	26.4	48.6	477	466	423	380	336	267
4800	4800	27.6	53.0	415	404	360	317	274	205
5000	5000	28.7	57.5	350	339	296	252	209	140
5200	5200	29.9	62.2	283	271	228	185	142	73

Notes:

Use this table to determine the design axial strength (ΦN_u) for a wall of any clear height that does not exceed the slenderness ratio limit set in AS 3600:2009. Note that the slenderness ratio limit for walls is 30 (refer Clause 11.5) 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 only restrained laterally and not rotationally. Ensure always that there is adequate connection between the walls and the roof or floor slabs to provide such restraint (refer Clause 11.3)
The tabulated values of ΦN_u 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.
A capacity reduction factor (Φ) of 0.6 has been used when calculating the tabulated strengths.

DIAGRAM 2-1:

Refer AS 3600 Clauses 11.4b) and 11.4c)

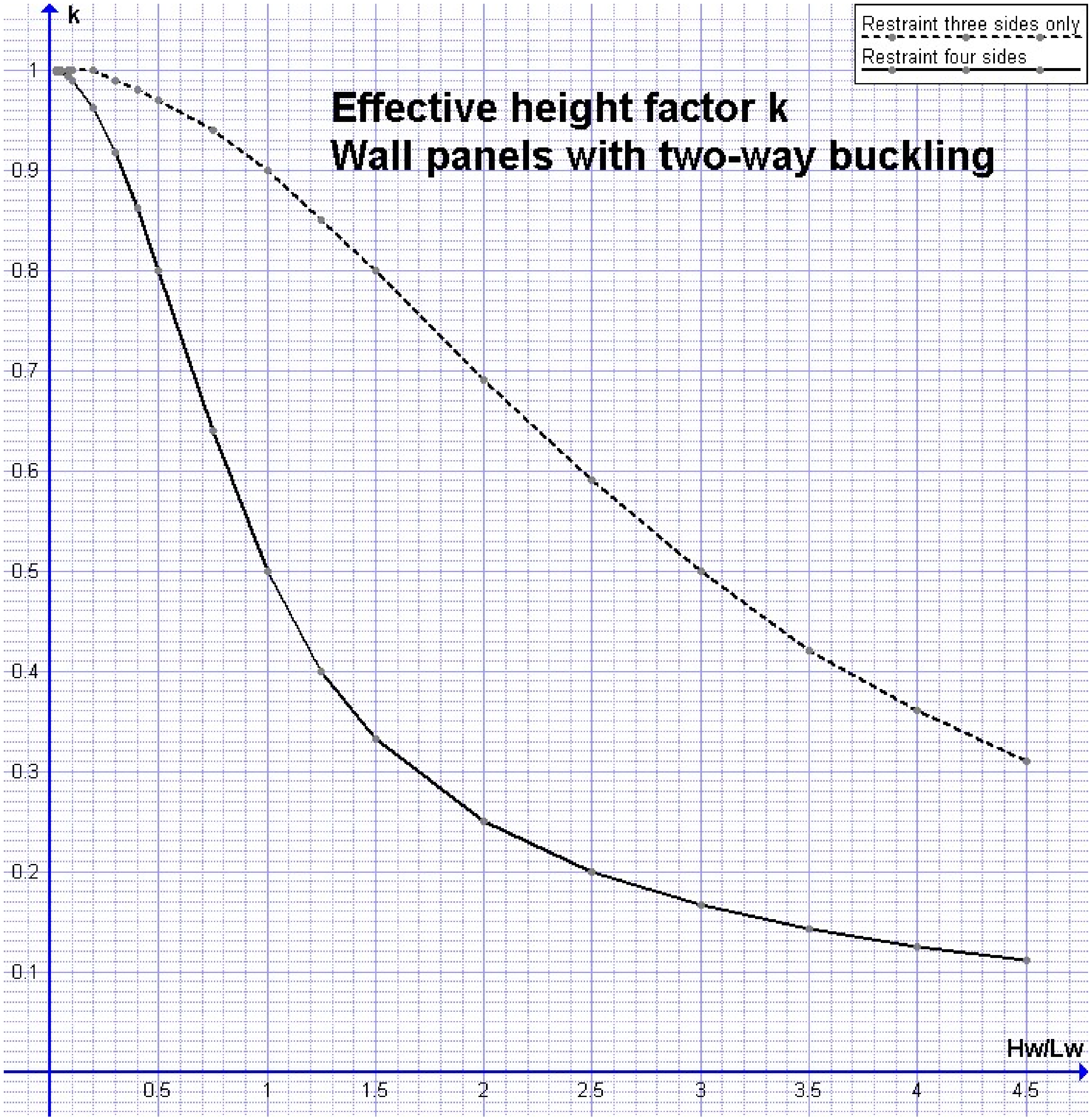


TABLE W5-200U

15MPa Blocks
20MPa Core fill (*f'*$_c$ = 20Mpa)

200 Mortarless (unchamfered)

SR	e_a	Design ultimate strength ΦN_u (kN/m)					
		e = 8.7mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 25mm	*e* = 33mm
12	10.0	775	767	734	702	669	618
13	11.8	756	748	715	683	651	599
14	13.6	736	727	695	663	630	578
15	15.7	714	706	673	641	608	557
16	17.8	691	682	650	618	585	533
17	20.1	666	658	625	593	560	509
18	22.6	640	631	599	566	534	482
19	25.1	612	603	571	539	506	454
20	27.8	583	574	542	509	477	425
21	30.7	552	543	511	479	446	394
22	33.7	519	511	479	446	414	362
23	36.8	486	477	445	412	380	328
24	40.1	450	442	409	377	345	293
25	43.5	413	405	373	340	308	256
26	47.0	375	367	334	302	269	218
27	50.7	335	327	294	262	230	178
28	54.6	294	285	253	221	188	136
29	58.5	251	243	210	178	145	94
30	62.6	207	198	166	133	101	49

Notes:

Use this table to determine the design axial strength (ΦN_u) for a wall of any clear height that does not exceed the slenderness ratio limit set in AS 3600:2009. Note that the slenderness ratio limit for walls is 30 (refer Clause 11.5) 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 provided design engineers that are checking walls subjected to two-way buckling. It is valid also for walls subjected to one-way buckling but Tables W1 – W4 are more convenient for checking such walls.
The tabulated values of ΦN_u 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.
A capacity reduction factor (Φ) of 0.6 has been used when calculating the tabulated strengths.

TABLE W6-200U

20MPa Blocks
20MPa Core fill (*f*'$_c$ = 20Mpa)

200 Mortarless (unchamfered)							
SR	e_a	Design ultimate strength ΦN_u (kN/m)					
		e = 8.7mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 25mm	*e* = 33mm
12	10.0	1033	1022	979	936	892	823
13	11.8	1008	997	954	911	867	798
14	13.6	981	970	927	884	840	771
15	15.7	952	941	898	854	811	742
16	17.8	921	910	867	823	780	711
17	20.1	888	877	834	790	747	678
18	22.6	853	842	798	755	712	643
19	25.1	816	805	761	718	675	606
20	27.8	777	766	722	679	636	567
21	30.7	736	724	681	638	595	526
22	33.7	693	681	638	595	552	483
23	36.8	647	636	593	550	507	437
24	40.1	600	589	546	503	460	390
25	43.5	551	540	497	454	410	341
26	47.0	500	489	446	402	359	290
27	50.7	447	436	393	349	306	237
28	54.6	392	381	337	294	251	182
29	58.5	335	324	280	237	194	125
30	62.6	276	264	221	178	135	66

Notes:

Use this table to determine the design axial strength (ΦN_u) for a wall of any clear height that does not exceed the slenderness ratio limit set in AS 3600:2009. Note that the slenderness ratio limit for walls is 30 (refer Clause 11.5) 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 provided design engineers that are checking walls subjected to two-way buckling. It is valid also for walls subjected to one-way buckling but Tables W1 – W4 are more convenient for checking such walls.
The tabulated values of ΦN_u 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.
A capacity reduction factor (Φ) of 0.6 has been used when calculating the tabulated strengths.