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.

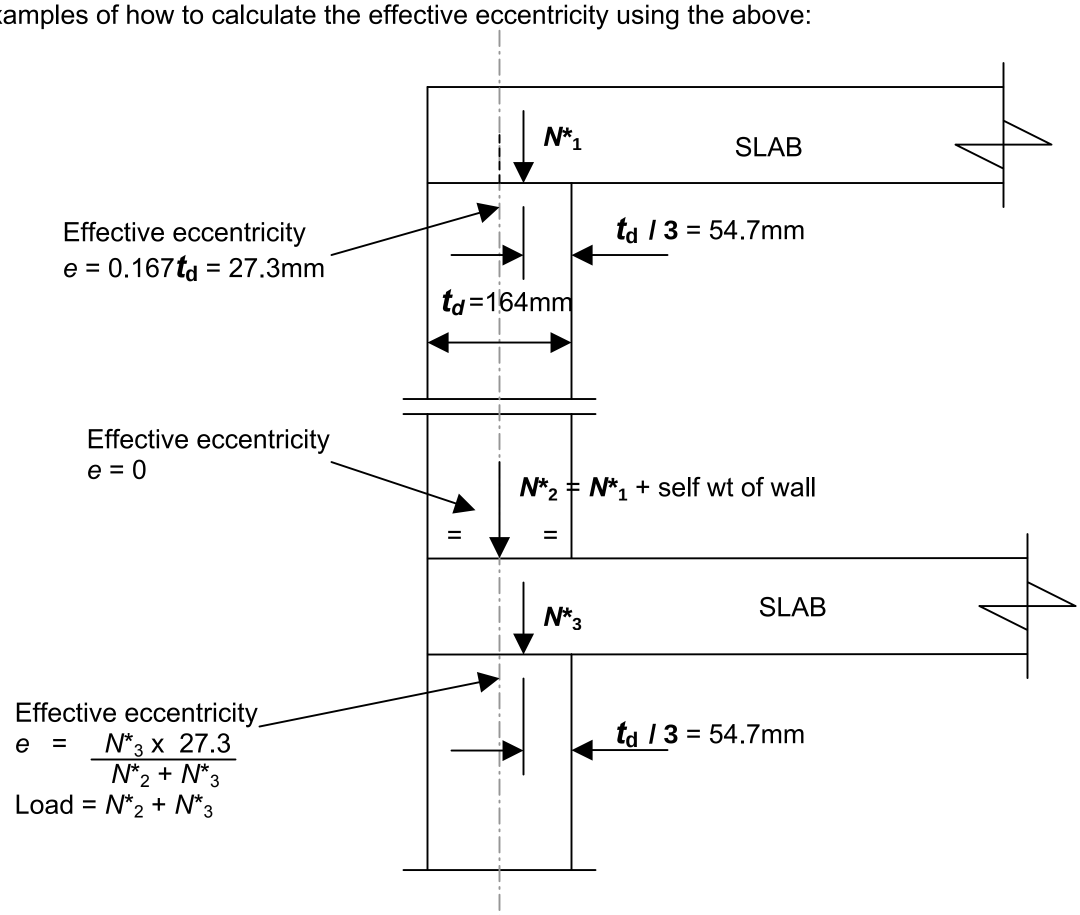
Calculation of effective eccentricity when designing for compression using simplified method:

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:



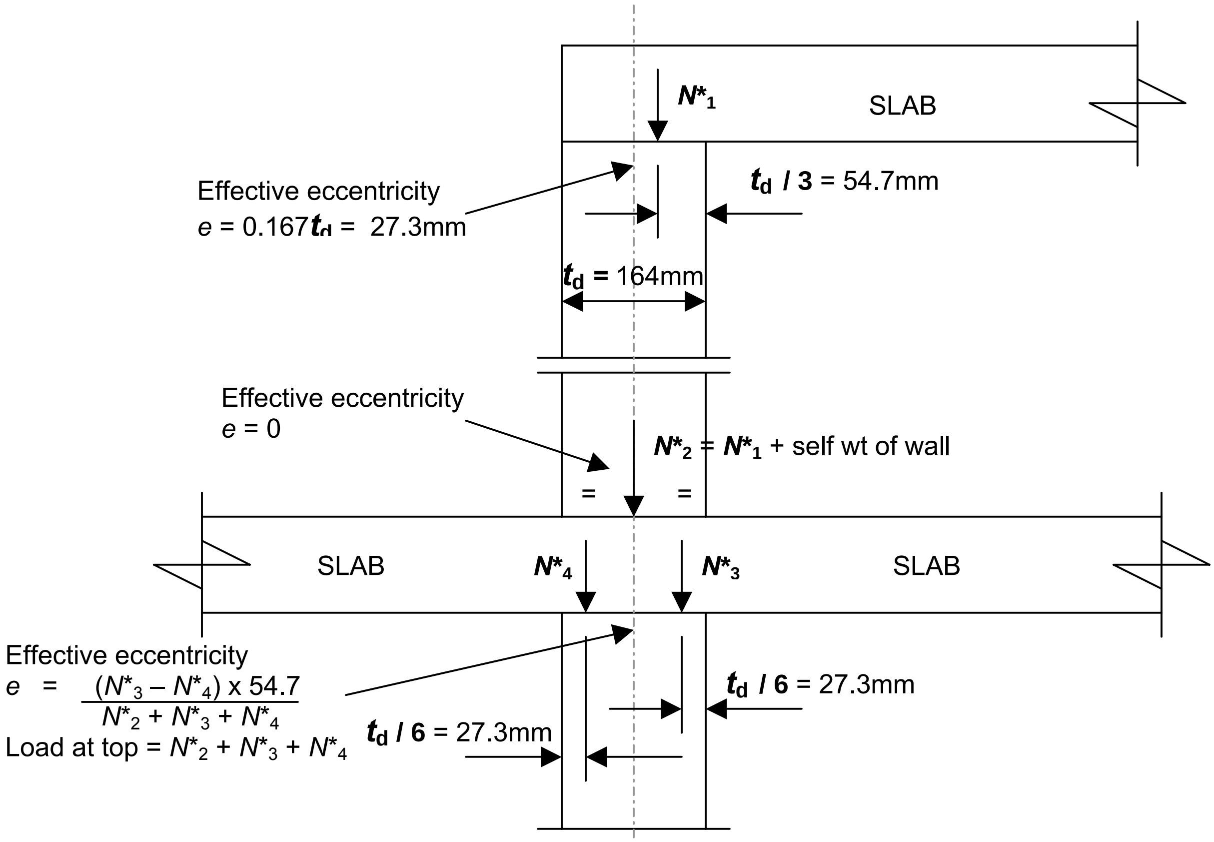

SLAB
N^*_1
Effective eccentricity
$e = 0.167 t_d$ = 27.3mm
t_d / 3 = 54.7mm
t_d = 164mm
Effective eccentricity
$e = 0$
$N^*_2 = N^*_1$ + self wt of wall
= =
SLAB
N^*_4
N^*_3
SLAB
Effective eccentricity
$e = \frac{(N^*_3 - N^*_4) \times 54.7}{N^*_2 + N^*_3 + N^*_4}$
Load at top = $N^*_2 + N^*_3 + N^*_4$
t_d / 6 = 27.3mm
t_d / 6 = 27.3mm

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 = 8.2mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	1500	9.1	5.5	773	762	729	697	664	612
2200	1650	10.1	6.6	761	749	717	684	652	600
2400	1800	11.0	7.9	747	735	703	671	638	586
2600	1950	11.9	9.3	732	721	688	656	623	572
2800	2100	12.8	10.8	716	705	672	640	607	556
3000	2250	13.7	12.3	699	687	655	623	590	538
3200	2400	14.6	14.0	681	669	637	604	572	520
3400	2550	15.5	15.9	661	650	617	585	552	500
3600	2700	16.5	17.8	640	629	596	564	532	480
3800	2850	17.4	19.8	619	607	574	542	510	458
4000	3000	18.3	22.0	595	584	551	519	487	435
4200	3150	19.2	24.2	571	559	527	495	462	410
4400	3300	20.1	26.6	546	534	502	469	437	385
4600	3450	21.0	29.0	519	507	475	442	410	358
4800	3600	22.0	31.6	491	479	447	415	382	330
5000	3750	22.9	34.3	462	450	418	386	353	301
5200	3900	23.8	37.1	432	420	388	355	323	271
5400	4050	24.7	40.0	400	389	356	324	292	240
5600	4200	25.6	43.0	368	356	324	291	259	207
5800	4350	26.5	46.2	334	322	290	258	225	173
6000	4500	27.4	49.4	299	287	255	223	190	138
6200	4650	28.4	52.7	263	251	219	186	154	102
6400	4800	29.3	56.2	226	214	181	149	117	65
6600	4950	30.2	59.8	187	175	143	111	78	26

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 = 8.2mm	e = 10mm	e = 15mm	e = 20mm	e = 25mm	e = 33mm
2000	1500	9.1	5.5	1031	1015	972	929	886	817
2200	1650	10.1	6.6	1014	999	956	912	869	800
2400	1800	11.0	7.9	996	981	937	894	851	782
2600	1950	11.9	9.3	976	961	918	874	831	762
2800	2100	12.8	10.8	955	940	896	853	810	741
3000	2250	13.7	12.3	932	917	873	830	787	718
3200	2400	14.6	14.0	908	892	849	806	762	693
3400	2550	15.5	15.9	882	866	823	780	736	667
3600	2700	16.5	17.8	854	838	795	752	709	640
3800	2850	17.4	19.8	825	809	766	723	680	610
4000	3000	18.3	22.0	794	778	735	692	649	580
4200	3150	19.2	24.2	761	746	703	660	616	547
4400	3300	20.1	26.6	727	712	669	626	582	513
4600	3450	21.0	29.0	692	676	633	590	547	478
4800	3600	22.0	31.6	655	639	596	553	510	440
5000	3750	22.9	34.3	616	600	557	514	471	402
5200	3900	23.8	37.1	576	560	517	474	431	361
5400	4050	24.7	40.0	534	518	475	432	389	320
5600	4200	25.6	43.0	490	475	432	388	345	276
5800	4350	26.5	46.2	445	430	387	343	300	231
6000	4500	27.4	49.4	399	383	340	297	254	184
6200	4650	28.4	52.7	351	335	292	249	205	136
6400	4800	29.3	56.2	301	285	242	199	156	86
6600	4950	30.2	59.8	249	234	191	147	104	35

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* = 8.2mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 20mm	*e* = 29mm
2000	1500	12.2	9.8	727	715	683	651	618	566
2200	1650	13.4	11.8	705	693	661	629	596	544
2400	1800	14.6	14.0	681	669	637	604	572	520
2600	1950	15.9	16.5	654	643	610	578	546	494
2800	2100	17.1	19.1	626	614	582	549	517	465
3000	2250	18.3	22.0	595	584	551	519	487	435
3200	2400	19.5	25.0	563	551	519	486	454	402
3400	2550	20.7	28.2	528	516	484	451	419	367
3600	2700	22.0	31.6	491	479	447	415	382	330
3800	2850	23.2	35.2	452	440	408	376	343	291
4000	3000	24.4	39.0	411	399	367	335	302	250
4200	3150	25.6	43.0	368	356	324	291	259	207
4400	3300	26.8	47.2	322	311	278	246	214	162
4600	3450	28.0	51.6	275	263	231	199	166	114
4800	3600	29.3	56.2	226	214	181	149	117	65
5000	3750	30.5	61.0	174	162	130	97	65	13

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)									
H_w	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 8.2mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 25mm	*e* = 33mm
2000	1500	12.2	9.8	969	954	911	868	824	755
2200	1650	13.4	11.8	940	924	881	838	795	726
2400	1800	14.6	14.0	908	892	849	806	762	693
2600	1950	15.9	16.5	873	857	814	771	727	658
2800	2100	17.1	19.1	835	819	776	733	689	620
3000	2250	18.3	22.0	794	778	735	692	649	580
3200	2400	19.5	25.0	750	735	692	648	605	536
3400	2550	20.7	28.2	704	688	645	602	559	490
3600	2700	22.0	31.6	655	639	596	553	510	440
3800	2850	23.2	35.2	603	587	544	501	458	389
4000	3000	24.4	39.0	548	532	489	446	403	334
4200	3150	25.6	43.0	490	475	432	388	345	276
4400	3300	26.8	47.2	430	414	371	328	285	216
4600	3450	28.0	51.6	367	351	308	265	222	152
4800	3600	29.3	56.2	301	285	242	199	156	86
5000	3750	30.5	61.0	232	216	173	130	87	18

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)

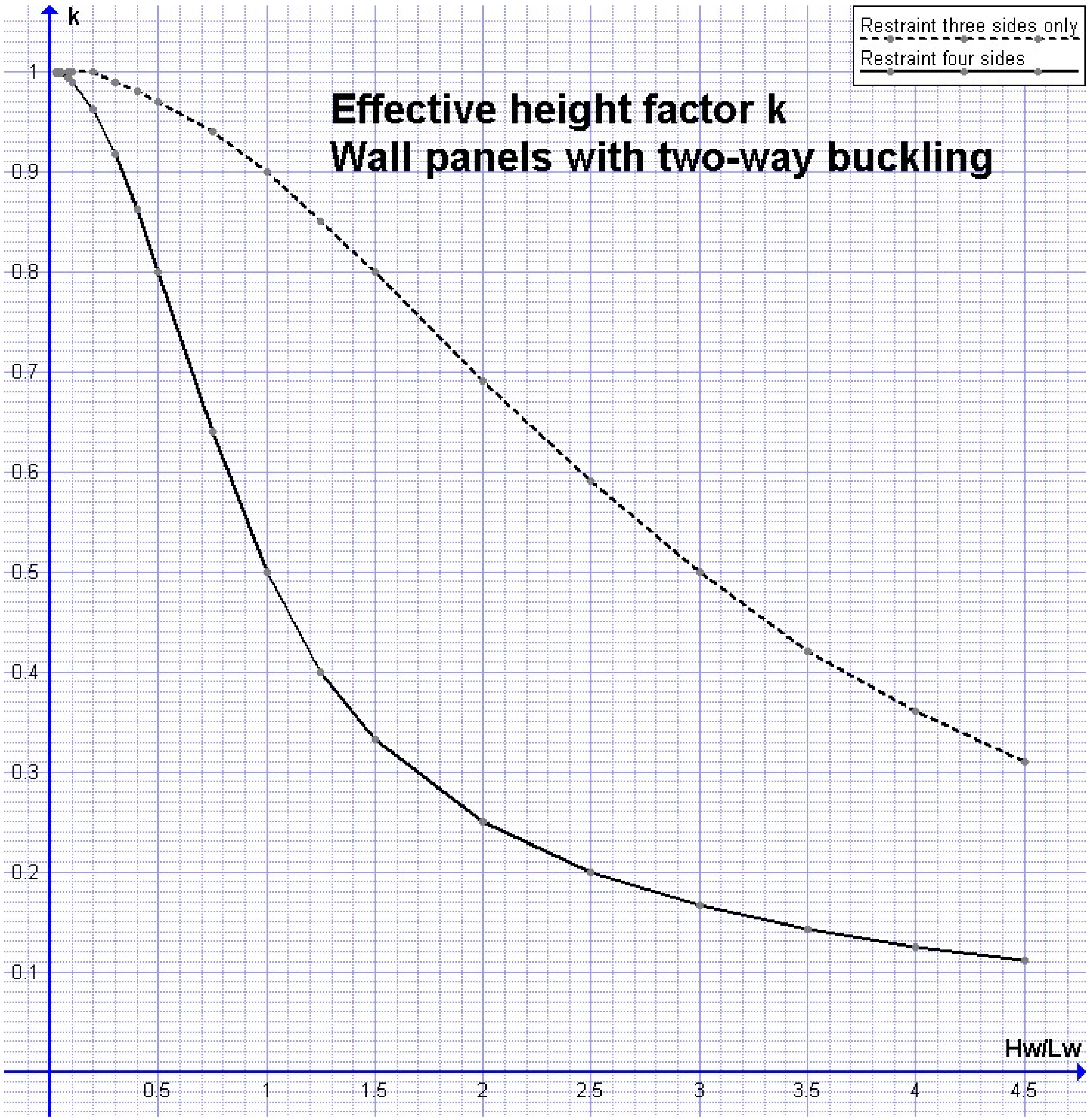


TABLE W5-200U

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

200 Mortarless (unchamfered)

SR	e_a	Design ultimate strength ΦN_u (kN/m)					
		e = 8.2mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 25mm	*e* = 33mm
12	9.4	730	719	686	654	622	570
13	11.1	713	701	669	636	604	552
14	12.9	694	682	650	617	585	533
15	14.8	673	661	629	597	564	512
16	16.8	651	639	607	575	542	490
17	19.0	628	616	584	551	519	467
18	21.3	603	591	559	526	494	442
19	23.7	577	565	533	500	468	416
20	26.2	549	537	505	473	440	388
21	28.9	520	508	476	444	411	359
22	31.8	490	478	445	413	381	329
23	34.7	458	446	414	381	349	297
24	37.8	424	413	380	348	316	264
25	41.0	390	378	346	313	281	229
26	44.3	354	342	309	277	245	193
27	47.8	316	304	272	240	207	155
28	51.4	277	265	233	201	168	116
29	55.2	237	225	193	160	128	76
30	59.0	195	183	151	118	86	34

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* = 8.2mm**	***e* = 10mm**	***e* = 15mm**	***e* = 20mm**	***e* = 25mm**	***e* = 33mm**
12	9.4	974	958	915	872	829	760
13	11.1	950	935	892	848	805	736
14	12.9	925	909	866	823	780	711
15	14.8	897	882	839	795	752	683
16	16.8	868	853	809	766	723	654
17	19.0	837	821	778	735	692	623
18	21.3	804	788	745	702	659	590
19	23.7	769	753	710	667	624	555
20	26.2	732	717	673	630	587	518
21	28.9	693	678	635	591	548	479
22	31.8	653	637	594	551	508	438
23	34.7	610	595	551	508	465	396
24	37.8	566	550	507	464	421	352
25	41.0	520	504	461	418	374	305
26	44.3	471	456	413	369	326	257
27	47.8	421	406	363	319	276	207
28	51.4	369	354	311	267	224	155
29	55.2	316	300	257	214	170	101
30	59.0	260	244	201	158	115	46

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.