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 140 ***mortarless*** walls of a wide range of heights and lengths 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 54% of the face shell thickness is considered in the calculation of compressive strength. The other 46% is ignored. Walls are designed assuming thickness t = 114mm which ignores any contribution that the outer 46% 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 given 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 W5-140U and Table W6-140U 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 W1-140U to W4-140U 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 W5-140U or Table W6-140U 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.

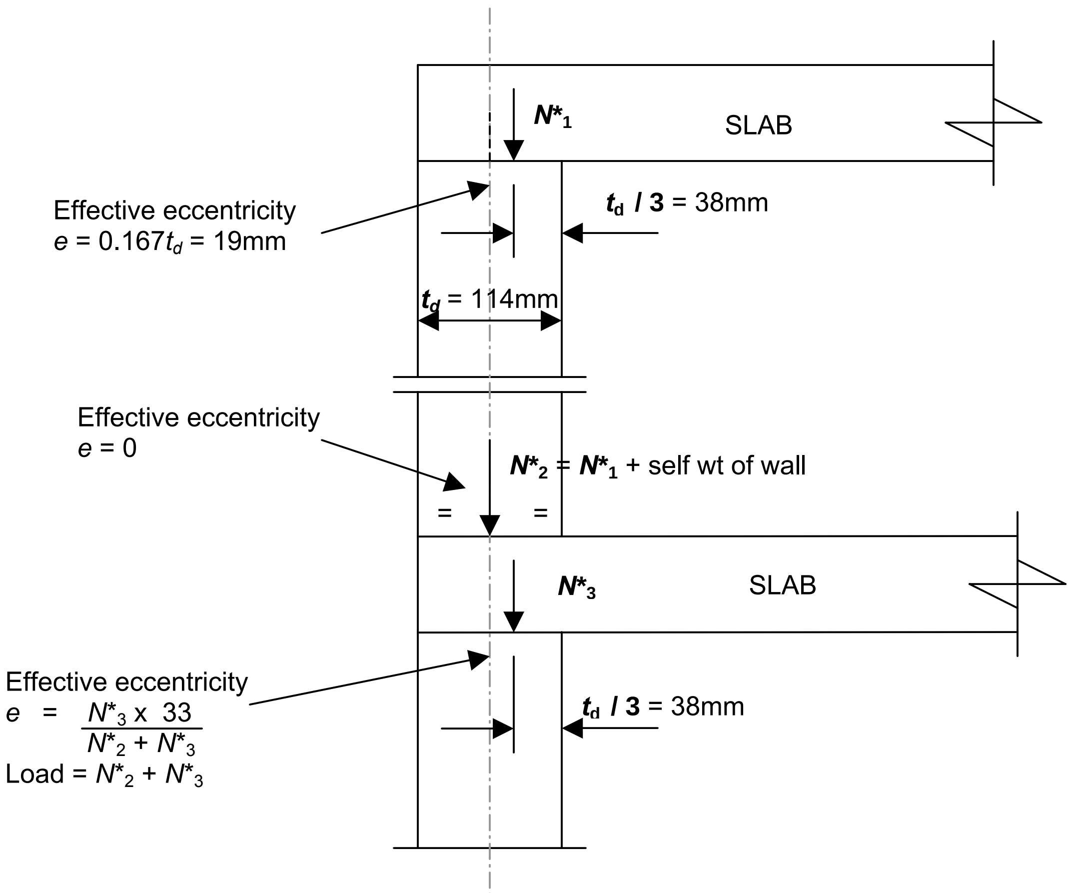
Calculation of effective eccentricity when designing for compression:

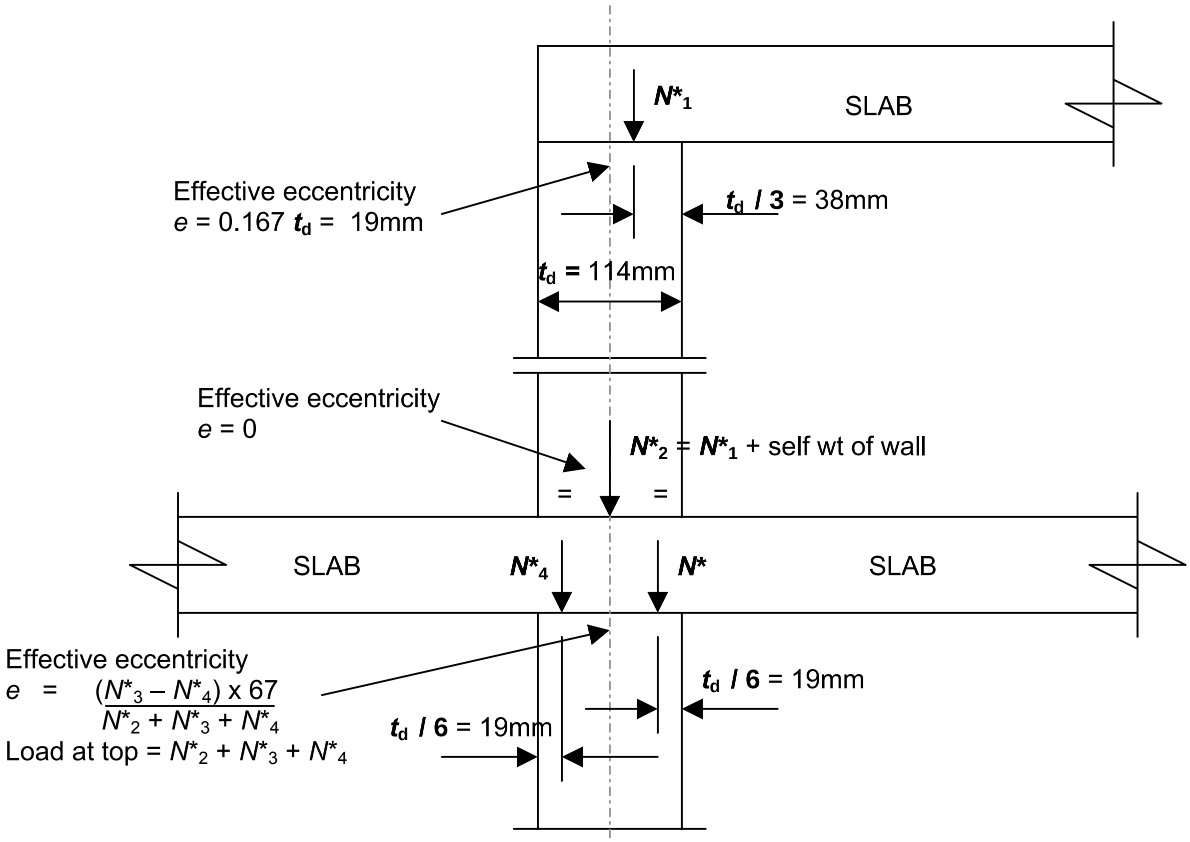
AS 3600 Clause 11.5.2 permits the calculation of eccentricity of applied vertical loads at the top of walls as follows:

- 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 = 0.167 td = 19mm
td / 3 = 38mm
td = 114mm
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 67 / N*2 + N*3 + N*4
Load at top = N*2 + N*3 + N*4
td / 6 = 19mm
td / 6 = 19mm

TABLE W1-140U Effective height factor k = 0.75

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

Rotational restraint both ends of wall panel

140 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 5.7mm	e = 8mm	e = 10mm	e = 15mm	e = 20mm	e = 23mm
2000	1500	13.2	7.9	493	478	466	433	401	381
2200	1650	14.5	9.6	475	461	448	415	383	363
2400	1800	15.8	11.4	456	441	428	396	363	344
2600	1950	17.1	13.3	435	420	407	374	342	322
2800	2100	18.4	15.5	412	397	384	351	319	299
3000	2250	19.7	17.8	387	372	359	327	294	275
3200	2400	21.1	20.2	360	345	333	300	268	248
3400	2550	22.4	22.8	332	317	304	272	240	220
3600	2700	23.7	25.6	302	288	275	242	210	190
3800	2850	25.0	28.5	271	256	243	211	178	159
4000	3000	26.3	31.6	238	223	210	177	145	126
4200	3150	27.6	34.8	203	188	175	142	110	91
4400	3300	28.9	38.2	166	151	138	106	73	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.

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) 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 W2-140U Effective height factor k = 0.75

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

140 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 5.7mm	e = 8mm	e = 10mm	e = 15mm	e = 20mm	e = 23mm
2000	1500	13.2	7.9	658	638	621	578	534	508
2200	1650	14.5	9.6	634	614	597	554	510	485
2400	1800	15.8	11.4	608	588	571	527	484	458
2600	1950	17.1	13.3	579	560	542	499	456	430
2800	2100	18.4	15.5	549	529	512	468	425	399
3000	2250	19.7	17.8	516	496	479	435	392	366
3200	2400	21.1	20.2	481	461	443	400	357	331
3400	2550	22.4	22.8	443	423	406	363	319	294
3600	2700	23.7	25.6	403	383	366	323	280	254
3800	2850	25.0	28.5	361	341	324	281	238	212
4000	3000	26.3	31.6	317	297	280	236	193	167
4200	3150	27.6	34.8	270	250	233	190	147	121
4400	3300	28.9	38.2	221	201	184	141	98	72

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.

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) 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 W3-140U 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)

140 Mortarless (unchamfered)

H_w or L_1	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
2000	2000	17.5	14.0	427	412	399	367	334	315
2200	2200	19.3	17.0	395	380	367	335	303	283
2400	2400	21.1	20.2	360	345	333	300	268	248
2600	2600	22.8	23.7	322	308	295	262	230	210
2800	2800	24.6	27.5	282	267	254	221	189	169
3000	3000	26.3	31.6	238	223	210	177	145	126
3200	3200	28.1	35.9	191	176	163	130	98	79
3400	3400	29.8	40.6	141	126	113	80	48	28

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.

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 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 W4-140U 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)

140 Mortarless (unchamfered)									
H_w or L_1	H_{we}	SR	e_a	Design ultimate strength ΦN_u (kN/m)					
				e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
2000	2000	17.5	14.0	569	550	532	489	446	420
2200	2200	19.3	17.0	527	507	490	447	403	378
2400	2400	21.1	20.2	481	461	443	400	357	331
2600	2600	22.8	23.7	430	410	393	350	306	281
2800	2800	24.6	27.5	375	356	338	295	252	226
3000	3000	26.3	31.6	317	297	280	236	193	167
3200	3200	28.1	35.9	254	234	217	174	131	105
3400	3400	29.8	40.6	187	168	150	107	64	38

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.

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 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)

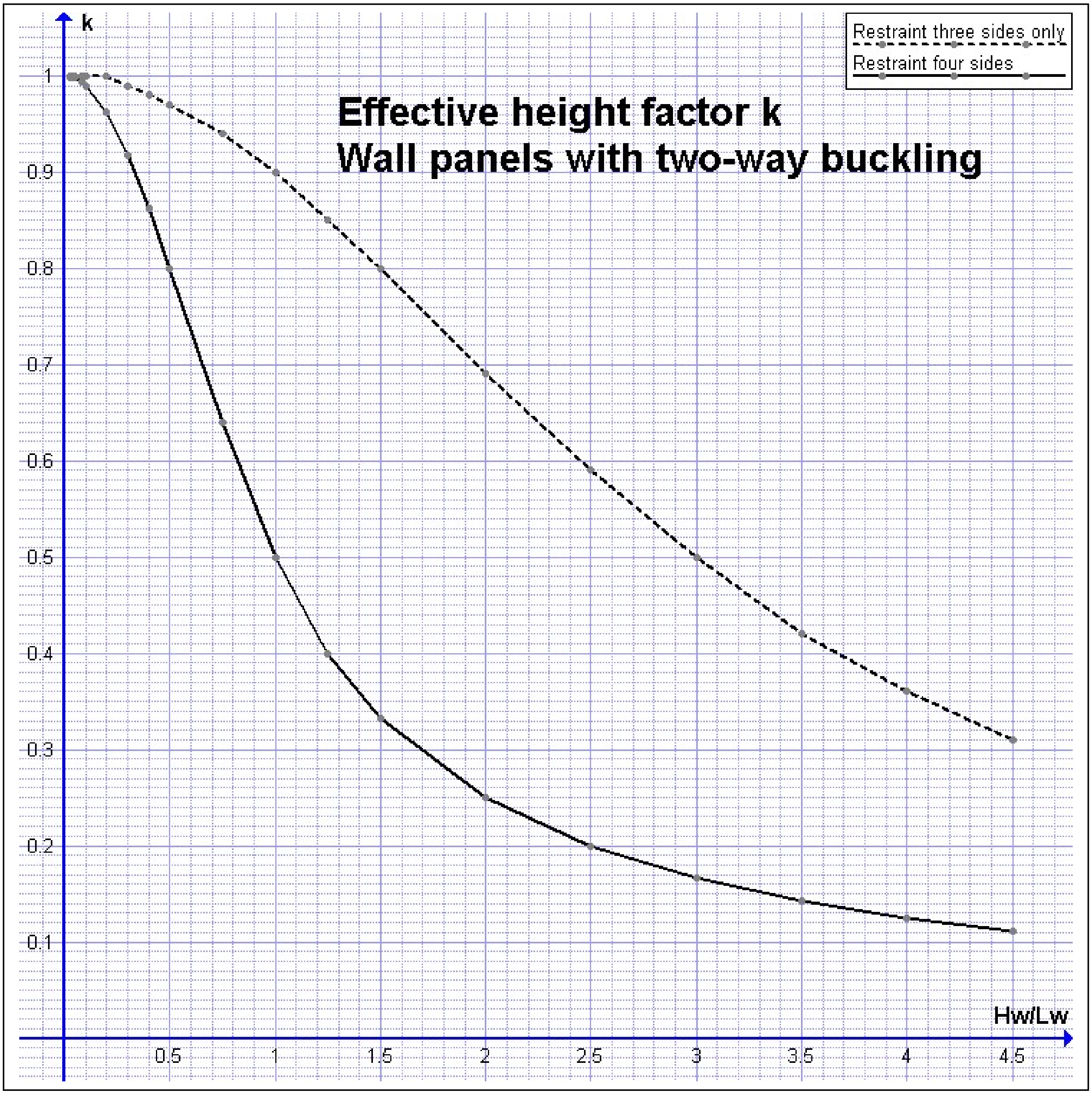


TABLE W5-140U

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

140 Mortarless (unchamfered)							
SR	e_a	Design ultimate strength ΦN_u (kN/m)					
		e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
12	10.0	508	493	480	447	415	396
13	11.8	495	481	468	435	403	383
14	13.6	482	467	454	422	389	370
15	15.7	468	453	440	408	375	356
16	17.8	453	438	425	392	360	340
17	20.1	436	421	408	376	344	324
18	22.6	419	404	391	359	326	307
19	25.1	401	386	373	341	308	289
20	27.8	382	367	354	321	289	270
21	30.7	361	347	334	301	269	249
22	33.7	340	325	312	280	248	228
23	36.8	318	303	290	258	225	206
24	40.1	295	280	267	235	202	183
25	43.5	271	256	243	211	178	159
26	47.0	246	231	218	185	153	134
27	50.7	220	205	192	159	127	108
28	54.6	193	178	165	132	100	80
29	58.5	164	150	137	104	72	52
30	62.6	135	121	108	75	43	23

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.

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 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.

TABLE W6-140U

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

140 Mortarless (unchamfered)

SR	e_a	Design ultimate strength ΦN_u (kN/m)					
		e = 5.7mm	*e* = 8mm	*e* = 10mm	*e* = 15mm	*e* = 20mm	*e* = 23mm
12	6.6	677	657	640	597	553	528
13	7.7	661	641	623	580	537	511
14	8.9	643	623	606	562	519	493
15	10.3	624	604	587	543	500	474
16	11.7	603	584	566	523	480	454
17	13.2	582	562	545	501	458	432
18	14.8	559	539	522	478	435	409
19	16.5	535	515	497	454	411	385
20	18.2	509	489	472	429	385	359
21	20.1	482	462	445	402	358	333
22	22.1	454	434	417	373	330	304
23	24.1	424	404	387	344	301	275
24	26.3	393	373	356	313	270	244
25	28.5	361	341	324	281	238	212
26	30.8	328	308	291	247	204	178
27	33.2	293	273	256	213	169	143
28	35.8	257	237	220	176	133	107
29	38.3	219	199	182	139	96	70
30	41.0	181	161	143	100	57	31

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.

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 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.