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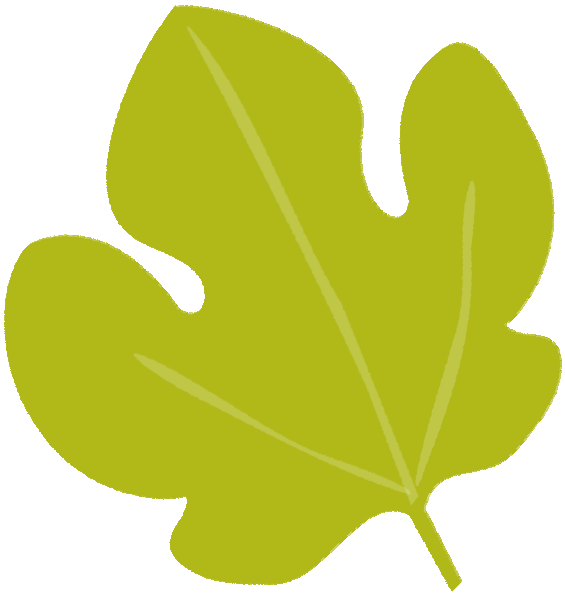
The Influence of Nails and Plasterboard on the Racking Resistance of Stud Walls



DATE 15/02/2010

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1) Introduction

Wind pressures on a building as defined by BS6399.2:1997 induce horizontal and vertical loadings, which should be taken into account in the design of timber frame buildings. The building structure is required to resist loads such as sliding forces, overturning moments and racking forces.
The racking force is primarily transferred by floor and ceiling diaphragms to the resisting walls which in turn transfer the load to the ground at the base of the ground floor walls.

A timber frame wall must meet certain criteria to be considered as a racking wall:

- Timber members should be more than 38x72mm rectangular section with ends cut square and the linings should be fixed to the narrower face.
- Studs spacing must not exceed 610mm
- Studs should be of grade C16 or higher
- Stud walls are adequately fixed to prevent sliding and overturning
- Nail lengths should be enhanced to take into account additional thickness as a result from fixing a secondary board onto an existing one.
- Board edges should be backed by framing and nailed at all edges.

2) Board Types

According to BS 5268.6.1.1996 wall linings are grouped in three categories:

Category 1 materials

- Plywood
- Medium board
- Chipboard (type C3M, C4M or C5)
- Tempered hardboard
- OSB (type F2)

Category 2 materials:

- 12.5 mm bitumen impregnated insulation board
- Separating wall of minimum 30 mm plasterboard (in two or more layers)

Category 3 materials

- 12.5 mm plasterboard

3) Parameters Influencing Racking Resistance

The British Standards provide the basic racking resistance of different types of timber frame walls. These values can be modified according to wall geometry, components and vertical loadings.
The different factors which contribute to the modification of the basic racking resistance are as follows:

- Variation in nail diameter
- Variation in nail spacing
- Variation in board thickness
- Height of wall panels
- Length of walls
- Framed openings in walls
- Variation in vertical load on timber frame walls
- The interaction of walls and floors through multiple fixings

4) Contribution of Plasterboard to Racking Resistance

Plasterboard (Category 3) alone should not be relied upon to provide the racking resistance of a dwelling with the exception of separating walls comprising two or more built-up layers of plasterboard. The predominant resistance must be from category 1 and 2 materials. The plasterboard contribution to the total resistance should not exceed 50% of the resistance provided by category 1 and 2 materials.

Example 1:
If the racking resistance provided by plywood sheathed walls is 100kN and the total resistance provided by 12.5m plasterboard linings is 80kN from which only 50kN can be taken into account, an enhancement to plywood sheathed walls by 20kN, will allow an addition of the plasterboard contribution to the total resistance by a value of 10kN.

A layer of 12.5 mm plasterboard alone can provide up to 16.7% additional resistance to a racking wall comprising a sheet of category 1 material such as plywood or OSB. Consideration must be given to the enhancement offered by nail centres as this is only effective if the centres are reduced to less than 114mm, in which case, the plasterboard contribution is ignored. Any enhancement to nail diameter does not modify the plasterboard contribution as shown in table 1. The British Standards recommend the use of 2.65mm diameter nails for the fixing of the plasterboard.

Enhancements	**Category 1 (eg: OSB, plywood)**	**Category 3 (Plasterboard)**
Reduced nail spacing Sp < 114mm	Racking resistance is enhanced	Plasterboard resistance is not taken into account.
Reduced nail spacing 114mm ≤ Sp ≤ 150mm	Racking resistance is not enhanced	Plasterboard resistance is taken into account with no enhancements to its value
Increased nail diameter Dn > 3mm	Racking resistance is enhanced	Plasterboard resistance is taken into account with no enhancements to its value

Table 1: Effect of nail spacing and diameters on plasterboard contribution to racking resistance

Plasterboard sheets can be fixed either on the opposite face of the sheathing or the same face given that the nails are extended in length to take into account the increased lining thickness. The addition of extra layers of plasterboard (category 3) on top of an existing layer of plasterboard does not enhance the resistance of the racking wall given that the other face can consist of category 1, 2 or 3 materials.
The contribution of the plasterboard in separating walls can be relied on in the calculation of the total racking resistance provided that the separating walls are lined according to any one of these following conditions:

a) Full panel height diagonal bracing is fixed to each separating wall panel with no less than two braces on any separating wall leaf. The diagonal braces should be of 100 mm× 25 mm timber and nailed to each stud with at least three steel nails of 3.25 mm diameter with a pointside penetration of at least 35 mm.
b) A panel height sheathing of category 1 material totalling at least 1200 mm in width, with no individual sheet less than 600 mm wide, should be placed on each separating wall leaf.
c) One of the layers of gypsum plasterboard fixed to each leaf of the timber frame separating wall should be of a moisture-resisting grade.

5) Effect of Nails on Racking Resistance

Nails are the most common type of fastener used in timber frame structures such as framed stud walls and floor diaphragms. Nails are manufactured in different sizes, shapes and strengths. Round wire nails have a minimum tensile strength of 600N/mm².
Nail performance under lateral and extraction load can be modified by changing the surface of a smooth round or square cross-sectional nail. Some improvements include cutting annular or helicoidal threads on the shank of the nails.
The most common types of nail are covered in BS EN 10230-1 but special nails, including improved nails, are still covered by BS 1202-1.
The British Standards specifies using at least 50mm long nails on category 1 and 2 materials and 40mm long on category 3 materials.

5.1) Nail Spacing

Category 1 sheathings can be enhanced by reducing the spacing between nails. The maximum spacing allowed by BS5268.6.1 is 150mm on the perimeter and 300mm internally. The internal nail spacing must not exceed twice the perimeter nailing as indicated in Eurocode 5.

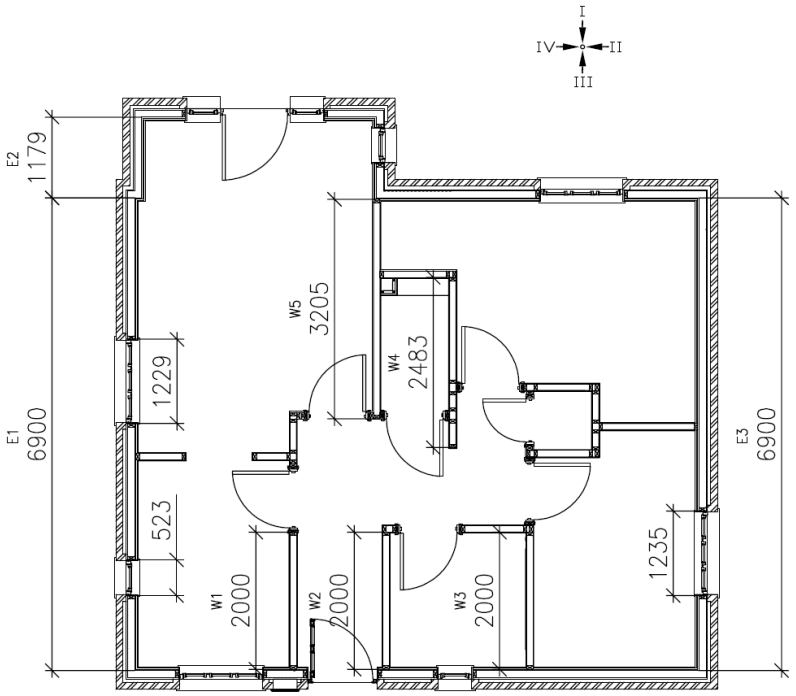
5.2) Nail Diameter

Nails used in racking walls can range between 2.25mm and 3.75mm in diameter according to the British Standards.
The standard nail diameter used for the basis of the calculation of the basic racking resistance of category 1 materials is 3mm. Any nail with a smaller diameter will decrease the racking resistance and vice versa.

Example 2:

A worked example is presented to show the effect of nail spacing and diameters on the racking resistance on a typical timber frame house shown in figure 1.

FRONT - SOUTH ELEVATION

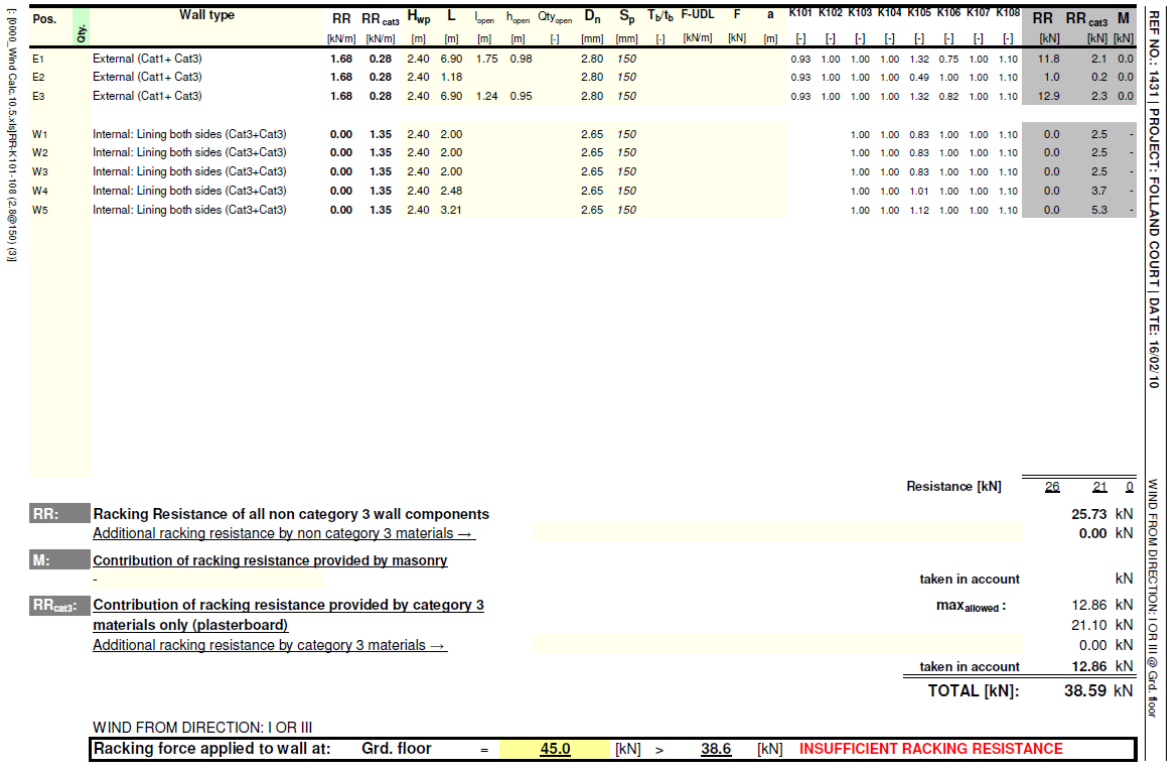


GROUND FLOOR PLAN

Figure 1: A typical timber frame house considered for racking along direction I-III

The racking calculations have been performed and illustrated in figure 2, 3, 4, 5 and 6 with different combinations of nail diameters and spacing. The first column lists the wall types used in determining the total racking resistance. These walls are defined by the combinations of boards categories, where category 1 is 9mm OSB or plywood and category 3 is 12.5mm plasterboard lining. The second and third columns show the basic racking resistance of each category as defined by the British Standards. The heights and lengths of the walls are inserted in the two following columns. Further along, the column labelled “Dn” and “Sp” represent the nail diameter and spacing respectively. The basic racking resistance is modified by several factors and summed to a total shown in the bottom of each figure. For illustration purposes, the masonry contribution to the total racking resistance has been omitted.

In this example we assume the applied wind force acting on the building has a value of 45kN and is compared to the total racking resistance provided by the walls.



Pos.	Qty	Wall type	RR [kN/m]	RR_{cat3} [kN/m]	H_{wp} [m]	L [m]	l_{open} [m]	h_{open} [m]	Qty_{open} [-]	D_n [mm]	S_p [mm]	T_b/t_b [-]	F-UDL [kN/m]	F [kN]	a [m]	K101 [-]	K102 [-]	K103 [-]	K104 [-]	K105 [-]	K106 [-]	K107 [-]	K108 [-]	RR [kN]	RR_{cat3} [kN]	M [kN]
E1		External (Cat1+ Cat3)	1.68	0.28	2.40	6.90	1.75	0.98		2.80	150					0.93	1.00	1.00	1.00	1.32	0.75	1.00	1.10	11.8	2.1	0.0
E2		External (Cat1+ Cat3)	1.68	0.28	2.40	1.18				2.80	150					0.93	1.00	1.00	1.00	0.49	1.00	1.00	1.10	1.0	0.2	0.0
E3		External (Cat1+ Cat3)	1.68	0.28	2.40	6.90	1.24	0.95		2.80	150					0.93	1.00	1.00	1.00	1.32	0.82	1.00	1.10	12.9	2.3	0.0
W1		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W2		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W3		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W4		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.48				2.65	150							1.00	1.00	1.01	1.00	1.00	1.10	0.0	3.7	-
W5		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	3.21				2.65	150							1.00	1.00	1.12	1.00	1.00	1.10	0.0	5.3	-

Resistance [kN] 26 21 0

RR: Racking Resistance of all non category 3 wall components — 25.73 kN
Additional racking resistance by non category 3 materials → — 0.00 kN

M: Contribution of racking resistance provided by masonry
- taken in account kN

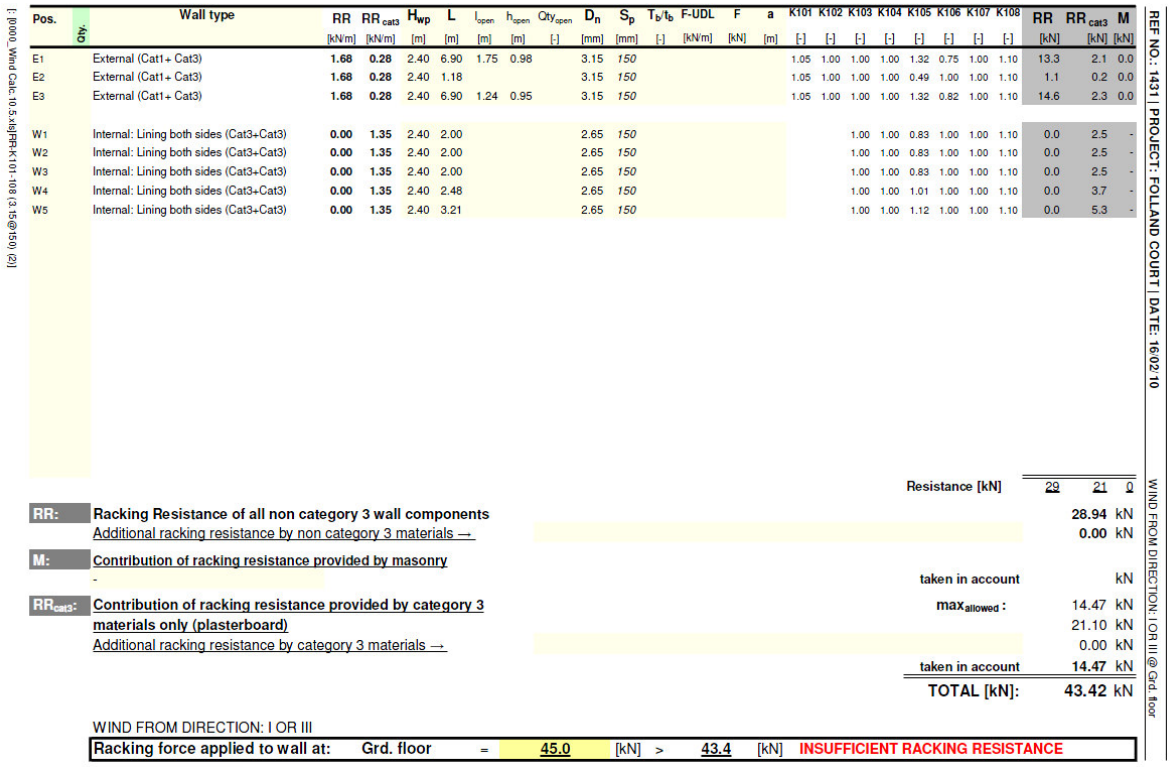
RR_{cat3}: Contribution of racking resistance provided by category 3 materials only (plasterboard) — $max_{allowed}$: 12.86 kN
21.10 kN
Additional racking resistance by category 3 materials → 0.00 kN
taken in account 12.86 kN

TOTAL [kN]: 38.59 kN

WIND FROM DIRECTION: I OR III

Racking force applied to wall at: Grd. floor = 45.0 [kN] > 38.6 [kN] INSUFFICIENT RACKING RESISTANCE

Figure 1: Case of 2.8mm diameter nails spaced at 150mm centres (case 1)



Pos.	Qty	Wall type	RR [kN/m]	RR_{cat3} [kN/m]	H_{wp} [m]	L [m]	l_{open} [m]	h_{open} [m]	Qty_{open} [-]	D_n [mm]	S_p [mm]	T_b/t_b [-]	F-UDL [kN/m]	F [kN]	a [m]	K101 [-]	K102 [-]	K103 [-]	K104 [-]	K105 [-]	K106 [-]	K107 [-]	K108 [-]	RR [kN]	RR_{cat3} [kN]	M [kN]
E1		External (Cat1+ Cat3)	1.68	0.28	2.40	6.90	1.75	0.98		3.15	150					1.05	1.00	1.00	1.00	1.32	0.75	1.00	1.10	13.3	2.1	0.0
E2		External (Cat1+ Cat3)	1.68	0.28	2.40	1.18				3.15	150					1.05	1.00	1.00	1.00	0.49	1.00	1.00	1.10	1.1	0.2	0.0
E3		External (Cat1+ Cat3)	1.68	0.28	2.40	6.90	1.24	0.95		3.15	150					1.05	1.00	1.00	1.00	1.32	0.82	1.00	1.10	14.6	2.3	0.0
W1		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W2		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W3		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W4		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.48				2.65	150							1.00	1.00	1.01	1.00	1.00	1.10	0.0	3.7	-
W5		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	3.21				2.65	150							1.00	1.00	1.12	1.00	1.00	1.10	0.0	5.3	-

Resistance [kN] 29 21 0

RR: Racking Resistance of all non category 3 wall components — 28.94 kN
Additional racking resistance by non category 3 materials → — 0.00 kN

M: Contribution of racking resistance provided by masonry
- taken in account kN

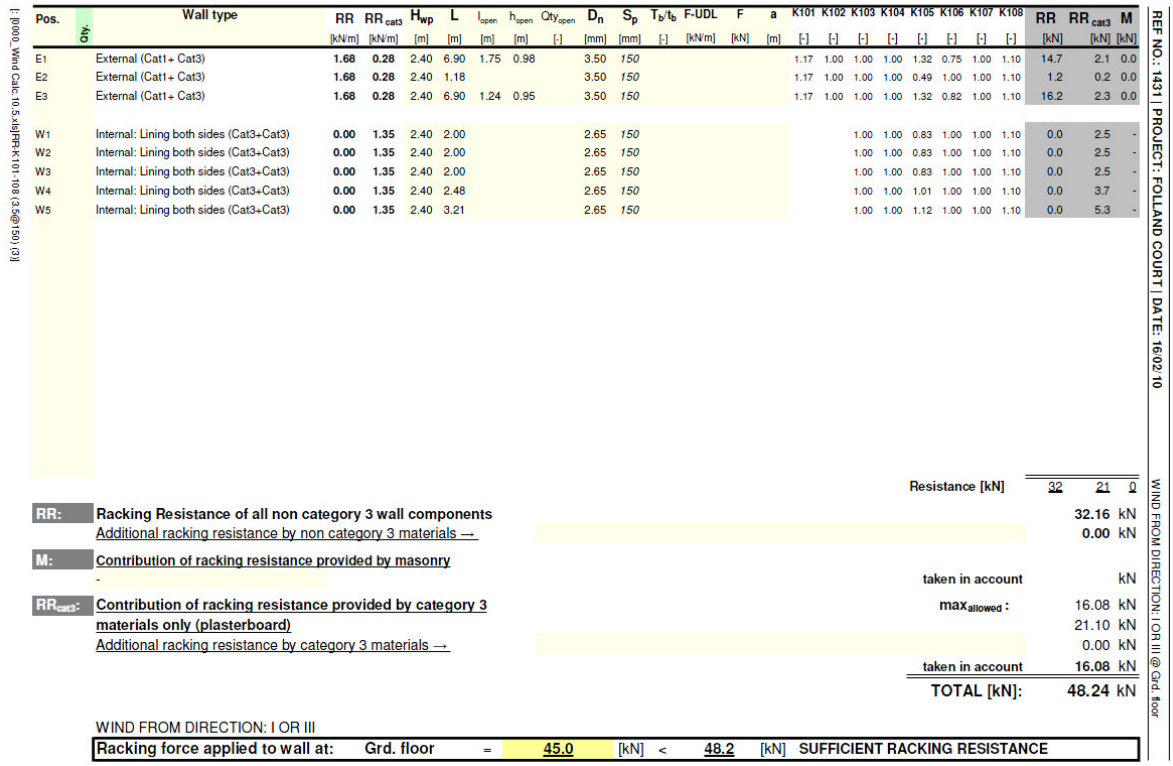
RR_{cat3}: Contribution of racking resistance provided by category 3 materials only (plasterboard) — $max_{allowed}$: 14.47 kN
21.10 kN
Additional racking resistance by category 3 materials → 0.00 kN
taken in account 14.47 kN

TOTAL [kN]: 43.42 kN

WIND FROM DIRECTION: I OR III

Racking force applied to wall at: Grd. floor = 45.0 [kN] > 43.4 [kN] INSUFFICIENT RACKING RESISTANCE

Figure 2: Case of 3.15mm diameter nails spaced at 150mm centres (case 2)



[: [0000_Wind Calc.10.5.xls]RR-K101-108 (3.5@150) (3)]

REF NO.: 1431 | PROJECT: FOLLAND COURT | DATE: 16/02/10

Pos.	No	Wall type	RR [kN/m]	RR_{cat3} [kN/m]	H_{wp} [m]	L [m]	l_{open} [m]	h_{open} [m]	Qty_{open} [-]	D_n [mm]	S_p [mm]	T_b/t_b [-]	F-UDL [kN/m]	F [kN]	a [m]	K101 [-]	K102 [-]	K103 [-]	K104 [-]	K105 [-]	K106 [-]	K107 [-]	K108 [-]	RR [kN]	RR_{cat3} [kN]	M [kN]
E1		External (Cat1+ Cat3)	1.68	0.28	2.40	6.90	1.75	0.98		3.50	150					1.17	1.00	1.00	1.00	1.32	0.75	1.00	1.10	14.7	2.1	0.0
E2		External (Cat1+ Cat3)	1.68	0.28	2.40	1.18				3.50	150					1.17	1.00	1.00	1.00	0.49	1.00	1.00	1.10	1.2	0.2	0.0
E3		External (Cat1+ Cat3)	1.68	0.28	2.40	6.90	1.24	0.95		3.50	150					1.17	1.00	1.00	1.00	1.32	0.82	1.00	1.10	16.2	2.3	0.0
W1		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W2		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W3		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W4		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.48				2.65	150							1.00	1.00	1.01	1.00	1.00	1.10	0.0	3.7	-
W5		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	3.21				2.65	150							1.00	1.00	1.12	1.00	1.00	1.10	0.0	5.3	-

Resistance [kN] 32 21 0

RR: Racking Resistance of all non category 3 wall components — 32.16 kN
Additional racking resistance by non category 3 materials → — 0.00 kN

M: Contribution of racking resistance provided by masonry
-
taken in account — kN

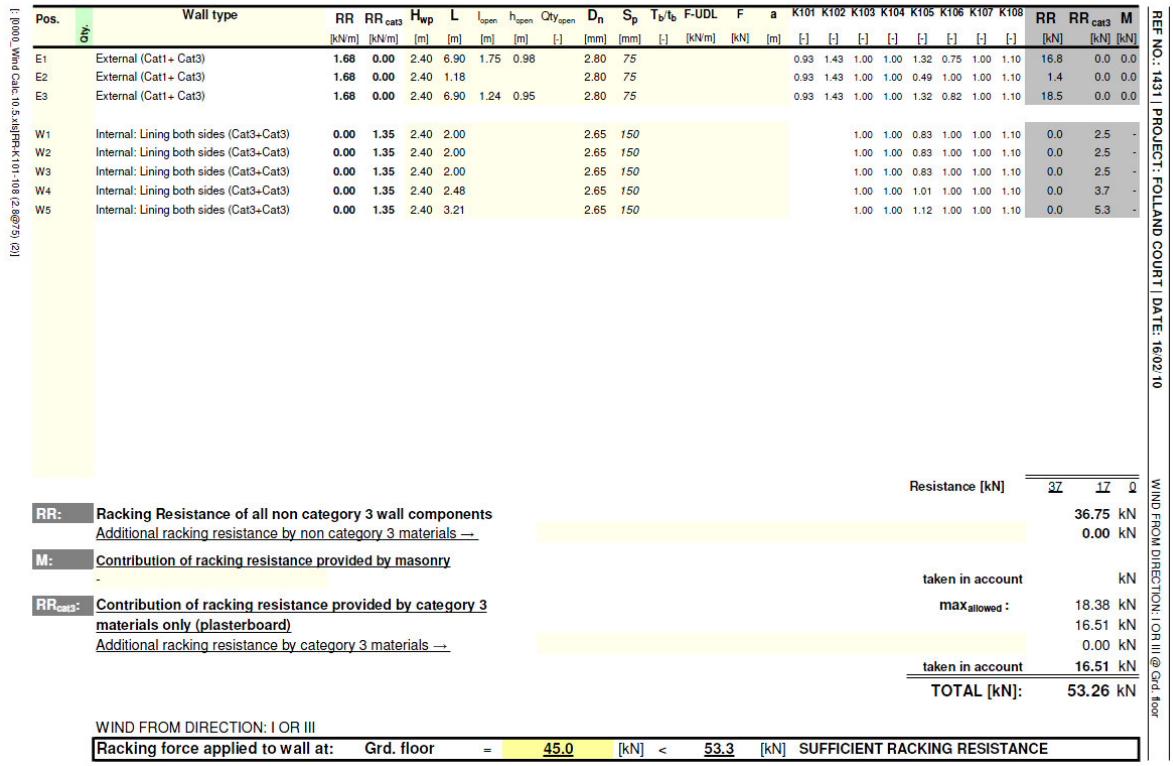
RR_{cat3}: Contribution of racking resistance provided by category 3 materials only (plasterboard)
$max_{allowed}$: 16.08 kN
21.10 kN
Additional racking resistance by category 3 materials → 0.00 kN
taken in account 16.08 kN
TOTAL [kN]: 48.24 kN

WIND FROM DIRECTION: I OR III

Racking force applied to wall at: Grd. floor = 45.0 [kN] < 48.2 [kN] SUFFICIENT RACKING RESISTANCE

WIND FROM DIRECTION: I OR III @ Grd. floor

Figure 3: Case of 3.5mm diameter nails spaced at 150mm centres (case 3)



[: [0000_Wind Calc.10.5.xls]RR-K101-108 (2.8@75) (2)]

REF NO.: 1431 | PROJECT: FOLLAND COURT | DATE: 16/02/10

Pos.	No	Wall type	RR [kN/m]	RR_{cat3} [kN/m]	H_{wp} [m]	L [m]	l_{open} [m]	h_{open} [m]	Qty_{open} [-]	D_n [mm]	S_p [mm]	T_b/t_b [-]	F-UDL [kN/m]	F [kN]	a [m]	K101 [-]	K102 [-]	K103 [-]	K104 [-]	K105 [-]	K106 [-]	K107 [-]	K108 [-]	RR [kN]	RR_{cat3} [kN]	M [kN]
E1		External (Cat1+ Cat3)	1.68	0.00	2.40	6.90	1.75	0.98		2.80	75					0.93	1.43	1.00	1.00	1.32	0.75	1.00	1.10	16.8	0.0	0.0
E2		External (Cat1+ Cat3)	1.68	0.00	2.40	1.18				2.80	75					0.93	1.43	1.00	1.00	0.49	1.00	1.00	1.10	1.4	0.0	0.0
E3		External (Cat1+ Cat3)	1.68	0.00	2.40	6.90	1.24	0.95		2.80	75					0.93	1.43	1.00	1.00	1.32	0.82	1.00	1.10	18.5	0.0	0.0
W1		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W2		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W3		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W4		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.48				2.65	150							1.00	1.00	1.01	1.00	1.00	1.10	0.0	3.7	-
W5		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	3.21				2.65	150							1.00	1.00	1.12	1.00	1.00	1.10	0.0	5.3	-

Resistance [kN] 37 17 0

RR: Racking Resistance of all non category 3 wall components — 36.75 kN
Additional racking resistance by non category 3 materials → — 0.00 kN

M: Contribution of racking resistance provided by masonry
-
taken in account — kN

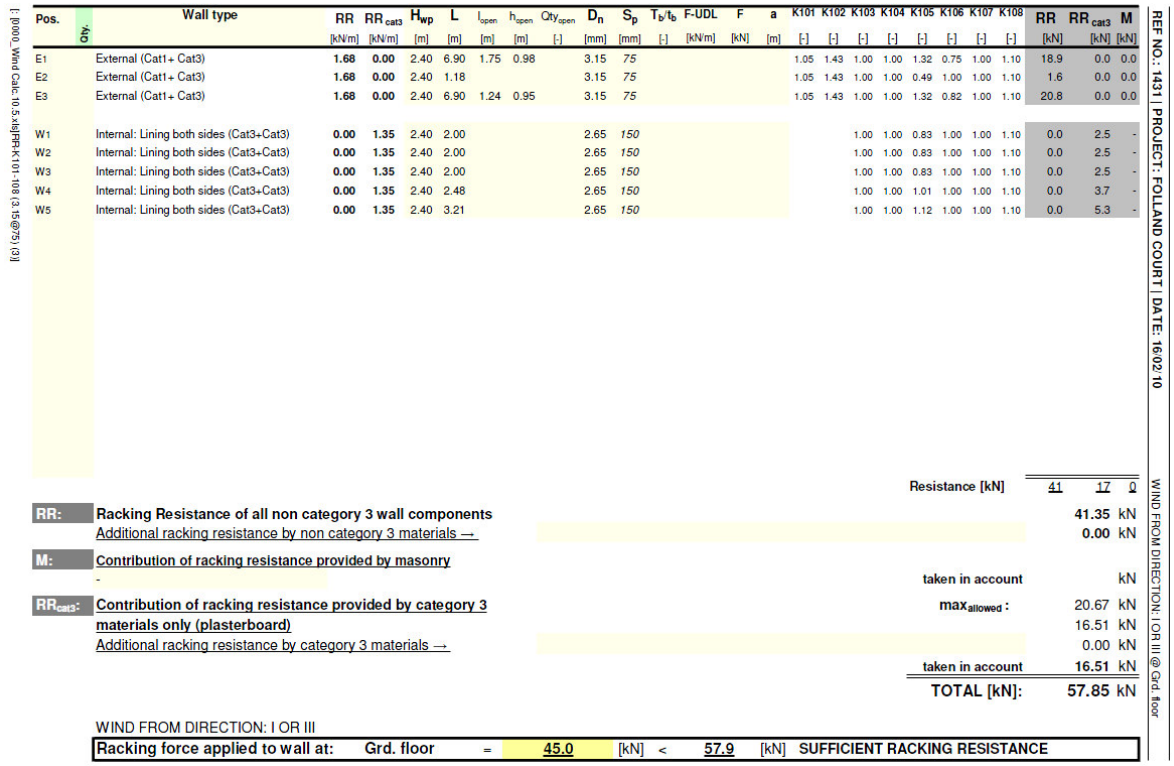
RR_{cat3}: Contribution of racking resistance provided by category 3 materials only (plasterboard)
$max_{allowed}$: 18.38 kN
16.51 kN
Additional racking resistance by category 3 materials → 0.00 kN
taken in account 16.51 kN
TOTAL [kN]: 53.26 kN

WIND FROM DIRECTION: I OR III

Racking force applied to wall at: Grd. floor = 45.0 [kN] < 53.3 [kN] SUFFICIENT RACKING RESISTANCE

WIND FROM DIRECTION: I OR III @ Grd. floor

Figure 4: Case of 2.8mm diameter nails spaced at 75mm centres (case 4)



Pos.	No.	Wall type	RR [kN/m]	RR cat3 [kN/m]	H_{wp} [m]	L [m]	l_{open} [m]	h_{open} [m]	Qty_{open} [-]	D_n [mm]	S_p [mm]	T_b/t_b [-]	F-UDL [kN/m]	F [kN]	a [m]	K101 [-]	K102 [-]	K103 [-]	K104 [-]	K105 [-]	K106 [-]	K107 [-]	K108 [-]	RR [kN]	RR cat3 [kN]	M [kN]
E1		External (Cat1+ Cat3)	1.68	0.00	2.40	6.90	1.75	0.98		3.15	75					1.05	1.43	1.00	1.00	1.32	0.75	1.00	1.10	18.9	0.0	0.0
E2		External (Cat1+ Cat3)	1.68	0.00	2.40	1.18				3.15	75					1.05	1.43	1.00	1.00	0.49	1.00	1.00	1.10	1.6	0.0	0.0
E3		External (Cat1+ Cat3)	1.68	0.00	2.40	6.90	1.24	0.95		3.15	75					1.05	1.43	1.00	1.00	1.32	0.82	1.00	1.10	20.8	0.0	0.0
W1		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W2		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W3		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W4		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.48				2.65	150							1.00	1.00	1.01	1.00	1.00	1.10	0.0	3.7	-
W5		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	3.21				2.65	150							1.00	1.00	1.12	1.00	1.00	1.10	0.0	5.3	-

Resistance [kN] 41 17 0

RR: Racking Resistance of all non category 3 wall components — 41.35 kN
Additional racking resistance by non category 3 materials → — 0.00 kN

M: Contribution of racking resistance provided by masonry
- — taken in account — kN

RR cat3: Contribution of racking resistance provided by category 3 materials only (plasterboard) — $max_{allowed}$: 20.67 kN; 16.51 kN
Additional racking resistance by category 3 materials → — 0.00 kN
taken in account — 16.51 kN

TOTAL [kN]: 57.85 kN

WIND FROM DIRECTION: I OR III

Racking force applied to wall at: Grd. floor = 45.0 [kN] < 57.9 [kN] SUFFICIENT RACKING RESISTANCE

[: [0]000_Wind Calc 10.5.xls]RR-K101-108 (3.15@75) (3)]

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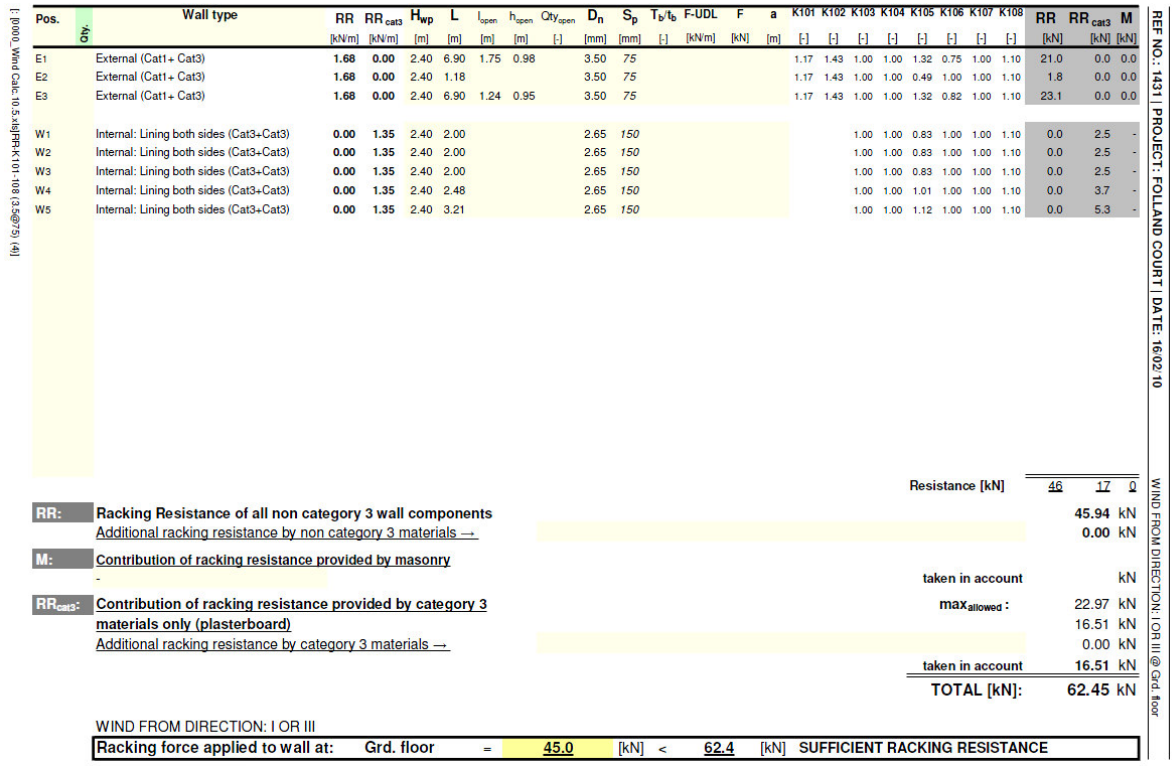
WIND FROM DIRECTION: I OR III @ Grd. floor

Figure 5: Case of 3.15mm diameter nails spaced at 75mm centres (case 5)



Pos.	No.	Wall type	RR [kN/m]	RR cat3 [kN/m]	H_{wp} [m]	L [m]	l_{open} [m]	h_{open} [m]	Qty_{open} [-]	D_n [mm]	S_p [mm]	T_b/t_b [-]	F-UDL [kN/m]	F [kN]	a [m]	K101 [-]	K102 [-]	K103 [-]	K104 [-]	K105 [-]	K106 [-]	K107 [-]	K108 [-]	RR [kN]	RR cat3 [kN]	M [kN]
E1		External (Cat1+ Cat3)	1.68	0.00	2.40	6.90	1.75	0.98		3.50	75					1.17	1.43	1.00	1.00	1.32	0.75	1.00	1.10	21.0	0.0	0.0
E2		External (Cat1+ Cat3)	1.68	0.00	2.40	1.18				3.50	75					1.17	1.43	1.00	1.00	0.49	1.00	1.00	1.10	1.8	0.0	0.0
E3		External (Cat1+ Cat3)	1.68	0.00	2.40	6.90	1.24	0.95		3.50	75					1.17	1.43	1.00	1.00	1.32	0.82	1.00	1.10	23.1	0.0	0.0
W1		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W2		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W3		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.00				2.65	150							1.00	1.00	0.83	1.00	1.00	1.10	0.0	2.5	-
W4		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	2.48				2.65	150							1.00	1.00	1.01	1.00	1.00	1.10	0.0	3.7	-
W5		Internal: Lining both sides (Cat3+Cat3)	0.00	1.35	2.40	3.21				2.65	150							1.00	1.00	1.12	1.00	1.00	1.10	0.0	5.3	-

Resistance [kN] 46 17 0

RR: Racking Resistance of all non category 3 wall components — 45.94 kN
Additional racking resistance by non category 3 materials → — 0.00 kN

M: Contribution of racking resistance provided by masonry
- — taken in account — kN

RR cat3: Contribution of racking resistance provided by category 3 materials only (plasterboard) — $max_{allowed}$: 22.97 kN; 16.51 kN
Additional racking resistance by category 3 materials → — 0.00 kN
taken in account — 16.51 kN

TOTAL [kN]: 62.45 kN

WIND FROM DIRECTION: I OR III

Racking force applied to wall at: Grd. floor = 45.0 [kN] < 62.4 [kN] SUFFICIENT RACKING RESISTANCE

[: [0]000_Wind Calc 10.5.xls]RR-K101-108 (3.5@75) (4)]

REF NO.: 1431 | PROJECT: FOLLAND COURT | DATE: 16/02/10

WIND FROM DIRECTION: I OR III @ Grd. floor

Figure 6: Case of 3.5mm diameter nails spaced at 75mm centres (case 6)

The results of example 2 are summarised in the table below:

Cases	Perimeter nail centres (mm)	Nail diameter (mm)	Total resistance (kN)	Applied Force (kN)	Net force (kN)	Design result (Fail/Pass)
1	150	2.8	38.6	45	-6.4	Fail
2	150	3.15	43.4	45	-1.6	Fail
3	150	3.5	48.2	45	3.2	Pass
4	75	2.8	53.3	45	8.3	Pass
5	75	3.15	57.9	45	12.9	Pass
6	75	3.5	62.4	45	17.4	Pass

Table 2: Effect of nail spacing and diameter on racking resistance

The effect of nail spacing and diameters on the overall racking resistance performance can be substantial as pointed out in this example where between case 1 and 6, an enhancement of 61.7% has been achieved.
Specific nail sizes may be imposed during the manufacturing process of wall panels. This example shows that it is possible in some cases to meet factory restrictions by changing the nail spacing as shown in this example by case 3 and 4.

6) Conclusions

The racking resistance of stud wall panels can be affected by many parameters such as panel lengths and heights, vertical loadings, lining boards and nails.

Plasterboard lined walls, 12.5mm thick, cannot be used alone to provide a resistance to racking. Their total contribution is limited to 50% of the resistance provided by category 1 and 2 materials.

Nail diameter and spacing can modify considerably the racking capacity of category 1 materials such as plywood and OSB.

Racking walls consisting of category 1 and 3 materials are not affected by a variation in nail centres ranging between 114mm and 150mm. An enhancement can be effective only if the nail spacing is reduced to a value below 114mm, in which case the plasterboard contribution to such racking walls is ignored. The increase of nail diameter does not improve the racking capacity of plasterboard.

The contribution of the plasterboard should be ignored in wall panels where service voids are incorporated.

A suitable design must reach a trade-off between performance and practical limitations such as stock availability, pricing, the adaptability of nail guns and machinery compatibility.

Engineers, designers and manufacturers are required to communicate nail requirements among themselves and this should be clearly indicated on wall panel fabrication information.

Buyers should also be aware that although a smaller nail diameter may be cheaper from the nail suppliers, double the quantity may be required to provide suitable racking. i.e. cases 1 and 4 in the table above.

7) Bibliography

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