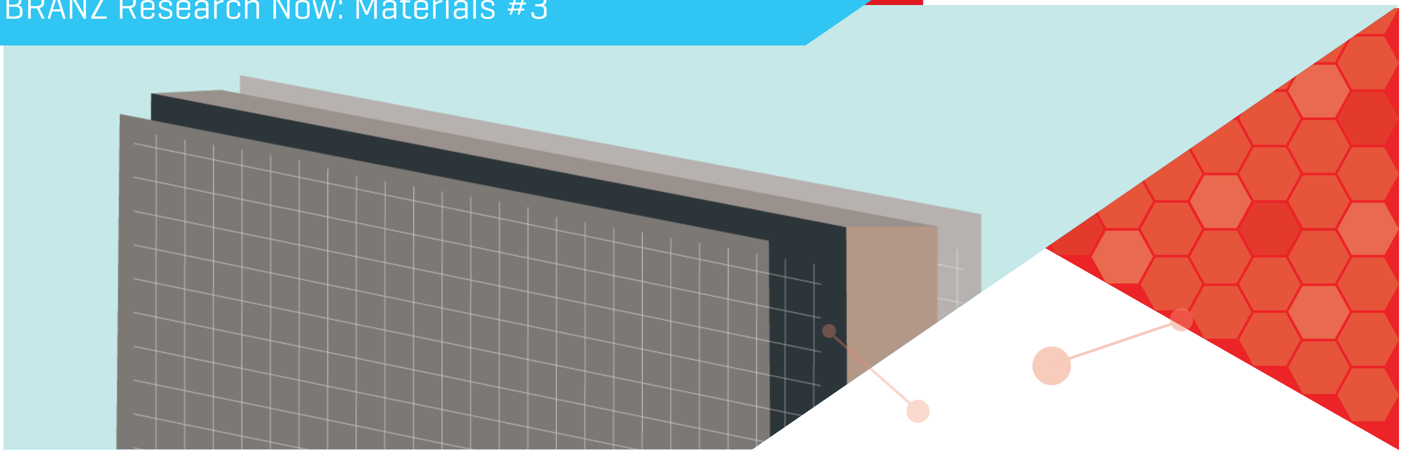


Performance of magnesium oxide boards in New Zealand conditions

Magnesium oxide (MgO) boards are a relatively new building material in New Zealand. They can be used instead of traditional sheet materials such as fibre-cement and gypsum boards. They are fire resistant, strong, lightweight and widely available. However, there have been reports of moisture-related issues in building systems using these boards. BRANZ investigated the performance of four MgO boards available in New Zealand. The performance of different boards on the market varies, and it is important to consider the likely moisture conditions when specifying MgO boards for a build.

As the use of MgO boards increased around the world, issues were seen in performance of some products. For example, MgO board was widely used in Denmark since 2010 for ventilated façades in new or renovated buildings. Problems began to appear in 2014 involving moisture absorption in panels and corrosion in fasteners and metal components. MgO board failures were later reported elsewhere, including in Australia and New Zealand.

Issues observed were not consistent across all products. Some boards tested showed issues when exposed to high humidity for many months while others showed no deterioration.

Research shows that MgO boards produced by different manufacturers can have different physical and chemical characteristics. This affects how they perform in conditions with a high relative humidity. To find out more about the performance of MgO boards available in New Zealand, BRANZ tested four different MgO boards.

Presently available products were chosen to investigate performance using tests meaningful to New Zealand conditions, including:

- any differences in composition
- bending strength after immersion in water
- frost resistance
- effect of repeated soaking and drying
- soundness of cement
- performance in high humidity
- corrosion of fasteners.

Available testing standards

The International Code Council Evaluation Service (ICC-ES) published AC386 *Acceptance criteria for fiber-reinforced magnesium-oxide-based sheets* in 2007. MgO boards used as interior substrate sheets can be recognised in an ICC-ES evaluation report under the US-based building codes. Testing to AC386 In New Zealand is not a requirement in New Zealand as it doesn't guarantee compliance with the New Zealand Building Code.

The British Standards Institute and MgO Building Board Trade Association developed PAS 670:2021 *Magnesium oxide-based boards for use in buildings - specification*. This is a positive step towards future quality assurance.

Findings of BRANZ investigation

While AC386 specifies tests, it does not provide limits for some parameters. Therefore, AS/NZS 2908.2:2000 *Cellulose-cement flat sheets* was also used given its applicability to well-known boards that have been used extensively in New Zealand. Differences were found in the composition and performance of the products.

Testing what is in the cement

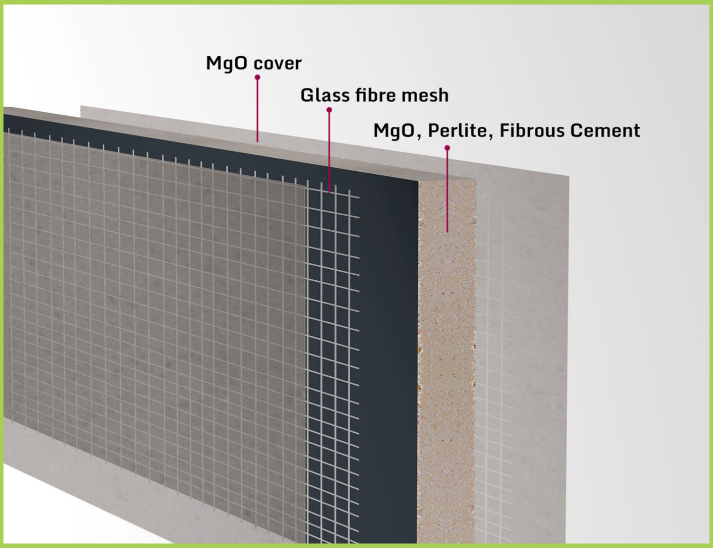
The MgO content, chlorine and sulphur varied among the four samples (Table 1). The

MgO boards: a relatively new building material

Using MgO boards in lightweight building systems is relatively new both in New Zealand and internationally. They are an alternative to fibre-cement and gypsum boards. In New Zealand, they have been used on building exteriors and interiors for:

- sheathing
- internal linings
- rigid wall underlays
- cladding
- components of prefabricated building systems such as structural insulated panels.

To produce an MgO board, the cement component is combined with filler materials such as wood and perlite and a reinforcing mesh layer. The cement contains magnesium oxychloride and/or magnesium oxysulphate so the composition of the cement in these boards can vary between products.



Typical structure of a magnesium oxide (MgO) board.

compositional analysis suggests that two of the boards (samples 3 and 4) contain an oxychloride cement whereas the other two may have an oxysulphate binder. This finding may explain why some boards perform differently from others. Further work is needed to confirm this.

Changes in bending strength

The bending strength was tested after soaking the board samples in water for 24 hours. Dry and wet samples were then loaded until they broke. Figure 1a shows the bending strength as a ratio of test samples compared with reference control samples. All boards meet the acceptance criteria of clause 6.1 of AS/NZS 2908.2:2000.

Testing frost resistance

BRANZ tested the frost resistance of the samples (Figure 1b). Freeze-thaw testing assesses how the material could fail when water-filled pores freeze and expand. The board samples were soaked and put through 50 freeze-thaw cycles and their bending strength tested. Two of the MgO boards retained 89% and 93% of their bending strength. This meets the acceptance criteria in AS/NZS 2908.2:2000 to exceed 75% of the original bending strength after this sort of testing. The other two samples did not meet these acceptance criteria, retaining 38% and 46% of their bending strength.

Cellulose fibre degradation

Cellulose fibres in these boards can degrade through chemical reactions with fluids leaching from the cement. Prolonged warm water soaking is a way to evaluate whether a material could be susceptible. None of the MgO samples met the acceptance criteria for this test (Figure 1c). One of the samples delaminated completely.

Simulating natural weathering

Deterioration of these boards through natural weathering can happen if the fibre content repeatedly becomes wet and then dries out. This causes swelling and shrinkage and can break down the fibre or disrupt the bonding between the cement and fibres. BRANZ used soak-dry testing to assess the likelihood of board deterioration due to natural weathering. Samples were soaked and dried 25 times each. The results are similar to the freeze-thaw testing (Figure 1d). Two boards performed well but the other two did not meet the acceptance criteria of the standard.

Performance in high humidity

The samples were tested for performance in environments with a high relative humidity. After 90 days kept at 30°C and 90% relative humidity, all MgO samples exceeded the acceptance criteria of PAS 670:2021 (Figure 1e).

Water vapour permeability

BRANZ tested how easily water vapour could travel through the samples. Three 90 mm discs were cut from the four MgO boards. Each disc was mounted over water contained in a dish and sealed. Any loss in mass over time would show that water vapour is evaporating and travelling through the samples. After 19 days, the results showed that samples 1 and 2 were more resistant to water vapour. The amount of water vapour moving through these boards was 88.2 grams per square metre per day (g/m²/day) and 91.2 g/m²/day. Samples 3 and 4 were more vapour permeable. The amount of water vapour seen to move through these samples was 169.79 g/m²/day and 149.80 g/m²/day.

Water absorption in the samples

The samples were oven dried and weighed, soaked for just over 48 hours and weighed again. An increased mass would confirm they absorbed and held water. All four samples increased in mass during this testing by 27–39%.

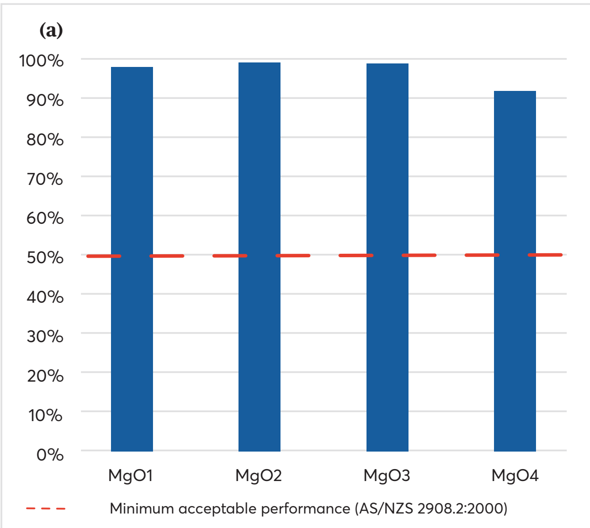
Testing for corrosion in the fasteners

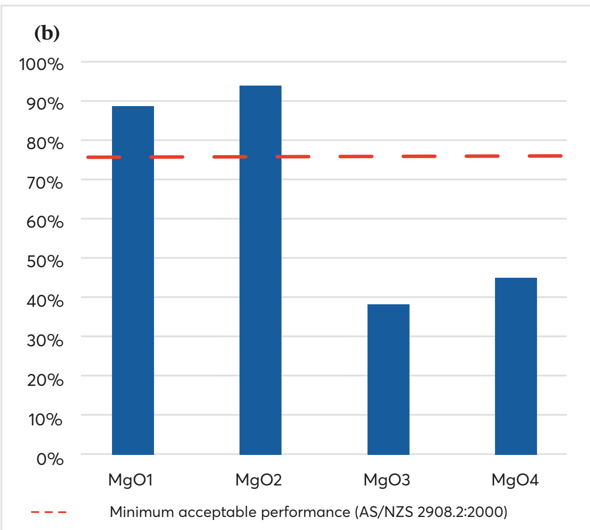
BRANZ also tested the risk of corrosion in humid environments in the fasteners used to secure these boards in place. After 90 days at 30°C and 90% relative humidity, non-stainless fasteners became corroded in the boards with a higher chloride content (Table 2).

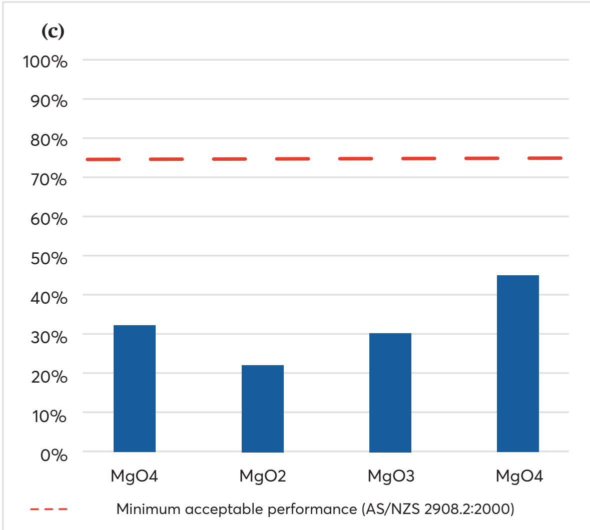
Table 1. Differences in composition of four samples of MgO board (wt%).

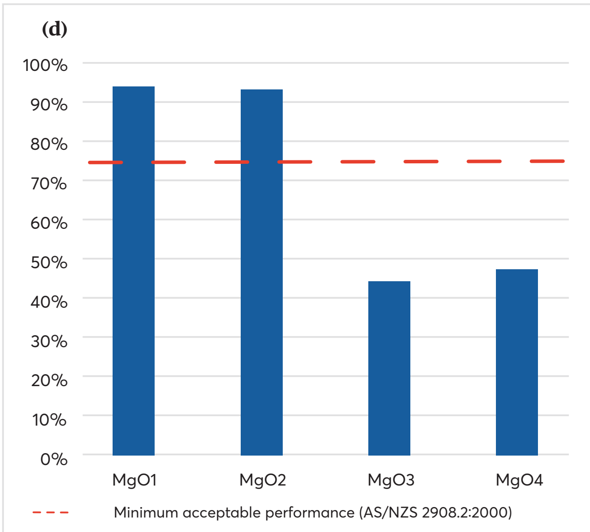
	MgO sample 1	MgO sample 2	MgO sample 3	MgO sample 4
MgO	46.37	41.83	48.78	47.20
Chlorine	0.04	0.073	10.32	9.76
Sulphur	4.19	4.76	0.23	0.20
Other components	49.40	53.34	40.67	42.84

Figure 1. How the bending strength of each sample changes (as a ratio of test samples compared with reference control samples) after (a) it is soaked for 24 hours , (b) 50 freeze-thaw cycles, (c) warm water immersion, (d) 25 soak-dry cycles, (e) 90 days in high humidity. The red line in (a) to (d) shows acceptance criteria in AS/NZS 2908.2:2000 that the average bending strength under test shall not drop below a percentage of the average bending strength of the original sample. The red line in (e) shows the equivalent acceptance criteria of PAS 670:2021.









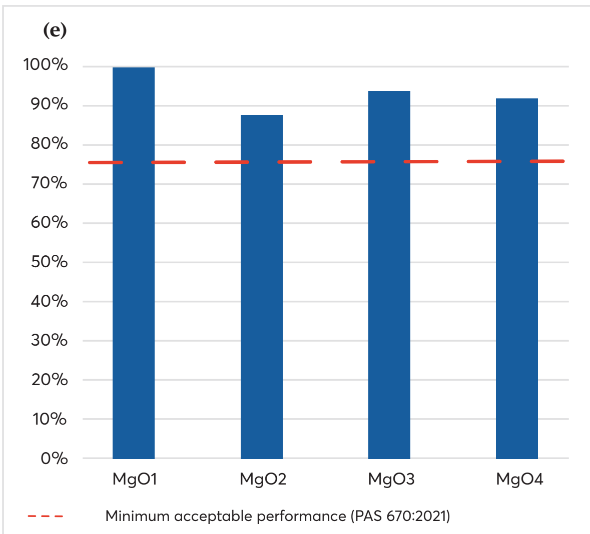


Table 2. Corrosion observed in MgO board fasteners secured parallel and perpendicular to the surface of the board.

	Board sample	Screw sample (type)				
		A (316 Stainless)	A (304 Stainless)	C (Mechanically plated)	D (Electroplated)	D (Passivated electroplated)
Parallel to surface	MgO1	-	-	-	-	-
	MgO2	-	-	-	-	-
	MgO3	-	-	Mild corrosion	Severe corrosion	Severe corrosion
	MgO4	-	-	Mild corrosion	Severe corrosion	Severe corrosion
Perpendiclar to surface	MgO1	-	-	-	-	-
	MgO2	-	-	-	-	-
	MgO3	-	-	Severe corrosion	Severe corrosion	Severe corrosion
	MgO4	-	-	Severe corrosion	Severe corrosion	Severe corrosion

- = 0–10% surface coverage of corrosion products
Mild corrosion = 10–50% surface coverage of corrosion products
Severe corrosion = 50–100% surface coverage of corrosion products

Findings

- The performance of MgO boards from different suppliers varies. Different boards do not perform the same in all conditions.
- Analysing the cement showed there are at least two types of board currently on the market based on differences in the amount of chloride in the cement. Boards containing more chloride did not perform well in the freeze-thaw or soak-dry tests. Their bending strength was reduced compared to the other boards.
- None of the MgO boards performed well after soaking them in warm water. The fibre mesh delaminated and the cement was degraded in some boards.
- All four boards transmitted water vapour to some degree and absorbed water when soaked for just over 48 hours.
- Boards with more chloride also tended to corrode their fasteners under the conditions tested. Stainless screws were not affected.
- BRANZ recommends considering the likely in-service conditions when assessing the suitability of a given MgO board for a particular building project. This would ensure that the right board is used in the right place.

Further reading

BRANZ Study Report SR472
Performance of magnesium oxide (MgO) boards in New Zealand (2022)

BRANZ Research Now: Materials #4
Comparing the performance of magnesium oxide and fibre-cement