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TEST REPORT

Ceram Reference:	124752 (QT23897/2/SL) Ref 1.0A
Project Title:	Testing of Properties of Magnesium Oxide Board in Accordance with BS EN 12467:2004
Client:	Magboard Benelux Postbus 302, 4700 AH Roosedaal The Netherlands
For the Attention of:	Mr R. van Meeteren
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This report supercedes the report issued on 24 October 2012.

Miss Lisa Cobden
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Reviewer

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CONTENTS

1 INTRODUCTION

A magnesium oxide board was supplied by Magboard for testing for material characterisation in accordance with BS EN 12467:2004 Fibre-cement flat sheets. Product specification and test methods and for embedment strength and tensile strength in accordance with Ceram in-house test methods

2 SAMPLE DESCRIPTION

Magnesium oxide board of nominal dimensions 2400mm x 1200mm x 9mm thick.

Magnesium oxide board of nominal dimensions 2400mm x 1200mm x 6mm thick.

3 TEST PROGRAMME

Samples of board were tested under the following modes:

- Tensile strength
- Water impermeability
- Heat rain weathering incorporating thermal shock
- Water vapour permeability in accordance with BS EN ISO 12572:2001
- Freeze-Thaw
- Soak Dry
- Bending Strength- Modulus of Rupture (MOR)

4 METHOD OF TEST

4.1 Tensile Strength

Five sections of the 9mm and 6mm board 600mm tall by 125mm wide were cut from larger board samples. These were shaped so as to produce a dog bone sample with a 60mm wide central waist.

A steel clamp was fixed to the top and bottom of the sample and the sample was conditioned for 48 hours at 50% relative humidity (RH) and a temperature of 20^{o}C before immersing in water for 48 hours.

The sample was fixed down to the structures lab strong floor and a steel pyramid reaction frame was positioned so that the centre of the top clamp was in line with the sample. On top of the reaction frame, a calibrated load cell and hydraulic pull-through ram was positioned. A M12 threaded bar was guided vertically through the whole system and screwed into the spreader plate, the opposite end of the threaded bar clamped the whole system via a M12 nut and washer. A tensile load was applied to the sample at a rate such that failure occurred within 3-5 minutes. A hydraulic pump was used to apply the load via the hydraulic pull-through ram. Load was recorded via a calibrated data logger.

4.2 Water Impermeability

Three no. 400x400mm specimens were cut from the large board samples. These were conditioned at ambient laboratory temperatures for 7 days prior to sealing the sample into the test frame and filling with water to a depth of 20mm above the face of the sample.

The samples were left in controlled lab conditions at 23^{o}C and 55%RH for 24 hours.

The underside of the sample was examined for any signs of moisture or dripping water.

4.3 Heat-Rain Incorporating Thermal Shock

Two full size boards 9mm thick and one full size board 6mm were fixed back to a 2.6m x 3.2m vertical lightweight steel frame with studs at 800mm centres. The boards were screwed back to the studs with 4 no. 5.5x55mm self-tapping, self-drilling screws one into each corner.

The sample was placed into a large scale hygrothermal test chamber such that the face of the sample would be subjected to the test conditions.

The sample was subjected to 50 cycles of heat rain as follows:

Cycles	Duration	Conditions
Water spray	2hr 50 min	1l/m^2/min at a water temperature of 15^{o}C
Pause	10 min	Ambient
Radiant heat	2hr 50min	60^{o}C at a ramp rate of 15 minutes
Pause	10 min	Ambient
Total cycle Time	6hrs	-
Repeats	50	

The sample was examined daily for signs of cracking, blistering or delamination.

On completion of the heat rain regime three samples were cut to 400x400mm and the samples were subject to water impermeability testing as in 4.2 above.

4.4 Water Vapour Permeability

Five samples nominally 100 mm diameter and 9 mm thick were cut from the supplied board.

BS EN 12467 advises that method C be followed hence the temperature was set at 23ºC with the relative humidity being 93% inside the dish (wet state) and the relative humidity being 50% outside the dish and sample(dry state).

Ammonium dihydrogen phosphate was used to obtain 93% relative humidity conditions within the dish.

The test apparatus consisted of the dishes being set within a dessicator having a relative humidity of 50%. The samples were very quickly removed from the dessicator for each weighing to ensure accuracy. The samples were weighed to three decimal places at specific time intervals.

4.5 Freeze Thaw

Ten samples nominally 250x250mm by 9mm thick were cut from the boards. These were immersed in water at an ambient temperature of 12°C for 48 hours then the samples were subjected to the following freeze thaw cycle regime:

Freeze the samples to -20°C (±4) within 1 ½ hours then hold for 1 hour

Thaw the samples in a water bath at a temperature of 20°C (±4) within 1 ½ hours then hold for 1 hour

The cycles were repeated 100 times.

On completion of the testing the samples were tested under bending as detailed in Section 4.5 below.

4.6 Soak Dry

Ten samples nominally 250 x 250mm by 9mm thick were cut from the boards were subjected to the following soak dry regime:

Immerse the samples in water at 12°C for 18 hours

Dry in an oven at 60°C and less than 20% RH for 6 hours

The cycles were repeated 50 times.

On completion of the testing the samples were allowed to dry in the laboratory ambient conditions for 7 days before testing under bending as detailed in Section 4.5 below.

4.7 Bending Strength - MOR

Ten 250x250mm by 9mm thick specimens were cut from the sample perpendicular to the longitudinal direction and ten samples were cut in the parallel direction.

The specimens were soaked in water for 24 hours prior to testing under three point bending.

The samples were positioned at a span 200mm on two roller bearers with a 10mm radius. A roller bearer was placed on the top of the mid-span of the sample and loaded to failure via a hydraulic ram at a loading rate such that failure occurred within 25 seconds. The maximum load was recorded.

5 RESULTS

5.1 Tensile Strength

The tensile strength of the board is given in the table below:

Test number	Tensile strength (N/mm^2)	
	9mm Thick Board	6mmThick Board
1	3.45	3.59
2	3.36	3.61
3	3.28	3.58
4	3.51	3.60
5	3.49	3.60
Mean	**3.42**	**3.60**

5.2 Water Impermeability

The board showed no signs of water penetration after the 24 hour test. No dampness or dripping on the undersides of the sample was noted.

5.3 Heat-Rain Incorporating Thermal shock

Neither the 6mm thick nor the 9mm thick board samples showed any signs of warping, cracking, blistering or delamination after being subjected to 50 cycles of heat- rain incorporating thermal shock from the water spray.

The tested samples were subjected to a water impermeability test on completion of the cycles. These showed no signs of water penetration after the 24 hour test. No dampness or dripping on the undersides of the sample was noted.

5.4 Water Vapour Permeability

The water absorption coefficient by partial absorption of the MgO board when tested according to BS EN ISO 15148:2002 was 0.142 Kg/m^2.h$^{0.5}$.

5.5 Freeze Thaw

There was no visual damage noted to the freeze thaw specimens on completion of the 100 cycles**.**

The results of the freeze thaw samples tested under bending (MOR) are given the table below:

Test Number	MOR (N/mm^2)	
	Parallel	Perpendicular
1	16.6	9.6
2	15.6	10.2
3	14.8	9.7
4	15.5	10.7
5	16.0	10.5
Mean	**15.7**	**10.1**

The MOR is the average value of the samples tested in the two directions hence the MOR of the post freeze thaw samples is 12.9Mpa.

5.6 Soak Dry

There was no visual damage noted to the soak dry specimens on completion of the 50 cycles**.**

The results of the Soak Dry samples tested under bending (MOR) are given the table below:

Test Number	MOR (N/mm^2)	
	Parallel	Perpendicular
1	15.9	11.2
2	15.8	10.8
3	15.8	11.1
4	15.4	11.0
5	16.1	10.9
Mean	**15.8**	**11.0**

The MOR is the average value of the samples tested in the two directions hence the MOR of the post freeze thaw samples is 13.5Mpa.

5.7 Bending Strength – MOR

The Bending strength of the samples after conditioning with a 24 hour soak are given in the Table below:

Test Number	MOR (N/mm^2)	
	Parallel	Perpendicular
1	17.1	13.2
2	17.4	13.5
3	17.1	13.5
4	17.3	13.8
5	17.1	12.9
Mean	**17.2**	**13.4**

The MOR is the average value of the samples tested in the two directions hence the MOR of the control samples is 15.3Mpa.

6 DISCUSSION

A category A board as defined in BS EN 12467:2004 Fibre-cement flat sheets. Product specification and test methods are defined as:

"Sheets which are intended for applications where they may be subjected to heat, high moisture and severe frost."

The majority of tests were carried out on 9mm thick samples with spot checks carried out on a limited range of tests on the 6mm board thickness i.e. under tensile strength and heat-rain with thermal shock. The 6mm board showed no difference in performance over the 9mm board thickness.

6.1 Tensile Strength

The tensile strength tests were not included in BS EN 12467:2004 hence were carried out in accordance with a CERAM in-house test method.

All results were consistent with a calculated mean of 3.42N/mm^2 for the 9mm boards and 3.60N/mm^2 for the 6mm boards

6.2 Water Impermeability

According to BS EN 12467 a category A sheet is allowed to show traces of moisture on the under surface of the sheet but shall not show any formation of water drops.

The sheets showed neither traces of moisture nor water drop formation therefore would be classed as a category A sheet in accordance with the standard.

6.3 Heat-Rain Incorporating Thermal shock

According to BS EN 12467 after 50 cycles of heat rain testing any visible cracks deformation, delamination, warping and bowing or other defects in the sheets should not affect the performance of the sheet in use.

No bowing, warping, cracking or delamination was noted. The sheets showed no deterioration in their water impermeability performance after testing showing neither traces of moisture nor water drop formation. The sheet therefore would be classed as a category A sheet in accordance with the standard.

6.4 Water Vapour Permeability

Water vapour permeability is defined for Category D boards only. This is defined as a sheet used for rigid underlay only. The manufacturer cannot declare a value greater than the 0.142kg/m^2 which is the value determined during the test.

6.5 Freeze Thaw

After freeze thaw testing the ratio R_L shall not be less than 0.75 where:

MRi= MORfi / MOR_{fci}

MORfi is the modulus of rupture of the specimen from the fifth pair after freeze thaw cycling (the second lot)

MORfci is the modulus of rupture of the specimen from the fifth pair tested for reference (first lot)

The average R, and standard deviation, S, of the individual ratio MRi

The lower estimation RI, of the mean ratios at 95% confidence level;

R_L = R-0.58xS

RL is greater than 0.75 hence the board can be defined as a category A

6.6 Soak Dry

After soak dry testing the ratio R_L shall not be less than 0.75 where:

MRi= MORfi / MOR_{fci}

MORfi is the modulus of rupture of the specimen from the fifth pair after warm water cycling (the second lot)

MORfci is the modulus of rupture of the specimen from the fifth pair tested for reference (first lot)

The average R, and standard deviation, S, of the individual ratio MRi

The lower estimation RI, of the mean ratios at 95% confidence level;

R_L = R-0.58xS

RL is greater than 0.75 hence the board can be defined as a category A

6.7 Bending Strength-MOR

For a category A board the MOR of the board in the weak direction should be greater than 70% of the MOR of the board in the weak direction.

The MOR of the board tested when perpendicular to its longitudinal dimension was 13.4MPa this was 78% of the value of the board in the stronger direction i.e. when parallel to its longitudinal dimension when tested under wet conditions.

The board can be classified as a Class 4 Category A board.

7 SUMMARY

The results of the tests carried out on the 9mm MgO board gives a Class A category board in accordance with BS EN 12467.

The reduced tests carried out on the 6mm board would indicate that boards thinner than 9mm board would attain a Category A classification.

The MgO boards are manufactured in a variety of thickness form 3mm-20mm. As long as the manufacturing process and materials used in the production of the boards is constant throughout the range, the various thickness of board would be expected to reach a Class A category.

NOTE: The results given in this report apply only to the samples that have been tested.

END OF REPORT