MASTER WORKS

TECHNICAL DATA

MATERIAL ONE

Material One has many unique properties, which contribute to its strength, durability, weight to strength ratio, nontoxic, ease of manufacture and its performance under stringent fire and impact tests.

M1
MASTER WORKS™

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ADVANCED COMPOSITE SOLUTIONS

TECHNICAL DATA

INTRODUCTION

Material One is essentially an organic composite ideally suited for hand or spray lamination to create lightweight cladding systems. The process of lamination is similar to that employed in the manufacture of laminates (GRG).

Material One can be used as a casting compound with none of the difficulties associated with many other materials.

Material One has many unique properties. These contribute to its strength, durability, weight to strength ratio, nontoxic, ease of manufacture and its ability to comply with many of the necessary test requirements of the construction industry, specifically those in regard to performance in fire and performance under impact.

Material One has a low toxicity both in its component parts and in its manufacturing process. Its potential uses are wide-ranging and could effectively replace much GRG, GRC and GRP in many of the situations where those materials are now used, both internally and externally. In comparison with GRC, **Material One** offers much greater versatility as a panelized cladding system in that the manufacturing tolerance can be much tighter.

Special or 'one off's' units can be easily produced alongside standard run and if site tolerances have not been strictly observed the panels can be 'humoured' to fit and made good on site. Of great significance is the material's high strength to weight ratio which allows for much lighter fixing systems and sub grids.

All these attributes contribute towards further potential savings having started with a material which has already cost advantages over alternatives.

Material One is wholly resistant to chemical attack and possesses a high resistance to ultraviolet degradation. It can therefore be used in situation where other materials would suffer.

Material One can overcome many of the problems associated with GRP, a material that is becoming less favoured by specifiers because of its inherent toxic fume and dense smoke emissions in fire and its poor performance after long exposure to ultraviolet.

SURFACE FINISHES

Material One should be viewed as a matrix in which a variety of filler materials can be incorporated, either to enhance mechanical performance or for the sake of appearance.

It is possible with **Material One** to include any non-reactive filler up to, and in some cases exceeding 200%. This allows a great deal of freedom when deciding upon encast and ex-mould finishes .

An extensive and impressive range of finishes has been produced. These include a variety of metals (bronze, brass and copper and stainless steel), pigmented materials imitating terracotta, brick and earthenware, and encast stone finishes from white marble through to dark granite, Portland and Bath stone.

It is thus possible to create a finish to meet the architect's or designer's specification rather than, as is usual, the designer or architect having only two of three established finishes from which to make a choice.

The standard of finishes that can be produced is extremely high both in their resemblance to the materials that they are imitating and in the quality of the surface finish.

A wide variety of finishes can either be incorporated into the material as a facing in the mould where this is going to be backed up by a lamination or other composite foam material or they can be included in the mix if the material is being used as solid cast. The method of manufacture obviously varies from situation to situation depending upon the design.

Recent developments include reproduction of hardwoods, through in-mould finishes, in both light and dark shades, such as oak and mahogany, rosewood and sycamore.

A range of fine textures and colours can be further produced. These include leather cloth through this specialised process.

Reproduction marble finishes are available that closely resemble a range of natural marbles. In this case 'dry' production process, **Material One** is filled with marble dust and coloured with stable liquid pigments. The surface is then buffed to produce a deep shine.

DESIGN

Material One's excellent weight-to-strength ratio means that when used as a lamination the designer is allowed greater freedom to produce large panels incorporating, if required, complex and fine detail.

When this is considered in combination with the ease of fixing and calculation of load, **Material One** can be seen as a major step forward in pushing back the boundaries of design limitation.

MAINTENANCE

The surface finish of **Material One** is extremely durable and will withstand aggressive use (shopping trolleys, floor cleaners, etc.).

For public areas the material can be treated post-mould with anti-graffiti coating which allows for the removal of paint, crayons, pens, etc.

In normal maintenance conditions the material can be simply washed with detergents and water or, if required, with stronger substances such as solvents, with no detriment to the surface finish.

PROPERTIES

MECHANICAL PROPERTIES

"E" glass fibre 12-15 wt% test conditions 20°C, 65% RH

Property	Unit of Measure
Density	1500 - 1800 kg/m³
Compressive strength	25 - 30 MPa
Tensile strength (UTS)	25 - 35 MPa
Bending elastic limit (LOP)	15 - 20 MPa
Bending strength (MOR)	50 - 65 MPa
Youngs modulus	5 - 6 GPa
Strain to Failure	2%
Impact Strength (Charpy)	20 KJ/m²

PHYSICAL PROPERTIES

Equilibrium moisture content

20°C / 20% RH	0.06%
20°C / 65% RH	0.5%
20°C / 85% RH	1.2%
20°C / 95% RH	11.0%
Maximum expansion due to water absorption, 24 hours immersion in water	0.8%

Water absorption after immersion in water dependent largely on curing procedure

1 Day	3 - 6%
28 Days	10 - 11%
More than 150 days	16%
Co-efficient of thermal expansion	1 / K 20° 10^{-6} 1 / F 11.1° 10^{-6}
Freeze thaw	Excellent

TESTS

SUMMARY OF DURABILITY TESTS

The durability tests are carried out on **Material One** GRG (Glass Reinforced Gypsum) and PGRC (Polymer Glass Reinforced Cement). Conducted by Intron B.V. and SABC.

These results are summarised as follows:

A.
Curing for 90 days: This period of time was chosen to ensure that the three selected materials cured adequately.

B.
Test boards were cut from large production sheets. The test boards for each system were placed in the three environmental conditions listed prior to being tested. The flexural test was ASTM C947. The most severe of the conditioning environments in the 'wet' i.e. ten days immersion in water at 20°C.

C.
Test boards were tested in the weather-o-meter for 400 cycles. This equates to 20 years natural weathering.

D.
After completing the 400 cycles in the weathering-o-meter only the **Material One** and PGRC test board remained suitable for further testing. These test boards were then subjected to the same three environmental conditions and thereafter tested for flexural and tensile properties.
Again, the most severe conditioning environment would be wet, especially after having been through 400 cycles in the weather-o-meter.

E.
The density of the composites is reported for two reasons:
- Density is an indication of the quality of the composite as produced.
- Density reflects the effect of the conditioning environment on the material system, i.e. moisture content.
- Typical density for **Material One** before conditioning is 1600/1680 Kg /m³.
  Typical density for PGRC before conditioning is 2060/2160 Kg /m³.
  The density for PGRC is related to the polymer content and sand / cement ratio.

F.
The property that was not report but is part of the flexural and tensile tests is the strain capacity of the composites. **Material One** maintains a high strain capacity after conditioning in all environments.

G.
In summary, one should focus on the test results for each system reported under 'wet' criteria, this being the most extreme condition.

DEFINITION OF TERMS

LOP - Limited of Proportionality
The amount of load the composites can absorb before the first crack occurs; matrix strength; flexural yield of composite before first crack.

MOR - Modulus of Rupture
Indicates the effectiveness of the fibre reinforcement; composite strength; flexural ultimate; point at which composite can take no more loading.

Effects of cure on flexural properties
Laminate:
13% wt. Fibre content: 25mm fibre minimum length. Cured for 2 days at 20°C. Stored 5 days at 40°C 30% R.H.

UNIT	2 days 20°C	5 days 40°C
Density Kg/m³	1746	1714
MOR MPa	32.2	70.2
LOP MPa	17.9	24.7

Influence of fibre content on flexural properties:

UNIT	13% wt.	10%
Density Kg/m³	1714	1714
MOR MPa	70.2	40.6
LOP MPa	24.7	14.0

NOTE:
Test results are the average of six test coupons from the same board where three coupons are tested mould face up and three coupons mould face down in the test jig. Tests conducted by intron B.V. and SABS (an independent testing laboratory).

DURABILITY TEST

The durability of the **Material One** system is tested using sample boards produced by the laminated process with 13% by weight glass fibre reinforcement.

As a reference in these tests, sample boards of unmodified glass fibre reinforced alpha-hemihydrates gypsum (GRG) and polymer modified glass fibre reinforced cement (PGRC with high polymer content and "E" fibre reinforcement) were also tested.

After 90 days of curing the flexural strength of the boards were tested in three environmental conditions as follows:
- Air dry (20°C and 65% RH)
- Wet (+ 10 day soak in 20°C water)
- Dry (+ 10 day drying at 40°C for gypsum or 100°C for cement)

Flexural properties of composite after 90 days curing in various environmental conditions.

UNIT	WET			AIR DRY			DRY		
	M1	GRG	PGRC	M1	GRG	PGRC	M1	GRG	PGRC
Density Kg/m³	1840	2050	2115	1762	1824	2034	1698	1810	1954
MOR MPa	28.7	10.3	23.8	50.9	26.7	22.1	65.9	22.9	24.8
LOP MPa	12.5	5.1	13.3	13.9	12.3	16.0	22.9	11.5	17.9

NOTE :
When tested wet the GRG board loses over half its strength. From these results it appears the flexural strength of all three composites is dependent on moisture content.

ACCELERATED AGING DURABILITY

A weather-o-meter has been used to accelerate the effects of weathering on **Material One**.

The boards tested have cured for 90 days according to the regime described earlier. The test procedure was :

heating the specimens for five hours with a combination of IR and UV light (to test polymer decomposition) and one hour of rain as one cycle for a total of 400 cycles (2000 hours UV and 400 hour's rain).

After 840 hours in the test the gypsum in the GRG board had flushed completely leaving only fibers.

The **Material One** and PGRC boards were visually checked periodically for cracking and erosion as a result of the rainwater. No cracking or erosion was observed.

After 2400 hours in the weather-o-meter the **Material One** and PGRC boards were tested in the same environmental conditions as described earlier with the following results:

Flexural properties of **Material One** and PGRC after 2400 hours accelerated aging in various environmental conditions :

UNIT	**WET**		**AIR DRY**		**DRY**	
	M1	PGRC	**M1**	PGRC	**M1**	PGRC
Density Kg/m³	1962	2089	1602	2034	1586	1986
MOR MPa	32.6	22.6	58.0	23.8	65.4	24.9
LOP MPa	10.5	16.0	15.6	17.5	19.6	20.3

Also after 2400 hours in the weather-o-meter the tensile strength of **Material One** and PGRC was tested. The tensile strength of **Material One** does not appear to have dropped after artificially aging.

Tensile strength of **Material One** and PGRC after 2400 hours of accelerated aging:

UNIT	**M1**	**PGRC**
Density Kg/m³	1602	2034
Tensile MPa	36.9	10.4

Material One after 2400 hours of accelerated aging on unfilled, unpainted, unsealed test specimen's examination of surface under a microscope showed some effect of the aging test, i.e. surface roughness. Some discoloration of the surface is evident, together with trace of white bloom.

Both these noted effects can be significantly improved by adding sand or stone fillers to the facing mix layer or by sealing the surface with a water based breathable acrylic coating.

FIRE PERFORMANCE

The performance of the **Material One** system has been determined by subjecting **Material One** to the following test:

A.
Fire propagation test to BS 476 Part 6 1989 Fulmer Yarsley Report No. J 863723/3 dated Sl.7.90. The indices of performance were 0.5 at 3 minutes and 8.9 finally.

B.
Surface spread of flame test for materials to BS 476 Part 7 1987, Fulmer Yarsley Report No. J 86732/2 dated 31.7.90. In accordance with the flame spread classification, the results show that **Material One** has a Class 1 surface with the same indices of performance in Part 6 report No. J 86372. **Material One** can be defined as a Class "0" material in Accordance with appendix "A" Clause A8 of the approval document B2/3/4 to the Building Regulations 1985.

C.
Airbus Industry Technical Specification 1000.001 Issue 4. Fulmer Yarsley Report No. j 81940 /6 dated 26.2.88.

RETENTION OF PERFORMANCE	
Soft Body Impact	50Kg with energy of 34Nm
Soft Body Impact	3Kg with energy of 30Nm
Hard Body Impact	0.5Kg with energy of 6Nm

IMPACT STRENGTH TEST

The Impact strength of the **Material One** system has been measured in two tests described as follows:

A.
Impact resistance has been measured with Charpy Impact device for unnotched samples in accordance with RILEN recommendations of Technical Committee 48 TFR. The test specimens were conditioned at 20°C and 65% R.H. Results of tests gave an average impact characteristic strength of 16 KJ/m^2. These values are over 40 tests with a 5% margin of error.

B.
Material One panels with a reconstructed stone facing with a hand Laminated backing have been tested to UEAtc directives for Impact Testing Opaque Vertical Building Components M.O.A.T. No. 43 1987. A 1,5 x 1.5 meter panel with stiffening ribs at 750mm centres was supported vertically by steel bracing members. The most severe category of test was chosen; this was defined as E2; readily accessible to public and others with little incentive to exercise care; change of accident occurring or misuse. Two types of impact tests are specified:

a - Safety impacts to ensure that in service accidental impact will not use danger to impair structural integrity.

b - Retention of performance impacts to ensure that the panels continue to perform in regard to appearance and physical properties after repeated impact.

In order to meet the requirements of category E2 performance the following impacts were used in the test:

RETENTION OF PERFORMANCE	
Soft Body Impact	50Kg with energy of 34Nm
Soft Body Impact	3Kg with energy of 30Nm
Hard Body Impact	0.5Kg with energy of 6Nm

For the above three tests the panels must retain their functional characteristic and also overall appearance.

SAFETY IMPACT	
Soft Body Impact	50Kg with energy of 100Nm
Hard Body Impact	1Kg with energy of 10Nm

The requirements are for the soft body test that the panel may be damaged but must not allow the body to penetrate, become dislodged from its fixings, cause falling debris or impair safety of the structure. For the hard body test, the above conditions apply except that the impact body can pass through the panel.

RESULTS	
Soft Body Impact	PASS
Hard Body Impact	PASS

TEST FOR CHLORINE ATTACK

These tests were conducted as a result of a particular need in a architectural application in the UK.

DESCRIPTION OF TEST PROGRAM CARRIED OUT

Chlorine used in tests 'oasis' stabilized chlorine granules (sodium dechloroisocyanurate dehydrate). Chlorine solution, 2 level s of solution were used in the test:
A - Normal level chlorine residual of 1.5 mg / f (ppm) ph level 7.2 - 7.8.
B - A solution made up to 5 times the normal level with chlorine residual of 7.5 mg/l 9 (ppm)

TEST SPECIMENS

12no test coupons were cut from **Material One** laminated flat sheet, size 250 x 50 x 6 mm (size for four point bending test).

TEST DATA

A.
Test coupons conditioned at 20°C / 55 RH to reach a standard weight to provide dry weight.
B.
3no. test coupons immersed in clean water for a period of 26 days at 20°C as control coupons.
C.
3no. test coupons immersed in normal level chlorine solution, as A above, for 28 days at 20°C.
D.
3no. test coupons immersed in THE 5 times normal level solution, as B above, for 28 days at 20°C.
E.
3no. test coupons, placed in a humidity cabinet with the normal level solution, as A above, 85 RH at 20°C.
F.
The chlorine levels were maintained constant during the test period.

RESULTS OF THE TESTS

At the end of the 28 day test period each test coupon was examined and weighed.

Absorption - average 4.8% on dry weight

Weight - No significant difference on the absorbed weight of any of the test specimens.

Visual Examination - Slight surface erosion on test coupons subjected to high level chlorine solutions.

Test coupons were then conditioned at 20°C at 55 RH to reach air dry weight.

Weight - Each coupon was weighed and compared with the pretest weight. A weight loss of 0.8% maximum was recorded on the coupons subjected to the high l eve l of chlorine.

Four Point Bending Test - Each coupon was tested to BS 6432 (1984) to determine Modulus of Rupture. Results of between 42.3 and 48.6 Mpa were reported. There was no detectable loss of strength in coupons subjected to the high level of chlorine.

CONCLUSION

Slight loss of weight and surface erosion detected on coupons subjected to high chlorine level. No significant loss of strength on the air dried coupons on composition of the tests.