TECHNICAL INFORMATION

ACRYLIC IN MOULD COATINGS

Technical Information

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All the information contained in this product list is given in good faith. However, it remains at all times the responsibility of the customer to ensure that the materials are suitable for the particular purpose intended.

1. Introduction

Acrylic in mould coating 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).

Acrylic in mould coating can be used as a casting compound with none of the difficulties associated with many other materials.

This material has many unique properties. These contribute to its strength, durability, weight to strength ratio, non-toxicity, 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.

The Acrylic in mould coating material 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, Acrylic in mould coating offers much greater versatility as a panelized cladding system in that the manufacturing tolerance can be much tighter.

Special or 'once-off' units can be easily produced alongside standard runs 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 cost advantages over alternatives.

Acrylic in mould coating is wholly resistant to chemical attack and possesses a high resistance to ultra violet degradation. It can therefore be used in situations where other materials would suffer.

Acrylic in mould coating can overcome many of the problems associated with GRP, a material that is becoming less favored by specifiers because of its inherent toxic fume and dense smoke emissions in fire and its poor performance after long exposure to ultra violet. It has been used as a lightweight cladding on many notable U.K., U.S.A. and South African buildings.

2. Surface Finishes

Acrylic in mould coating 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 Acrylic in mould coating 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 development includes 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 specialized process.

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

3. Design

Acrylic in mould coating's excellent weight-to-strength ration 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, the Acrylic in mould coating material can be seen as a major step forward in pushing back the boundaries of design limitation.

4. Maintenance

The surface finish of the Acrylic in mould coating 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, without it being detrimental to the surface finish.

5. Mechanical Properties

E glass fibre 12 – 15 wt% test conditions 20°C, 65% RH	
Density	1500 – 1800 kg / m^3
Compressive strength	25 – 30 MPa
Tensile strength (UTS)	25 – 35 MPa
Bending elastic limit (LOP)	15 – 20 MPa
Bending strength (MOR)	50 – 65 Mpa
Young Modulus	5 – 6 Gpa
Strain to Failure	2%
Impact Strength (Charpy)	20 Kj / m^2

6. 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 dependant 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

1. Summary of Durability Tests

The durability tests are carried out on Acrylic in mould coating GRG (Glass Reinforced Gypsum) and PGRC (Polymer Glass Reinforced Cement). Conducted by Intron B.V. and SABS (an independent testing laboratory). To the layman the attached test report can be confusing. Therefore, the following important criteria should be noted:

Curing for 90 days –

- This period of time was chosen to ensure that the three selected
- Materials cured adequately

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.

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

After completing the 400 cycles in the weathering-o-meter only the Acrylic in mould coating 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 sever conditioning environment would be wet, especially after having been through 400 cycles in the weather-o-meter.

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 Acrylic in mould coatings before conditioning is 1600 / 1680 KG / M^3. Typical density for PGRC before conditioning is
- 2060 / 2160 KG / M^3. The density for PGRC is related to the polymer content and sand / cement ratio.

The property that was not report but is part of the flexural and tensile tests is the strain capacity of the composites. Acrylic in mould coatings maintains a high strain capacity after conditioning in all environments. 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 : Limit 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 two days at 20°C. Stored five days at 40°C 30% R.H.

		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 contact on flexural properties ;

		13% wt.		10% wt.
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 Acrylic in mould coatings system is tested using sample boards produced by the laminated process with 13% by weight “E” glass fiber reinforcement.

As a reference in these tests, sample boards of unmodified glass fiber reinforced alpha-hemihydrates gypsym (GRG) and polymer modified glass fiber 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° 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.

PROPERTY UNIT		WET		AIR DRY				DRY	
	ES	GRG	PGRC	ACRY	GRG	PGRC	ACRY	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	659	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 independent on moisture content.
- Accelerated Aging Durability
- A weather-o-meter has been used to accelerate the effects of weathering on Acrylic in mould coatings Composites. 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 fibres.

The Acrylic in mould coatings 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 Acrylic in mould coatings and PGRC boards were tested in the same environmental conditions as described earlier with the following results:

Flexural properties of Acrylic in mould coatings and PGRC after 2400 hours accelerated aging in various environmental conditions:

PROPERTY UNIT		WET		AIR DRY		DRY	
		ES	PGRC	Acrylic	PGRC	Acrylic	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 Acrylic in mould coatings does not appear to have dropped after artificially aging.

Tensile strength of Acrylic in mould coatings and PGRC after 2400 hours of accelerated aging.

UNIT	ACRYLIC IN MOULD COATINGS	PGRC
DENSITY KG / M³	1602	2034
TENSILE MPA	36 – 9	10.4

Acrylic in mould coatings 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 water based breathable acrylic coating.

2. Accelerated Aging Durability

The performance of the Acrylic in mould coatings system has been determined by subjecting Acrylic in mould coatings to the following test:

a) Fire propagation test to BS 476 Part 6 1989 Fulmer Yarsley Report No. J863723 / 3 dated S1.7.90. 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 Acrylic in mould coatings has a Class 1 surface with the same indices of performance in Part 6 report No. J 86372. Acrylic in mould coatings can be defined as a Class "O" 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.

CRITERION	COMPLIANCE
Smoke density	Pass
Toxicity	Pass

3. Impact Strength Test

The Impact strength of the Acrylic in mould coatings system has been measured in two tests described as follow:

a) Impact resistance has been measured with Charpy Impact device for un-notched 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) Acrylic in mould coatings 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 centers 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; chance 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	0.5 kg 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	50 kg with energy of 100NM
Hard Body Impact	1 kg 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

Copies of test reports are available on request.

4. Test for Chlorine Attack

The background and date relating to this stems from a technical appraisal carried out on the Acrylic in mould coatings material by architects 'Skidmore Owings Merrell (S.O.M.) for use on the Broadgate Project, resulting in Acrylic in mould coatings panels being installed.

Description of test program carried out:

Chlorine used in tests 'oasis' stabilized chlorine granules (sodium dechloroisocyanurate dehydrate). Chlorine solution, 2 levels 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 / g (ppm)

Test Specimens

12Test coupons were cut from Acrylic in mould coatings 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) 3 test coupons immersed in clean water for a period of 26 days at 20°C as control coupons.

c) 3 test coupons immersed in normal level chlorine solution, as a), for 28 days at 20°C.

d) 3 test coupons immersed in THE 5 times normal level solution, as b), for 28 days at 20°C.

e) 3 test coupons, placed in a humidity cabinet with the normal level solution, as a), 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 coupons 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 level 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 defected on coupons subjected to high chlorine level. No significant loss of strength on the air dried coupons on composition of the tests.

Acrylic in mould coating when filled with Polyurethane filler and tested for Acoustic Sound Test

Against sound transfer through cladding board:

- Sound insulation of 30 dB up to 49 dB.

To noise reduction and regulation of the reverberation time:

- Middle frequency sound absorption from 15% to 80%.