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British Standard Specification for

E glass fibre chopped strand mat for reinforcement of polyester and other liquid laminating systems

Mats en verre textile E à fils coupés pour le renforcement des stratifiés à base de polyester ou autres résines liquides — Spécifications

Glasfaserschnittmatten (E-Glas) zur Verstärkung in PE-Laminatsystemen

British Standards Institution

Foreword

This British Standard has been prepared under the direction of the Plastics Standards Policy Committee and supersedes BS 3496 : 1973, which is withdrawn.

In this revision the limit on strand length has been removed, the requirement to carry out a hot water extraction test by the BS 3266 method has been deleted and the field of application of the reinforcement has been widened to all thermosetting resins. The provision of selected and normal grades has been deleted, but a note has been included drawing users' attention to the availability of grades with tighter tolerances on the average mass per unit area than indicated in this standard. The definitions have been aligned with ISO 6355, published by the International Organization for Standardization (ISO). Also the requirement to test at specified frequencies has been removed (see appendix A).

Mats are available as powder or emulsion bound mats for use in the hand lay-up process, the matched die moulding process and the mechanical production of sheeting. The physical characteristics of the mat used in each application are decided largely by customer preference, and for this reason no attempt has been made to define them in this standard. Appendix B, which gives guidance on assessing the handling characteristics of chopped strand mat and is intended to assist the user to select the most suitable material for a given application, has been augmented.

NOTE. Unless the contrary is stated by the supplier, it may be presumed that the minimum storage life of the mat is one year, when stored in accordance with the manufacturer's instructions.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Contents

Specification

1 Scope

This British Standard specifies requirements for E glass fibre chopped strand mat, the strands being laid at random and held together with a binder, for the reinforcement of liquid resin systems in accordance with the mat supplier's instructions. The liquid resin systems include unsaturated polyesters, epoxy, phenolic, ureaformaldehyde, silicone, melamine, furane, polyurethane and vinyl, bisphenyl and acrylic esters.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1 binder. Material(s) applied to staple fibres and to strands in order to hold them in a desired arrangement, for example in chopped strand mat, continuous strand mat and surfacing mat.

2.2 chopped strand mat. A mat formed of strands cut to a short length, randomly distributed, without intentional orientation, and held together by a binder.

2.3 coupling agent. A substance that promotes or establishes a stronger bond at the interface of the resin matrix and the reinforcement.

2.4 E glass. A glass containing not more than 1 % by mass of alkali (calculated as Na_2O) and used for the manufacture of glass fibres.

2.5 filament. A single textile element of a small diameter and a very long length, considered as continuous.

2.6 size. Material applied to glass fibres or filaments during the course of their manufacture.

NOTE. The size may contain a coupling agent.

2.7 strand. An assembly of parallel filaments simultaneously produced and slightly bonded, without intentional twist.

3 Manufacture

The strand shall be composed of filaments each with an average diameter within the range from 8 µm to 15 µm. The strand length shall be discontinuous and not less than 25 mm. A coupling agent shall be incorporated in the filament size.

4 Defects and impurities

The mat shall be free from discoloured areas, wet areas and oil and grease spots.

5 Property requirements

The mat shall comply with the property requirements given in table 1 when tested by the appropriate methods, using a sample of sufficient size to provide specimens for all the tests in table 1.

6 Packaging and marking

The mat shall be rolled on a tube and packed in a container in such a manner as to prevent free movement. Not more than three pieces shall be permitted in one roll and no piece shall be less than 5 m in length.

Each roll or its container shall be clearly marked with the following:

(a) the name or trade mark of the supplier;

(b) the nominal mass per unit area of the mat (in g/m^2);

(c) the supplier's identification of the mat, including the binder type and date of manufacture;

(d) the nominal length of the roll (in m);

(e) the net weight of the roll (in kg);

(f) the nominal width of the mat (in cm);

(g) the number and date of this British Standard, i.e. BS 3496 : 1989*.

*Marking BS 3496 : 1989 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Table 1. Property requirements for the mat

Property	Limits	Method of test
Width (cm)	$^{+3}_{-0}$ at any point of the value declared by the supplier NOTE 1. These tolerances apply only to mat trimmed on both edges.	—
Moisture content (% mass)	0.5 % max. of the value declared by the supplier	Appendix C
Loss on ignition (% mass)	± 2 % of the value declared by the supplier NOTE 2. For example, if the nominal loss on ignition is 6 %, the actual loss on ignition may be between 4 % and 8 %.	Appendix D NOTE 3. Only specimens that have been prepared and dried in accordance with **C.2** are used to determine the percentage loss of mass on ignition in accordance with appendix D.
Average mass per unit area (g/m^2)	± 8 % of the value declared by the supplier NOTE 4. Manufacturers are able to provide material for special purposes with much lower limits for average mass per unit area. NOTE 5. The most common average mass per unit area values are 300, 450, 600 and 900 g/m^2.	Appendix E
Percentage variation in mass per unit area (not applicable to mats less than 50 cm wide)	For individual specimens, not more than 19 % of the value declared by the supplier and the range not to exceed the following. **No. of specimens** / **Range** 3 / 22 % of the value 4 / 23 % declared 5 / 24 % by the 6 / 25 % supplier	Appendix F
Flexural strength of laminate (MPa*)	Dry: 205 min. Wet: 155 min.	Appendix G
*1 MPa = 1 MN/m^2 = 1 N/mm^2.		

Appendices

Appendix A. Quality control testing

The following guidance on the nature of the requirements and test methods given in this British Standard is provided to assist in the preparation of quality plans for the manufacture of glass fibre chopped strand mat in accordance with this specification.

Type tests are intended to prove the suitability and performance of a material. Such tests should be performed when a change is made in material composition or the design of the product, but may be performed more frequently by incorporation into a plan for monitoring the consistency of manufacture.

Quality control tests are carried out during manufacture to prove the quality of a production run and such tests may be performed in respect of any of the requirements specified in the standard. However, certain additional test methods may be preferred because of the practicality and speed with which they may be performed in conjunction with a production process as compared to some of the type tests.

Attention is therefore drawn to guidance given in **4.14** of BS 5750 : Part 5 : 1981 on the possible use of alternative procedures for quality control (e.g. on line monitoring under production conditions) as compared with the methods required by the British Standard specification for determining the properties of the final product.

In view of this, the minimum frequency of testing specified in the previous edition of this British Standard, i.e. one test per 1500 m of length, is now only given for guidance.

Appendix B. Guidance for the assessment of the handling characteristics of the mat

B.1 Introduction

The purpose of these recommendations is to assist in the selection of suitable materials for specific applications, by providing information regarding the properties and appropriate tests that have been used for assessing the handling characteristics of chopped strand glass mat.

The properties fall into the following two classes:

(a) those that can only be assessed by inspection or observation;

(b) those that can be established by test.

Levels of properties are not given since these necessarily vary according to the purchaser's requirements and the intended use of the mat.

B.2 Inspection and testing

B.2.1 General

B.2.1.1 The properties of mat that can be assessed by inspection or by observation are as follows:

(a) general appearance, uniformity of fibre and binder distributions (**B.2.2.1**);

(b) fibre shedding of unimpregnated mat (**B.2.2.2**);

(c) consolidation, ease of air removal and strand integrity of impregnated mat (**B.2.2.3**).

B.2.1.2 The properties of mat that can be established by subjection to a test procedure are as follows:

(a) thickness of mat (**B.2.2.4**);

(b) handling (**B.2.2.5**);

(c) breaking strength (**B.2.2.6**);

(d) wet out time (**B.2.2.7**);

(e) drape and mouldability (**B.2.2.8**);

(f) mat binder solubility (**B.2.2.9**);

(g) maximum and minimum resin pick-up (**B.2.2.10**);

(h) effect of mat on resin gel time (**B.2.2.11**);

(i) apparent (bulk) density (**B.2.2.12**).

NOTE. Queries arising from the application of the various test methods listed in **B.2.1.2** should be a matter for consultation between the purchaser and the supplier.

B.2.2 Tests

B.2.2.1 *Appearance.* Unroll a sample of mat at least 2 m long on to a flat table and inspect the whole length for the following:

(a) cleanliness;

(b) uniformity of appearance in colour and texture;

(c) uniformity of strand distribution (absence of thin patches, of thin or thick streaks and of fibre bundles or clumps);

(d) uniformity of binder distribution (absence of overbonded and/or underbonded areas).

B.2.2.2 *Behaviour of unimpregnated mat.* Lift the sample of mat from the table and shake it lightly. Hang the mat over a rod of 40 mm diameter and brush with a gloved hand lightly over the surface. Observe whether or not more than a few loose surface strands fall from the mat.

B.2.2.3 *Behaviour of resin impregnated mat.* Check the following properties.

(a) *Consolidation.* Impregnate a 300 mm square specimen of mat with 2.5 times its mass of resin. After impregnation, place on it a further 300 mm square specimen of mat and again apply 2.5 times its mass of resin. Observe whether or not the two distinct layers of mat consolidate without excessive working.

(b) *Air removal.* During the lay-up operation observe whether or not the air bubbles can be removed without excessive working. Record the number and kinds of bubbles remaining in the laminate, e.g. numerous, slight, none or large bubbles. Alternatively, record as 'foam'.

(c) *Strand integrity.* During the working of the laminate, observe whether or not the strands separate excessively into their constituent filaments. Observe closely the reverse of the laminate after gelation for strand integrity or filamentization.

B.2.2.4 *Thickness of mat.* Cut three specimens across the full width of the mat under test.

NOTE. The specimens should be approximately 150 mm wide and should be spaced 150 mm apart.

Measure the thickness of each strip at six roughly evenly spaced points, using a dial gauge with a contact plate in the shape of a circle with an area of 500 mm^2 and under a pressure of 10 kPa*. Report the average of the 10 readings as the thickness of the mat and note the range.

B.2.2.5 *Handling.* Unroll a sample of mat on to a table so that it lies flat, without curling. From the mat, cut a specimen 2.0 m in length with a sharp knife or with scissors.

Drape the specimen over a length of rod of 40 mm diameter so that 1.0 m hangs freely on either side. Observe whether or not the mat breaks when left for 20 min in this position.

B.2.2.6 *Breaking strength.* With the aid of a template, cut as many specimens 150 mm wide and 300 mm long across the mat as its width will allow when the 300 mm dimension is parallel to the length of the mat.

Place each specimen in the 150 mm wide clamps of a tensile testing machine with a distance of 200 mm between the edges of the clamps. Employ suitable means, e.g. a rubber lining, to avoid crushing the mat in the clamps. Separate the clamps at 100 ± 10 mm/min and record the breaking force.

Report the breaking strength of the mat as the average of a minimum of five results (excluding jaw breaks) distributed equally across the width of the mat and also report the range.

B.2.2.7 *Wet out time.* Determine the mass of a specimen of mat 300 mm square. Spread three times this mass of a general-purpose, hand lay-up resin evenly over an area of 300 mm square within a frame or tray on a sheet of release film. Lay the specimen gently on to the resin. Note the time taken by the resin to penetrate through the mat to the stage of complete impregnation, i.e. when no white fibres can be seen.

B.2.2.8 *Drape and mouldability.* This test is designed to establish the ability of a mat, when impregnated with resin, to form around contours, into channel sections and double curvatures. Suitable shapes for this test are corrugated sheet, keel sections of boats, shallow curvature domes, fluted dustbin lids, etc.

Coat the mould with a general-purpose, hand lay-up resin and lay on to the resin a pre-cut and, if necessary, tailored specimen of mat slightly larger than the surface of the shape to be covered. Using a brush and more resin, stipple the mat down on to the mould. Consolidate the lay-up with a suitable roller, taking care to remove all obvious air bubbles. Note the ease with which the mat achieves full and permanent contact with the mould.

B.2.2.9 *Mat binder solubility.* Another indication of the ease with which a mat can be moulded is the time in which the mat binder can be dissolved. It is possible to do this test either in the resin itself (which involves considerable cleaning problems between tests) or in other suitable liquids such as acetone, styrene or a 5 % emulsion of styrene in water. The use of this emulsion is recommended if the dissolution times, when using undiluted styrene or acetone, are too short.

The apparatus required consists of a dish and a loading frame (see figure 1). The loading frame carries a stationary bulldog clamp and a second clamp, which is attached to a cord which carries a mass over a pulley. Two crossbars, of stainless steel or glass tubes of 10 mm outside diameter, are so positioned that their centres are 10 mm above base level. A stopwatch is also required.

Prepare sufficient of the test liquid to fill the dish to a depth of 20 mm. Select the appropriate mass according to the mass per unit area of mat tested from table 2 and attach it to the free end of the cord (see figure 1).

Table 2. Mass to be used in the mat binder solubility test

Mass per unit area of mat	Mass
g/m^2	g
300	100
450	150
600	200
900	300

Cut six 300 mm × 75 mm test specimens from the mat with their longer sides parallel to the length direction of the mat. Clamp 5 mm of one end of one specimen in the stationary bulldog clamp and the other end in the second clamp in such a manner that the bottom of the mass hangs approximately 25 mm above the level of the bench. Ensure that the specimen lies at right angles to the two crossbars. Place the loading frame in the dish and start the stopwatch. Stop the stopwatch when the mass falls and record this time. Test each of the remaining specimens and report the average of the determinations, together with their range.

B.2.2.10 *Maximum and minimum resin pick-up.* Depending on the application of the mat, the user may wish to employ a maximum or minimum amount of resin in the manufacture of the laminate.

Cut 12 specimens 300 mm square from the mat. Weigh three of these together, M_1. Impregnate the first of the specimens by applying with a spatula or palette knife the minimum quantity of resin necessary to cover it completely. Roll the mat with a split washer roller until all obvious air is excluded. Place the second on the first and impregnate it with the minimum amount of resin. Roll the mat until all obvious air is excluded. Place the third weighed specimen on the other two and impregnate it with the minimum amount of resin. Roll the mat until all obvious air is excluded.

*1 kPa = 1 kN/m^2 = 0.001 N/mm^2.

Weigh the uncured assembly of mat and resin, M_2. Repeat this procedure with another three specimens. Calculate the resin/glass ratio G from the following equation:

$$G = \frac{M_2 - M_1}{M_1}$$

Report the result as the arithmetic mean of these first two determinations. This ratio indicates the minimum amount of resin required to impregnate the mat.

To establish the maximum resin-holding capacity of the mat, repeat the procedure on the remaining specimens, but this time apply as much to each layer as is possible without pushing significant quantities of resin out of the mat during rolling.

Calculate the resulting resin/glass ratio as above and report the arithmetic mean of the second two determinations. This ratio indicates the maximum resin-holding capacity of the mat.

B.2.2.11 *Effect of mat on resin gel time.* The addition of chopped strand mat to a resin system can change the gel time of the system.

Prepare a resin mixture to give a convenient gel time at 20 °C, e.g. 30 min. Place a steel plate 4 mm thick with two holes each 100 mm square on a sheet of release film (e.g. regenerated cellulose or polyethylene terephthalate film). Cut two layers of glass mat each 100 mm square, place them in one of the holes and impregnate them with 2.5 times their mass of resin. Fill the other hole with resin to the same level as the first. Compare the time taken for the resin and for the resin/glass combination to gel.

B.2.2.12 *Apparent (bulk) density.* From the sample selected for test, cut 24 specimens 125 mm long and 100 mm wide and determine their total mass to the nearest 0.5 g. Stack the specimens to give an orthogonal pile 24 plies high and place a steel plate of dimensions 1.25 mm x 125 mm x 100 mm on top of the pile.

NOTE 1. The thickness of the plate is an ISO metric preferred size.

NOTE 2. The stacking is best accomplished by using a specially constructed wooden jig that might be likened to an open-topped box from which the front and one side have been removed.

Measure the height of the stack to the nearest 0.5 mm at opposite corners and average the two readings. The determination of stack height is facilitated by fixing vertical millimetre scales to the walls of the jig, one scale being 125 mm from the corner where the two vertical walls meet and the other 100 mm from this corner. Mount the scales at such a height that a reading of zero is obtained when the flat metal plate alone is placed in the jig.

Calculate the apparent (bulk) density ρ (in kg/m^3) of the mat from the following equation:

$$\rho = \frac{80M}{H}$$

where

M = mass of stack (in g);

H = height of stack (in mm).

Appendix C. Method for the determination of moisture content

C.1 Principle

The moisture content is determined as the percentage loss in mass occurring when chopped strand mat is dried at a specified elevated temperature.

C.2 Procedure

Cut three specimens of mat, each of approximately the same mass, between 2 g and 5 g, from the roll of mat to be tested. Cut one specimen from each side and one from the centre at the open end of the mat. Determine the collective mass of the three specimens to the nearest 5 mg, A. Dry the specimens in a forced draught oven at 105 ± 2 °C for 1 h. Allow them to cool in a desiccator and redetermine the collective mass to the nearest 5 mg, B.

C.3 Calculation

Calculate the moisture content Q (in % by mass) from the following equation:

$$Q = \frac{(A - B)}{A} 100$$

where

A = the original collective mass of the specimens (in g);

B = the collective mass of the oven dried specimens (in g).

Appendix D. Method for the determination of loss on ignition

D.1 Principle

The loss on ignition is determined as the percentage loss in mass occurring when the chopped strand mat is ignited in a muffle furnace under specified conditions.

NOTE. This method determines the total organic content that is derived from the size applied to the filaments and the mat binder. The total organic content is commonly referred to as the 'binder content'.

D.2 Procedure

Prepare and dry three specimens in accordance with **C.2.** Heat the dried specimens in a suitable container in a muffle furnace for not less than 10 min at 575 ± 25 °C. After removing the specimens from the muffle furnace, cool them in a desiccator to room temperature and redetermine the collective mass to the nearest 5 mg.

D.3 Calculation

Calculate the loss on ignition K (in % by mass of the dried product) from the following equation:

$$K = \frac{(B - C)}{B} 100$$

where

B = the collective mass of the oven dried specimens (in g);

C = the collective mass of the specimens after ignition (in g).

Appendix E. Method for the determination of the average mass per unit area

Determine the average mass per unit area Y (in g/m^2) for each roll from the following equation:

$$Y = \frac{100D}{LW}$$

where

D = net mass of mat in the roll (in g);

L = nominal length of mat in the roll (in m);

W = nominal width of mat (in cm) or, if the mat has a feathered edge, the nominal width (in cm) +1.5 cm.

Appendix F. Method for the determination of percentage variation in mass per unit area

F.1 Principle

The percentage variation in mass per unit area is determined by averaging the mass per unit area of a specified number of specimens determined by their thickness.

NOTE. This test is not applicable to mats less than 50 cm wide.

F.2 Procedure

Trim untrimmed mats to the appropriate nominal width before taking the specimens.

Cut specimens 400 mm × 250 mm from the mat, with the longer sides parallel to the length direction of the mat, in the numbers given in table 3.

For widths of 75 cm and above, take the specimens in line across the width of the mat, cutting one for each side of the mat to include the edge and the remainder at a regular spacing from the intervening width. For widths of less than 75 cm, cut the specimens as shown in figure 2. Determine the mass of each specimen to the nearest 0.5 g.

Table 3. Number of specimens to be cut

Width of mat	Number of specimens
cm	
50 up to but not including 120	3
120 up to but not including 150	4
150 up to but not including 180	5
180 up to but not including 210	6
210 and over	7

F.3 Expression of results

Calculate the percentage variation in mass per unit area T (in %) for each specimen from the following equation:

$$T = \frac{100(10S - N)}{N}$$

where

S = mass of specimen (in g);

N = nominal mass of a square metre (in g/m^2).

Calculate the range of percentage variation in mass per unit area R (in %) from the following equation:

$$R = \frac{1000(S_h - S_l)}{N}$$

where

S_h = mass of the heaviest specimen (in g);

S_l = mass of the lightest specimen (in g);

N = nominal mass of a square metre (in g/m^2).

Appendix G. Method for the determination of flexural strength of the laminate

G.1 Principle

The flexural strength of the laminate is determined using mat specimens selected according to mat mass per unit area bonded in a specified manner to the test specimens.

G.2 Preparation of the laminate

Cut specimens from each mat each about 300 mm × 275 mm, with the longer sides parallel to the length direction of the mat. Cut the number of specimens that is sufficient to provide a total mass of about 1800 g/m^2. The total mass of samples shall be about 150 g, e.g.

six specimens from 300 g/m^2 mat;
four specimens from 450 g/m^2 mat;
three specimens from 600 g/m^2 mat;
two specimens from 900 g/m^2 mat.

Dry the specimens in a ventilated oven for 1 h at 105 ± 5 °C, remove them from the oven, allow them to cool and use them within 1 h of removal.

Impregnate the specimens with resin complying with type C of BS 3532 : 1962 to give a final glass content of 40 % to 45 % of the total mass (see figure 3). Ensure that the wet lay-up is uniformly translucent and that there is therefore thorough impregnation. Make the laminate at a temperature between 17 °C and 25 °C.

A suitable method is as follows.

Method. Calculate the mass of resin necessary to give the required resin/glass ratio from the mass of mat to be used (i.e. mass of mat × 1.5 = mass of resin). Formulate this quantity of resin according to the resin manufacturer's instructions. Cover a polished metal or glass plate of a size larger than that of the sample with a sheet of regenerated cellulose or polyethylene terephthalate film about 0.05 mm thick.

Spread a layer of resin on the glass or metal plate the approximate size of the sample. Place one specimen on the resin and consolidate using a suitable laminating roller until the mat is fully impregnated and all visible air inclusions are removed from the laminate. Repeat this procedure with alternate layers of resin and mat until the build up is complete. Superimpose each specimen on its predecessor so that the longer sides are parallel.

When all the specimens have been impregnated, cover the top with a second sheet of film and use the roller to consolidate the laminate, squeezing any excess resin out of the laminate. Place a second glass or metal plate on top of the laminate and a 5 kg weight on top of the glass or metal plate.

Cure the laminate in accordance with the resin manufacturer's instructions. Then cure for 2 h at 105 ± 5 °C.

NOTE. The laminate should be reasonably free from voids and other defects.

Cool the laminate to room temperature and then trim approximately 10 mm from all edges of the laminate.

G.3 Test procedure

G.3.1 General

Cut 20 rectangular strips not less than 100 mm × 25 $^{+0}_{-2}$ mm, 10 each with the longer direction parallel to the longitudinal and transverse directions of the original roll of mat. Determine the flexural strength of these strips in accordance with BS 2782 : Method 335A after testing in accordance with **G.3.2** and **G.3.3**. The rate of separation of the grips shall be in the range 10 mm/min to 15 mm/min.

G.3.2 Dry condition

Test five longitudinal test specimens and five transverse test specimens in the dry condition as soon as convenient after cutting. Report the mean flexural strength of the 10 specimens. After testing, determine the resin content of the dry test specimens in accordance with **6.2** of BS 2782 : Method 1006 : 1978.

G.3.3 Wet conditions

Immerse five longitudinal test specimens and five transverse test specimens in boiling distilled water for 2 h and cool in distilled water at room temperature. Wipe to remove excess water and test immediately. Report the mean flexural strength of the 10 specimens.

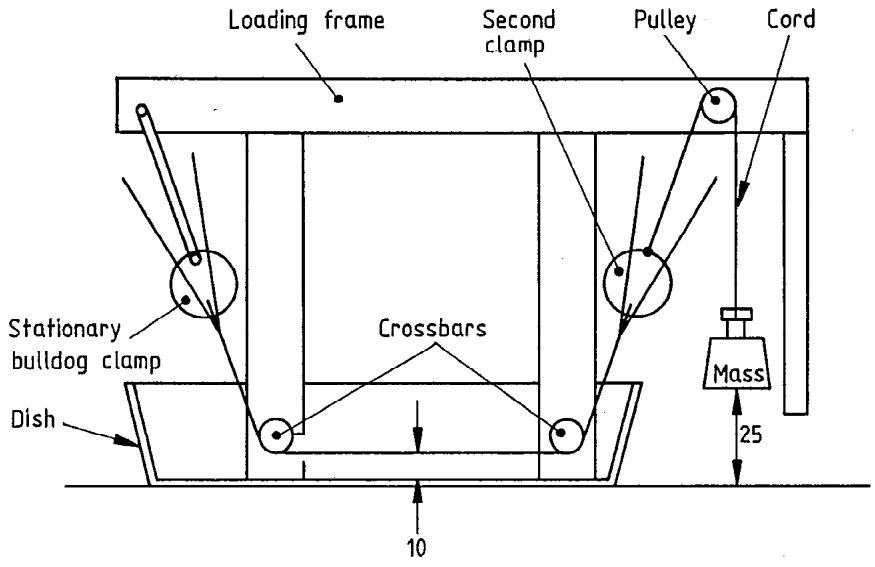

Figure 1. Apparatus for the determination of mat binder solubility

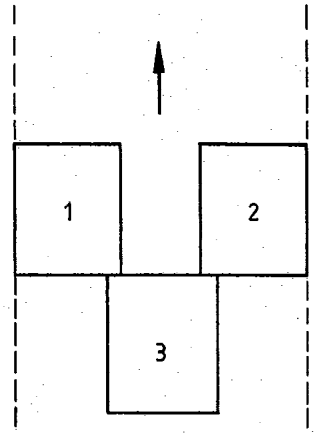

Figure 2. Selection of specimens for the determination of variation in mass per unit area

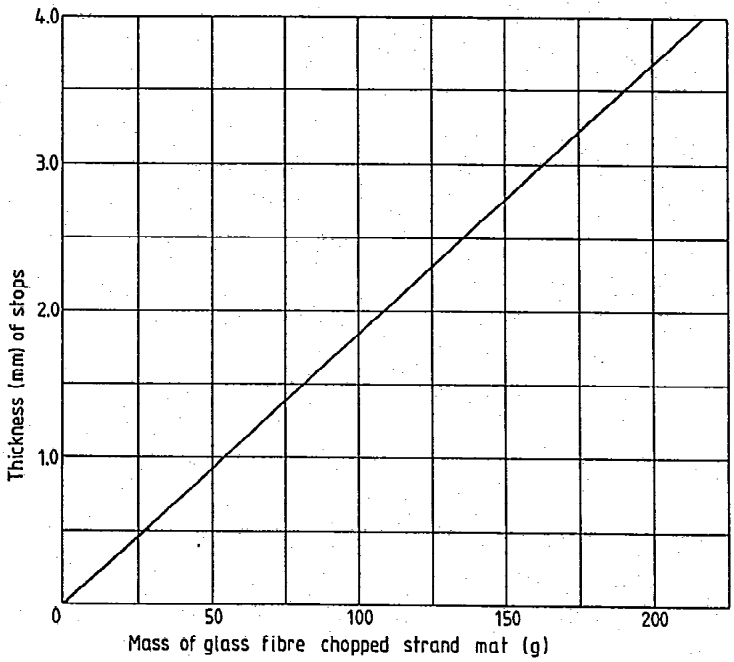

Figure 3. Mass of glass fibre chopped strand mat to produce 300 mm × 275 mm laminate with a glass content of 42.5 % by mass

Publications referred to

BS 2782	Method of testing plastics Part 3 Mechanical properties Method 335A Determination of flexural properties of rigid plastics Part 10 Glass reinforced plastics Method 1006 Determination of volatile matter and resin content of synthetic resin-impregnated textile glass fabric
BS 3266*	Methods of test for determination of conductivity, pH, water-soluble matter, chloride and sulphate in aqueous extracts of textile materials
BS 3532	Specification for unsaturated polyester resin systems for low pressure fibre reinforced plastics
BS 5750	Quality systems Part 5 Guide to the use of BS 5750 : Part 2 'Specification for manufacture and installation'
ISO 6355*	Textile glass — Vocabulary

*Referred to in the foreword only.

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British Marine Industries Federation
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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Imperial College of Science and Technology

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