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The Specification and Selection of CE Marked Reinforced Bitumen Membranes for Low Sloped Roofs to Ensure Their Durability in the UK

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ABSTRACT

In order to ensure the specifier can select the right quality of reinforced bitumen membrane for a given roof type a new British Standard , BS8747, has been developed. This paper presents the development process and the methodology used to establish BS8747. It shows how the key parts of BS8747 lead to the successful specification and selection of reinforced bitumen membranes so that a durable roof is achieved.

Bitumen membranes have been used in the United Kingdom for waterproofing low sloped roofs for many years. They have been covered by a British Standard (BS747) where the membrane is identified by the materials it contains. The standard can be called a recipe standard which had 5 separate types of base reinforcement. The best membrane type in terms of performance and durability is type 5 which uses a polyester based carrier. If a high performance membrane is required the specifier could easily require those to BS747:type 5 to be used.

Recently a new European standard (EN13707) has been produced by CEN TC254 which refers to flexible sheets for roof waterproofing. This presents data according to a number of test methods which have been based upon the regulatory requirements of the various member states. It is a requirement that EN13707 refers to all products that are legally placed on the market. This means the CE mark covers low quality as well as high quality products. The product information given with CE marking is in the form of results from a series of tests. This means that an in-depth knowlede of material properties would be needed to assess quality and durability.

KEYWORDS

Bitumen, Membranes, Durability

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1 THE HISTORICAL USE OF BS747

BS 747:2000 – Reinforced bitumen sheets for roofing - Specification [British Standards Institution] was first published in 1937. Other editions have been published in 1952, 1961, 1968, 1970, 1977, 1994 and the last in 2000. The products that have been covered by this standard have been traditionally known as 'bitumen felt' but to better reflect the latest European standards they are now referred to as ' reinforced bitumen sheets for roofing'.

The various types of materials covered by this standard have a matted fibre base which is coated with bitumen. There are a number of types which have been identified according the material used for the base. These are shown in table 1 together with their reference within the standard.

Table 1. The types of pre-formed base materials covered by BS747.

Types of pre-formed base roofing sheets	*Type 1 Fibre base*	*Type 2 Asbestos base*	*Type 3 Glass fibre base*	*Type 5 Polyester base*
Fine mineral surfaced sheet, e.g. fine sand, talcum etc.	-	-	3B	5B and 5U
Granule surfaced sheet, e.g. slate, granite or ceramic	-	-	3E	5E
Reinforced sheet	1F	-	-	-
Venting base layer	-	-	3G	-

There are marked differences in the performance and durability of the various materials. Those of type 1 with a base of organic fibres, often referred to as 'ragfelt', performed so poorly in the application of waterproofing for flat roofs that they were removed from BS747 in the 1994 amendment. The only reference for type 1 products (type 1F) is for use as underlays for the use beneath slates or tiles in pitched roof construction.

Type 2 products were manufactured using an asbestos base but these were formally withdrawn probably in the 1977 version.

Type 3 products are manufactured using a glass fibre base are for general use in what are now considered to be relatively low performance situations. The building may be temporary or the substrate maybe be stable so the membrane is at low risk of failure due to building movements. The life of this type of membrane, usually comprising at least two layers is generally accepted as being about 10 years.

The type 3G is specifically manufactured to provide a venting base layer. This was developed to lay over new concrete decks and avoids blisters due to entrapped moisture during construction. More recently it has been used as a first layer over certain types of insulation board.

Type 4 is a specialist product for a specific application beneath mastic asphaltic and is not included in table 1 and are not considered further here.

Type 5 products are made from polyester. The base is provided in a variety of weights (mass per unit area) and has been manufactured by one of two methods. The lighter and medium weight sheets are non-woven materials while the heaviest can be needle punched. The combination of a light weight underlay (125 g/m^2) and a heavyweight capsheet (350 g/m^2) has been responsible for a service life of at least 30 years.

The last version of BS747 developed in 2000 also recognised that different weights of membranes based on polyester were in use so the additional types were added. These included the refined types 5B/180, 5B/250 and 5B/350. Type 5E with a mineral surface were also denoted in this way.

In the manufacturing process the base material maybe impregnated first with straight run bitumen and then coated with oxidised bitumen. BS747 does not cover products developed more recently that use polymer modified bitumen. Reinforced bitumen membranes manufactured using polymer–modified bitumen have generally been covered by third party certification.

2 THE INTRODUCTION OF EN13707:2006 – BITUMEN SHEETS FOR ROOF WATERPROOFING [CEN]

The reason for the development of a series of Europen Norms (ENs) was the agreement of the Construction Products Directive in 1989 between the member states of the European Union (EU). The intention was to establish free trading of construction products throughout the EU. After an initial period of development the European Committee for Standardization Technical Committee 254 (CEN TC254) was established to produce test methods and product standards for a particular group of products callled 'flexible sheets for waterproofing'.

The requirements for product standards was established by the requirements in member states based on their (building) regulations. These requirements were collated by the Standing Committee for Construction and issued as a mandate. This mandate was sent to CEN or European Office for Technical Approval (EOTA) who responded with a reply which contained relevant product standards and test methods.

Within the structure of CEN TC254 bitumen sheets for roof waterproofing were dealt with by Sub-committee 1 (SC1) and the same for plastics and rubbers in SC2. It was recognised that there would be some common test methods and separate working groups (WGs) were established by CEN TC254 to produce test methods.

EN13707 is the product standard developed by CEN TC254/SC1 for bitumen sheets for roof waterproofing. It refers to a series of test methods and contains information which leads a manufacturer to be able to CE mark a product. The CE mark on a product or a label, can contain information based on results of test methods. This information may only refer to a few tests results (such as external fire performance) necessary for satisfying the regulation of any member state where the product may be sold. A wider range of information about the product can be found on the manufacturers data sheet including tensile properties, tear resistance and shear and peel of joints.

The value assigned for a particular material property may not give the same value as stated by a manufacturer. This is because EN13707 requires information to be stated as a manufacturers declared value or a manufacturers limiting value and there are rules which relate to both of these.

EN13707 contains reference to product characteristics for which a series of test methods have been developed. They are for initial characterisation of the product or for factory production control. The characteristics as listed in Table 2.

Table 2. Product characterisitcs in EN13707.

Initial type tests	*Tests for Factory Production Control*
Watertightness	Visible defects
External Fire performance	Length & width
Reaction to fire	Straightness
Watertightness after stretching at low temperature	Mass per unit area and thickness
Joint strength (peel and shear resistance)	Tensile properties
Water vapour properties	Resistance to tearing (nail shank)
Resistance to impact	Dimensional stability
Resistance to static loading	Flexibility at low temperature
Resistance to root penetration	Flow resistance at elevated temperature
Form stability under cyclic temperature change	Adhesion of granules
Artificial ageing behaviour	

3 THE DEVELOPMENT OF BS8747:2007 [BRITISH STANDARD INSTITUTION]

BS8747:2007 was developed by a British Standards Institution (BSI) committee reference B 546/1. The committee has been Chaired by the author of this paper for over 10 years.

The initial decisions made were firstly to refer to bituminous products as ‘reinforced bitumen membranes’ (RBMs). Previously the word ‘felt’ had been used and tended to convey a meaning of poor performance and failure. Secondly, it was found to be possible to retain the numbers ‘747’ in the new British Standard thereby ensuring a continuance with the industry in the use of these numbers in reference to bituminous products.

The task faced by the committee was to determine how to link the old standard BS747 and the new European standard EN13707 so that the end user and would be able to select and specify bituminous products based on performance and durability.

The committee identified a need to concentrate on a number of items of work;

- To identify the product characteristics from the list in EN13707 which could best be used to determine a change in levels of performance and durability
- To match the chosen product characteristics with the end use conditions ensuring compliance with existing Codes of Practice
- To produce a simple coding system which would allow specifiers to select bituminous products according to performance
- To compile a list of test results for the product characteristics for a range of the most widely used reinforced bitumen membranes.

All of these were needed to develop the final document so two working groups were established, a users group and a manufacturers group.

The committee were mindful that a system had been developed in France called the 'FIT' system (Chaize 1991). This was based on fatigue, impact and temperature. Impact and temperature are referred to in the product characteristics in EN13707 i.e. resistance to impact and flexibility at low temperature.

A problem that was recognised was that as far as end users were concerned they only needed 3 levels of performance – low, medium and high. This was also strongly linked to short, medium and long term requirements for service life (and hence durability). On the other hand the typical manufacturer has about 40 different bituminous products and wants to sell all of them. A standard with just 3 levels of performance would not be acceptable to the industry.

This can be considered against the old standard which had effectively 3 levels of performance through type1, 3 and 5 products. However, this only referred to products manufactured using oxidised bitumen. BS8747 needed to encompass those manufactured with polymer-modified bitumen also.

3.1 The Coding System Developed

A classification for RBMs for roofing was developed. The system is based on two parameters, tensile strength and indentation and is used to define the following:

a) the performance achieved by any particular membrane
b) the performance required by any particular roof construction.

The characteristics chosen from EN 13707 were tensile strength (S) and resistance to puncture or indentation (P). Hence the SP classification. Each letter is assigned a numerical suffix that increases with performance level. The lowest perfoming membrane is hence S1P1. A total of 5 levels were chosen so the highest performing is S5P5.

The tensile strength is determined according to EN12311-1:2000 [CEN]. The S class is determined by a number levels e.g. 150 to 350 N/50mm for S1 and 350 to 450 N/50mm for S2. The values stated are minimum values as quoted by the manufacturer and are required in both the longitudinal and transverse direction. The class for the P parameter is determined from 2 sub-classes based on the resistance to impact (EN 12691:2006 [CEN]) for Dx and resistance to static loading (EN12730:2001[CEN]) for Lx. Table 3 below shows how these are combined to determine the P class.

Table 3. Combinations of D subclass and L subclass to give P class.

Subclass D	*Subclass L*	*Combination*	*P class*
D1	L1	D1L1	P1
D2	L2	D2L2	P2
D2	L3	D2L3	P3
D2	L4	D2L4	P4
D3	L4	D3L4	P5

The values from the impact test are a drop height e.g. up to 700mm for subclass D1. The values for static loading are expressed as a load e.g. 5 kg for subclass L1.

3.2 How to Use The Snpn Classification System.

Two approaches have been taken in BS8747 to use the SnPn system.

The French FIT system was used as a basis to deveop a table which gave membrane classification by performance requirement. A small part of the performance table is shown in Table 4 as an example.

Table 4. A small part of the performance table.

Substrate below the membrane	*Slope/Falls*	*Roof use and type of protection*	
		No access apart from maintenance	
		Self-protected	*Ballast (coarse gravel)*
Concrete	1 to 5	S3P2	S2P3
	>5	S3P2	-
Plywood, OSB or timber boarding	1 to 5	S3P2	S2P3
	>5	S3P2	S2P3

In the performance approach the specifier is free to modify the performance if other factors are involved. An example may be to increase the puncture resistance (Pn +1) if a softer substrate is used i.e. thermal insulation.

A flow chart was also developed which gave a system selection for warm deck roofs and for inverted roofs. Table 5 is based on a small section of the flow chart.

Table 5. System selector for a typical warm deck roof.

Step 1	Choose a deck/substrate Preparation	Close boarded timber Correct any uneven planks and punch in nail heads
Step 2	Select a vapour control layer	RH low: nailed RBM to minimum of S2P2 with sealed laps RH medium: nailed RBM as above, and fully bond a second S2P2 layer RH high: nailed RBM S2P2 and fully bond a metal-cored second layer
Step 3	Select thermal insulation After bonding/fixing insulation boards, for pour and roll or torch-on systems the following preparations are needed before the application of the first working layer	e.g Polyurethane (PUR) Apply a type 3G layer (specialised product originally developed in BS747 for use over wet concrete. Experience has shown blisters can develop when membranes are fully bonded to PUR boards)
Step 4	Select working waterproofing layer	First working layer: could be S2P2 but specifier is free to choose Final Layer: depends on application (see performance table) typical choice could be S3P2

3.3 Other Information in BS8747

Before considering the specification of the RBM waterproofing layer it has been assumed that the roof has been designed by a competent person and that the roof design has been considered for wind loading, condensation risk, designed for drainage and complies with the UK building regulations. For consideration as an RBM in BS 8747 the RBM must pass the following tests in EN13707:

- watertightness , for all applications
- root resistance for green or garden roofs.

BS 8747 also considers other product information and gives a typical range of values for tensile strength, elongation, nail shank tearing, static load resistance, impact resistance, flexibility at low temperature, flow resistance at elevated temperature, durability, external fire performance and reaction to fire.

Information is also given as to what performance level would be acceptable. For example a minimum value for nail shank tearing of greater than 175 N would be acceptable in all instances. Durability is

assessed by exposure to heat aging in an oven for 12 weeks (EN1296 [CEN]) and then assessing flexibility at low temperature. The UK expectation is that no change will take place for durable products. Such is the performance of polymer-modified polyester reinforced bitumen membranes that a service life in excess of 50 years is anticipated.

3.4 Worked Examples

The BSI committee did realise that the new approach taken to help the specification and selection of RBMs might, in the first instance, not be readily understood so a series of worked examples have been given in an annex. The worked examples chosen are:

- Single-storey rural school classroom
- Three-storey block of flats/offices
- Swimming pool
- Hospital refurbishment
- Garage block(domestic).

All of the worked examples follow the same format and blank forms are included for copying to aid the development of a specification.. The reasons for the choices made in the worked examples are given in each case.

4 CLOSING COMMENTS

The BSI committee reaslised the need to develop guidance for the specification and selection of reinforced bitumen membranes. This has in part been due to the active UK participation in the relevant meetings of CEN TC254 in developing EN13707. It has been the case that British Standards tend to lag behind the current practices of the day and only incorporate these practices into a Standard as they become the accepted and successful method of construction. In this context BS8747 is ground breaking in that it leads the industry into the use of EN13707 products rather than waiting to see what the industry would do. It would be difficult to produce effective specifications without the guidance in BS8747. The rag based felts were withdrawn from the old BS747 sometime ago because of their poor perfromance in construction methods incorporating thermal insulation on flat roofs. Such products will be legally marketed within Europe with a CE mark. It is therefore essential that a system is developed so that the lower performing products are used only in those applications for which they are suited. The use of low perfoming products could result in unexpected costs due to early replacement. It is anticipated that the use of BS 8747 will avoid such expense and result in the correct selelction and specification of reinforced bitumen membranes.

5 REFERENCES

Chaize, Alain., 1991, Classification FIT des systemes d'etancheite de toitures, Third Internation Symposium on Roofing Technology, National Roofing Contractors Association, USA.

BSI – British Standards Institution. Customer Services +44 (0)20 8996 9001.http://www.bsi-global.com.

CEN – European Committee for Standardization. Management Centre: rue de Stassart, 36 B-1050 Brussels.