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BBA BRITISH BOARD OF AGRÉMENT
TECHNICAL APPROVALS FOR CONSTRUCTION

Agrément Certificate
No 02/3925

LARSEN FIBRES FOR CONCRETE

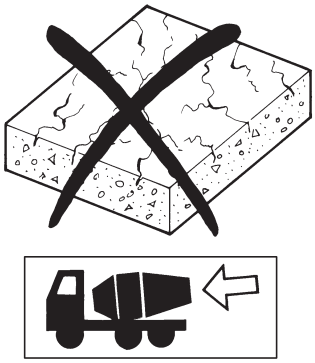
PRODUCT SHEET 1 — LARSEN FIBERFLEX

PRODUCT SCOPE AND SUMMARY OF CERTIFICATE

This Certificate relates to Larsen Fiberflex, polypropylene fibres for use in concrete to reduce plastic shrinkage cracking and settlement.

AGRÉMENT CERTIFICATION INCLUDES:

- factors relating to compliance with Building Regulations where applicable
- factors relating to additional non-regulatory information where applicable
- independently verified technical specification
- assessment criteria and technical investigations
- design considerations
- installation guidance
- regular surveillance of production
- formal three-yearly review.



KEY FACTORS ASSESSED

Plastic shrinkage cracking — concrete containing the product will reduce the occurrence of plastic shrinkage cracking when compared to the equivalent plain concrete mix (see section 4).

Bleeding and plastic settlement — concrete containing the product will have greater resistance to bleed, segregation and plastic settlement when compared to the equivalent plain concrete mix (see section 5).

Resistance to freeze/thaw — concrete containing the product will have greater resistance to damage caused by freeze/thaw when compared to the equivalent plain concrete mix (see section 6).

Resistance to impact — concrete containing the product will have greater resistance to damage caused by impact when compared to the equivalent plain concrete mix (see section 7).

Durability — concrete containing the product is generally more durable than the equivalent plain concrete mix (see section 18).

The BBA has awarded this Agrément Certificate for Larsen Fiberflex to Larsen Building Products Ltd as fit for its intended use provided it is installed, used and maintained as set out in this Agrément Certificate.

On behalf of the British Board of Agrément

Date of First issue: 24 June 2002
Date of Second issue: 14 January 2008

Greg Cooper: Chief Executive

The BBA is a UKAS accredited certification body — Number 113. The schedule of the current scope of accreditation for product certification is available in pdf format via the UKAS link on the BBA website at www.bbacerts.co.uk

Readers are advised to check the validity and latest issue number of this Agrément Certificate by either referring to the BBA website or contacting the BBA direct.

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Regulations

In the opinion of the BBA, Larsen Fiberflex is not subject to these Building Regulations:

The Building Regulations 2000 (as amended) (England and Wales)

The Building (Scotland) Regulations 2004 (as amended)

The Building Regulations (Northern Ireland) 2000 (as amended)

Construction (Design and Management) Regulations 2007
Construction (Design and Management) Regulations (Northern Ireland) 2007

Information in this Certificate may assist the client, CDM co-ordinator, designer and contractors to address their obligations under these Regulations.

See section: 2 *Delivery and site handling* (2.3).

Non-regulatory Information

NHBC Standards 2007

NHBC accepts the use of Larsen Fiberflex, when installed and used in accordance with this Certificate, in relation to *NHBC Standards*, Chapter 2.1 *Concrete and its reinforcement.*

Zurich Building Guarantee Technical Manual 2007

In the opinion of the BBA the use of Larsen Fiberflex when installed and used in accordance with this Certificate is capable of satisfying the requirements of the *Zurich Building Guarantee Technical Manual,* Section 5 *Internal/external works, services and finishes*, Sub-sections *External works* and *Concrete mixes — General.*

General

This Certificate relates to Larsen Fiberflex polypropylene fibres for use in concrete mixes to reduce the occurrence of plastic shrinkage cracking and plastic settlement and to enhance the surface properties of the hardened concrete.

Technical Specification

1 Description

1.1 Larsen Fiberflex polypropylene fibres are 12 mm long and 19.5 µm diameter.

1.2 The short lengths of multifilament yarn separate into individual monofilaments when mixed in concrete.

1.3 Fibres are coated with surfactant to:

- improve wetting
- improve bond to the hardened concrete
- improve dispersion within the cement paste
- increase the extent of contact.

2 Delivery and site handling

2.1 The fibres are manufactured in a continuous process by the extrusion of polypropylene. The extruded material is heated, stretched to improve tensile strength, coated with surfactant and cut to a nominal length of 12 mm.

2.2 Quality control is exercised over raw materials, during manufacture and on the final products.

2.3 The fibres are packed in measured quantities of 0.91 kg in dispersible paper bags, suitable for 1 m^{-3} of concrete. The bagged fibres are delivered in cardboard boxes each weighing 18.2 kg.

2.4 Boxes of fibres must be stored on a clean surface, in dry conditions under cover and away from the possibility of damage.

2.5 Each box bears the product name and batch number.

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on Larsen Fiberflex.

Design Considerations

3 General

3.1 Larsen Fiberflex is satisfactory for use in concrete mixes at an addition rate of 0.91 kgm^{-3}, to reduce the occurrence of plastic shrinkage cracking and plastic settlement, and enhance the surface properties of the hardened concrete.

3.2 The fibres may be used as an alternative to steel wire mesh for crack control purposes when sufficient movement joints are detailed in a slab, but are not a substitute for conventional structural steel reinforcement or normal good curing procedures for concrete.

3.3 Mixes containing the fibres should be properly designed and placed, and comply with the relevant requirements of BS 8204-1 : 2003 and BS 8204-2 : 2003 and the guidelines given in BS 8500-1 : 2006 and BS EN 206-1 : 2000.

3.4 The addition of fibres does not normally require adjustment to the concrete mix design.

4 Plastic shrinkage cracking

4.1 The reduction in plastic shrinkage, bleed water migration and segregation contribute to reducing both the occurrence and degree of plastic cracking.

4.2 The addition of the fibres reduces the amount of plastic shrinkage cracking when compared to concrete made from the equivalent plain mix.

5 Bleeding and plastic settlement

5.1 The presence of the fibres in a concrete mix reduces the amount of bleeding. Concrete with the fibre generally has better surface integrity than plain concrete with the same mix design.

5.2 The addition of the fibres reduces the plastic settlement (volume change) of concrete.

6 Resistance to freeze/thaw

Freeze/thaw resistance tests conducted in accordance with BS 5075-2 : 1982 indicate that fibre concrete has a greater resistance to frost attack than similar concrete made from the equivalent plain mix.

7 Resistance to impact

Concrete containing the fibres has a greater impact resistance than the corresponding plain concrete. The degree of spalling and damage to arrises of joints will be lessened.

8 Workability

8.1 The fibres increase the apparent cohesiveness and may reduce the slump of a concrete mix.

8.2 A slump test may be used as a general indicator of uniformity of concrete mixes containing fibres. Care is required when interpreting the value obtained since it may suggest a misleadingly low workability.

8.3 The presence of the fibres does not affect the compacting factor of the concrete.

8.4 The placeability of the fibre concrete and its compactability under vibration is better than indicated by the value obtained in the slump test.

8.5 Additional water must not be added to increase the slump of fibre concrete mixes.

9 Distribution of fibres

The fibres are uniformly and rapidly dispersed throughout the concrete mix without balling or agglomeration.

10 Stiffening times

10.1 The addition of the fibres slightly reduces the setting times of concrete.

10.2 The fibres do not affect the hydration rate of the concrete.

11 Water absorption

11.1 The addition of the fibres has a small but generally positive effect in reducing water absorption of the hardened concrete.

11.2 The reduced surface water absorption characteristics of the concrete improve its penetration resistance to de-icing salts.

12 Resistance to abrasion

The addition of the fibres does not have a detrimental effect on the concrete's resistance to surface abrasion when compared with concrete made from the equivalent plain mix.

13 Length changes on wetting and drying

The changes in length on wetting and drying depend on the concrete mix proportions and density, and are unaffected by the presence of the fibres.

14 Strength characteristics

14.1 The fibres have no significant effect on the compressive strength of concrete cubes.

14.2 The fibres have no significant effect on the flexural strength of concrete and structural reinforcement will still be required, if specified, as for the equivalent plain concrete.

15 Chemical resistance

The fibres are inert and alkali-resistant, and their presence does not alter the chemical resistance of the concrete.

16 Performance in relation to fire

16.1 The results of tests indicate that when concrete containing Larsen Fiberflex is subjected to fire, the structural integrity will be the same as for the equivalent plain concrete. The potential for explosive spalling will be reduced.

16.2 Fire will destroy fibres located close to the surface, resulting in an increase in porosity of the concrete.

17 Surface appearance

17.1 The fibres improve the surface quality of concrete by reducing the number of bleed holes. Consequently, both water and dirt are absorbed more slowly and evenly into the surface, and will result in a more uniform appearance.

17.2 The fibres are not readily visible on the concrete surface.

18 Durability

The presence of Larsen Fiberflex in conventional concrete mixes reduces the amount of plastic shrinkage cracking and bleeding in its plastic state, and improves the resistance to impact, water absorption and freeze/thaw resistance of the hardened concrete. Concrete containing Larsen Fiberflex, therefore, is generally more durable than plain concrete to the same mix design.

Installation

19 General

19.1 Larsen Fiberflex must be added to the concrete mix strictly in accordance with the Certificate holder's instructions.

19.2 The workmanship should comply with the relevant requirements of BS 8000-2.1 : 1990 and BS 8000-2.2 : 1990.

20 Mixing

20.1 Preferably, fibres should be added at the batching plant. Where this is not practicable, the fibres may be added to the ready-mix truck on site, care must be taken to ensure that adequate mix control and supervision is available.

20.2 When dry mixing, the fibres should be added first, followed by the fine and the coarse aggregates.

20.3 When wet mixing, it is important that the consistency of the concrete is such it ensures that the fibres are immediately dispersed and intermixed. This may be achieved by adding the fibres at the same time as the aggregate. If this is not possible the fibres should be added as detailed in section 20.2.

20.4 The concrete should be mixed for a minimum of either five minutes or a minimum of 70 revolutions at full mixing speed (approximately 12 revolutions per minute), to ensure a uniform fibre dispersion.

21 Placing

21.1 Concrete mixes containing the fibres can be transported by conventional methods. The presence of the fibres lessens the danger of segregation. When assisted by very light vibration, the fibre concrete mixes flow easily out of the hopper outlet.

21.2 Special precautions are not necessary when pouring into moulds or shutters.

21.3 The fibre concrete mixes will flow around reinforcement, into restricted areas and against mould faces in the same manner as plain concrete of similar mix proportions.

21.4 The fibre concrete mixes may be hand tamped or vibrated by conventional means to provide the necessary compaction.

22 Curing

22.1 It is essential that all normal good curing procedures are strictly followed.

22.2 The fibres are made from polypropylene and should not be used when curing is to be carried out at temperatures in excess of 140°C.

23 Finishing

Placed concrete mixes containing the fibres may be floated and trowelled using any normal hand or power tools, to provide a smooth, fibre-free surface appearance.

Technical Investigations

24 Tests

Tests on Larsen Fiberflex concrete were conducted using the mix designs given in Table 1. The result of these tests are summarised in Tables 2 and 3.

Table 1 Test mix designs[1]

Component	Quantity (kgm^{-3})	
	Mix 1	Mix 2
Portland cement (to BS 12 : 1991)	400	317
Water	200	212
Sand (5 mm) (Weeford/Bunter)	595	827
Gravel (5 mm to 20 mm) (Weeford/Bunter)	1105	1170
Larsen Fiberflex	0.91	0.91

(1) Plain concrete control mixes were the same but did not include the fibres.

Table 2 Plastic concrete test results

Test (units)	Mix design	Results		Method[1]
		Larsen Fiberflex concrete	Plain concrete	
Air content (%)	1	1.9	1.95	BS 1881-106
	2	1.6	1.1	
Slump (mm)	1	50	70	BS 1881-102
	2	65	80	
Compaction factor	1	0.98	0.98	BS 1881-103
	2	0.92	0.98	
Bleeding rate (%)	1	0.25	0.3	ASTM C 232-87, Method A
Stiffening time	1			BS 5075-1
resistance to penetration				
0.5 Nmm^{-2}		2 h 42 min	3 h 7 min	
3.5 Nmm^{-2}		3 h 54 min	4 h 12 min	
Flow (mm)	2	335	430	BS 1881-105
Change in height (%)	1	0.231	0.381	
Resistance to plastic cracking (rings)	1	no cracking present	each plain concrete ring cracked	FCB (Trondheim, Norway)
Resistance to plastic cracking (slabs)				BBA test specification
crack area (mm^2)	1	137.8	1199.5	

(1) Test documents are detailed in the *Bibliography*.

Table 3 Hardened concrete test results

Test (units)		Mix design	Results		Method[1]
			Larsen Fiberflex concrete	Plain concrete	
Initial surface absorption test ($ml m^{-2} s^{-1}$)		1			BS 1881-5
air dried	10 min		0.73	0.71	(65 mm thick slab non-crazed areas)
	120 mm		0.31	0.30	
water cured	10 min		0.63	0.71	
	120 mm		0.21	0.18	
Permeability of cores (ms^{-1})		1	3.6×10^{-2}	8.7×10^{-2}	RMCS test specification
Water absorption (%)		1	3.2	3.6	BS 1881-122
Impact resistance		1			BBA test specification
blows to first crack			41	8	
blows to failure			58	12	
Distribution of fibres		1	Good distribution	Not applicable	Microscopic examination
Change in length (%)		1			
drying shrinkage			–0.03	–0.03	
wetting expansion			+0.02	+0.02	
Flexural strength (mean) (Nmm^{-2}) (beams)		1			BS 1881-118
1 day			4.37	5.07	
3 days			6.32	6.22	
7 days			6.84	6.89	
28 days			6.93	6.96	
Compressive strength (mean) (Nmm^{-2}) (equivalent cube method)		1			BS 1881-119
1 day			22.9	13.1	
3 days			39.8	40.2	
7 days			45.2	50.0	
28 days			45.8	53.2	
Cube compressive strength (mean) (Nmm^{-2})					BS 1881-116
1 day		1	22.7	14.2	
3 days		1	38.1	39.7	
7 days		1	46.9	49.7	
		2	33.3	33.8	
28 days		1	57.0	53.9	
		2	41.3	44.6	
Freeze/thaw resistance (change on length after 50 cycles) (%)		3[2]	0.009	0.21	BS 5075-2
Surface hardness (Nmm^{-2}) (rebound hammer)		1	27.2	27.5	BS 1881-202
Abrasion resistance					A'Court, BS 784
reduction in rate of abrasion (%)		1	11.0	—	

(1) Test documents are detailed in the *Bibliography*.

(2) Mix design to specification given in BS 5075-2 : 1982.

25 Investigations

25.1 A survey of users and specifiers was conducted to assess the ease of use, practicability of installation, and performance in service of Larsen Fiberflex concrete mixes.

25.2 An examination of independent fire test data was made to assess polypropylene fibre concrete's behaviour in relation to fire.

25.3 An assessment was made of the product's range of use and durability.

25.4 The manufacturing process was examined, including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

Bibliography

BS 12 : 1996 *Specification for Portland cement*

BS 784 : 1973 *Methods of test for chemical stoneware*

BS 1881-5 : 1970 *Testing concrete — Methods of testing hardened concrete for other than strength*
BS 1881-102 : 1983 *Testing concrete — Methods for determination of slump*
BS 1881-103 : 1993 *Testing concrete — Method for determination of compacting factor*
BS 1881-105 : 1984 *Testing concrete — Method for determination of flow*
BS 1881-106 : 1983 *Testing concrete — Methods for determination of air content of fresh concrete*
BS 1881-116 : 1983 *Testing concrete — Method for determination of compressive strength of concrete cubes*
BS 1881-118 : 1983 *Testing concrete — Method for determination of flexural strength*
BS 1881-119 : 1983 *Testing concrete — Method for determination of compressive strength using portions of beams broken in flexure (equivalent cube method)*

BS 1881-122 : 1983 *Testing concrete — Method for determination of water absorption*
BS 1881-202 : 1986 *Testing concrete — Recommendations for surface hardness testing by rebound hammer*

BS 5075-1 : 1982 *Concrete admixtures — Specification for accelerating and retarding water reducing admixtures*
BS 5075-2 : 1982 *Concrete admixtures — Specification for air-entraining admixtures*

BS 8000-2.1 : 1990 *Workmanship on building sites — Code of practice for concrete work — Mixing and transporting concrete*
BS 8000-2.2 : 1990 *Workmanship on building sites — Code of practice for concrete work — Sitework with in-situ and precast concrete*

BS 8204-1 : 2003 *Screeds, bases and in-situ floorings — Concrete bases and cement sand levelling screeds to receive floorings — Code of practice*
BS 8204-2 : 2003 *Screeds, bases and in-situ floorings — Concrete wearing surfaces — Code of practice*

BS 8500-1 : 2006 *Concrete — Complementary British Standard to BS EN 206-1 — Method of specifying and guidance for the specifier*

BS EN 206-1 : 2000 *Concrete — Specification, performance, production and conformity*

ASTM C 232 : 1987 *Standard Test Methods for Bleeding of Concrete*

ASTM C 827 : 1995 *Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures*

26 Conditions

26.1 This Certificate:

- relates only to the product/system that is named and described on the front page
- is granted only to the company, firm or person named on the front page — no other company, firm or person may hold or claim any entitlement to this Certificate
- is valid only within the UK
- has to be read, considered and used as a whole document — it may be misleading and will be incomplete to be selective
- is copyright of the BBA
- is subject to English law.

26.2 References in this Certificate to any Act of Parliament, Statutory Instrument, Directive or Regulation of the European Union, British, European or International Standard, Code of Practice, manufacturers' instructions or similar publication, are references to such publication in the form in which it was current at the date of this Certificate.

26.3 This Certificate will remain valid for an unlimited period provided that the product/system and the manufacture and/or fabrication including all related and relevant processes thereof:

- are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA
- continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine
- are reviewed by the BBA as and when it considers appropriate.

26.4 In granting this Certificate, the BBA is not responsible for:

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- individual installations of the product/system, including the nature, design, methods and workmanship of or related to the installation
- the actual works in which the product/system is installed, used and maintained, including the nature, design, methods and workmanship of such works.

26.5 Any information relating to the manufacture, supply, installation, use and maintenance of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used and maintained. It does not purport in any way to restate the requirements of the Health & Safety at Work etc Act 1974, or of any other statutory, common law or other duty which may exist at the date of this Certificate; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care. In granting this Certificate, the BBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the manufacture, supply, installation, use and maintenance of this product/system.

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