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OVERVIEW OF LIGNOCELLULOSIC CEMENT COMPOSITES IN TURKEY

Eyyüp KARAOĞUL[1], M. Hakkı ALMA[1]

[1]*Department of Forest Industry Engineering, KahramanmaraşSütçüimam University, 46100, Kahramanmaraş, TURKEY e.karaogul@ksu.edu.tr, alma@ksu.edu.tr*

ABSTRACT

Over the last two decades in Turkey, Industries have been committed to manufacturing lignocellulosic cement sheets and boardsthatare becomingmore and more popular facade cladding material all over the world. Turkey research and industry has concentrated on natural fibers in fibercement board and natural chip in particle board cement.

This review reports some of the Turkish industry and the research that was carried out to establish natural lignocellulosic material as a suitable reinforcement for cement products. The properties of special products known as wood cement composites in the industries discussed briefly as well as congruity with existing processing technology. Besides, According to HekimConstruction and Tepe Betopan industries, explanation of annual production amounts and export respectively were shown as 4700 m^3, 2.75 million dollar and 60000 m^3 4200 m^3. Annual usage quantites of raw materials from lignocellulosic composit respectively were shown as 52.49% quartz, 39.32% cement, 8.19 cellulose for HekimConstruction and 60% cement, 25% chip, 10% water, 5% minerals for Tepe Betopan. The range of applications for which the natural lignocellulosic cements are used is discussed briefly.

KEYWORDS:

Turkey, lignocellulosic cement, Annual production amounts, Export rations, raw materials

INTRODUCTION

Cement and lignocellulosic material have been used as two basic materials of construction for a long time. Studies to use cement and wood, which were conventionally used as two separate construction materials, in a mixture started in early 1920s and determination of physic and chemical relationships of these two elements constituted the majority of researches. In late 1920s, mixing wood chips instead of sand with cement for construction became a more common practice. In early 1940s, knowledge required to transform cement and chips mixture into a board had already been accumulated. Thus, in 1940 long strands were added to cement and pressed resulting in the production of the first wood strand boards. Thereafter production of panels that were primitive versions of current cement-bonded particleboards was realized by mixing shorter wood flakes into cement. The first factory, producing the present cement-bonded particleboards was setup in 1967 in Switzerland and researches were made to create multi-functional, user-friendly, environment-friendly and fully ecological boards of these materials. Starting from the 1970s, cement-bonded particleboard factories began to be setup in various places all over the world.

Wood fiber cement is part of a new generation of engineered products preceded by wood laminated veneer lumber, parallel strand lumber, laminated strand lumber, medium density fiberboard, and Oriented Strand Board (OSB). Compared to competing products, wood fiber cement is at the early stage of its diffusion curve (Soroushian 2006). The products are usually corrugated roofing, roofing tiles and flat sheet products that depend on a cheap fibre source and labour intensive production methods (Swamy RN. 1992).

The idea of finding new solutions for interior and exterior wall cladding of houses has led to continuous investigation and many different products have been developed in lignocellulosic-cement field. At the end of the nineteenth century, a Czech named Hatschek developed a production method called in his name and produced the asbestos cement sheets. Fibre cement was a major user of asbestos and as such new reinforcing fibres were being sought as alternatives to asbestos in this class of building material (Robert 2005).

These first fibercement sheets were used by all countries all over the world for about hundred years. Following the ban of asbestos and the products containing asbestos in early 90's, the non-asbestos fibercement products were developed by the leadingproducers. Autoclaved fibercement products, a perfect composition of ordinary Portland cement, high quality silica and cellulose fiber, are marketed in smooth and cedar textured surface appearance as interior and exterior facade cladding material. The fibercement roof tiles are produced using PVA and cellulose fibers in certain ratios in the mixture by air-curing method.

As seen on the Figure 1, the crystalline silica finely ground in a wet mill, cellulose pulp and Portland cement are blended in a special tank and transformed into flat fibercement green sheets in a unique production system known as Hatschek process. Following the trimming process, the green sheets are stacked between high quality steel templates and autoclaved under high pressure and temperature by steam energy. The sheets which become highly durable against hard climatic conditions via the production method are stored in stock halls and dispatched as packed on pallets.

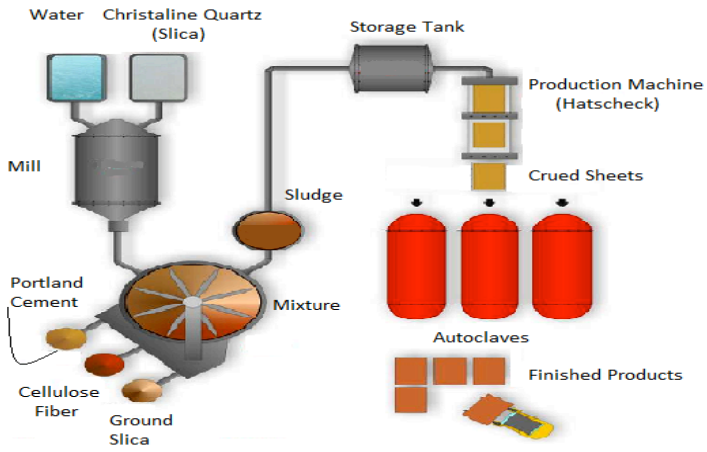

Figure 1 - Fibercement Production Stages

Advantages of Lignocellulose Cement Sheets

The advantages and importance of lignocellulose cement composites are that:

- They are composed of all natural materials, which they are environmentally and human friendly,
- Contains no asbestos or other harmful materials,
- Incombustible (A1 class fire resistant building material according to EN 13501-1),
- No hazardous gas emission even when exposed to extreme temperatures,
- Water resistant, water absorption ratio is lower than concrete buildings, safely used in humid climates, very low reaction ratio against water (max. 0.5 mm/m when restored in water for 24 h),
- Resistant against sea water moisture, so it can be used safely as external wall of seaside buildings,
- Resistant against ultraviolet rays, very good heat and sound insulation,
- Imperishable, long life, easy maintenance,
- Unaffected by insects harmful to woods, not inhabitable for insects,
- Can be painted with acrylic exterior paint and plastic based interior paint due to cement and silicate in its mixture,
- Warm and comfortable appearance because of the wooden effect, but physically more advantageous than wood, can be easily processed by hard wood tools,
- Easy to install, economical because does not need plaster
- Durable against impact
- Lightweight, can be easily handled(weight of 8mm thick sheet is 11.2 kg/m^2),
- Odorless, produces no gas harmful to human health, resistant against chemical elements and animal waste,

- Resistant to frost, can be used safely in hard climatic conditions,
- Breathing material, enables the building to breathe, can be used much more safely in any application, where similar covering materials used,
- Perfect binding to several insulation materials, so can be used as sandwich panel for multiple purposes.

Lignocellulose Cement Application

Lignocellulose-cement is used as:

- Interior and exterior facade cladding of any kind of buildings,
- Sandwich panel wall element,
- Suspended ceiling element (6 mm),
- Backerboard under roof tiles (instead of OSB),
- Underlying material for ceramic tiles in wet areas,
- Flooring material on elevated flooring systems,
- Cedar textured decorative interior applications,
- Soffit and fascia elements on roof projections,
- Concrete moulds,
- Backerboard on the billboards,
- Decorative shop window applications,
- Underlying elements in thermal sheathing applications,
- Wall elements in wet areas (as PP foil laminated),
- Trims, door and window framings,
- Supporting material in composite elements,
- Decorative element on garden walls,
- Supporting element son curtain wall systems,
- Wall elements in prefabricated pools.

There remains a great need to study new cheaper methods of fibre production, low cost production processes, and the all-important question of durability. Durability is related to matrix formulations, processing methods and curing regimes and if natural fibre reinforced cement products are to be readily available for low cost housing much research still remains to be conducted (Coutts R. S. P., 2005).

MANUFACTURERS WITHIN TURKEY

Hekim Construction Company

Hekim Construction Industries and Trade which is a company of Hekim Holding found in 2001 with the idea of manufacturing the fiber cement sheets and planks which are getting more and more popular facade cladding material all over the world. A know-how license agreement was signed, for the production technology, with REDCO S.A. which is a company of ETEX GROUP. The foundation of the factory started in 2002 and the trial work started in 2004 at the premises which were designed as a modern sheet production line. The factory which has been established on a land of 100.000 sqm in Hendek/Adapazari had a production capacity of 32.000 m^3per year as three-shift-working. Soon after the start-up of the first production line the capacity of the existing plant fell behind the demand and the foundation of a second production plant became inevitable. In 2007, a new know-how license agreement was signed with SIM S.r.l. which is a very well-known Italian company designing and supplying fibercement sheet production plants both air cured and autoclaved technology, and the projecting and the erection of the second line started. In August 2008, the commissioning of the plant was carried out successfully Together with the new line the production capacity has reached upto 80000 m^3.

There are three main products in the product range of Hekim construction used in any kind of buildings needing autoclaved, calcium silicate based, smooth or cedar textrured flat sheets for all internal and external façade cladding applications. These are

- Hekim board sheets are used as facade cladding material and backer board,

- Turksidingplanks are used as indoor or outdoor cladding material as overlapped application,
- Fibercementlam which is paper or polypropylene foil laminated fiber cement boards,

Table 1 - Technical specifications of main products in the product range of HekimConstruction in Turkey

Tolerance on length	±5 mm
Tolerance on width	±3% a (a: sheet width)
Tolerance on thickness	±10% e (smooth sheet) -10% e / +15% e (textured sheet) (e: sheet thickness)
Squareness of edges	± 2 mm/m
Straightness of edges	±0.1% a (a: sheet length or width)
Surface appearance	Smooth or textured (cedar texture)
Apparent density	1350 ±50kg/m^3
Diffusion resistance number	$\mu = 250$
Porosity	~30%
Modulus of rupture (smooth sheet)	~18.0 N/mm^2 (machine direction=longitudinal) ~12.0 N/mm^2 (transverse to machine direction)
Modulus of rupture (textured sheet)	~15.0 N/mm^2 (machine direction=longitudinal) ~10.0 N/mm^2 (transverse to machine direction)
Pressure strength	~30.0 N/mm^2 (perpendicular to sheet surface)
Tensile strength	~2.0 N/mm^2 (perpendicular to sheet surface)
Frost Resistance	Frost resistant according to TS EN 12467
Water impermeability	Impermeable according to TS EN 12467
Reaction to fire	Incombustible (A1 Class building material according to EN 13501-1)
Content of asbestos	Non-asbestos (NT type sheet)
Release of other dangerous substances	None
Thermal expansion coefficient	$\alpha_t = 0.005$ mm/mK
Thermal conductivity coefficient	$\lambda = 0.18$ W/mK
Water absorption ratio	30% (full saturation, including ambient moisture)
Moisture in storage	10% (subject to ambient moisture)
Hygrical movement	0.5 mm/m (full saturation)
Bending radius	~12 m

The fibercement products of HekimConstruction are mostly consumed in the domestic market but are also exported to many countries as directly sheets and sidings or as a component of final product such as prefabricated buildings and containers. The products are safely used in the countries having the climatic conditions from hottest to coldest. Table 1 summarises some mechanical and physical properties of lignocellulosic cement board in HekimConstruction.

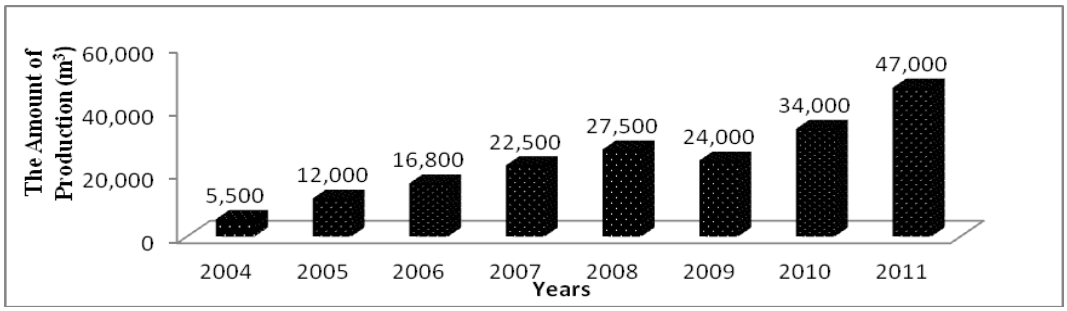

Figure 2 - Theamount of production (m^3) of main products in the product range of HekimConstruction in Turkey

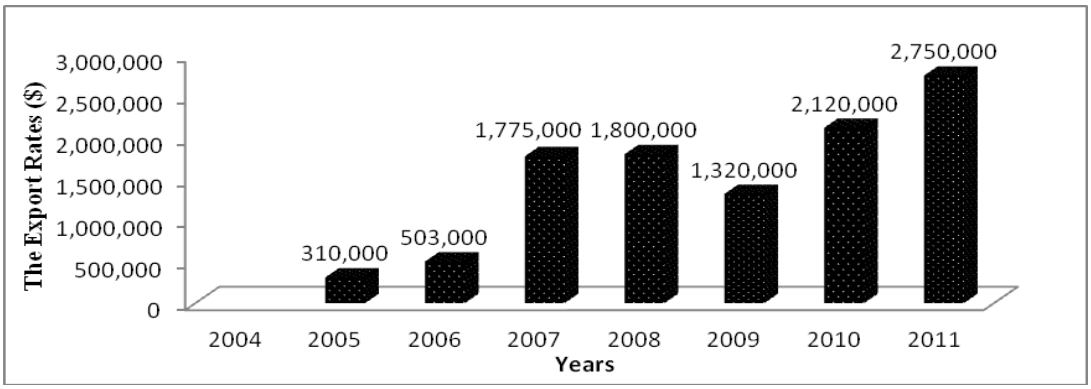

Figure 3 - The export rates ($) of main products in the product range of HekimConstruction in Turkey (1 euro is equal to 1.23$)

Table 2 - Annual usage quantities of raw materials as present (%) for HekimConstruction

Quartz	Cement	Cellulose
52.49	39.32	8.19

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Tepe Construction Company

TepeBetopanas a company of Bilkent Holding, set up betopan factory in 1984 in its Ankara Beytepe Facilities under its then parent company Tepe Group; marking the start of first Cement Bonded Particleboard production in Turkey. In 1999, the factory was upgraded by using modem technology systems, and the capacity was doubled.In 2001, another cement bonded particleboard factory in Arhavi district was acquired and subsequently TepeBetopan has become the sole producer in Turkey. In 2008, TepeBetopan gathered under a single roof all its factories in Ankara/Beytepe facilities and took its place among the leaders in the world, with an annual capacity of 80000 m^3.

In 2000, "stable and durable Betopan, Betopanplas" developed after long-lasting R&D studies conducted within the firm, was included in the product range. TepeBetopan took its place among the firms developing technology by launching the production and starting sale of betopanplus. TepeBetopan in addition to its first production of Betopan, has launched its "wood-patterned yalipan" and "stone-patterned tasonit" products following the production of betopanplus.

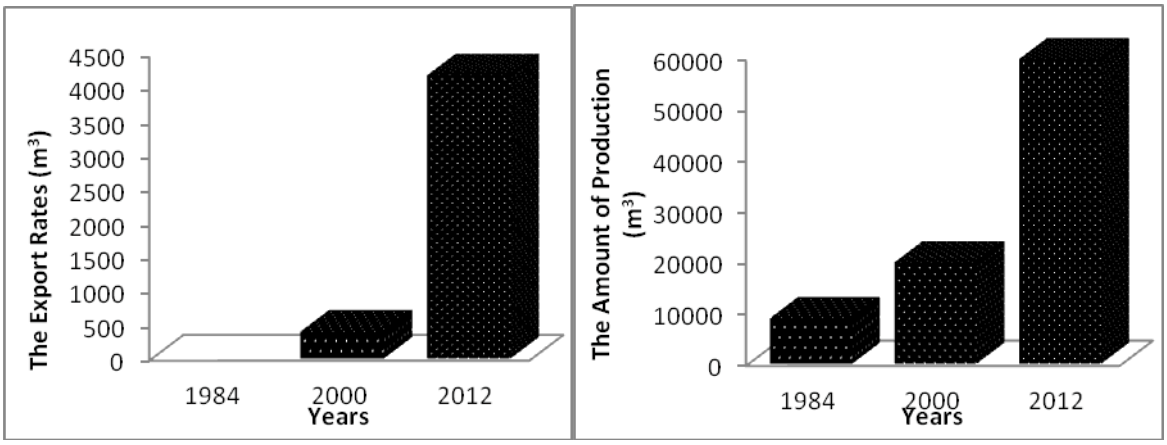

Figure 4 - Theamount of production (m^3) andThe export rates (m^3) of main products in the product range of TepeBetopan in Turkey

TepeBetopan with the power and dynamism stemming from research and development activities and respect shown towards production, has significantly contributed to the improvement of quality and the expansion in range of use of boards.

Table 3 - Annual usage quantities of raw materials as present (%) for Tepe Construction

Quartz (%)	Cement (%)	Cellulose (%)
52.49	39.32	8.19

In Fig 4, it is shown the amount of production (m^3) and the export rates (m^3) of main products in the product range of TepeBetopan in Turkey. TepeBetopan did not export in the early years. Then, it began to export 2 percent of total production in the 2000s. After that, TepeBetopan exported 7 percent of total production in the 2012. Table 4 summarizes the some mechanical and physical properties of technical characteristics of Betopan and betopanplus, yalipan and tasonit products in TepeBetopanConstruction. Table 3. shows Annual usage quantities of raw materials as present (%) for Hekim Construction

Table 4 - Technical specifications of main products in the product range of TepeBetopanconstraction in Turkey

	Betopan (unsanded) Cement Chip Boards	Betopanplus Cement Chip Boards with No Chip Surface
Unit Volume Weight **(14)	≥1000(1300±50kg/m^3)	1600kg/m^3(*)
Bending Strength **(8, 18)	≥9N/mm^2(CLASS1)	to production direction :9.3N/mm^2* to production direction 9.1N/mm^2*
Modules of Elasticity in bending **(18, 8)	≥4500N/mm^2 (CLASS1)	to production direction12865N/mm^2* to production direction:12567N/mm^2*
Internal bend **(11, 18)	≥0.5N/mm^2	0.96N/mm^2*
Internal bend after cyclic Test(TensionVertical to Surface)	≥0.3N/mm^2 **(12, 11, 18)	0.76N/mm^2(*)
Tensile Strength Parallel to surface	≥4N/mm^2**(19)	
Pressure resistance (Parallel to	≥15N/mm^2**(19)	

Surface)		
Swelling in Thickness after immersion in Water for 24 hours	≤1.5% **(11, 9)	%0.61(*)
Swelling in Thickness after Cyclic Test	≤1.5% **(12, 9, 18)	%0.60(*)
Screw Holding strength 10mm thick	168N for 4.2w 65 screw**(6)	
Screw Holding strength 18mm thick	300Nfor4.2w 65 screw **(6)	
Moisture Content **(17, 13)	%9±3	%7.60(*)
Biological durability **(16)	Risk of being affected by wood pests may be considered insignificant.	Risk of being affected bywood pests may be considered insignificant.
Thickness tolerance **(17, 15)	8-10mm±0.7mm, 12-14mm±1.0mm 16-18mm±1.2mm >18mm±1.5mm	8-10mm±0.7mm 12-14mm±1.0mm 16-18mm±1.2mm >18mm±1.5mm
Length and width tolerance **(17, 5)	Length: ±5mm width: ±5mm	Length: ±5mm width: ±5mm
Heat Transmission (λ) (between 8-12mm thickness at 10°C)	0.212W/Mk **(5)	
Heat Transmission (λ) (between14-20mm thickness at 10°C)	0.213W/MK, **(5)	
Heat expansion Coefficient (µm/mK) for 10mm thickness	11.45 **(3)	
Heat expansion Coefficient (µm/mK) for 18mm thickness	11.6 **(3)	
Fire Resistance, **(1, 2, 4)	Fire: B ,duman :s1, Droppingburnt:d0	
Dimensional stability (in length)(mm/m) 8-12mm thick in shadow according to	-1.0(65%-→35%RH) +0.4(65%-→85%RH) TS EN 318, TS EN 318	
Dimensional stability (in length)(mm/m) 14-20mm thick in shadow	-1.4(65→35RH) +0.3(65%-->85RH) **(10)	
Dimensional stability in length(mm/m) according to experiment on 12 mm unpainted Betopan,under the sun in Ankara on south facade	-5.9(initial material moisture12%)	-2.4(ınitial material moisture:9%)

Sound transmission loss(R) **(7)	29dBin10mm thickness 32dBin18mm thickness	31dB in12mm thickness 33dB in18mm thickness

*based on Experiment Report of T.S.E dated 28.03.03

**DIN 13501-1 (1), DIN 13823 (2), DIN 51045 (3), DIN EN ISO 11925-2 (4), TS EN 12624 (5), TS EN 1380 (6), TS EN 13986 (7), TS EN 310 (8), TS EN 317 (9), TS EN 318 (10), TS EN 319 (11), TS EN 321 (12), TS EN 322 (13), TS EN 323 (14), TS EN 324-1 (15), TS EN 335-3 (16), TS EN 634-1 (17), TS EN 634-2 (18), TS EN 789 (19)

Atermit Construction Company

Atermit Company was founded by Mr. EminOzgur in Adana province to produce roofing materials in 1956. This facility was the first Turkish facility to produce industrial roofing materials. Atermit Company is to manufacture construction, packaging and food packaging and automotive products in our 4 facility.

Atermit has been producing roofing and cladding materials since 1956. The first plant to produce fiber-cement flat and corrugated sheets was founded in Adana in 1956. This was followed by the Izmir and Gebze (Kocaeli) facility in 1977 and 1987 respectively. With the growing awareness of insulation in industrial buildings, Atermit diversified production with the introduction of insulated sandwich panels in 1994. Currently sandwich panels with EPS core are produced in Adana and Gebzefacility.

Atermit developed its own technology for the production of non-asbestos fiber-cement sheets (known as NT, New Technology) in 2006 and has been producing non-asbestos fiber-cement roofing and cladding materials ever since. With the development of asbestos-free roofing sheets the export markets have been revitalized and currently Atermit exports to more than 20 countries in Middle East, North and Central Africa and Western Europe. Fiber-cement corrugated and flat sheets and sandwich panels are complemented with single layer metal roofing products with various trapezoidal and sinusoidal profiled sheets for industrial roofing and metal tiles for residential buildings.

I can provide limited information about this company.

CONCLUSION

Cement and lignocellulosic material have been used as two basic materials of construction. The advantage of cement in lignocellulosic cement composite is its moisture resistance in wet areasand exterior surfaces. Even if left in water for 24 h, increase in thickness (swelling) of lignocellulosic cement is at a negligible level (less than 1.5%). It resists moulds and insects and pests because of its cement content.

According to Table 1 and Table 4, 1 cm thick lignocellulosic cement material provides the equivalent heat insulation of 10 cm concrete. Heat insulation given by a 8.4cm thick sandwich wall covered with lignocellulosic cement composite on both sides is equal to that of 39 cm wall with air gap. It is the strongest against impact loads when compared with similar materials and can be drilled and edges can be cut into forms, to form tongue and grooved and rebated joints and it is a light material. In accordance to investigations of TepeConstruction industry, due to high alkalinity (pH 12-13) and density, lignocellulosic cement composite is resistant to biological wastes and the effects resulting from environmental pollution. In excessively moist location, its sensitivity against mold and mildew over and underground has been tested. No mold or mildew was seen on board over the ground, and some mildewing traces were found on boards buried underground for 8 years. However, this deterioration remained within 0.9 mm thickness (at surface). It was found (in a test made in open space for pest formation) that the boards were not affected by pests for general lignocellulosic composites.

Because of the amount of production, the export rates and technical specifications of main products, the lignocellulosic cement industryin Turkeygrows with each passing day.and Turkey also begin to take its place in world market for this sector. Some special organization also is planning to invest about lignocellulosic cement composite.

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REFERENCES

Appropriate building materials for low cost housing (1982). International Council for Building Research Studies and Documentation, International Union of Testing and Research Laboratories for Material and Structures, vol. 2. 1985.

Coutts R. S. P., (2005), A review of Australian research into natural fibre cement composites, Cement & Concrete Composites 27 (2005) 518-526

Robert S.P. Coutts (2005). A review of Australian research into natural fibre cement composites, Cement& ConcreteComposites27 (2005) 518–526

Soroushian P., Elzafraney M., Nossoni A., Chowdhury H. (2006). Evaluation of normal-weight and light-weight fillers in extruded cellulose fiber cement products, Cement & Concrete Composites 28 (2006) 69–76

Swamy R. N. Fibre reinforced cement and concrete (1992). In: Proceedings of the Fourth International Symposium held by RILEM, Sheffield,July 1992(Spon,London,1992).