Treatment of Natural Fibers for Improving Cement Composites Behavior-An Overview

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Abstract

Fiber-reinforced concrete (FRC) provides a convenient, practical and economical solution for reducing the microcracks and other similar types of deficiencies to enhance the properties of concrete. Natural fibers have a rough surface and absorb water, which decreases the strength of concrete with the passage of time. The improving of the natural fiber properties is necessary to enhance the surface of the fibers, reduce water absorption of the fibers and enhance the strengthening properties like flexural strength and ductility, etc. which intern enhance the properties of composites. For this purpose, different types of treatment techniques are used on natural fibers for improving their surface and enhance the properties of fiber-reinforced composites. In this paper different papers studies about the properties of natural fibers, the use of natural fibers in composites, treatment techniques used for enhancing the properties of the natural fibers, and effects of the treatment techniques on natural fiber for improving the composite behavior. To achieve these goals, the treatment techniques used on natural fibers to smooth the surface of the natural fibers and make fiber resist the absorption of water. The treatment techniques used for this purpose are chemical, physical, and surface treatment to improve the properties of the natural fiber and make the fiber more durable and sustainable than the non-treated natural fibers. The different treatment techniques of fibers used not only improve the contact between fiber and concrete but also increase the natural fiber's strength as well as reduce the water-absorbing capacity of concrete and mechanical properties of natural fibers increased which clearly show the enhancement of the behavior of the composite using treated natural fibers in the composites.

Keywords: *Natural fibers reinforced concrete, treatment techniques of natural fiber, enhance properties, reduce water absorption.*

I. INTRODUCTION

Pakistan is one of the amongst developing countries where natural fibers are abundantly available. The utilization of natural fibers for use in concrete has great interest nowadays, which making economical materials for infrastructure. The natural fibers like wheat straw etc. before used in clay works as well for reducing the number of cracks and cracks width in clay for use in houses and increase the contact on the wall as well as the ground. Nowadays the natural fibers used in concrete increase the properties of concrete as they are abundantly available at a very low cost [1]. The replacement of man-made fibers in concrete by natural fibers reduces the environmental problem as well as reduces the cost of concrete and improves the properties of concrete as like man-made fibers [2].

Fiber-reinforced composites play important role in Civil Engineering applications because of their efficient strength, high modulus, and reduced carbon content in the environment. Natural fiber from coir, oil palm, sisal, banana, jute, bamboo, rice husk, and kenaf, etc. are environmentally friendly materials that proved to be good reinforcement reducing the density and cost of the composites [3]. Natural fiber-reinforced composites have high corrosion and impact resistance, low maintenance requirements, and non-conductive. Different types of Fibers used as reinforcement material in concrete were glass, carbon, aluminum oxide, and Natural fibers, especially flax, hemp, jute, henequen, and many others were applied by researchers as fiber reinforcement in concrete.

Natural fibers used in concrete have low density, low cost, recyclable and biodegradable [4]. The mechanical properties of natural fibers are good and can compete with other types of fibers in strength and modulus. Natural fiber can be used in concrete for improving the properties of concrete and reduced the cost as well as reduce environmental problems [5]. The natural fiber also reduces microcrack, shrinkage cracks, and also increases the strength of the composites-like synthetic, artificial, and other man-made fibers. However, replacing other kinds of fibers with natural fibers, which take time, using cost for producing give economical solution to prepare fiber reinforced concrete. The main advantages of using natural fibers in composites are the environmental aspect as natural fibers absorb carbon content from the air especially plant fibers. The pineapple leaf (PALF) which has good flexural and tensile properties can be useful for construction and automotive industries [6].

This paper gives information about the different types of natural fibers using in composites for enhancing the composite behavior, using the treatments techniques for natural fibers for improving composite behaviors. For this purpose, different papers studied natural fiber using in composites, treatment techniques used for natural fibers, and their effects on natural fibers. The different techniques used for natural fiber commonly are physical, chemical, and physiochemical treatment techniques which depend on the fiber types, required properties of the fibers to be achieved. This paper

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basically about the need for treatment of fibers, types of treatment using and their effects on the behavior of composites.

II. USE OF NATURAL FIBERS IN CEMENT COMPOSITES

Natural fiber using in concrete and plaster, which improve the sustainability of the composite at low cost and abundantly available in many countries especially plant-based fibers [7]. The researchers utilizing natural fibers in construction to reduce waste, improve the construction material properties, and get low-cost construction materials. For improving the dynamic properties and impact resistance of concrete panels jute fiber is used as a reinforcing material, which improves properties and reduces the steel reinforcement up to 30% [8]. Some natural fibers like wheat straw were also used in concrete which shows enhance flexural strength up to 7.5%, toughness indices 11.1%, and energy absorption up to 30.4% [9]. The natural fibers were used in concrete for the road with a content of silica fume which enhances the mechanical properties and results in the reduction of road thickness up to 8% [10]. Types of fibers show in figure 01 below.

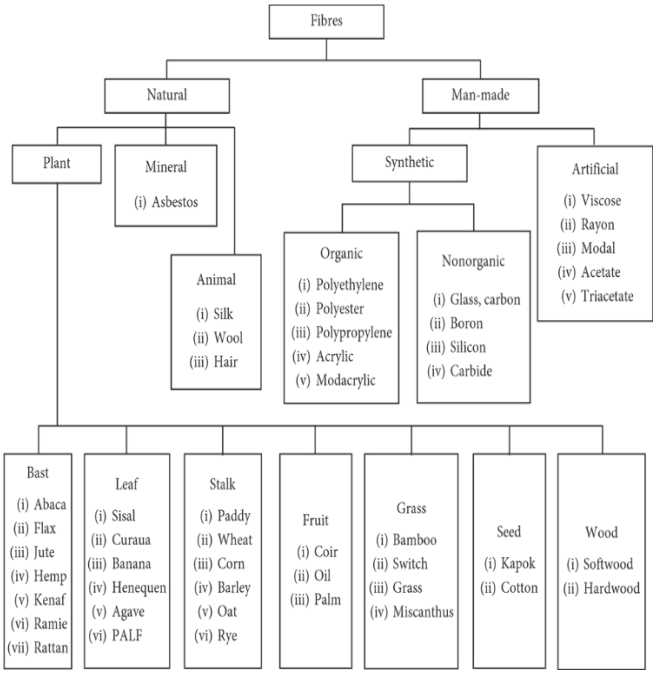

Figure 01: Fiber Classifications [11]

Natural fibers are used in plaster as well which effectively show lateral resistance of the mortarless interlocking masonry structures like sisal fiber and rice straw fibers [12]. A lot of work done on coconut fibers for use in concrete to enhance the properties of concrete and uses the ropes of coconut fiber as well in structural members which show improve in the lateral resistance of the structural members and improve dynamic properties of the structural members effectively [13]–[17]. Nowadays research work in progress on hybrid fibers which show better performance than the single fiber used in concrete to improve the fiber reinforced concrete properties and reduce cracks propagations [18]. The fibers using concrete enhance the properties like toughness indices, flexural strength, tensile strength and reduces wasting of materials as well as reduces cracks and cracks propagation of the fiber-reinforced concrete.

III. CHARACTERISTICS OF NATURAL FIBERS

The natural fibers are obtained from the product that is used, it is a waste material obtained from the waste of the product, and their use in concrete as fiber-reinforced concrete gives an economic solution for improving the concrete properties [19]. The natural fibers have low durability as they deteriorate in the alkaline cement matrix due to erosive behavior [20]. Table number 01 shows the chemical composition of the natural fibers as shown below.

Table 1. Chemical composition of Common Natural Fibers [21]

Fiber	Cellulose (%)	Lignin (%)	Hemicellulose (%)	Pectin (%)	Ash (%)
Fiber Flax	71	2.2	18.6 - 20.6	2.3	-
Seed Flax	43-47	21-23	24 - 26	-	5
Kenaf	31-57	15-19	21.5 - 23	-	2-5
Jute	45-71.5	12-26	13.6 - 21	0.2	0.5-2
Hemp	57-77	3.7-13	14 – 22.4	0.9	0.8
Ramie	68.6-91	0.6-0.7	5 - 16.7	1.9	-
Abaca	56-63	7-9	15 - 17	-	3
Sisal	47-78	7-11	10 - 24	10	0.6-1
Henequen	77.6	13.1	4 - 8	-	-

The chemical composition of common natural fibers shown in table number 01 which contain different content on different proportions. The treatment techniques improve not only the surface of the fiber but also enhances the chemical composition of the natural fibers. The treatment technique type using for natural fiber treatment depends on the type of fibers or chemical composition of the fiber as well to enhance the properties of the fiber to required or up to some level.

IV. TREATMENT TECHNIQUES USED

As natural fibers used in concrete have a rough surface, which causes a weakness in the bond between fiber and matrix. The natural fiber has water absorption capacity which tends to deteriorate the composite with the passage of time. The untreated natural fiber has low durability, sustainability, weak bond, and corrosive nature. To enhance the properties of fiber-reinforced concrete different treatment techniques of surface improving are used, which include physical treatments, chemical treatments, and physicochemical treatment techniques to modify the natural fiber surface and improve the desired properties of fibers. These treatment techniques are used mostly for the plant fibers to enhance their properties and to increase the life of the composite. These fiber treatment techniques are necessary to enhance the strength properties of the fibers and improve the durability of the fiber which in result will enhance the properties of the fiber-reinforced concrete. The different treatment techniques used for modification of natural fibers are followings. As can see different treatment techniques are using for fiber to improve the properties of the fibers. The technique selected for fiber treatment depends on the fiber properties improving and types of fiber. The most common techniques using are Physical treatment,

Chemical treatment, and Physiochemical treatment which are selected on the basis of fiber type and required properties to achieve.

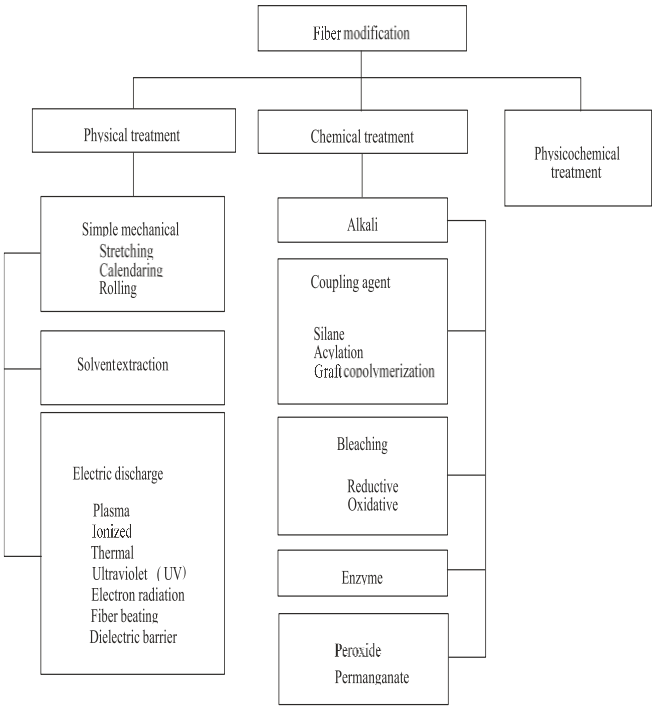

Figure 02: Fiber Modifications [11]

A. *Physical Treatment*

The physical treatment technique used for natural fibers can change the surface and structural characteristics of natural fibers, improve thermal properties as well as the mechanical bonding of the concrete without affecting the chemical characteristics of natural fibers. These treatment techniques are implemented on natural fibers only to separate the bundle of fiber into a single filament to improve their surface and other properties for composite applications. Physical treatment includes solvent extraction, simple mechanical and electric discharge techniques.

B. *Chemical Treatment*

The chemical treatment technique is used for the purpose of changing and activate the natural fiber structure by using a hydroxyl group, which modifies the composition of the fiber with a new element to connect with the matrix. By using chemical treatment techniques for the fiber modification increase the mechanical properties of the fiber and adhesion of the fiber for increasing the bonding of the fiber in composites and reducing the water absorption capacity of concrete. Chemical treatment includes Alkali, coupling agent, enzymes, and peroxide techniques.

C. *Physiochemical Treatment*

The physicochemical treatment technique is a combination of both physical and chemical treatment techniques. This technique has an advantage on physical and chemical techniques using separately because it is the combination of both techniques to support the chemical reaction as well as separate the bundle into filaments. This type of treatment provides high quality of fibers and these fibers have good mechanical properties and show significant improvement in mechanical properties of fibers.

V. EFFECTS OF TREATMENT OF NATURAL FIBERS ON COMPOSITE BEHAVIOR

The method used on natural fibers of surface treatment shows improvement in mechanical properties of concrete such as tensile, compressive, and flexural strength of the natural fibers as well as enhance the durability and sustainability of natural fibers as compared to untreated natural fibers. The bamboo fiber was treated with Ca $(OH)_2$ for the reinforced cement composite which enhances the properties of fiber and increases the flexural strength of the composite up to 40% after 90 days of curing period the untreated fibers [22]. The Kenaf fiber used in cement treated sandy soil was efficiently shown in enhancing the properties like unconfined compressive strength, splitting tensile strength, and decrease the brittle indices, modulus of elasticity, and ultrasonic wave velocity [23]. The treated coir fiber of 1% and pond ash 10% used with 4% of cement content in the cement-stabilized clay which enhances the unconfined compressive strength 3.72 times and split tensile strength 3.83 times while reducing the stiffness and brittle behavior of the composite change to ductile behavior [24]. Treated Hemp Fiber Reinforced Composite (THFRC) and untreated Hemp Fiber Reinforced Composite (UHFRC) properties are shown in table number 02.

Table 2. Effects of treatment on properties of Hemp Fiber [25]

Type of Fiber	Age (days)	Flexural Load (N) p_{max}	Modulus of Elasticity E(MPa)
UHFRC	14	1,907	17,584
	28	2,325	20,481
THFRC	14	2,158	17,015
	28	2,488	18,279

From table 02 it can be seen that the load sustained by THFRC is 7-13% more than the UHFRC while the modulus of elasticity of THFRC is 3-11% less than the UHFRC. This means that the flexural strength ductility of the composite increased by treating the hemp fibers. The flexural strength and ductility of the coconut fiber-reinforced composites also increased by treating the coconut fibers [26].

VI. CLEANER PRODUCTION

Cleaner production is basically the process of product and production process which focuses on utilizing the natural resources to minimize the waste generated. The utilization of natural resources like natural fibers in composites gives a better solution for reducing waste. As waste pollution is a major issue in many developing especially in Asia's countries. This waste of the natural fibers can be reduced by using the natural fibers in composite like in concrete, plaster. As natural fibers improving the properties of the composite like flexural strength, durability, ductility, and reducing the number of cracks as well as the propagation of the cracks of the composites. So, utilizing the natural fibers in composite gives a better solution for reducing waste pollution.

VII. CONCLUSION

The treated natural fibers used in composites show improvement in the behavior of the composites as compared to using untreated natural fibers. It has been observed from the review of the papers that treatment techniques used for natural fibers improve the

strength of the fibers, improve water absorption resistance of the fibers, and improve durability as well as the ductility of the composites. The selected treatment techniques depend upon the natural fiber type and the required properties of the fibers to be improved. The utilization of natural fibers reducing waste pollution as well which a major issue in many developing countries.

The following conclusion is made from the treatment of fibers

1. Treatment techniques used on natural fiber increase the quality of NF for use in concrete.
2. Treatment techniques of natural fiber increase the bonding strength of fiber and matrix.
3. Treatment techniques of natural fiber increase the durability as well as the sustainability of fibers.
4. Treatment techniques of natural fiber reduce water absorption of the fiber.

The replacement of man-made fibers in concrete with natural fibers has great potential nowadays. The natural fibers using in concrete reduce environmental problems and well as it has very low cost and economical which abundantly available. As the treatment techniques using on natural fibers improve the quality of fibers and enhance their mechanical properties of natural fibers. The bonding strength of fiber and matrix is also enhanced by treatment of NF as well as improving the durability and sustainability of NF. As the natural fiber has the capacity of absorbing water which can be reduced by the treatment of fibers. The physicochemical treatment is getting intention then using separately physical or chemical because it shows that it improves both physical as well as chemical properties of natural fibers. Natural Fiber as fiber-reinforced concrete will be very useful for utilizing to avoid waste pollution caused by natural fibers and enhance the concrete properties.

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