Date Palm Fiber(DPF) and its Composites: A Comprehensive Survey

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Date Palm Fiber(DPF) and its Composites: A Comprehensive Survey

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Abstract

Concrete has a very complicated system since it is establish mineralogical by several ingredients; whose effect is significant throughout loading of the constructional element.Due to its various nature and eco-friendly properties, natural fibers and its composites take a wide field of study from different researchers. Natural fibers have several advantages that make them widely used in the new industries, the most important benefit are biodegradable nature, continual source, easy handling and harmless treatment. While natural fibers showgorgeous mechanical and physical properties differ with the herbal source, classes, topography, and so forth. Annually, large amount of natural fibers are collected and unused everywhere in the world.Date Palm Fibers (DPF) can be an innovative gate of engineering material and can be prospective alternate of the costly and non-renewable manufactured fiber.The use of this fiber in engineering application as an original material would add to the worth of natural and sustainable wealth. Though, few studies on DPF have existed prepared defining the interfacial bond through fibers and composites but a full researches on DPF properties and its applications in civil field is not obtainable. This paper collected the basic details of DPF and compares the physical, mechanical and chemical characteristics with other natural fibers. Moreover, it abstract the previous effort collected on the introducing of DPF in concrete and cementitious composites and the behaviour of reinforced element like, strength, thermal shrinkage, thermal conductivity, and thermal insulation and so on after inclusion of DPF. This studyaims to find the probability of using date palm fiber as a raw material in construction industries.

Keywords: *Date Palm Fiber (DPF); local wastes; reinforced concrete; sustainability.*

1. Introduction:

Energy consumptions in one of the greatest and important challenges in construction field all over the world [1].The United Nation Environment Program approximates that constructions consume about 40% of the world total energy, 25% of the overall water, 40% of the overall resources; structures are also responsible of about 1/3 of greenhouse gas emissions of the whole planet [2][3]. Many studies have been conducted to investigate the potential possibility to employ plant wastes in concrete, as cement replacement, aggregate replacement as well as fiber reinforcement [4][5].Because of its peculiar characteristics and eco-friendly nature, the composites that are reinforced with natural fiber are under intensive study. Unremitting source, biodegradable nature and safe and easy handling are the most important advantages of natural fibers. It differs with plant source, geography, species and so forth [6][7].Indeed, the last years were noticeable by aintensegrowth in the use of agricultural waste as natural fibers like leaves from flax, jute, hemp, pineapple, sisal and date palm for making a new type of environmentally- friendly composites [6][8].

Date palm (*Phoenix dactylifera*L.) is a dioecious fruit tree to the hot arid regions of the world, generallyfounded in the Middle East, and North Africa[9]. In addition to be a source of delicious fruits which can be eat fresh, dried or processed, providing a nutritious source of sugars, minerals, and vitamins, date palm trees provide raw materials for furnishings, housing and a lot of handcrafts.Economically, date palm offers a main source of income for local farmers and associated industries in communities where it is grown[10][11][9].In this paper more information about the date palm fibers and a range of results on the performance of date palm fiber (DPF) reinforced concrete, like, strength, thermal shrinkage, thermal conductivity, and thermal insulation are present. The aim of

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this review is to study the possibility of introducing DPF as alternative material in construction projects.

2. Natural fiber

Natural fibers found in all plants and animals, and have graded structures that generally show multifunctional behaviour [12]. Combination of these incorporated microstructures and micro-mechanisms provides considerable prospective to engineers in the designing and improvement of composite material performance [12]. These fibers have several advantages such as low cost, biodegradability, renewable, their availability everywhere and show less health and safety concern during handling and processing [10][13][14][15]. These properties favour the use of natural fibers as reinforcement on the matrix[16].Concerning to environmental safety and recyclability, natural fiber has proven to be suitable reinforcement material with its good physical properties [12][17].In the last few years, many effort has been accomplished to natural fibers to substitute synthetic fibers [18][19].The choice of these materials and the measure of their profitability are based on few criteria, such as availability and cost of treatment. [20]. Natural fibers can be employed in concrete especially in developing countries and countries that need low-cost construction[4]. Cotton fiber [8], Sisal fiber [21], Flax fiber [22], Jute fiber [8],Coconut fibers[23] and others are examples of naturals fibers that are used by different researchers as alternative fiber in concrete and other construction materials. These natural fibers offer an promising alternatives to costly synthetic fibers that is also having an impact on environment[24]. The effective introducing of natural fibers derived from renewable sources offers environmental benefits with respect to utilization of raw material and ultimate disposability [12].

2.1. Date Palm Fiber

Date palms are categorized as female and male tree. whereas the female palm trees generate flowers, the male palm trees generate pollen[25]. Date palms consist of fibrous structure and haveeightparts of fiber: rachis, petiole, fibrillium (mesh), leaflets, trunk, pedicels, bunch andsurface fibers (around the trunk) see Figure 1. Every yearafter trimming setups, huge quantities of DPF wastes are disposed, excluding in minor scales used for artist[1].Wood from date palmused as insulation materials in building, meanwhile it is a renewable and abundant material.Its estimated annual production all over the world is over 1,200,000 tons of petioles, 410,000 tons of leaves and 300,000 tons of bunches [26].

2.1.1 Characteristics of date palm fiber

Date palm fibers are considered as one of the most available natural fiber types worldwide. Annually, huge amounts of date palm biomass wastes are accumulated without accurate operation [27]. From the economical and environment view, the utilization of fibers from the date palm tree is a promising project. Many studies investigate the reinforcement of composites with DPF. This study investigates the mechanical and physical characteristics of date palm wood and its use as a composite substance. More information on these properties is required in order to improve the industrial process and materials [10]

2.1.1.1 Lignocellulosicorgano-components

Natural fibers (NF) have a very complex microstructure consist of cellulose, hemicelluloses, and lignin, in the cell wall. The main part is cellulose that forms in a linear polysaccharide with high degree of crystallinity and regularity, which give the natural fiber its strength properties. Hemicelluloses consist of heteropolysaccharides made up of pentoses, hexoses and sugar acids with a random and amorphous structure. Lignin is a phenol propane-based amorphousresin that fills the spaces between the polysaccharide fibers, occupying mainly the middle lamella of NF cells and providing shape and structure to the NF. These constituents differ among NF species and affect the physical, mechanical, and thermal properties of the resulting polymer composites[28].Vegetable fibers classified as natural compounds with a cellular microstructure[24]. Each type of natural fiber has its proportions of cellulose, lignin and hemicellulose create the diverse layers. Table 1 present the lignocellulosicorgano-components of DPF compared with some other natural fibers.

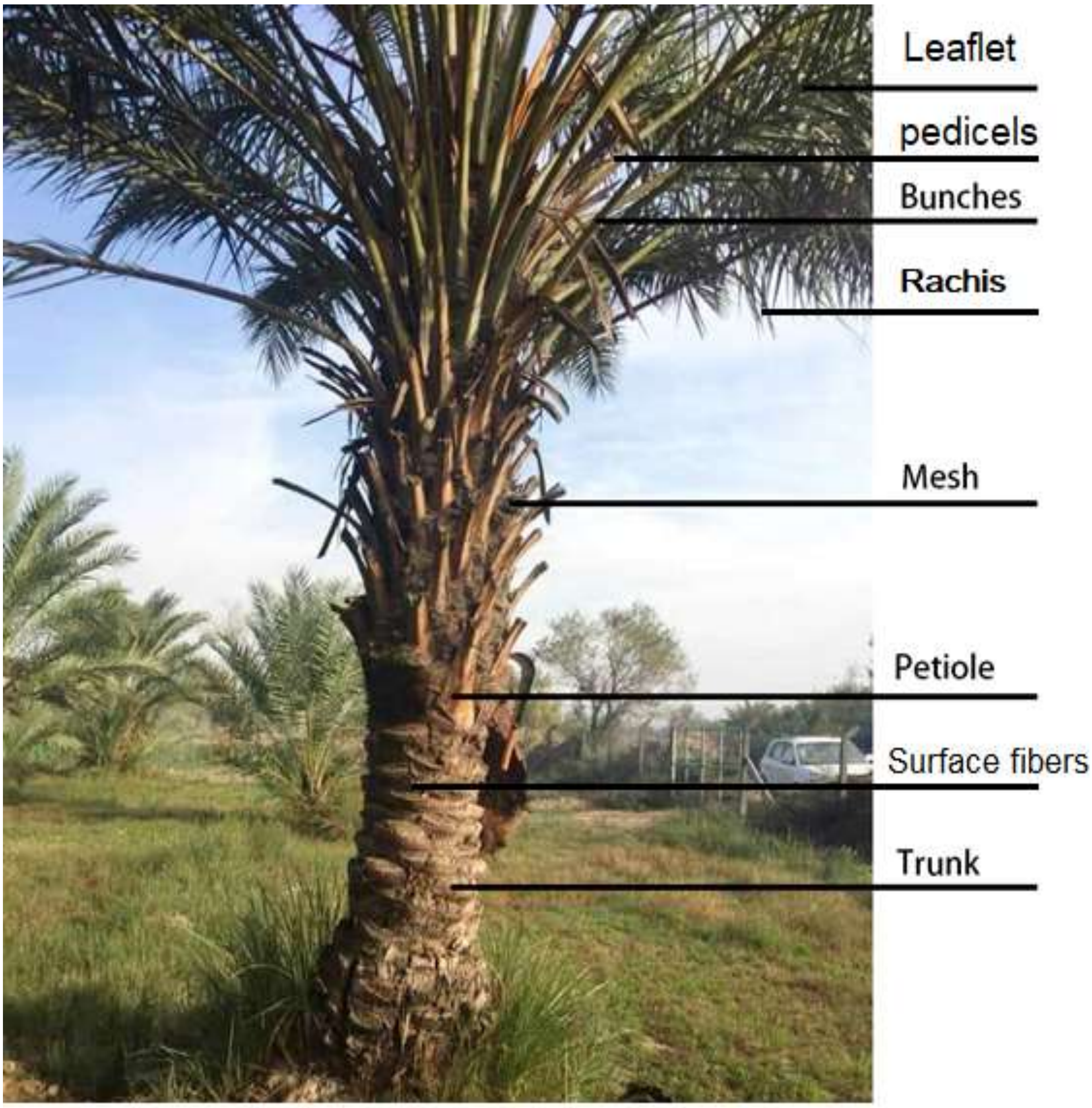

Figure 1. Photograph of date palm plant.

Table 1.Lignocellulosicorgano-components of DPF compared with some natural fibers.

Fiber	Reference	Cellulose wt%	Hemicellulose %	Lignin %	Ash %	Extractives %
Surface DPF	[29]	43 ± 2	8 ± 2	35 ± 5	1.2 ± 0.3	---
Fibrillium (Mesh) DPF	[30]	43.94	21.68	27.80	1.55	4.32
Leaflets DPF	[30]	38.58	20.05	28.57	2.62	9.56
Pedicels DPF	[30]	33.29	21.15	27.64	3.05	5.89
Petiole DPF	[30]	33.79	20.44	26.03	3.70	13.86
Jute	[8]	45 – 71.5	13.6 – 21	12 – 26	0.5 – 2	---
Sisal	[21]	33.2 - 88.0	10.0 - 26.0	3.8 - 20.5	---	---
Bamboo	[31]	76.0	8.8	14.4	---	1.5
Coconut tissue	[23]	29.7	31.05	19.22	8.39	1.74
Coconut coir	[23]	46.48	21.46	12.36	1.05	8.77

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It's clearly to notice that the cellulose content for surface and fibrilliumfiber DPF (43%) is higher than other date palm fiber.This cellulose value is nearly to that for jute and coconut coir fiber. On the other hand these two kinds of fiber branded by low ash contents (1.2-1.5 %) which are very close to Jute and coconut coir. This low ash content can positively affect the processing machinery[32].It's clearly to note thatleaflets and petiole (9.56 and 13.86)are categorized by high quantities of extractives similar with coconut coir (8.77). The high extractives in petiole and leaflets derived as an benefit for decline resistance when used as compressed wood[30]. Moreover, cellulose high content in pedicels (33.29) and fibrillium (43.94)increase the resistance in alkaline and acidsolutions which makes these part of date palm more suitable to reinforce alkaline medium[30].

2.1.1.2 Physical Properties

Table 3 presents the physical properties of the varieties of date palm fiber. It could be noted that surface fiber has higher values of absolute density (1300-1450) kg/m^3 similar with jute fiber (1300–1460) kg/m^3[8] in relation to the other kinds of fiber reported in this table. On the other hand water absorption to saturation value for the Petiole (146.32 ± 21) % and Fibrillium (115.11 ± 15.7) % fiber noted to be higher than other date palm fibers and other natural fiber.

Table 2.Physical properties of Date palm fiber and some natural fibers.

Reference	Fiber type	Bulk density (kg/m^3)	Absolute Density (kg/m^3)	Natural moisture content (%)	Water absorption to saturation (%)
[33]	Surface DPF	512 -1089	1300 - 1450	9.5 - 10.5	97 - 203
[30]	Petiole DPF	160 ± 54	866 ± 20.5	---	146.32 ± 21
[30]	Leaflets DPF	411 ± 41.4	830 ± 23.6	---	96.6 ± 1.4
[30]	Pedicels DPF	425 ± 23.6	749 ± 25.6	---	73.78 ± 3
[30]	Fibrillium DPF	209 ± 31.7	786 ± 23.6	---	115.11 ± 15.7
[21]	Sisal	900	---	10.4 - 13.3	110.0 - 240.0
[8]	Jute	---	1300–1460	12	---

2.1.1.3 Mechanical properties

The elongation at break, modulus of elasticity and the tensile strength values of each part of date palm fiber compared with some natural fiber are summarized in Table 3. Date palm fibers have a slight difference value in mechanical properties according to its part for example; surface fiber has the maximumrate of tensile strength of (170 MPa) andmodulus of elasticity (4.74 GPa), whereas pedicels fiber has the lowest tensile strength (86 MPa) and modulus of elasticity of (3.00 GPa). Petiole DPF has the lowest Elongation value of (0.95 %), while surface DPF has the highest value of (16 %). This variation in properties because of its physical and chemical characteristics[30] (high content of cellulose as shown in Tables 1 and 2).

Table 3.Mechanical characteristics of date palm fiber compared with some natural fibers.

Reference	Fiber type	Tensile strength(MPa)	Elongation %	Modulus of elasticity (GPa)
[33]	Surface DPF	170 ± 40	16 ± 3	4.74 ± 2
[30]	Petiole DPF	90 ± 8.87	0.95 ± 0.42	7.00 ± 2.00
[30]	Leaflets DPF	100.12 ± 43.87	2.68 ± 0.49	4.00 ± 1.33
[30]	Pedicels DPF	86 ± 5.00	2.37 ± 0.15	3.00 ± 1.00
[30]	Fibrillium DPF	90 ± 30,70	4.59 ± 0.90	3.66 ± 2.33
[8]	Cotton	287 – 597	3.0 – 10.0	5.5 – 12.6
[21]	Sisal	137 – 577	---	15.2 – 34.0
[22]	Flax	345 – 1500	1.2–3.2	27.6 – 80
[8]	Jute	393 – 800	1.5 – 1.8	10 – 30

3. Date Palm Fiber in Concrete Matrix

One of the most important materials that's used all over the word is concrete[23]. Because of containing different materials, concrete has a complexmicrostructure;in which the influence is significantthrough loading of the structure [34].Phoenix dactylifera date palm is the one of the most cultivated palms in the world. It is usuallyconcentrated in the Afro-Asiatic dry-band, which spread from North Africa to the Middle East. It has a good tolerance to cold and dry-hot climates[9]. The performance of the natural fibers in the concrete primarily depends on the phenomenon of adhesion between the latter and the matrix [13]. Different researchers focused on studying the influence of inclusion DPF as reinforcement in concrete matrix. Some of them try to use date palm fiber as a shrinkage reducing admixture; others fined the ability of DPF to improve the thermal performance of concrete. Table 4 cover the articles that deal with concrete reinforcement with different types and parts of date palm fibers.

This paper offers more info and range of results on the behaviour of DPF composites.

As shown in Table 4, concrete reinforcement with date palm fiber has advantage and trend-off. The main outcomes of using DPF in concrete can be concluded as follow:

3.1. Shrinkage

Drying shrinkage is one of the most dangerous problems that lead to the deterioration of concrete structures. Dying shrinkage can be occur due to the difference in relative humidity and ambient temperature cause variations in the properties of hardened concrete which can affect their mechanical and drying shrinkage characteristics [38].The effect of introducing date palm fibers on early age (EA) shrinkage and hardened properties of concrete in hot-dry climate and laboratory condition was reported [36],[9] and [29].The effect of date palm fiber in reducing EA drying shrinkage and risk of SCC cracking was similar with shrinkage reducing admixture. The low volume of DPF addition was enough in reducing cracking and EA drying shrinkage in hot-dry environment. (0.1 % with 2cm length) were acceptable in EA drying shrinkage reduction by 50% comparing with plain SCC specimens. On the other hand slightly decrease in compressive strength of SCC by adding DPF as reported in Table 4. The insertion of low quantities of DPF has not noticeable effect on the physical, mechanical and hardened performance of self-compacting properties[29].

3.2. Thermal properties

Since the beginning of the 20th century, engineering researchers take consideration to improve the insulation properties of building materials. The innovative construction materials and structures afford a lot of benefits and some disadvantages in terms of the comfort conditions of buildings [39][40]. Current cooling, heating and air-conditioning systems for buildings contribute significantly in an opposite way to the concept of sustainable development [41].Agoudjil et al. characterized palm wood and found a thermal transmittance similar to common insulating materials. Asdrubali et al. present a review of thermal properties (thermal conductivity, specific heat and density) of unconventional and sustainable materials finding in natural wood based materials competitive properties in comparison with conventional commercialized insulation materials (e.g. Date palm, Durian peel, Oil palm fiber)[41].The influence of the date palm fiber/lime ratio on the behaviour of the lightweight aggregate was studied by Belakroum *et al.* systematically [36]. The thermal conductivity is sensitive to the variation of the fiber/lime composition ratio. The measured thermal conductivity reached a minimum of 0.091 W/m.K for samples of 50% fiber, which indicates that it can be used as a good thermal insulator. Also A. Djoudi et al fined that trunk fiber can decreased thermal conductivity and thermal diffusivity even when little percentage of DPF were used [32].

Table 4.Date palm fiber application in concrete.

Part of Date palm fiber	Usage	Type of fiber and its details	Effect of usage of DPF in concrete	Reference	Fibers treatment
Surface fiber	Fiber reinforced concrete	Gender (male tree); Position (surface fiber); Fiber length (1.5-6)cm; Fiber Diameter (0.2-0.8)mm; Fiber percentage (0, 2 and 3)%	First cracking strength (decreased); Maximum post-cracking (improved); Continuity index (increased); Compressive strength (decreased); Flexural strength properties (improved); SEM test (amorphous).	[9]	Under water, the separation process into individual fiber becomes more easer.
Surface fiber	Fiber reinforcement in concrete	Gender (male tree); Position (surface fiber); Fiber length (1.5-6)cm; Fiber Diameter (0.2-0.8)mm; Fiber percentage (0, 2 and 3)%	First cracking strength (increased); Load and the maximum load ratio obtained from bending test (increased); and SEM test (amorphous).	[35]	Fiber submerged in three typesof alkaline solutions: sodium hydroxide, calcium hydroxide and Lawrence solution. The pH value reaching 12.5 and 12.95.
Surface fiber	Fiber reinforced self-compacting concrete	Gender (male tree); Position (surface fiber); Fiber length (1-2 and 3)cm; Fiber Diameter (0.1-0.8)mm; Fiber percentage (0.1, 0.5 and 0.2)%	Workability (decreased); Compressive strength (decrease in hot dry curing); Shrinkage (decreased).	[1]	DPF are dragged from trunk in nearly rectangular mesh formed with three or four superposed layers. Under water, the separation process into individual fiber becomes more easer.
Surface fiber	Fiber reinforced self-compacting concrete	Gender (male tree); Position (surface fiber); Fiber length (1-2)cm; Fiber Diameter (0.1-0.8)mm; Fiber percentage (0.1 and 0.2)%	Early age drying shrinkage (reduced); Evaporation rate (reduced); Cracking risk (reduced); Compressive strength (slightly reduced); Internal temperature (not affected)	[29]	The heating treatment starts with boiling Cut date palm fiber. After that, draining the water and, finally, carefully washing to the fibers is necessary to take away all traces of organic matters.
Trunk fiber	Fiber reinforced hemp concrete	Gender (female tree); Position (trunk fiber); Fiber length (---)cm; Fiber Diameter (---)mm; Fiber percentage (20, 30, 40 and 50)%	Thermal characterization (reduced); Moisture buffer value (excellent); Bending test (reduced); Compressive test (reduced); Sound absorption measurement (medium and high frequencies);	[36]	Not reported

Trunk fiber	Fiber reinforced plaster concrete	Gender (---); Position (trunk fiber); Fiber length (2,3 and 4)cm; Fiber Diameter (0.2-1)mm; Fiber percentage (1, 1.5 and 2)%	Thermal conductivity (decreased); Thermal diffusivity (decreased).	[37]	Under water, the separation process into individual fiber becomes more easer.
Surface fiber	Fiber reinforced concrete	Gender (male tree); Position (surface fiber); Fiber length (2-4 and 6)cm; Fiber Diameter (0.1-0.8)mm; Fiber percentage (0.2, 0.3, 0.4, and 0.5)%	Bending resistance (increased)	[33]	(MDPSF) rectangular mesh (30-50 cm length and 20-30 cm width) shaped with three superimposing layers. Under water, the separation process into individual fiber of diameter of 0.1-0.8 mm becomes more easer.
Petiole fiber	Fiber reinforced concrete (mortar)	Gender (---); Position (petiole fiber); Fiber length (5)mm; Fiber Diameter (3)mm; Fiber percentage (15)wt.%	Hygrothermal properties (excellent) moisture buffer (excellent value)	[20]	DPF was first washed by waterand dried under natural environment. Finally, fibers were obtained by after twosteps of grinding (crushingfollowed by crude grinding).
---	Fiber reinforced concrete	Gender (---); Position (---); Fiber length (2, 4, 6 and 8)cm; Fiber Diameter (---); Fiber percentage (0.4 and 0.5)%	Shrinkage (reduced)	[34]	Fiber treatment not reported

3.3. Sound Absorption

Like other physical properties, sound absorption is also taken into consideration from various researchers. Belakroum *et al.*fined that the inclusion of DPF give good absorption capacity based on the measured sound absorption coefficient which is for 50% of fiber: for medium and high frequencies 0.65 and 0.55 respectively [36].

3.4. Mechanical Properties and cracking

To improve the flexural strength against post cracking in water curing and hot dry curing, (2-3) % percentage and (15–60 mm) fiber length is efficient. Toughness coefficients were improved also with this adding of fiber. On the other hand the addition of fiber in this percentage leads to reduction in compressive strength and first cracking. For each concrete type, first cracking strength decrease in hot-dry climate. Cracks and global degree of voids decreased in water curing and increased in hot-dry climate [9]. Using date palm fiber increases the ability of materials to absorb water vapour due to its porous morphology. This behaviour accomplished in high relative environment and the materials can restore the absorbed water in dry conditions. So, it could therefore turn as a hygric regulator [36]. The results of compressive strength testing indicated that DPF incorporation led to a reduction in resistance limit, however, the recorded average values are still acceptable [36].

Also it should be noted that the male date palm surface fiber is most used type of fiber in concrete which is concentrated around the trunk. On the other hand the common used length for all parts of fiber is (1.5-8) cm, the diameter between (0.1-0.8) mm and the percentage of use between (0-3) %. As shown in Table 4 the fiber treatment that is most widely used is the separation process into individual fiber under water.

4. Date Palm Fiber in Cement Mortar

Nowadays, it is expected that the world is heading for renewable natural resources such as biomass resources [16].Sustainable development is one of the main scientific, economic and social challenges of the building efficiency [42]. However, from commercial and technological points of view, cotton, kenaf, sisal, flax, palm, coir, arecanut and banana fibers acquire utmost significance, since reinforced plastics, strings, cords, cables, ropes, mats, brushes, hats, baskets and fancy articles such as bags are manufactured with those fibers [14].

The use of fibers as reinforcement for cement matrices is a major importance to enhance local materials and for improving the characteristics of the cement matrix [9][43]. Reinforcing cement matrices with various fibers have been reported to resist rapid propagation of micro cracking under applied stress as well as the ability to withstand loads even after initial cracking [25]. Natural fibers were used as reinforcement in cement mortar to improve some properties of cement composites such as hygric properties, thermal conductivity flexural strength and so on. Different researchers attempt to study the possibility of utilizing DPF to produce fibers as reinforcement for cement composite as shown in Table 5.

4.1. Moisture buffer (Hygric properties)

Hygroscopic materials in building envelopes effectively contribute for improving the energy efficiency of buildings as well as the indoor air quality [46]. Hygroscopic materials are able to moderate the indoor relative humidity variations, to ensure the comfort of occupants and also to reduce the energy consumption [42]. Using 15 wt.% of Date Palm Fibers “DPF” loading in cement mortar allows obtaining composites that may satisfy both thermal and mechanical properties as structural or insulating materials [46]. Porosity is a very important physical parameter which may affect both hygric and thermal properties of building materials. The total porosity and apparent open porosity are widely used to investigate the void content of the building materials.

As shown in Table 5, the high rate of open porosity may contribute to let the building ‘‘breathe” allowing water vapour to be transmitted to the outside [42][48]. It can be concluded that using DPF concrete in buildings can be advantageous and good solution for moisture control and for minimizing interstitial condensation when exposed to high RH environments [46].

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Table 5.Date palm fiber application in cement mortar.

Part of Date palm fiber	Usage	Type of fiber and its details	Effect of usage of DPF in mortar	Reference	Fibers treatment
---	Fiber reinforced cement mortar	Fiber length (3)mm Fiber percentage (15)wt.%	Total porosity (increase); Apparent open porosity (high content of open pores (58%) which represents (91%) of the whole porosity); Water uptake (high value); Water vapour permeability (permeable); Moisture diffusivity (very low); Thermal conductivity (good).	[42]	Fiber treatment not reported
Mesh fiber	Binderless boards mortar	Gender (not reported); Position (mesh fiber); Fiber length (5 and 6)cm; Fiber Diameter (0.7)mm; Fiber percentage (0 and 51) %.	Thermal conductivity (decrease); Density (lightening effect); Total porosity (increase); Water retention capacity (decrease).	[44]	The DPFs were cleaned with high pressure water to eliminate the impurities. Then dried out: firstly depending on sun dried for two days and then additional oven dried at 70 ℃ until getting constant weight.
Leaflets fiber	Cement matrix	Gender (male); Position (leaflets fiber); Fiber length (15)cm; Thickness (0.55)mm; Fiber width (7)mm; Fiber percentage (---) %.	Adhesion properties (improved when using pozzolanic materials)	[13]	The Chemical treatment is done by immersing the fibers in solution of Sodium hydroxide (NaOH) with a concentration of (0.5%, 1%, 1.5%, 5% and 10%) for one hour under a source of temperature at 100 ° C. Then Water was used to wash fibersin order to remove the excess of (NaOH), the last wash is made with distilled water, after that the fibers are dried in the open air.
Surface fiber	Cement mortar	Gender (male); Position (surface fiber); Fiber length (2-6-10)cm; Fiber diameter (0.1-1)mm; Fiber percentage (0.6) %.	Compressive strength (decreased); Flexural strength (increased).	[45]	Surface date palm fiber dragged out from the trunk in nearly rectangular shape mesh formed with superposing stratums. Under water, the separation process into individual fiber becomes more easer.
---	Cement mortar	Gender (---); Position (---);	Moisture buffer value (excellent)	[46]	Fiber treatment not reported

		Fiber length (---)cm; Fiber diameter (---)mm; Fiber percentage (15) %.			
Leaflets fiber	Cement mortar	Gender (---); Position (leaflets); Fiber length (---)cm; Fiber diameter (3-6)mm; Fiber percentage (5, 10, 15, 20, 25 and 30) %.	Water absorption (increased); Thermal conductivity (decreased); Compressive strength (decreased); Density (decreased).	[47]	The rachis and petiole dried bynormal conditions
---	Fiber reinforced cement mortar	Gender (not reported); Position (---); Fiber length (---)cm; Fiber Diameter (3-6)mm; Fiber percentage (15)%	moisture buffering capacity (excellent)	[48]	Fiber treatment not reported
Mesh fiber	Fiber reinforced cement mortar	Gender (---); Position (mesh); Fiber length (0.7-1)cm; Fiber Diameter (3-6)mm; Fiber percentage (0, 2, 4, 6, 8 and 10)%	Flexural strength (not affected); Fracture toughness (not affected); Post-peak behaviour (improved); Ductility (improved).	[15]	The fibers are cut from the trunk of date palm in a form of rectangular mesh sheets. Under water, the separation process for the mesh sheets into individual fiber becomes more easer. After that fibers dried at room conditions for one week and then cut to the suitable length.
Leaves fiber	Fiber reinforced cement mortar	Gender (female); Position (leaflets); Fiber length (10)cm; Fiber thickness (0.7-4)mm; Fiber percentage (0, 0.5, 1 and 2)%	Tensile strength (improved); Stiffness properties (improved); Flexural strength (improved); Water absorption (decreased); Setting time (prolonged); Durability (increase resistance for mortar against sulfate attack).	[25]	The srapfibers immersed and treated either with 0.173% $Ca(OH)2$ or 2.0% of NaOH solution or (as per room temperature solubility range). Additionally, for direct comparison, 0.173% of NaOH solution was also considered. The fibers were immersed in the solution for an hour and then placed in an oven at 60 ℃ for 3 h to dry.

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4.2. Thermal properties

The thermal insulation materials play an important role in achieving building's energy efficiency [49]. Date palm tree residues are one of the interesting sources of the natural fibers since they are renewable and abundantly available [30]. Other natural fibers have also been studied by deferent researchers, hemp [9], rice husks [21] or other vegetal fibers [10]; where the mortars containing these loadings display a good durability and are already used for insulating or coating applications.Benmansour et al. [47] worked on new composite material with date palm fiber.They find that introducing a appropriate DPF amount in the mortar allows gaining a composite with good mechanical and thermal properties and can be used in building as thermal insulation [47]. The thermal conductivity results show an important thermal insulation capacity in dry state [42].

Also it should be noted that leaflets and mesh fibersare the most used types of fiber in cement mortar. On the other hand the length of fiber that's used in cement mortar varied from (3-10) cm, the diameter between (0.7-6) mm and the percentage of use between (0.5-10) %. As shown in Table 5 the fiber treatment that is most widely used is the separation process into individual fiber under water.

As a conclusion, theinclusion of DPFs in cement mortars does offer thermal, acoustic and mechanical properties as well as durability performance improvements.

The results from previous studies showed that concrete with DPF has good ability for heat regulation, good moisture sorption behaviour and high thermal insulation capacity.On the other hand using DPF in cement composites come as a trade-off in losing in workability and reduction in compressive strengths.

5. Conclusion:

This study investigated the physical, chemical, and mechanical characteristicsas well as thermal properties of date palm fiber, also the effect of introducing date palm fiber in concrete and cement composite were reported. Information from various researches finds that the presence of natural fibers in concrete is beneficial for thermal insulation and acoustic properties.All the above results let us believe that this material can help in improve some properties of cementitious composite as follow:

1- Small percentage (1-2) % can reduce thermal conductivity of concrete spatially when trunk fiber was used;
2- Leaf fiber (5-30) % enhance in reducing thermal conductivity of cement mortar;
3- First cracking strength decreased and maximum post-cracking improved for concrete when using male date palm surface fiber;
4- Compressive strength decreased, flexural strength properties improved and bending resistance increased for concrete with addition of DPF;
5- Excellent moisture buffer value was reported for concrete and cement mortar;
6- Shrinkage reduced and first cracking strength increased for concrete when using male surface date palm fiber;

As a conclusion, date palm fiber reinforced concrete members can be advantageous and suitable way to minimize interstitial condensation and control moisture at high RH environments. Also, it is important to notice that availability and low cost of DPF make it competitive compared with other synthetic fiber. DPF composites have good mechanical and thermal properties, which help this fiber to be used as new bio-composite materials for energy efficiency in the buildings. Further investigation requires studying the probability of using DPF in special types of concrete as well as studying the behaviour of this type of fiber under different applications.

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