Jurnal Teknologi

Full Paper

COMPARATIVE INVESTIGATION OF DATE PALM FIBER AND TIRE STEEL FIBER BEHAVIOR IN NORMAL STRENGTH CONCRETE

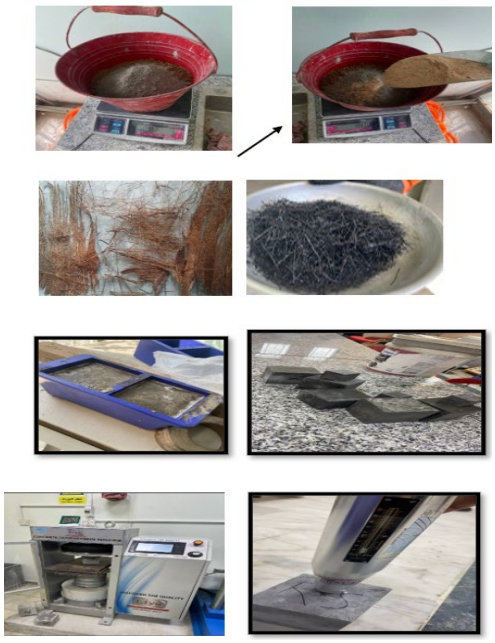
Omar R. Khaleel[a]*, Mohanad Hatem Shadhar[a], Mohammed J.Abed [b], Hussin A. M Yahia[c]

[a]Civil Engineering, Engineering Campus, Al-Iraqia University, 7366, Baghdad, Iraq
[b]Civil Engineering, Engineering Campus, University of Tikrit, 34001, Salahuddin, Iraq
[c]Civil Engineering Department, MEC Campus, Middle east college, 124, Muscat, Sultanate of Oman

Article history
Received
19th March 2025
Received in revised form
31st October 2025
Accepted
27th February 2026
Published
1st November 2026

*Corresponding author
omar.r.khaleel@aliraqia.edu.iq

Graphical abstract



Abstract

The significant contamination caused by dumping large quantities of steel wire present in tyres in landfills has increased the demand for recycling trash steel wire of fibers. The recycling process of fibers is significant not only for construction but also a plays role in restricting waste materials consequently crucial for the evnvironment. By utilizing these fibers waste in the construction industry, countries can improve waste management process, lower the disposal expense, and promote sustainable development. This study focuses on using date palm fibers as organic fibers and tire steel fibers as inorganic fibers to produce more sustainable concrete. A Comparative study is implemented in order to compare the influences of behaviour of these two types of fibers in the concrete with using the same ratio. This study aims to evaluate how the inclusion of date palm fibers and tire steel fibers in concrete impacts the engineering properties of concrete and to compare their influences. In the current study, the use of tire steel fibers and date palm fibers with 0.5% ratio by cement weight, with the length 4-6cm and diameters 0.1-0.5 mm were selected in the mixtures. Three different mixtures were designed, prepared, mixed, and tested by diverse tests such as slump test, compressive strength test, flexural strength test, hardened density test, and rebound hammer test. The results showed that the use of tire steel fibers in concrete enhanced the compressive strength of the concrete mix by 5% and 10% compared to normal concrete and date palm fiber concrete, respectively. Moreover, the flexural strength of the concrete was remarkably affected by fibers, where with inclusion of tire steel fibers in concrete exhibits the highest values of flexural strength compared to that of date palm fiber concrete and normal concrete by 7.5-14%, respectively. However, the workability of concrete was negatively affected by the inclusion of date palm fibers and tire steel fibers, with the fiber reinforced concrete mixes revealed minimized slump values compared to that of normal concrete by 85%.
Generally, the use of both date palm and tire steel fibers in concrete had beneficial effects on the environment and the concrete properties signifiying the future possibility of green construction.

Keywords: palm fiber, tire steel wire fiber, compressive strength, flexural strength, sustainability.

©2026 Penerbit UTM Press. All rights reserved

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

1.0 INTRODUCTION

One of the major factors that contribute to climate change and could endanger human health is environmental pollution. For the industrial revolution to proceed smoothly, waste materials must be managed effectively [1;2]. Recently, researches have focused on repurposing waste materials to create profit, including energy production [3-5]. Morevoer, waste materials can be recycled and repurposed to produce additional useful products, mitigate the impact of waste materials on the environment, and reduce the use of manufactured construction materials, thereby decreasing carbon dioxide emissions [6-8]. For several years now, waste materials have been incorporated into infrastructure development, particularly in concrete [9-11].

Large amounts of used tires are dumped in landfills worldwide, making them an underappreciated global resource. Recycling steel fibers extracted from these tires is a modern practice. The addition of steel fibers from used tires to concrete produces results similar to industrial steel fibers [12].

In addition to agricultural fibers such as jute, sisal, date palm mesh, etc., a few organic fibers like asbestos and cellulose are also used in concrete [13 and 14]. Date Palm Fiber (DPF) is one of the most popular, affordable, sustainable, and environmentally friendly natural fibers. This study investigates the behavior of Date Palm Fiber (DPF) in concrete. Date palm trees produce large volumes of waste, most of which are discarded unused. One clear advantage of Date Palm Fiber (DPF) over other natural and synthetic fibers is its bettesuperior strength-to-cost ratio [15].

The main ingredients of fiber-reinforced concrete (FRC) are aggregates, hydraulic cements, and discrete reinforcing fibers. Various inorganic materials can be used as reinforcement of concrete such as glass, steel, and organic polymers. In addition, some organic materials can be used as reinforcement of concrete such as vegetable fibers (e.g., sisal, jute and asbestos fibers). The matrices of the concretes may be cement mortar mixes that are normally proportioned, or mixtures that are specially made to cater to a specific need. Normally, the fibers that are used in FRC are those whose maximum size is 0.04 in. (1 mm) and a up to 3 in. (76 mm) [16]. consequently The properties of fibers in this study are within these ranges.

The use of natural fibers as a source of reinforcement in concrete has great economic and energy advantages compared to the use of conventional steel reinforcement. This is due to that the fiber reinforcement amount necessary is less compared to normal reinforcement and is consequently more environmentally friendly and less costly [17].

The inclusion of Steel fiber in concrete can enhance the flexural performance of concrete, as observed by the current study. This improvement is especially useful for pavement applications, leading to thinner pavements that enhance the resistance to vehicle loads [18].

This comparative study is significant, as it confirms the necessity for a balanced approach that deems both environmental sustainability and superior performance. It investigates the different characteristcs of two fibers (inorganic and organic) and their effect on behaviour of concrete, giving acumen into the unique contributions of each material. There is a deficiency of research regarding to this subject, making this study particularly valuable. Inorganic and organic fibers have different properties that make them significant for comparing their effect on concrete.

The objective of the current study is to compare the effect of tire steel fiber as recycled waste fiber (inoraganic) and palm date fiber as natural fiber (organic) on engineering properties of normal strength concrete.

The use of discrete tire steel fibers with short length in concrete or mortar can improve the engineering properties of the material. While this study suggests that the addition of such kind of fibers may not significantly increase the compressive strength of concrete, it does improve its toughness and ductility [18-20]. Several researchers have explored the use of recycled steel fibers in concrete to promote sustainability and enhance its performance [21-26].

Zia et al. [27] reported that the typical properties of recycled steel fibers used in concrete from previous studies include fiber lengths ranging from 7 mm to 101 mm and fiber diameters varying from 0.1 mm to 1.4 mm, the values in the current study are falling within this range. Moreover, the tensile strength of these fibers ranges from 781 to 2570 MPa. Their study also noted that the compressive strength either increases or decreases compared to control concrete mix. This variation depends on some factors such as fiber dispersion and mixing and sometime longer fibers can cause a balling effect resulting in lower packing density. The current study demonstrated an improvement in the compressive strength of tire steel wire concrete compared to that of normal concrete. The discrepancy with the literature study is that the aspect ratio is higher, which is the main reason for the strength reduction.

M. Leone et al. [28] conducted a comparative study on industrial steel fibers and recycled steel fibers from tires used in concrete. The study used steel fibers obtained from the trash tire. The study showed that the inclusion of recycled steel fibers in concrete revealed satisfactory concrete characteristics in terms of toughness and shear compared to industrial steel fiber reinforced concrete. This enhancement was due to the capability of the fibers to hinder the propagation of crack by bridging the cracks. Enzo et al. [29] implemented a comparative analysis on recycled steel fibers extracted from tires and industrial steel fibers included in concrete. They found that these fibers had a minimal impact on the

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

compressive strength of concrete due to their low percentages and the geometry of the fibers affecting the compressive strength.

Aiello et al. [30] reported that the addition of 0.46% waste tire steel fiber to concrete led to a 9% increase in flexural strength compared to reference concrete, which is approximately the same ratio of fiber used in the current study. Similarly, Telemat et al. [31] found that using 6% waste tire steel fiber in concrete increased flexural strength by up to 150%. Moreover, Sengul [32] mentioned in the report that the adding of tire steel fibers at rates of 20, 40, and 60 kg/m^3 to concrete improved flexural strength by 21.4%, 19.6% and 19.6% respectively, compared to control concrete. Similar outcomes have been observed in literature with different fiber sizes and volumes [32 - 33], and this increase is attributed to the fact that the strength of fiber in tension is better than in compression. Several studies found that 0.5% tire steel fiber content was the optimal percentage to achieve the highest flexural strength compared to control concrete [34-37]. Rahim et al. reported that the use of steel fiber enhanced the flexural strength of concrete because the steel fiber acts as a bridge to prevent Separation resulting from cracks [38]. Moreover, Setiawan et al. [39] reported that the optimum volume of steel fibers is 0.4%, which resulted in higher flexural strength. This is attributed to the presence of steel fiber concrete, which can prevent cracking in one direction. Rokbi et al. [40] examined the influence of the inclusion of date palm fibers on properties of polymer-reinforced concrete. Two types of fibers were used in concrete, untreated and treated palm fibers with various lengths of 2mm to 6 mm for reinforcement in concrete. This study indicated that the improvement of the strength of concrete is dependent on the sizes and nature of fibers used. Additionally, they also noticed that the inclusion of short date fibers in concrete improved the flexural strength of the concrete by approximately 6% compared to that of the reference concrete. Kriker et al. [41] used the inclusion of date palm fibers with a volume fraction of 2-3% and different fiber lengths of 15-60 mm in concrete. They observed that as the volume fraction and length of date palm fibers increase in the concrete, compressive strength of concrete reduced and the onset of the first crack occurred. Nevertheless, they also noticed an enhancement in toughness and post-crack flexural strength of concrete and they interpreted that the fibers acted as bridges intersecting crack spread. Ozerkan et al. [42] found that the inclusion 0.5% palm fiber in concrete enhanced both flexural and compressive strength relative to reference concrete. However, more fibers content led to reduction in the flexural strength of concrete. Benanibe et al. [43] observed that the increase of weight percentage (6-30%) of date palm fiber into concrete reduced compressive, flexural strengths, the density, thermal conductivity of concrete.

1.1 RESEARCH SIGNIFICANCE

This comparative study is significant, as it confirms the necessity for a balanced approach that deems both environmental sustainability and superior performance. It investigates the different characteristics of two fibers (inorganic and organic) and their effect on behavior of concrete, giving acumen into the unique contributions of each material. There is a deficiency of research regarding to this subject, making this study particularly valuable. Inorganic and organic fibers have different properties that make them significant for comparing their effect on concrete.

No investigations have been found regarding the comparison between the influence of steel tire wire and date palm fiber on some normal concrete properties. Therefore, this study aims to investigate the effect of fibers of the same length and diameter, both natural and industrial, on the compressive strength, flexural strength, density, hardness and workability of normal concrete.

Recycling steel tire fibers and fly ash can provide significant benefits in the construction industry by utilizing waste materials and positively impacting the environment. This practice not only benefits the country by improving waste disposal processes and reducing disposal costs but also enhances the mechanical properties of construction materials and reduces construction costs. Substituting a part of cement weight with fly ash can decrease cement production, leading to reduced CO_2 emissions and costs.

2.0 METHOD AND MATERIALS

In order to fulfil the objectives of the current study, NSC was used, including varied materials such as cementitious materials (Portland cement powder and fly ash powder), sand, coarse aggregate (stone), tap water, chemical admixture (plasticizer), tire steel fiber, and date palm fiber. The specific gravity of cement is 3.11, while fly ash is in powder form passing through a 100-micrometer sieve. Coarse and fine aggregates with a relative density of 2.65 were obtained from a crushed factory. The coarse aggregate has a maximum size of 20 mm and retains on a 4.75mm sieve, while the fine aggregate passes through a 4.75 sieve and retains on a 600-micrometer sieve. Two types of fibers were used: tire steel fiber recycled from waste tires and cut to a length of 4-6 cm according to ACI 2012 [16], and date palm fiber obtained from date palm trees, washed, immersed in water, air-dried, and chemically treated to achieve a Saturated Surface Dry condition with a tensile strength of 240 MPa. Date Palm fibers are treated prior to utilizing by 3% concentration of NaOH for 24 hours based on findings of Al-Oqla et al. [15] that come from varied several studies, where they concluded the best treatment method is utilizing

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

NaOH solution. The fiber lengths ranged from 4-6 cm, and diameters ranged from 0.1-0.5 mm.

Mixes information are listed in Table 1, which is designed according to BS EN 5328 standard. 10% fly ash content weight was replaced by 10% of cement weight in all mixtures to improve concrete characteristics. The plasticizer dosage used was 0.1/ 100 kg of cementitious materials to obtain optimum workability. The certain ratio of fibers to powders was 0.5% for both date palm fibers and tire steel fibers and this ratio is selected based on literature studies that revealed an improved compressive and flexural strengths [27, 32]. One of these studies is the study performed by Sengul 2016 [32] that indicated that compressive and flexural strengths of concrete were enhanced by using 0.5% of fibers to powders ratio.

Table 1: Mix proportions details of all mixes

Material	NSC	PFC	SFC
Cement kg/ m³	396	396	396
Fly Ash (kg/ m³)	44	44	44
Fiber content (kg/ m³)	-	2.2	2.2
Sand (kg/ m³)	630	630	630
Stone (kg/ m³)	1030	1030	1030
Water (kg/ m³)	203	203	203
S.P dosage (l/100 kg of cement)	0.44	0.44	0.44

All compound of mixes were blended by using a drum mixer and for 5 minutes. Stones as coarse aggregate was put first, proceeded by sand as and fibers, and then blended for 1 minute in a dry state. A blended mixture of cement and fly ash was then put and blended for another 3 minutes in a dry state to guarantee good fibers dispersion. Water mixed with plasticizer was poured gradually while the mixer was running for 5 minutes to obtain a homogeneous mix.

Each mixture was evaluated individually. workability of fresh mixture was tested utilizing the slump test and according to BS EN 12390-2 [47], while compressive strength was achieved using BS EN 12390-2 [48], flexural strength was achieved using BS EN 12390-5 [49], density BS EN 12390-5 [50], and Schmidt rebound hammer tests to evaluate the behavior of mixes in hardened test. These tests are used for mixes at 7 and 28 days. Three of 150 mm cubes per each test were utilized to evaluate the compressive strength and density at 7 and 28 days. Moreover, three of 150*150*500 mm prisms are utilized for each flexural strength test and rebound hammer test at 7 and 28 days. Schmidt rebound hammer test has been implemented as per ASTM C 805 [51]

3.0 RESULTS AND DISCUSSION

This section displays the comparative findings of workability, compressive strength and flexural strength, density, of all mixes.

3.1 SLUMP TEST

Figure 3 presents the slump values of three different mixes. The results revealed that the normal concrete has a slump value higher than date palm fiber and tire steel fiber concretes, which is 130 mm, and followed by the slump value of date palm fiber concrete and tire steel fiber concrete, which are 70 mm and 80 mm, respectively. Moreover, this proves that fiber concrete has a lower workability value compared to the normal concrete mix at the same plasticizer dosage level. The presence of fiber reduces the mobility of the mix due to the fact that fiber has a high flakiness ratio, and this promotes interlocks [52]. Moreover, date palm fiber has a balling effect that could lead to reduced workability of the mixes [53].

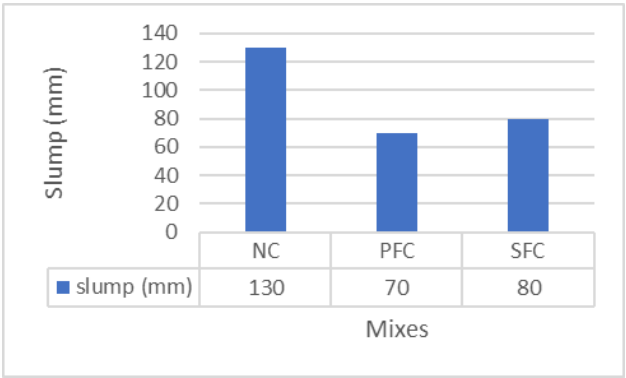


Figure 3 Slump values of different concrete mixtures

3.2 Compressive strength

Figure 4 presents the compressive strength of different concrete mixes. All results in this figure indicate that the compressive strength of all mixes increased with age due to the development of the cement hydration process over time.

The results shown exhibit that tire steel fiber concrete exhibited a slight raise in compressive strength of 4.9% compared to that of normal concrete. this result agrees with the result of Song and Hwang [54], Majain et al. [55], and Khaleel et al. [56]. Jhatial et al. 2018 [57] explained that the function of steel fibers is to hold and restrain tensile cracks and prevent them from propagation. As the tension zone in samples under compression load is minimum, and most of the sample is under compression stress, the influence of fibers on compressive strength is slight. Concrete failure occurs from the internal cracks propagation which is present in concrete sample and enlarge at weak points,

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

especially in the transition zone between cement paste and aggregate. The weakness of the transition zone is under tension and can be strengthened by inclusion steel fiber. This failure mode is critical in samples under tension [58]. Samindi et al. [59] found that the inclusion waste tire steel fiber in concrete enhanced the compressive strength by 5-12%, which support the results of this study. Furthermore, adding industrial steel fiber to concrete improved strength by 17-20%.

Figure 4 also indicates that steel fiber concrete has a compressive strength higher than that of palm fiber concrete by 9.8%. As shown in Figure 5, the strength of steel fiber exceeds that of date palm fiber, as well as having higher bonding strength. Moreover, the inclusion of date palm fiber in concrete reduces compressive strength of concrete slightly by 4.9% compared to normal concrete. the slight reduction could be due to the balling effect of date palm fiber, which in turn of reduce packing and consequently minimize the compressive strength [Ibrahim et al., 2022]. Ahmed and Umar [58] explained that the balling effects of fibers are due to the higher slenderness ratio of fibers, which lead to cluster formation along the flow path of mortar, consequently bad spread of fibers that could lead to inhomogeneous mixture. This could weaken the strength and workability of concrete. This phenomenon may interpret the reduction occurred in compressive strength of date palm concrete compared to normal concrete and tire steel fiber concrete.

Alatshan et al. [60] investigated inclusion varied lengths and amounts of palm fiber in concrete. they found that the optimum amount of date palm fiber in concrete was 0.5% and the proper length of fiber was 5 cm. determined that the optimal dosage of palm fiber was 0.5% with a fiber length of 5 cm, resulting in higher compressive and flexural strengths, the same content and fiber length to this study but showed contradict result of compressive strength. The contradictory result could be due to the fact that the slanders ratio of palm fiber used in their study is less than that of this study. Consequently, less balling effect will occur, resulting in better fiber dispersion and hence better compressive strength. Moreover, the percentage increase compared to normal concrete was only 6%, differing from this study in terms of mix proportions, the alveolar structure of palm fiber, and fiber treatment. Ahmad and Noor [61] found that palm fiber marginally reduces compressive strength, attributing it to the creation of voids by palm fiber, leading to strength reduction, which aligns with this study. Yasser E. Ibrahim et al. [53] noted that the incorporation of 1%, 2%, and 3% of palm fiber resulted in decreased strength of date palm fiber concretes, respectively, attributing it to weak adhesion between cementitious paste and date palm fiber, causing a weak transition zone and internal cracks in concrete and this could be another reason for the reduction in compressive strength of date palm fiber in this study. M. Dahou and A. Hamouine [62] reported that a 0.5 volume ratio of date palm fiber decreased the compressive strength of concrete by 24%, while this study observed a lesser reduction due to differences in fiber length. However, most of the aforementioned studies confirm that palm fiber contents ranging between 0.25% and 5% with an optimal dosage between 0.5% and 2%. Additionally, these studies recommend suitable fiber lengths ranging between 4 and 6 cm.

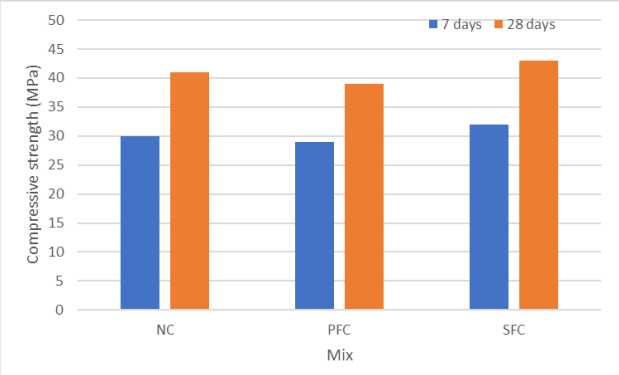


Figure 4 Compressive strength values of different concrete mixes.

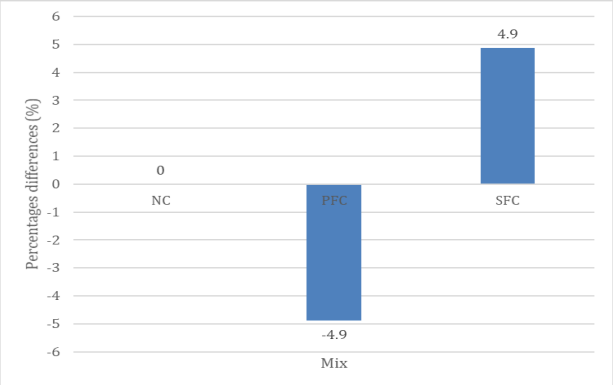


Figure 5 Variation of compressive strength between fiber mixes and control mix

3.3 FLEXURAL STRENGTH

Figure 6 illustrates the flexural strength of various concrete mixes with and without fibers. The results indicate that the flexural strength of the mixes increased over time. At 7 days, the flexural strength ranged between 4 and 4.5 MPa, while at 28 days, it ranged between 5 and 6 MPa. The difference in flexural strength between tire steel fiber concrete and the control mix was 10% at 7 days and increased to 14% at 28 days. Previous studies [63, 64, and 65] have shown that tire steel fiber can enhance the flexural strength of concrete by 100% to 140% compared to control concrete, depending on the

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

length and volume ratio of fibers. Additionally, tire steel fiber concrete exhibited higher strength than other mixes at both 7 and 28 days, surpassing date palm fiber concrete by 7.5% and control concrete by 14%. This enhancement is due to the high tensile strength and ductility of steel fiber, which is capable of spanning microcracks in concrete efficiently, preventing crack extension and improving toughness and ductility. Incorporating steel fiber into concrete pavement has the potential to disconnect microcrack initiation and progression, contributing to improved overall performance [67; 68]. This finding supports the rise in flexural strength reported in the study. Moreover, the results also show a 6% raise in the flexural strength of DPF concrete compared to reference concrete, lesser than 7.5% in the case of waste tire steel fiber concrete. This variation could be due to the high ductility of steel fiber and likely lesser cohesion of palm fiber with concrete. Previous studies by Kriker et al. [41] and Ramli and Dawood [69] showed that date palm fiber would improve post-crack flexural behaviour of concrete as well as to concrete toughness but reduce the first-crack compression strength of concrete cubes. The enhancement occurred of flexural strength of palm fiber concrete mix is in agreement with findings from other studies, such as M. Dahou and A. Hamouine [62], who found a 46% improvement in flexural strength with 0.5% volume fraction of DPF in concrete compared to that of reference concrete.

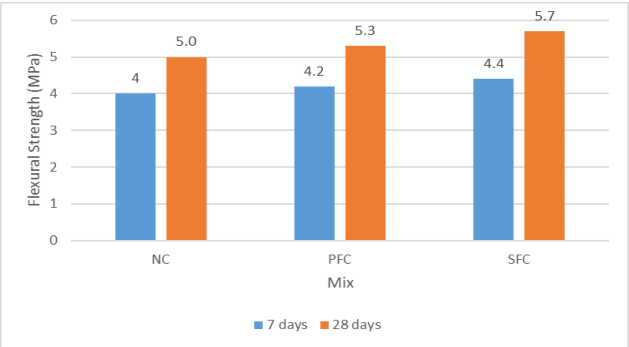


Figure 6 Results of Flexural strength of all mixes

3.4 RELATIONSHIP BETWEEN COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH

Figure 7 depicts the relationship between compressive strength and flexural strength, indicating that an enhancement in compressive strength compatible with a proportional raise in flexural strength with value of a square regression coefficient approximately equal to 0.9. The graph clearly demonstrates that the flexural strength of fiber concrete surpasses the standards set by ACI and IS, attributed to the incorporation of palm and tire steel fibers, even outperforming the findings of Fauzan et al. [70]. These results encompass data from different curing ages at 7 and 28 days, and all comparable outcomes are fitted with power equations. The data is scrutinized to derive predictive equations that can be applied to experimental results.

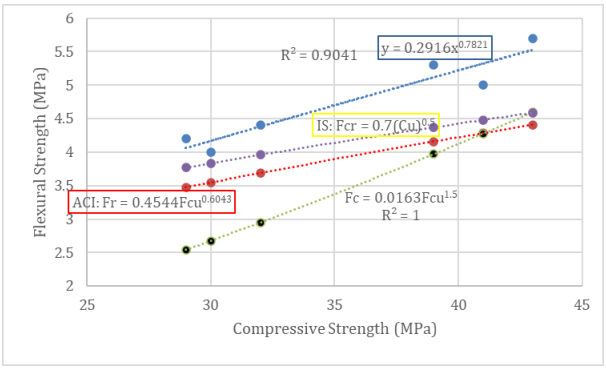


Figure 7 Relationship between flexural and compressive strength of concrete

3.5 HARDENED DENSITY

Figure 8 illustrates different densities of different mixes. No significant difference has been observed among the densities of hardened concrete results at the same age and curing. The difference is a clear increment of density of samples with curing when compared with samples density without curing, as shown clearly in Figures 8 and 9. In addition to that, it is noticed that the density of samples at 28 days is higher than that at 7 days by 0.1-0.9% for non-cured samples and by 1-2% for cured samples, and this is attributed to the fact that with age, the hydration products increased to fill all voids in concrete samples. Moreover, the results showed that tire steel fiber concrete had higher density than that of date palm fiber, and this could be attributed to the low density of date palm fiber compared to tire steel fiber due to the porous microstructure of palm fiber [71]. Bamaga [72] discovered that as the fiber content and length increase, there is a minimal decrease in the density of date palm fiber mortar. The balling effect is a contributing factor to this density reduction in concrete, as it creates additional voids within the material. This phenomenon helps to explain why palm fiber concrete has a lower density compared to traditional concrete and steel fiber concrete.

Shohana Iffat [73] observed that with the time, the density of concrete mixes enhances which agrees with the current research findings. Fadi et al. [74] noticed that adding 1% of steel fiber in concrete improved the density of concrete mixes by 3% in comparison with that of reference concrete mix. They also found that adding 0.6% of date palm fiber to concrete led to reduction in concrete density as compare to reference concrete density. There has been an inversely proportional relationship between compressive strength and density and as shown in Figure 9. From the correlation, it was evident that the

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

coefficient of determination (r^2) for various fiber-reinforced concrete and normal concrete was 0.932. Kareem et al. (2025) [75] found that the use of date palm fiber in concrete led to the loss of weight, as observed in findings of this study.

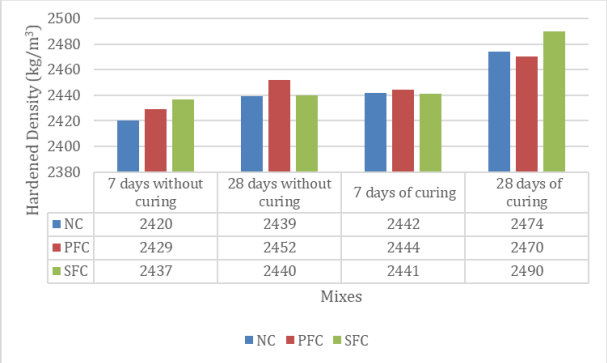


Figure 8 Hardened Density of different mixes

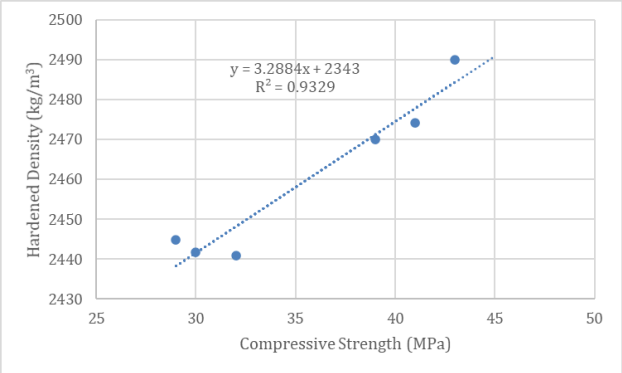


Figure 9 Relationship between Hardened Density and compressive strength of concrete

3.6 SCHMIDT REBOUND HAMMER

The Schmidt hammer test measures the hardness of a concrete surface. The rebound hammer number is not always in harmony with compressive strength values. The results of the rebound hammer test are presented in Figure 10, showing the values at 7 and 28 days. The samples exhibited higher rebound hammer values at 28 days compared to those at 7 days by 7-20%. The result shows that palm fiber mixtures achieved higher values of rebound hammer numbers at 28 days than that of steel fiber mixes and normal concrete. Overall, the values of rebound hammer number of all mixtures at 28 days are within the range 30-40, indicating good quality of concrete as per to Najim et al. [76]. The rebound hammer number is significantly affected by the location of hammer on concrete surface, the applied hammer location, the member's support and stiffness [77]. It is also indicated from results shown in figure 10 that date palm fiber reinforced concrete has a greater rebound number compared to that of tire steel fiber reinforced concrete, which contrary to compressive strength results. This contradiction could be due to the test procedure, where direct test of compressive strength is a measurement of the strength of the entire sample, while the Schmidt hammer experiment is a measurement of the sample's surface strength [76]. Further, when the hammer hits the fiber close the surface, it influences on the rebound hammer number. Figure 11 indicates the relationship between real compressive strength values and rebound hammer number of all mixes. This relationship has a liner equation with determination coefficient of 0.812. this relationship indicates the proportional increase of compressive strength and rebound hammer number.

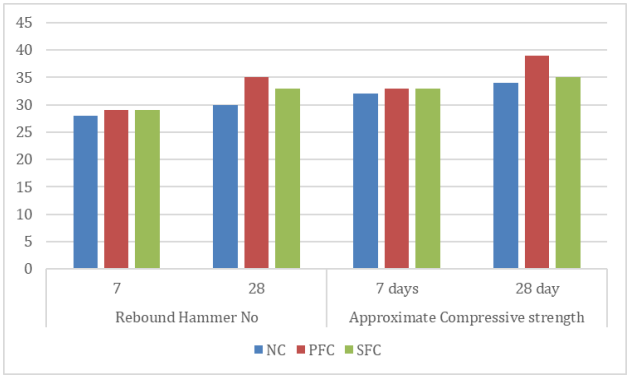


Figure 10 Schmidt Rebound Hammer Numbers of different mixes

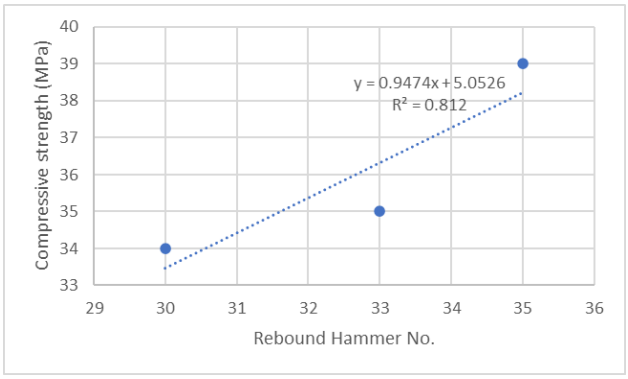


Figure 11 Correlation of Rebound Hammer Numbers of different mixes with compressive strength of concrete mixes @28days

4.0 CONCLUSION

The following conclusions can be obtained:

1. The addition of palm and steel fibers in concrete decreased workability, as evidenced by a decrease in slump from 130mm in normal concrete to 70-80mm in fiber concretes. More plasticizer is needed for fiber concretes to achieve the same workability as regular concrete.

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

2. Steel fiber concrete exhibited a 5% higher compressive strength compared to normal concrete, while palm fiber concrete had a 5% lower compressive strength.
3. Steel fiber concrete had the highest flexural strength, surpassing date palm fiber concrete and normal concrete by 7.5-14%.
4. The relationship between compressive strength and flexural strength in concrete mixes was found to be proportional and exceeded ACI and IS standards.
5. Generally, adding fibers to concrete had a minimal impact on the hardened density of the material.
6. Palm and steel fiber concretes showed higher rebound hammer values than normal concrete, with palm fiber concrete having higher values than steel fiber concrete at 28 days.

Acknowledgement

Authors would like to express their gratitude for the support of Middle East College for supporting this research.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethics declaration

Formal ethical approval was not obtained for this study. However, the authors confirm that the research was conducted in accordance with established ethical principles and good research practices, with due consideration given to participant rights, informed consent, confidentiality, and responsible data handling.

References

[1] Kelechi, S.E.; Adamu, M.; Mohammed, A.; Ibrahim, Y.E.; Obianyo, I.I. 2022. Durability Performance of Self-Compacting Concrete Containing Crumb Rubber, Fly Ash and Calcium Carbide Waste. Materials, 15, 488. [CrossRef] [PubMed]
[2] Priyadarshini, M.; Giri, J.P.; Patnaik, M. 2021. Variability in the compressive strength of non-conventional bricks containing agro and industrial waste. Case Stud. Constr. Mater., 14, e00506. [CrossRef]
[3] Aslam, F.; Zaid, O.; Althoey, F.; Alyami, S.H.; Qaidi, S.; Gil, J.D.P.; Martínez-García, R. 2022. Evaluating the influence of fly ash and waste glass on the characteristics of coconut fibers reinforced concrete. Structure Concrete.; in press. [CrossRef]
[4] Liuzzi, S.; Rubino, C.; Stefanizzi, P.; Martellotta, F. 2022. The Agro-Waste Production in Selected EUSAIR Regions and Its Potential Use for Building Applications: A Review. Sustainability, 14, 670. [CrossRef]
[5] Azevedo, A.; de Matos, P.; Marvila, M.; Sakata, R.; Silvestro, L.; Gleize, P.; Brito, J. 2021. Rheology, Hydration, and Microstructure of Portland Cement Pastes Produced with Ground Açaí Fibers. Applied Science., 11, 3036. [CrossRef]
[6] Blasi, G.; Leone, M. 2022. Inverse analysis-based model for the tensile behaviour of fibre-reinforced concrete with manufactured and waste tyres recovered fibres. Case Study Construction Material, 17, e01297. [CrossRef]
[7] Xiao, J.; Ma, Z. 2022. Utilization of recycled powder from construction and demolition waste. In Low Carbon Stabilization and Solidification of Hazardous Wastes; Elsevier: Amsterdam, The Netherlands, pp. 291–301.
[8] Oliveira, P.S.; Antunes, M.L.P.; da Cruz, N.C.; Rangel, E.C.; de Azevedo, A.R.G.; Durrant, S.F. 2020. Use of waste collected from wind turbine blade production as an eco-friendly ingredient in mortars for civil construction. Journal of Clean. Prod. 274, 122948. [CrossRef]
[9] Bun, P.; Cyr, M.; Laniesse, P.; Bun, K.N.; Idir, R. 2022. Concrete made of 100% recycled materials-Feasibility study. Resour. Conserv. Recycl. 180, 106199. [CrossRef]
[10] Srikanth, G.; Fernando, A.; Selvaranjan, K.; Gamage, J.; Ekanayake, L. 2022. Development of a Plastering mortar using waste bagasse and rice husk ashes with sound Mechanical and Thermal properties. Case Study Construction Materials 16, e00956. [CrossRef]
[11] Yaswanth, K.; Revathy, J.; Gajalakshmi, P. 2022. Strength, durability and micro-structural assessment of slag-agro blended based alkali activated engineered geopolymer composites. Case Stud. Constr. Mater. 16, e00920.
[12] Muhammad N. A. 2023, Kaffayatullah Khan, Sohaib Nazar, and Ahmed Farouk Deifalla Application of waste recycle tire steel fibers as a construction material in concrete; Reviews on Advanced Materials Science; 62: 20220319.
[13] Banthia, N. 1994. Fiber reinforced concrete. In ACI SP-142 Fiber Reinforced Concrete Developments and Innovations; American Concrete Institute: Farmington Hills, MI, USA, Volume 91, p. 119.
[14] Banthia, N. ACI 544.5R 2010-Report on the Physical Properties and Durability of Fiber-Reinforced Concrete; American Concrete Institute: Farmington Hills, MI, USA.
[15] Al-Oqla, F.M.; Alothman, O.Y.; Jawaid, M.; Sapuan, S.M.; Es-Saheb, M.H. 2014. Processing and Properties of Date Palm Fibers and its Composites. In Biomass and Bioenergy; Springer: Berlin/Heidelberg, Germany,; pp. 1–25.
[16] ACI 2012. State-of-the-Art Report on Fiber Reinforced Concrete. Reported by ACI Committee 544.
[17] Hussein M. Hamada, Jinyan Shi, Mohammed S. Al Jawahery, Ali Majdi, Salim T. Yousif, Gökhan Kaplan, Application of natural fibres in cement concrete: A critical review, Materials Today Communications, Volume 35, 2023, 105833, ISSN 2352-4928, https://doi.org/10.1016/j.mtcomm.2023.105833.
[18] Achilleos, C., D. Hadjimitsis, K. Neocleous, K. Pilakoutas, P. O. Neophytou, and S. Kallis. 2011. Proportioning of steel fibre reinforced concrete mixes for pavement construction and their impact on environment and cost. Sustainability, Vol. 3, No. 7, pp. 965–983.
[19] Steel, F., F. Glass, and F. Natural. 2001. State-of-the-Art Report on Fiber Reinforced Concrete, American Concrete Institute, United States.
[20] Yurtseven, A. E. 2004. Determination of mechanical properties of hybrid fiber reinforced concrete, MS Thesis, Middle East Technical University.
[21] Awolusi, T., O. Oke, O. Akinkurolere, and A. Sojobi. 2019. Application of response surface methodology: Predicting and optimizing the properties of concrete containing steel fibre extracted from waste tires with limestone powder as filler. Case studies in Construction Materials, Vol. 10, id. e00212.
[22] Ndayambaje, J. 2018. Structural performance and impact resistance of rubberized concrete, ASTM Standard, Pan-African University.
[23] Pacheco-Torgal, F., Y. Ding, and S. Jalali. 2012. Properties and durability of concrete containing polymeric wastes

(tyre rubber and polyethylene terephthalate bottles): An overview. Construction and Building Materials, Vol. 30, pp. 714–724.
[24] Thomas, B. S. and R. C. Gupta. 2016. A comprehensive review on the applications of waste tire rubber in cement concrete. Renewable and Sustainable Energy Reviews, Vol. 54, pp. 1323–1333.
[25] Thomas, B. S., R. C. Gupta, P. Kalla, and L. Cseteneyi. 2014. Strength, abrasion and permeation characteristics of cement concrete containing discarded rubber fine aggregates. Construction and Building Materials, Vol. 59, pp. 204–212.
[26] Su, H., J. Yang, T.-C. Ling, G. S. Ghataora, and S. Dirar. 2015. Properties of concrete prepared with waste tyre rubber particles of uniform and varying sizes. Journal of Cleaner Production, Vol. 91, pp. 288–296.
[27] Zia, A.; Pu, Z.; Holly, I.; Umar, T.; Tariq, M.A.U.R.; Sufian, 2022. M. A Comprehensive Review of Incorporating Steel Fibers of Waste Tires in Cement Composites and Its Applications. Materials, 15, 7420. https://doi.org/10.3390/ma15217420.
[28] M. Leone, G. Centonze, D. Colonna, F. Micelli, M.A. Aiello. 2018. Fiber-reinforced concrete with low content of recycled steel fiber: Shear behaviour, Construction and Building Materials, Volume 161, Pages 141-155, ISSN 0950-0618,
[29] Enzo M., Antonio C., Hernan X. 2015. An experimental study on the post-cracking behaviour of Hybrid Industrial/Recycled Steel Fibre-Reinforced Concrete, Construction and Building Materials, Volume 94, Pages 290-298, ISSN 0950-0618,
[30] Aiello, M. A., F. Leuzzi, G. Centonze, and A. Maffezzoli. 2009. Use of steel fibers recovered from waste tyres as reinforcement in concrete: Pull-out behaviour, compressive and flexural strength. Waste Management, Vol. 29, No. 6, pp. 1960–1970
[31] Tlemat, H., K. Pilakoutas, and K. Neocleous. 2006. Stress-strain characteristic of SFRC using recycled fibres. Materials and Structures, Vol. 39, pp. 365–377.
[32] Sengul, O. 2016. Mechanical behavior of concretes containing waste steel fibers recovered from scrap tires. Construction and Building Materials, Vol. 122, pp. 649–658.
[33] Hu, H., P. Papastergiou, H. Angelakopoulos, M. Guadagnini, and K. Pilakoutas. 2018. Mechanical properties of SFRC using blended manufactured and recycled tyre steel fibres. Construction and Building Materials, Vol. 163, pp. 376–389.
[34] Martinelli, E., A. Caggiano, and H. Xargay. 2015. An experimental study on the post-cracking behaviour of hybrid industrial/recycled steel fibre-reinforced concrete. Construction and Building Materials, Vol. 94, pp. 290–298.
[35] Marthong, C. and S. Marthong, editors. 2016. An experimental study on the effect of PET fibers on the behavior of exterior RC beam column connection subjected to reversed cyclic loading. Structures, Elsevier, Amsterdam.
[36] Mohammadhosseini, H., M. M. Tahir, and A. R. M. Sam. 2018. The feasibility of improving impact resistance and strength properties of sustainable concrete composites by adding waste metalized plastic fibers. Construction and Building Materials, Vol. 169, pp. 223–236.
[37] Mohammadhosseini, H., R. Alyousef, N. H. A. S. Lim, M. M. Tahir, H. Alabduljabbar, A. M. Mohamed 2020. Waste metalized film food packaging as low cost and ecofriendly fibrous materials in the production of sustainable and green concrete composites. Journal of Cleaner Production, Vol. 258, id. 120726.
[38] Mustaqqim Abdul Rahim, Siti Nor Amanina Ramli, Shamshinar Salehuddin, Norlia Mohamad Ibrahim,Afizah Ayob, Nur Liza Rahim. The mechanical properties of crumb rubber steel fiber concrete. Jurnal Teknologi, 86:5 , 69-75, (2024.
[39] Agustinus Agus Setiawan, Fredy Jhon Philip, Eka Permanasari. MECHANICAL PROPERTIES OF WASTE PLASTIC BANNER FIBER REINFORCED CONCRETE. Jurnal Teknologi, 80(5), 113-119, (2018).
[40] Rokbi, M.; Rahmouni, Z.E.A.; Baali, B. 2019. Flexural characterization of polymer concrete comprising waste marble and date palm fibers. Technical Science, 2, 169–182
[41] Kriker A., Debicki G., Bali A.,Khenfer M.M., Chabannet M. 2005. Mechanical properties of date palm fibres and concrete reinforced with date palm fibres in hot-dry climate. Cement and Concrete Composites journal, Volume 27, Issue 5, May, Pages 554-564
[42] Ozerkan, N.G., Ahsan, B., Mansour, S. and Iyengar, S.R., 2013. Mechanical performance and durability of treated palm fiber reinforced mortars. International Journal of Sustainable Built Environment, 2(2), pp.131-142.
[43] Benaniba, S.; Driss, Z.; Djendel, M.; Raouache, E.; Boubaaya, R. 2020. Thermo-mechanical characterization of a bio-composite mortar reinforced with date palm fiber. Journal of Engineering Fibers Fabr, 15, 1558925020948234.
[44] BS 5328:2019 Concrete Part 2 Methods for Specifying Concrete Mixes.
[45] Sarvat Gull, Shoib B. Wani, Ishfaq Amin. Exploring optimum percentage of fly-ash as a replacement of cement for enhancement of concrete properties. Challenge Journal of Concrete Research Letters 11 (1) (2020) 16–25
[46] Chatarina Niken. The Influence of Fly Ash on The Relationship between Autogenous Shrinkage and Hydration Heat in High-Performance Concrete. Jurnal Teknologi (Sciences & Engineering) 86:4 (2024) 171–180.
[47] BS EN 12390-3:2019. Slump test of concrete. This British Standard
[48] BS EN 12390-3:2019. Compressive strength test of concrete. This British Standard
[49] BS EN 12390-3:2019. Flexural strength test of concrete. This British Standard
[50] BS EN 12390-3:2019. Density test of concrete. This British Standard
[51] ASTM, C. "Standard test method for rebound number of hardened concrete." (2008).
[52] Grünewald, Steffen. 2004, Performance-based design of self-compacting fibre reinforced concrete. Technology. https://conferences.tiu.edu.iq/iec/wp-content/uploads/2018/02/iec2018.15.pdf
[53] Ibrahim, Y.E.; Adamu, M.; Marouf, M.L.; Ahmed, O.S.; Drmosh, Q.A.; Malik, M.A. 2022. Mechanical Performance of Date-Palm-Fiber-Reinforced Concrete Containing Silica Fume. Buildings, 12, 1642. https://doi.org/10.3390/buildings12101642
[54] Song P S and Hwang S. 2004. Mechanical properties of high-strength steel fiber-reinforced concrete Construction and Building Materials. 18(9) 669–73
[55] N Majain , A B A Rahman , R N Mohamed1 and A Adnan (2018) 10th Asia Pacific Structural Engineering and Construction Conference 2018 IOP Conf. Series: Materials Science and Engineering 513, 012007
[56] Khaleel H. Younis1 , Fatima Sh. Ahmed2 , Khalid B. Najim, 2018, "Self-Compacting Concrete Reinforced With Steel Fibers from Scrap Tires: Rheological And Mechanical Properties" 4th International Engineering Conference on Developments in Civil & Computer Engineering Applications 2018 (ISSN 2409-6997)
[57] Jhatial AA, Goh WI, Mohamad N, Sohu S, and Lakhiar MT (2018).Utilization of palm oil fuel ash and eggshell powder as partial cement replacement: A review. Civil Engineering Journal, 4(8):1977-1984
[58] Ahmad S. and Umar A., 2018. Fibre-reinforced Self-Compacting Concrete: A Review. International Conference on Mechanical, Materials and Renewable Energy. IOP Conf. Series: Materials Science and Engineering 377, 012117.
[59] S.M Samindi M.K Samarakoona, Pål Rubena, Jørgen Wie Pedersena, Luis Evangelistaa,b, 2019. Mechanical performance of concrete made of steel fibers from tire waste"; Case Studies in Construction Materials, 11.
[60] Alatshan F., Altlomate, A. M., Mashiri F. and Alamin W. 2017. Effect of date palm fibers on the mechanical properties of concrete. The International Journal of Sustainable Building Technology and Urban Development. June. pp. 68-80.

DOI: https://doi.org/10.11113/jurnalteknologi.v88.24549

[61] Mohd Hilton Ahmad, Nurazuwa Mohd Noor, "Mix Design of Palm Oil Fiber Concrete" UTHM Institutional Repository;
[62] M. Dahou and A. Hamouine, 2018. Study of The Cracking of Reinforced concrete between the Vegetable Fibers of Date Palm "Beam and Pulling"; International Journal of Civil Engineering and Technology (Ijciet); Volume 9, Issue 6, June 2018, Pp. 838–849, Article Id: Ijciet_09_06_097 Available Online At http://Iaeme.Com/Home/Issue/Ijciet?Volume 9&Issue 6 Issn Print: 0976-6308 And Issn Online: 0976-6316.
[63] Rossli, S.A.; Ibrahim, I.S. 2012. Mechanical Properties of Recycled Steel Tire Fibres in Concrete; Technical Report; Universiti Teknologi Malaysia: Johor Bahru, Malaysia.
[64] Siraj, N.; Kedir, N.S. 2017. Synthesis and characterization of pyrolised recycled steel fibers for use in reinforced concrete. International Journal Engineering Science Management Research, 4, 21–32.
[65] Skar˙zy´ nski, Ł.; Suchorzewski, J. 2018. Mechanical and fracture properties of concrete reinforced with recycled and industrial steel fibers using Digital Image Correlation technique and X-ray micro computed tomography. Construction and Building Materials, 183, 283–299.
[66] Ashraf H. Abdalkader, Omer R. Elzaroug and Farhat I. Abubaker. 2018. Effect of Steel Fibre on Mechanical Properties of Normal Strength Concrete, 14th ASEC conference in Jordan 12-15 April 2018 Jordan University of Science & Technology
[67] Banthia, N.; Gupta, R. 2004. Hybrid fiber reinforced concrete (HyFRC): Fiber synergy in high strength matrices. Material Structure, 37, 707–716. [Google Scholar] [CrossRef]
[68] Banthia, N.; Sappakittipakorn, M. 2007. Toughness enhancement in steel fiber reinforced concrete through fiber hybridization. Cement and Concrete Research, 37, 1366–1372. [Google Scholar] [CrossRef]
[69] Mahyuddin Ramli and Eethar Thanoon Dawood 2010. ffects of Palm Fiber on the Mechanical Properties of Lightweight Concrete Crushed Brick. American J. of Engineering and Applied Sciences 3 (2): 489-493, 2010.
[70] Fauzan, Ruddy Kurniawan, Oscar Fitrah N, Claudia Lovina A. N, and Zev Al Jauhari 2019. "Experimental Study on The Effect of Steel Fiber Waste Tyre on High Strength Concrete"; International Journal of GEOMATE, June, Vol.16, Issue 58, Pp.14 - 19
[71] Bamaga, S.O. A Review on the Utilization of Date Palm Fibers as Inclusion in Concrete and Mortar. Fibers 2022, 10, 35. https://doi.org/ 10.3390/fib10040035
[72] Bamaga, S.O. Physical and mechanical properties of mortars containing date palm fibers. Mater. Res. Express 2022, 9, 015102.
[73] Shohana Iffat, 2015, Relation Between Density and Compressive Strength of Hardened Concrete" Concrete Research letters journal, Vol. 6(4).
[74] Althoey F, Hakeem IY, Hosen MA, Qaidi S, Isleem HF, Hadidi H, Shahapurkar K, Ahmad J, Ali E. Behavior of Concrete Reinforced with Date Palm Fibers. Materials. 2022; 15(22):7923. https://doi.org/10.3390/ma15227923
[75] Asad Kareem, Syed Saqib Mehboob, Diyar Khan, Qadir Bux alias Imran Latif Qureshi, Aïssa Rezzoug, Khizar Hayat, Afsar Ali and Mohd Aamir Mumtaz. A Review on Date Palm Fiber as a Sustainable Reinforcement for Concrete Applications. Int J Concr Struct Mater (2025) 19:98.
[76] Najm, H.M.; Nanayakkara, O.; Sabri, M.M.S. Destructive and Non-Destructive Evaluation of Fibre-Reinforced Concrete: A Comprehensive Study of Mechanical Properties. Materials 2022, 15, 4432. https://doi.org/10.3390/ma15134432
[77] Kumar Mehta and Paulo J. M. Monteiro 2014 "Concrete Microstructure, Properties, and Materials Book"; McGraw-Hill.