Review

Effect on Performance of Concrete materials with Partial Replacement of Natural Materials with Waste Tire Rubber and Nanoparticles:

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Abstract

This paper was dedicated in reviewing of the effect on the performance of concrete with partial replacement of natural materials with scrap tire (waste tire) rubber and with nanoparticles. Currently, the disposal of waste tires is a worldwide challenge, due to their non-degradability and negative impacts related with the environmental and human health aspects. Recycling of scrap tire has become a potential solution for managing, such a waste. A sustainable and durable concrete is vital components for the current and future development. Increasing of the demands of automobile and its industry leads the increase of waste tires in the entire world. It is estimated that in the entire world, about 1 billion end of life tires are produced annually and half of them are discarded without any treatment. Hence, recycling and reusing of waste tire rubber in concrete technology is critical issue. Similarly, the incorporation of nanoparticles into concrete is used to build green and sustainable construction. The nanoparticles are fine-level materials, especially 1 to 150nm scale, but bring vivid changes on the material properties. The aims of this review paper was intended to show the opportunity for utilization of waste tire as a partial replacement of coarse and fine aggregates in concrete, and also indicate the influences of nanoparticles in the concrete structure. As we realized, the substitution of waste tire rubber and nanoparticles in concrete mix positively impacted durability and mechanical properties.

Key Words; Scrap Tire, Landfilling, Waste Disposal, Nanoparticles, Environmentally unfriendly

1. Introduction

The civil constructions, like house buildings, bridges, highways, roads, subway tunnels and light rail transit lines usually consumes gigantic amounts of natural materials or resources and that requires great costs as well. Therefore, there is a great interest in replacing the traditional ingredients of concrete through unwanted waste materials without compromising mechanical strength and durability properties. Among various wastes released to environment; waste tire rubber is one. The most common used method to handle waste tire is landfilling, but it takes 80–100 years to degrade in landfills (L. Chao et al 2020, and Li et al 2019). As researches conducted in the area shows, landfilling is not a feasible process in many aspects. It upsets the fertility of land, human health, and causes of firing hazards. It has direct effect on contamination of soil and ground water due to the leaching effect of toxic metals present in tires (Li et al 2019). Similarly, burning is one of the measurements taken to remove waste tires. However, it released harmful emissions that cause the ozone depletion and related health hazards (Bravo et al 2012). It is not favorable and environmentally detrimental method, since large amounts of toxic gases released into the environment (Saputra R. et al 2020). As various authors in their work indicated, concretes containing supplementary materials are widely regarded as a durable, long lasting and sustainable structural material (D.K. Panesar, and R. Zhang 2020). The partial substitution of waste tire in the concrete, as aggregates, is an effective approach of immobilizing waste, especially when 60–75% of concrete is made of aggregates. There is rapid growth of population and the usage of cars; waste tires are causing serious environmental problems and ecological threats, which can be solved by recycling them as aggregates in concrete. It is estimated that in the entire world, about 1 billion end of life tires are produced annually and half them are discarded without any treatment. By the end of 2030, more than 5 billion of tires are expected to be scraped regularly and 1.2 billion rubber tires will be discarded (F. Abbassi, F. Ahmad 2020). As previous research works assured, the current recycling trend of waste tire is less than 50% and the remaining part goes to landfills (Hamid et al 2020). Recycling of waste tires shall not only reduce consumption of natural aggregates, rather creating mechanisms to let safe disposal (A.M. Mhaya et al 2020).

As the findings of scholar's shows that the partial replacement of scrap tires as a coarse and fine aggregates in concrete reduces its performance, like mechanical strength and durability properties. Hence, to solve the disadvantages of replacing of some fine and coarse aggregates with scrap tires, various mechanisms has been understood. Among these various means of techniques; using of reduced contents of scrap tire, and treating with fillers; such as fly ash or silica fumes were realized. Substitutions of the natural aggregates with the recycled tire as aggregates in concrete, will help to produce structural element with improved behavior; increased capacity for deformation (ductility), toughness, better dissipation of energy, thermal insulation, and low density (Fernando et al 2011).

On the other hand, the influence of nanoparticles (NPs) in concrete technology has reviewed. Substitution of cement with nanoparticles with optimal usage level of 2% by mass due to its tendency to agglomerate (Ö.B Ceran et al 2019) has improved concrete materials mechanical and durability properties. Since, nanoparticles provide large specific surface area, leading to the speeding up of the hydration rate, and the filling effects of voids with non-reactive particles. Furthermore, NPs can bring specific properties to concrete such as antimicrobial, hydrophobic or self-cleaning surfaces (Ö.B Ceran et al 2019). In recent times, mixing of concrete with NPs, as an additive, can improve the concrete structure performance, due to their properties at the extreme-fine level. This was due to two main advantages; such as filling of the pores between the cement grains, acting as filler and enhancing the bond between aggregates and cement paste (A.M. Diab et al 2019).

The recycling of scrap tires and partial substitutions of nanoparticles in concrete composition; leads to the production ecological constructions (Kristina et al 2019) in minimizing the consumption of natural materials. Authors (Li et al 2019) study showed in order to maintain mechanical especially durability properties of concrete, scrap tires might be partially replaced the commonly used concrete materials. Previously conducted research works assured that the properties of concrete; like workability, bulk density, compressive strength, flexural strength, split tensile strength, modulus of rigidity, abrasion resistance, fatigue life, fracture energy and toughness, water absorption, porosity, carbonation (Bravo et al 2012), chloride ion permeability have been enhanced.

The concrete modified with scrap tire as well as nanoparticles has superior features. Since, concrete is the most commonly used building materials because of features; such as versatility, ease of raw materials existence, low costs, ease of productions, high mechanical strength, impermeability to water and great durability (Fernando et al 2011). Although, there have been limited numbers of reviewed papers published in the past with partial substitution of scrap tires with coarse and fine aggregates, and nanoparticles with cement in various proportions in concrete technology. Furthermore, we show the possibility of utilizations of waste tires in replacing some virgin material in concrete without compromising the mechanical strength and durability properties. Therefore, various articles have been reviewed with recycling of waste tires and incorporations innovative nanomaterials, like TiO_2 and ZnO_2 in concrete.

2. Scrap tire recycling mechanisms

Burning of scrap tires hamper an atmospheric and health problem. As from articles reviewed, landfilling is not the possible solution of waste tire disposal. Therefore, an alternative means of scrap tire is recycling it in green concrete technology (V. Vishwakarman, D. Ramachandran 2018). The disposals of rubber from discarded tires are reused by recycling and millions of them are stockpiled, buried or landfilled. Stockpiled tires caused numerous types of health, economical risks, and environmental issues through the soil, water and air pollution. Waste rubber tires which are buried or landfills constitute a major part of the solid waste and responsible for a serious ecological treat (F. Abbassi, F. Ahmad 2020). In this case, it can be used as an aggregate of partial replacement material. The same study clearly assured that scrap tire modified concrete is recommended for concrete structures especially in areas of severe earthquake risks and severe dynamic actions.

Scrap tire has unlikely to be disintegrated (decomposed), and are as burying the waste tires would shorten the service life of the burial ground. In addition, buried scrap tires regularly emerge from the burial ground surface or destroy the anti-leakage cover of the burial ground and the exposed scrap tires accumulate water that may breed bacteria, molds etc. In case of fire, waste tires generate toxic gases (Saputra R, et al 2020), such as dioxin, that could result in severe pollution problems (Bekhiti et al 2014). Incineration is not an environment-friendly way, either, due to the release of CO, CO_2, dioxins, dioxin-like compounds, volatile organic compounds (VOC) and particulates which imposes a hazard to public health (L. Chao et al 2020). The experimental result of various scholars shows that, they affect a number of organs and systems in a body. Once dioxins pass in the body, they last a long in the body because of their chemical stability and their ability to be absorbed by fat tissue. As all reviewed papers indicated with details, recycling scrap tire in concrete industry works for a means of filler. Disposal of scrap tire is main environmental issue in almost all parts of world. A small percentage of waste tires are recycled and millions of them are stockpiled, buried or landfilled. The stockpiled tires caused many types of health, economical risks, and environmental issues. When waste tires are stockpiled, various pests especially dengue mosquitoes can breed in the stored water. The easiest and low-cost method to dispose waste tire is burning, but it generates hazardous gases, which consequently pollutes the environment (Abbassi & Ahmad 2020).

3. Preparation Stages of Coarse and Fine aggregates

As the research works of (A.M. Mhaya et al 2020) showed, the sieve analysis conducted for the grading of coarse aggregates according to ASTM C-136. The particles size distribution was performed with the standards, and the particles size from 1 to 4mm was classified as fine aggregates and used to replace partially to the natural fine aggregates. The particles size of scrap tire between 5 to 8mm was classified as coarse aggregates and replaced to the natural coarse aggregates.

The scrap tire aggregates is an engineered product made by cutting scrap tires into small pieces using shredder and shearing equipment. However, the treatment of the scrap tire expected with using chemical materials; such as sodium hydroxide (NaOH) to enhance the surface adhesion. Although, the treatment of scrap tires with treating materials, increases the costs of the concrete production as the partial replacement. For this reason, mostly the scrap tire wastes can be recycled without any chemical treatment. The coarse and fine aggregates preparation stages have been presented in (fig.1).

Fig (1): Preparation stages of the coarse and fine aggregates scrap tire wastes (A.M. Mhaya et al 2020)

The research works of (L. Liu et al 2020) indicated the waste tire can be classified into the chipped/shredded aggregate (13–76 mm), the crumb rubber (0.425–4.75 mm), the ground rubber (<0.45mm) and the rubber aggregate (an average length of 12.5mm) as shown by fig (2). In addition, the waste tire rubber divided into rubber chips (10-25mm), ground rubber (0.5-4.75mm) and crumb rubber (0.5-1.5mm) it has been depicted in the fig (3).

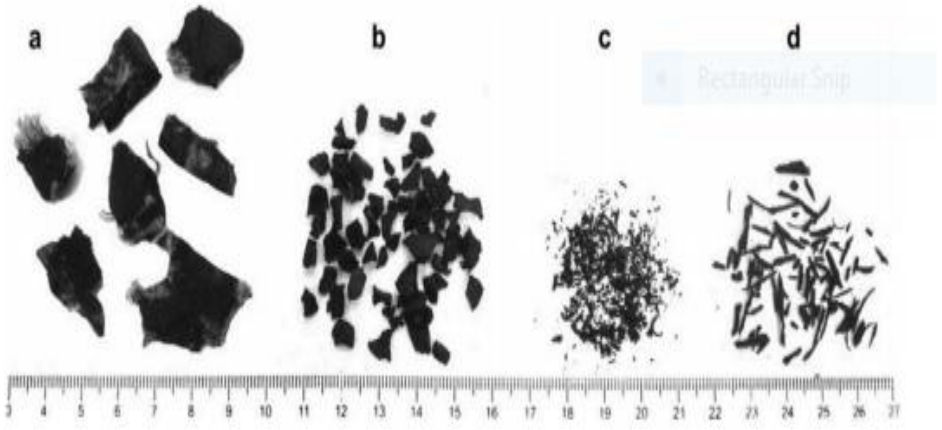

Fig - 2 (a) Chipped, (b) crumb, (c) granular and (d) fiber (L. Liu et al 2020)

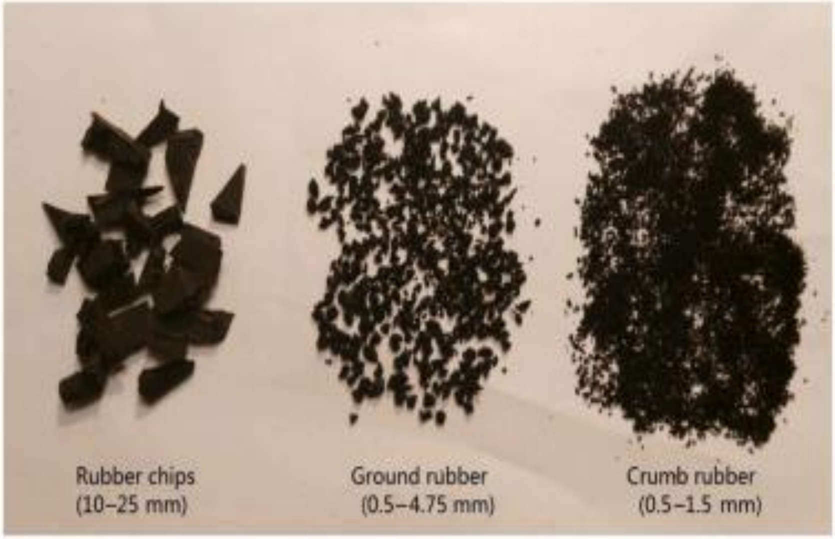

Fig (3) Designation of waste tires rubber tire particles (L. Liu et al 2020)

4. Nano-particles influence in concrete

The influences of some nanoparticles in concrete technology have been reviewed. The nanoparticles can result in dramatically improved properties from conventional grain size material of the same composition. Currently, many articles have been described on the application of nanotechnology in building materials. The use of nanoparticles in the concrete structures modifies the physical, mechanical and morphology. Nanoparticles regulate the matter at atomic level that deals with particle which is less than 100 nm in size. Nanoparticles with 4 nm diameters have more than 50% of its atoms at the surface, and are thus very reactive. Nanoparticles in the concrete matrix act as a filler and activator to encourage hydration process and thus develop the microstructures of concrete. Hereby, some important nanoparticles reviewed as following.

4.1. TiO_2 Nanoparticles

Titanium dioxide (TiO_2) is having hydrophilic and self-cleaning properties, which have the ability to break down organic pollutants and bacterial membranes because of powerful catalytic reactions. TiO_2 nanoparticles speed up the hydration of cement and thus enhance the strength of the concrete because of its filler effects. There are several reports of TiO_2 particles blended concrete having considerably higher compressive strength when compared to that of the concrete without nano-TiO_2 particles. The replacement of cement with nano-TiO_2 particles up to

(0.5%, 1%, 1.5%, and 2%) of particle sizes of around 15–20 nm improve the durability of the concrete. However, it was also established that partial replacement of cement by nano-TiO_2 particles declined workability of fresh concrete; therefore, use of super plasticizer or water reducing agents or some mineral admixtures is significant. Addition of TiO_2 nanoparticles by replacing the cement in concrete structures could succeed additional antibacterial and self-cleaning properties and durability. The major application of TiO_2 in building materials is due to its photo-catalytic action (Ö.B Ceran et al 2019) to reduce the pollution level, self-cleaning to maintain the aesthetic appearance and self-disinfection properties to achieve a microorganism free environment in concrete structures (N. Salemi et al 2014).

Nanoparticles can successfully improve the durability and mechanical properties of concrete, but they become agglomerate in the concrete beyond certain authors have determined that the optimum percentage of nanoparticles replacement has to be 1% or fewer due to the agglomeration problem, in which nanoparticles reveal a strong tendency to around each other as outcome of Vander Waals forces (Ö.B Ceran et al 2019).

4.2. $CaCO_3$ Nanoparticles

The habit of nano-$CaCO_3$ in the concrete structures acts as filler and offers additional strength and acceleration of hydration rate. The adding of nano-$CaCO_3$ diminished the ability to flow and the setting time was shortened. But, nano-$CaCO_3$ had no effect on water necessity of normal consistency of cement. According to the (V. Vishwakarma, D. Ramachandran 2018) adding 1% of nano-$CaCO_3$ could noticeably decrease the early age shrinkage of cement paste. Recently, conducted research works shows the seeding influence of the nano-$CaCO_3$ particles and the nucleation of C-S-H caused better strength development. Addition of nano-$CaCO_3$ in concrete mixture may shrink the calcium leaching problem and improves hydration time, filler with developed rate of hydration, compressive strength, better physical and chemical properties.

A study on the addition of large quantity of $CaCO_3$ established the acceleration of hydration of C_3S. The accelerating consequence of the finely ground $CaCO_3$ in the hydration of cement paste leads to the precipitation of some calcium carbon-silicate hydrate. The hydration of tricalcium silicate (C_3S) in existence of more than 30% $CaCO_3$, produce some calcium carbon-silicate hydrate with worthy mechanical performance.

4.3. Zinc oxide Nano-particles

The nanoparticles of ZnO_2 have similar properties, like TiO_2 nanoparticles are also antifungal, antibacterial and anticorrosive type of material. The partial replacement of cement by 4% ZnO_2 nanoparticles could accelerate C–S–H gel formation at beginning of hydration reaction. As the authors (N. Salemi et al 2014) showed in their works, ZnO_2 nanoparticles act as nano-fillers and used to reduce the pore structure of the specimens by decreasing of harmful pores. When the content of ZnO_2 nanoparticles is increased up to 3 % by weight, the flexural strengths of the specimens is increased which was confirmed by rapid formation of hydrated products within the composition (N. Salemi et al 2014).

4.4. Fe_2O_3 nanoparticles

Like other nanoparticles, 2% replacement of cement with Fe_2O_3 nanoparticles in concrete showed improved strength, whereas the ultimate strength of concrete was gained at 1.0% of cement replacement (N. Salemi et al 2014). The same study assured the partial replacement nanoparticles improves the split tensile and flexural strength of concrete, and also decreases its setting time and pore sizes, hence less pores, dense and compact microstructures has been attained in the microstructure of cement mortar.

However, increasing Fe_2O_3 nanoparticles up to 5% decreases the mechanical properties and durability properties as well. The addition of 4.0% of Fe_2O_3 nanoparticles in concrete increased the strength and water impermeability of the concrete specimens and reduced the harmful pores to improve the water permeability and considered as nanofillers.

As various researches finding in their experimental works showed the addition of Fe_2O_3 nanoparticles supports the formation of calcium silicate hydrate gel, which is responsible in playing filling effect with high pozzolanic action.

4.5. SiO_2 nanoparticles

The partial substitution of cement with SiO_2 nanoparticles provides additional strength to the concrete as it acts with calcium hydroxide of fresh concrete and make additional C-S-H gel to reduce permeability and refined pore structure, which results in a higher resistance to sulfate attack in aggressive environment. Nanoparticles of SiO_2 acts as a nano-filler because of formation of C–S–H gel and higher densification of the cement matrix improves the strength and durability of the material.

The uniform distribution of nanoparticles increased the compressive strength in cement mortar as well. As the (V. Vishwakarma, D. Ramachandran 2018), reviewed the influence of nano-silica as a partial substitution of cement in concrete, and at the age of 3 days, the compressive strength of concrete increased between 3.82 and 11.84%; while, at the age of 7 and 28 days, the compressive strength of concrete with nano-silica increased by 3.87–17.24% and 4.93–24.59% respectively. The same investigations indicated that the partial replacement of cement with SiO_2 generated additional C-S-H gel and which is responsible for the both mechanical strength and durability properties.

5. Mechanical strength

5.1. Compressive

The reductions in compressive strength have been encountered by the increase in scrap rubber content (Choudhary et al 2020). The incorporations of scrap tire rubber decreased the compressive strength of the concrete. The reasons behind, could be the weaker bonding and lesser stiff rubber particles. Also, the packing of lightweight waste tire rubber particles becomes difficult at large content, which generates voids in the rubber modified concrete. According to the investigations of (Li et al 2019, Sofi 2017, Bravo and Brito 2011, Rajan et al 2020) adding scrap tire rubber into the concrete blends in the most cases decreases its compressive strength and modulus of elasticity. This circumstance is mostly attributed to the poor strength of the interfacial transition zone (ITZ) between waste tire rubber particles, and surrounding cement matrix as well.

According to the (Kristina et al 2019), the substitution of fine aggregates with smaller size scrap tire particles caused the lowest decrease of compressive strength, while the greatest was with the substitution of coarse aggregates. When increasing the waste tire particles concentration and adding large particles; more air content is found which may cause micro-cracking and in consequence lower compressive values (Herrera-Sosa et al 2015).

Majority of previous studies have shown the trend of increase in compressive strength with a decrease in rubber aggregate size. This is because of the relatively better voids filling ability of the finer scrap tire rubber particles which lower the voids space and help in higher compressive strength. Almost all, the research works have been done shows less significance of replacing coarse aggregates with waste tire rubber. For example, as the observation of (Hamid et al 2019) shows, 85% reduction in compressive happened when 100% coarse aggregates were replaced with scrap tire rubber chips compared to 65% reduction up on 100% fine aggregate replacement with crumb rubber. Scrap tire particles excellent characteristics was the attribution to the crack bridging and crack arresting property in concrete materials.

Table -2: Utilizations of scrap tires aggregates in concrete

S.no	Properties	Results	Materials replaced	% of replacement	Reference
1	Compressive strength	The compressive strength of concrete decreases with in percentages of treated waste tire rubber.	Coarse and Fine aggregates	%(0, 2.5, 5, 7.5, 10)	Rajan et al 2020
	Split tensile strength	The split tensile strength decreases with increase in percentage of treated waste tire rubber.			
	Flexural strength	The flexural strength attains 100% of replacement of treated waste tire rubber in 2.5% by weight percent comparing conventional concrete.			
2	Compressive strength	Reduced	Coarse and Fine aggregates	% (5, 10, 15)	Bravo and Brito 2011
	Shrinkage	Uninfluenced with use of rubber aggregates			

	Water absorption	Increased			
	Carbonation resistance	Increased			
	Chlorides penetration	Increasing the size of replaced aggregates lead to a high chloride diffusion			
3	Compressive strength	Without a significant loss of strength	Coarse and Fine aggregates	% (10)	Fernando et al 2011
	Elastic modulus	Addition of rubber in the concrete directly affects its elastic modulus			
	Density	Density of concrete with recycled rubber is diminished by 13% in comparison with the reference concrete			
4	Compressive strength	Decreases with an increased replacement of rubber fibers	Fine and coarse aggregates, cement	% (5, 7.5, 10)	Sofi 2017
	Flexural strength	Decreases when the amounts of rubber has increased from 20 to 30%			
	Modulus of elasticity	Replacing rubber particles for aggregates and			

		cement will reduce modulus of elasticity of concrete			
	Tensile strength	Reduced with replacement of waste rubber contents increased			

5.2. Flexural strength

As the study of (Choudhary et al 2020) shows, the scrap tire rubber provided improved strength which helped in better flexure strength. Higher strength can also be attained due to the better pulling resistance of rubber fiber as compared to the natural fine aggregates. The increase in rubber fiber, increased the flexural strength compared to conventional concrete, this was due to better griping strength of rubber fibers in the lower layer of concrete (Choudhary et al 2020).

As the experimental findings of (Choudhary et al 2020), the flexural strength is dropped from 4.5MPa to 4.1, 3.8 and 3.3MPa, respectively when the replacement level is raised from 5% to 10, 20, and 30%. The overall, performance of the flexural strength was analogous to that of the compressive strength and the significance of deformability in the rubber particles could stand as against the cracks propagation in the concrete.

From the experimental results of (Sofi A. 2017), the flexural tensile strength of 7, 28 and 90 days with respect to the various percentages of tire rubber were shown in (fig 4). At 7days, the extreme value of (6.2MPa) was observed for the mixes with 0% and 2.5% crumb rubber and minimum value (4.6MPa) observed for the mixes with 17.5% and 20% tire rubber. Similarly, at 28days, the maximum value (7.3MPa) was obtained in the mixes with 2.5% crumb rubber and minimum value (5.5MPa) was obtained for the mixes with 20% crumb rubber. The same trend as 28days has been observed at the 90days, where the maximum and minimum values were 7.9 and 5.7MPa, respectively.

When the 90days strength was considered, there was 28% reduction in flexural strength (20% crumb rubber) when compared to the control mix specimen. Also, it was perceived that the control specimens revealed brittle failure and was broken to two pieces in loading while the waste tire rubber concrete didn't displayed brittle catastrophe under flexural tensile loading. The control specimens showed brittle failure and split into two pieces instantaneously after cracking, while the specimens containing tire rubber showed deformation without complete disintegration (Sofi A.2017). So that, the incorporations of waste tire rubber into concrete materials provides a chance to develop crack resistance behavior of concrete.

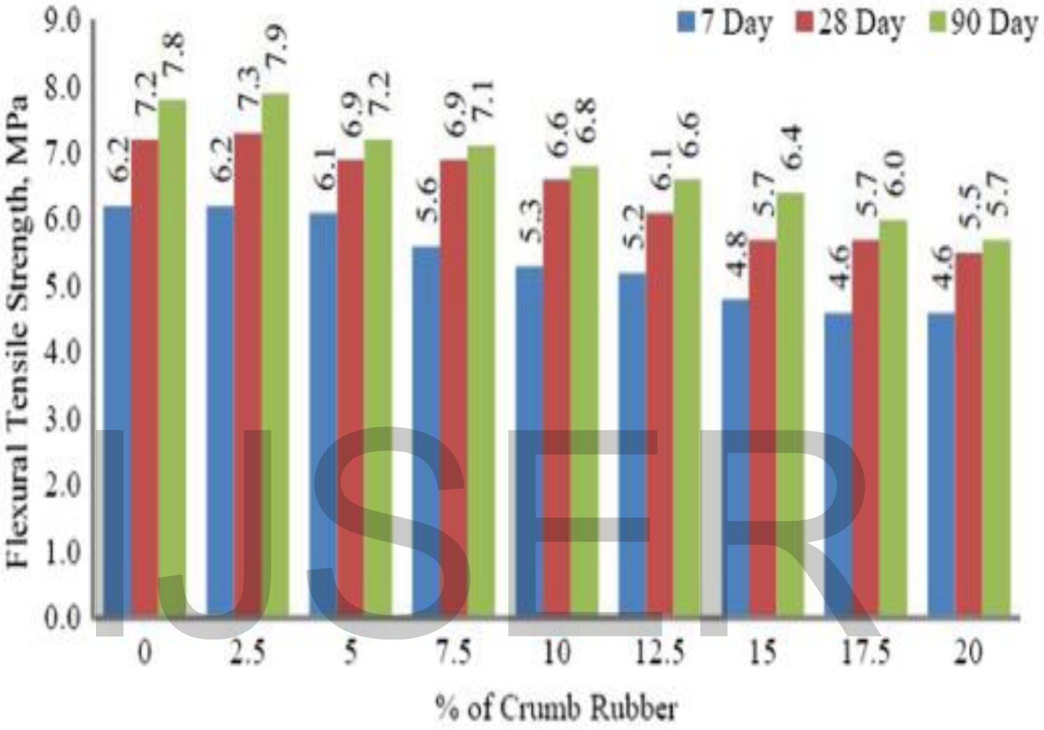

Fig -4: Flexural tensile strength for varying curing period 7 days, 28 days and 90 days (Sofi 2017)

5.3. Modulus of Elasticity

The elastic modulus of concrete materials reduced from 24.1GPa to 6.3GPa with the partial replacement of rubber particles at a high content of 100% (Copetti et al 2020). The rubber content should be limited to a maximum of 20-30%, however, the mechanical properties can be improved with higher content of cement, lower proportion of w/b, incorporating supplementary cementitious materials, such as metakaolin (compressive strength rises by up to 20%) and choosing the surface treatment method to increase the adherence between the rubber and the cement paste. However, unlike the effects on compressive strength, the performance of treated rubber concrete was better than that of the ones with untreated rubber. When the scrap tire rubber treated with the silica fume or limestone, the elastic modulus becomes increased. For example, the most dramatic improvement (12%) in the elastic modulus was observed in concrete with 15% scrap tire rubber addition and 7.5% silica fume.

The main reason considered by the authors; was the filling of pores with the silica fume between the aggregates and the cement paste in the concrete mix. The authors (Copetti et al 2020) indicated the tire rubber elastic modulus is considerably smaller than that of the modulus elasticity of the natural aggregates.

From the study of (Copetti et al 2020), we can see the possible correlation between compressive strength, and elastic modulus of the concrete for different rubber and silica contents in figure-7. The elastic modulus tends to decrease as the tire rubber has incorporated. In contrast, these properties increases with the incorporation of silica fumes, mainly due to microstructural densification in transition zone owing to the pozzolanic effects (Copetti et al 2020).

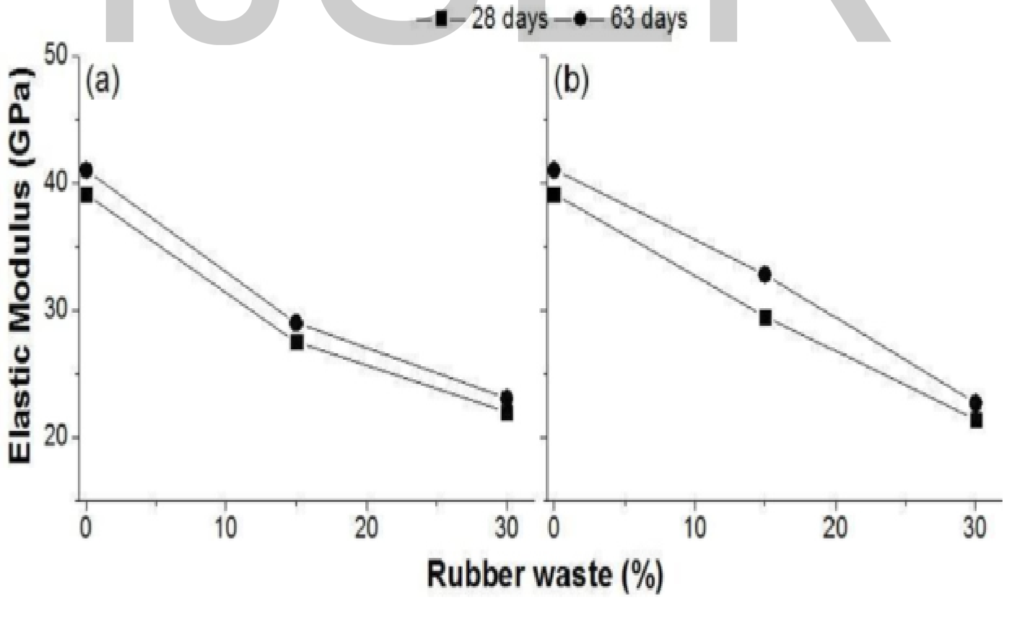

Fig -5: Elastic modulus of concretes with (a) untreated and (b) treated rubber (Copetti et al 2020)

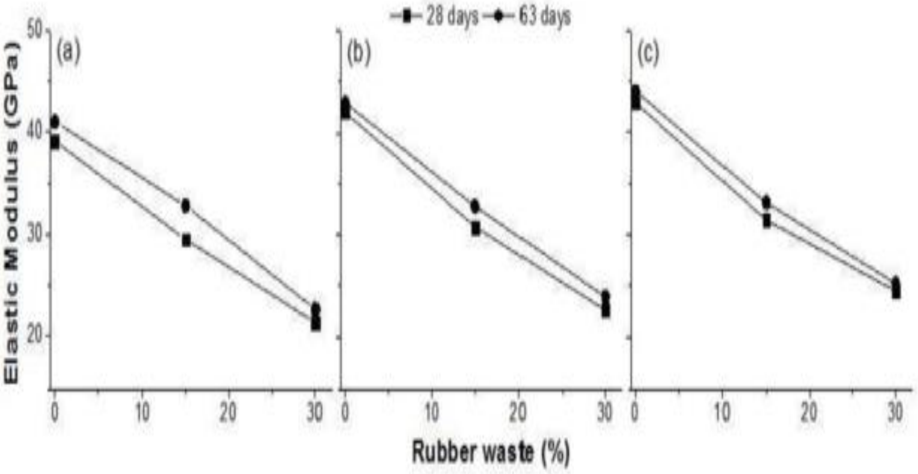

Fig -6: Elastic modulus for concretes with rubber treated with: (a) no silica fume, (b) 7.5% silica fume, and (c) 15% silica fume (Copetti et al 2020)

6. Microstructure analysis

As the microstructural analysis with scanning electron microscope (SEM) of concrete performed by authors (Fernando et al 2020) indicated, the morphology and porosity of the interface between the rubber and the cement matrix has seen in the fig (7).

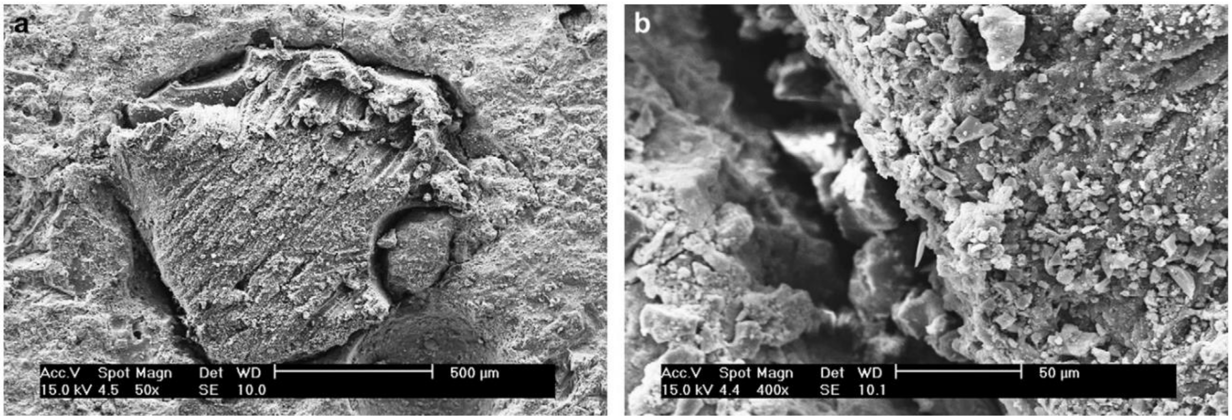

Fig -7: Microstructure of the concrete with rubber: (a) cement matrix with rubber particle; (b) interface rubber/concrete (SEM) (Fernando et al 2011)

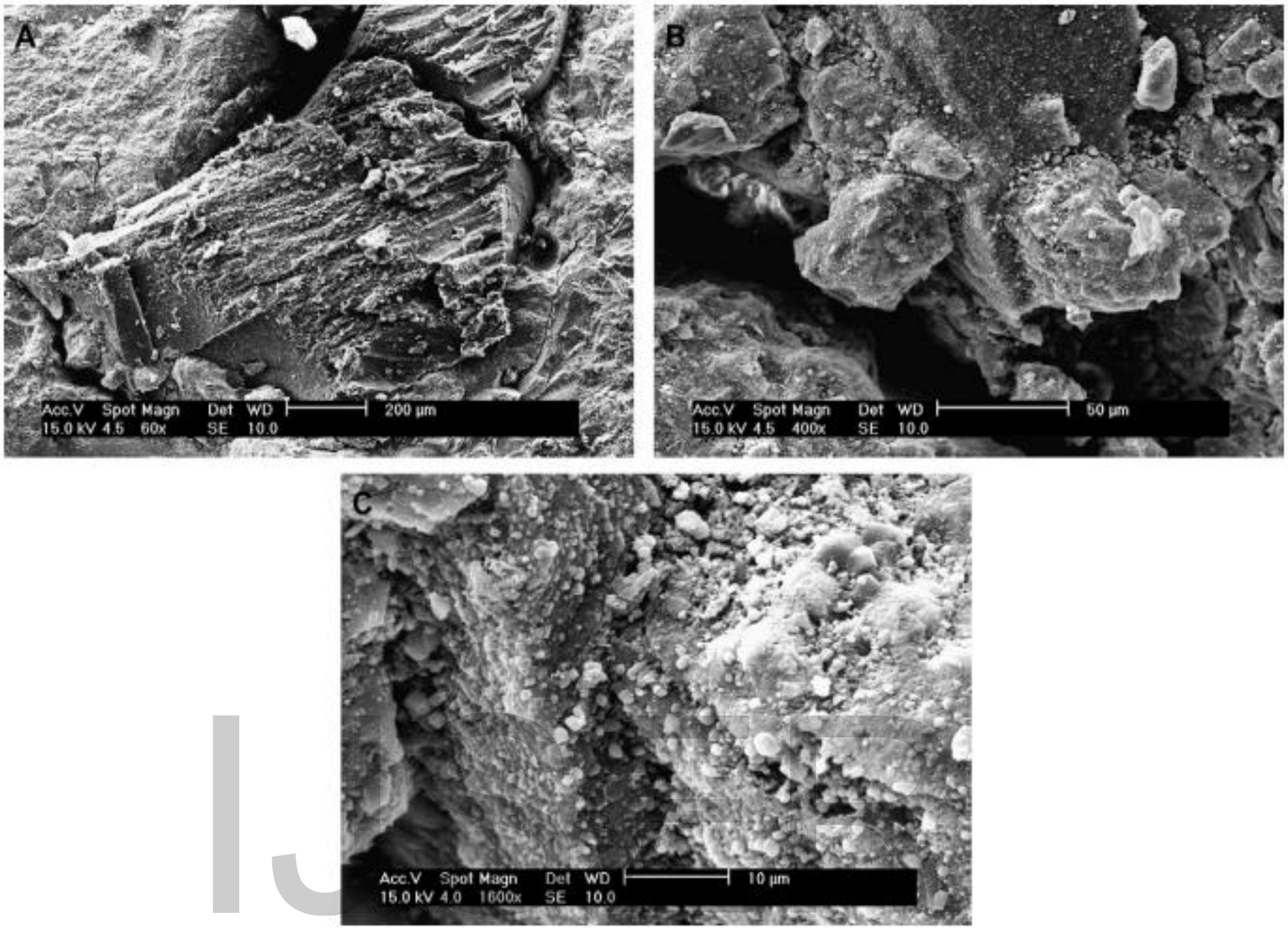

Fig 8: Microstructure of the concrete: (a) cement matrix with modified rubber particle; (b) interface modified rubber/concrete (SEM); (c) details showing the silica fume on the rubber particle (Fernando et al 2011)

The concrete materials made with scrap tire rubber shows large gaps in the boundary rubber/cement matrix as depicted (in fig. 7). The micrographs show that the scrap tire rubber particles have an uneven shape. As anticipated, the EDS analysis accomplished on the rubber surface shows high carbon content (in fig. 9). The other elements found in the result were Na, Mg, Al, Si, K, Ca and Fe as regular constituents of cement matrix.

In fig. 8a & b, as the SEM-EDS analysis indicated; the porosity reduction in the transition zone in modified rubber concrete. This was due to the hydrophilic effect with the treatment of rubber with sodium hydroxide. The addition of silica fume is also favorable for the porosity reduction in the interface of aggregates. The existence of silica fume and treating tire rubber with sodium hydroxide contributed to the recovery of the concrete strength and a lower permeability (F. Pelisser et al 2011).

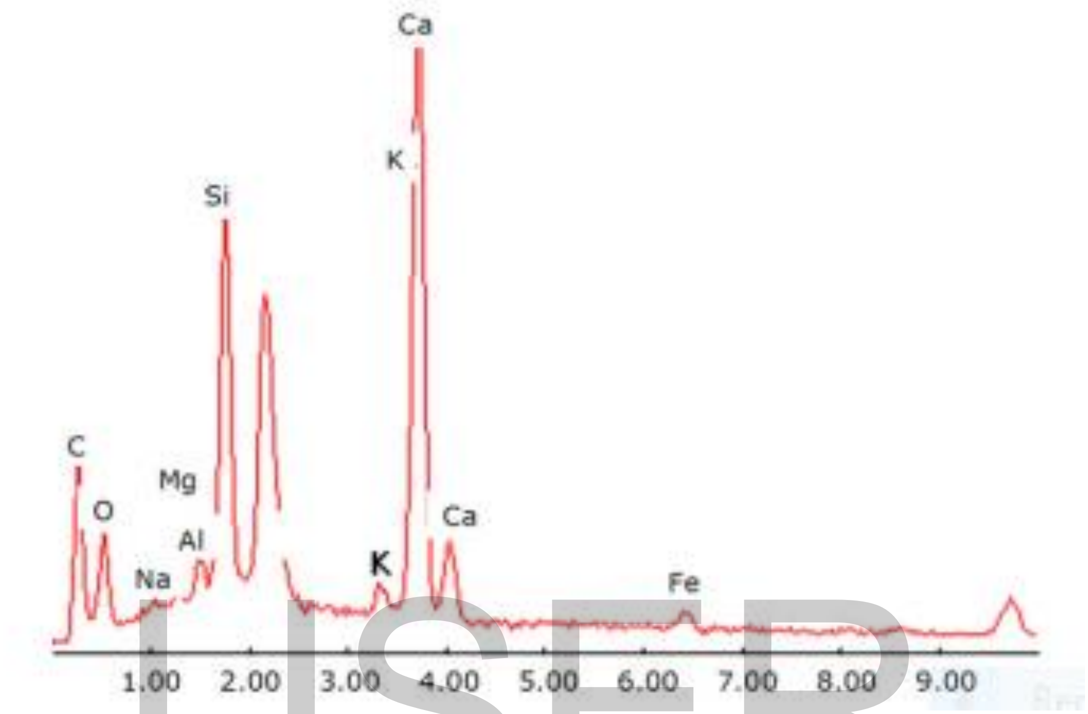

Fig 9: Chemical analysis (EDS) in the interface rubber/concrete (F. Pelisser et al 2011)

7. Conclusions

This paper reviews have been carried out to show the effects on concrete performance with partial replacement of coarse and fine aggregates with scrap tire rubber, and also incorporating cement with various types of nanoparticles. The concrete properties like; compressive strengths, flexural tensile strength, elasticity of modulus, ductility, durability, water permeability, and toughness have been enhanced through partial replacement of natural aggregates in concrete.

The sustainability, durability, and self-cleanness of building construction ensured through supplementary materials, like scrap tires and nanoparticles. The incorporation of scrap tire changed the concrete behavior from being brittle to ductile and their capability to absorb compression energy (compression toughness), whereas nanoparticles could accelerate C–S–H gel formation at beginning of hydration and hence, improved the concrete properties. Very interesting facts in concrete materials modified with scrap and nanoparticles were; controlling of crack propagation by bridging the cracks and transmitting tensile forces across them have been enhanced. In short, recycling of scrap tire rubber in concrete technology and replacing some amounts of cement with nanoparticles provides an opportunity of durable concrete structure, created health and fresh environment.

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