Review paper-Effect of crumb rubber tyre in conventional concrete

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Abstract

Disposal of waste tyre rubber has become a major environmental issue in all parts of the world representing a very serious threat to the ecology. One of the possible solutions for the use of scrap tyre rubber is to incorporate it into concrete, to replace some of the natural aggregate. The paper evaluates the influence of the rubber powder on material characteristics and durability of CRC. CRCs with various contents of fine and coarse crumb powder were compared. The tested parameters were slump, air content, permeability, resistance of concrete to water with deicing chemicals, compressive and splitting tensile strength. The tests showed that workability, compressive strength and permeability decreased as the amount of rubber increased, but the air content increased as the rubber content increased. Photos of air voids in cement matrix from electron microscope were captured (SEM is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample.) The results of laboratory tests showed that admixture of rubber powder in concrete could have a positive impact on durability of concrete and concurrently contribute to sustainable development. Considering the lower compressive strength, CRC is recommended for use in applications where the high strength of concrete is not required.

Keywords **:***Aggregates, Compressive strength, Crumb tyre, Flexural strength, Tensile strength, Weight loss.*

1.Introduction

The vehicle tyres which are disposed to landfills constitute one important part of solid waste. Stockpiled tyres also present many types of, health, environmental and economic risks through air, water and soil pollution. The tyres store water for a long period because of its particular shape and impermeable nature providing a breeding habitat for mosquitoes and various pests [1–3] .Tyre burning, which was the easiest and cheapest method of disposal, causes serious fire hazards [4]. In addition, the residue powder left after burning pollutes the soil.

An estimated 1000 million tyres reach the end of their useful lives every year [1]. At present enormous quantities of tyres are already stockpiled (whole tyre) or landfilled (shredded tyre), 3000 millions inside EU and 1000 millions in the US [2]. By the year 2030 the number of tyres from motor vehicles is expect to reach 1200 million representing almost 5000 millions tyres to be discarded in a regular basis. Tyre landfilling is responsible for a serious ecological threat. Mainly waste tyres disposal areas contribute to the reduction of biodiversity also the tyres hold toxic and soluble components [3]. Secondly although waste tyres are difficult to ignite this risk is always present. Once tyres start to burn down due to accidental cause’s high temperature take place and toxic fumes are generated [4] besides the high temperature causes tyres to melt, thus producing oil that will contaminate soil and water.

Crumb rubber of different sizes

2. Mechanical Properties

2.1. Compressive strength

The variations in compressive strength obtained at 7, 28 and 90 days with respect to the percentage of crumb rubber [6]. Gradual decrease in compressive strength was noticed as the percentage of crumb rubber increased. The reduction in compressive strength of the mix with 20% crumb rubber was more than 50% than the value of the control mix. At 7 days, the maximum compressive strength (65.5 MPa) was obtained for the control mix with 0% crumb rubber and the minimum value (27 MPa) for the mix with 20% crumb rubber. Same trend was observed for the compressive strength at 28 and 90 days. At 28 days, a strength above 60 MPa was obtained for all the mixes in which the amount of rubber was from 0% to 10% and at 90 days, all the mixes in which the crumb rubber was substituted from 0% to 12.5% crossed the 60 MPa threshold. The control specimens exhibited brittle failure while the rubberized concrete did not show brittle failure under compression loading. Horizontal cracks were observed for the specimens with rubber and inclined cracks were observed in the control specimens. The loss in mechanical properties of rubberized concrete was supported by the results obtained by various researchers [5]. The reasons for the decrease in compressive and flexural strength of the rubberized concrete [8]. (a) The aggregate would be surrounded by the cement paste containing rubber particles. This cement paste would be much softer than that without rubber. This results in rapid development of cracks around the rubber particles while loading and this leads to quick failure of specimens. (b) There would be lack of proper bonding between rubber particles and cement paste, as compared to cement paste and natural aggregate. This can lead to cracks due to non-uniform distribution of applied stresses. (c) The compressive strength depends on the physical and mechanical properties of the constituent materials. If part of the materials is replaced by rubber, reduction in strength will occur. (d) Due to low specific gravity of rubber and lack of bonding of rubber with other concrete ingredients, there is a tendency for rubber to move upwards during vibration leading to higher rubber concentration at the top layer. Such a non-homogeneous concrete sample leads to reduced strengths.

2.2. Flexural strength

The variations in flexural tensile strength obtained at 7, 28 and 90 days with respect to the percentage of crumb rubber shown in [7]. At 7, 28 and 90 days, gradual reduction in the flexural strength was noticed as the percentage of crumb rubber increased. At 7 days, the maximum value (6.2 MPa) was observed for the mixes with 0% and 2.5% crumb rubber and minimum value (4.6 MPa) observed for the mixes with 17.5% and 20% crumb rubber. At 28 days, the maximum value (7.3 MPa) was obtained in the mix with 2.5% crumb rubber and minimum value (5.5 MPa) was obtained for the mix with 20% crumb rubber. Same trend as 28 days has been observed at 90 days, where the maximum and minimum values were 7.9 MPa and 5.7 MPa respectively.

When the 90 days strength was considered, there was 28% reduction in the flexural tensile strength of the rubberized specimen (20% crumb rubber) when compared to the control mix specimen. Also it was observed that the control specimens exhibited brittle failure and was broken to two pieces under loading while the Compressive strength of varying crumb rubber (%). Compressive strength a curing period of 7 days. Compressive strength a curing period of 28 days. Effect of waste tyre rubber on mechanical and durability properties of concrete – A review. Ain Shams Eng rubberized concrete did not show brittle failure under flexural tensile loading[1]. The specimens containing tyre rubber (in the form of fibres) up to 20% exhibited higher flexural strength than the control specimens The flexural strength decreases when the amount of rubber was increased from 20 to 30%. The control specimens exhibited brittle failure and split into two pieces immediately after cracking, while the specimens containing rubber fibres showed deformation without complete disintegration. Su et al. [10] observed a reduction of 12.8% in the flexural strength when 20% fine aggregate was substituted with rubber aggregate. Less loss in strength was obtained when the size of rubber particles were smaller. This would be due to the filler effect of small rubber particles that increase the compactness of concrete, reduce the stress singularity at internal voids and hence reduce the likelihood of fracture. The addition of silica fume and reduction in watercement ratio has enhanced the flexural strength of rubberized concrete As the effect of silica fume enhanced the interfacial transition zone bonding, the reduction in strength of high strength rubberized concrete [11] was lower than that of the normal strength concrete. The highest strength (3.18 MPa) was obtained for the control mix specimens and lowest value (2.15 MPa) was observed for the specimens with 20% crumb rubber. Gradual decrease in the pull-off strength was observed as the percentage of crumb rubber substitution was increased. It was clear from the results that the variation in pull-off strength closely follows the trends of the corresponding compressive strength results of the mixes as reported by [9]. The results of flexural strength tests are shown in Replacement of rubber reduces flexural strength as expected. The reduction in flexural strength occurred in both mixtures and only the rate was different. A reduction of 37% with respect to the control sample was observed in the first mixture. This value reached to 29% for the second mixture. As a result the most important factor in reducing flexural strength, as well as the compressive strength is lack of good bonding between rubber particles and cement paste. This conclusion was reached because after breaking the concrete samples for flexural strength test, it was observed that chipped rubber could be easily removed from concrete.

2.3. Tensile strength

The results of tensile strength test are given in Tensile strength of concrete was reduced with replacement of rubber in both mixtures. The percentage reduction of tensile strength in the first mixture was about twice that of the second mixture for lower percentage of replacements. The reduction in tensile strength with 7.5% replacement was 44% for the first mixture and 24% for the second mixture as compared to the control mixture. Tyre rubber as a soft material can act as a barrier against crack growth in concrete. Therefore, tensile strength in concrete containing rubber should be higher than the control mixture. However, the results showed the opposite of this hypothesis. The reason for this behaviour may be due to the following variables: The interface zone between rubber and cement may act as a micro-crack due to weak bonding between the two materials; the weak interface zone accelerates concrete breakdown. Inspections of the broken concrete samples proved that the chipped rubbers were observed after breaking the concrete specimens in the first mixture The reason for this behaviour is that during crack expansion and when it comes into contact with rubber particle, the Flexural tensile strength for varying curing period 7 days, 28 days and 90 days. Compressive strength of concrete with aggregate replaced by rubber. Mixture Compressive strength (N/mm2).

3. Conclusions

The compressive and flexural values were gradually decreasing with increase in the amount of crumb rubber in concrete. In the compressive strength test, all the concrete mixes with 0–12.5% crumb rubber, crossed the limit of 60 MPa. The rubberized concrete exhibited better resistance to abrasion than the control mix. The water penetration of rubberized concrete was higher than control mix concrete and all the mixes with up to 12.5% crumb rubber had exhibited lesser or similar water absorption value when compared with the control mix. It is possible to design high strength concrete in which waste tyre rubber may be utilized as a partial substitute for fine aggregate up to 12.5% by weight. It can be applicable in structures where there are chances of brittle failure.

The high strength concrete with crumb rubber shows better resistance to abrasion than the control mix. So it can be applied in pavements, floors and concrete highways, hydraulic structures such as tunnels and dam spillways, or for other surfaces upon which the abrasive forces are applied by moving objects during service. The highest reduction was related to 7.5% and 10% replacement for both grades of rubber used. The reduction in compressive strength at 28 days of age was about 10–23% for aggregates and 20–40% for cement replacement. Modulus of elasticity of concrete was reduced with the replacement of rubber for aggregate or cement. Reduction in modulus of elasticity was 17–25% in the case of 5–10% aggregate replacement by chipped rubber and the corresponding reduction for powdered rubber was 18–36%. Tensile strength of concrete was reduced with increased percentage of rubber replacement in concrete. Tensile strength of concrete containing chipped rubber (replacement for aggregates) is lower than that of concrete containing powdered rubber (for cement replacement). Replacement of rubber for aggregate or cement in concrete caused a reduction in its flexural strength for both grades, but the rate of reduction was different. The depth of chloride penetration of the mixes with crumb rubber up to 7.5% was lower than that of the control mix in case of w/c 0.4. In the water absorption test of acid attacked specimens, gradual increase in the percentage of water absorption was observed as the percentage of crumb rubber was increased.

5.REFERENCES :

[1] Eldin NN, Senouci AB. Measurement and prediction of the strength of rubberized concrete. Cem Concr Compos 1994;16:287–98.

[2] Mohammed BS, Khandaker M, Anwar H, Jackson TES, Grace W, Abdullahi M. Properties of crumb rubber hollow concrete block. J Clean Prod 2012;23:57–67.

[3] Thomas BS, Gupta RC, Mehra P, Kumar S. Performance of high strength rubberized concrete in aggressive environment. Constr Build Mater 2015;83:320–6.

[4] Gesoglu M, Guneyisi E. Permeability properties of self-compacting rubberized concretes. Constr Build Mater 2011;25:3319–26.

[5] Pelisser F, Zavarise N, Longo TA, Bernarin AM. Concrete made with recycled tire rubber: effect of alkaline activation and silica fume addition. J Cleaner Prod 2011;19:757–63.

[6] ASTM C192. Standard practice for making and curing concrete test specimens in the laboratory. Annual Book of ASTM Standards; 2003.

[7] ASTM C 293/C293 M -10. Standard test method for flexural strength of concrete (using simple beam with center-point loading). Annual Book of ASTM Standards; 2010.

[8] Ganjian E, Morteza K, Ali AM. Scrap-tire-rubber replacement for aggregate and filler in concrete. Constr Build Mater 2009;23:1828–36.

[9] Pereira E, Marcelo HFM. Pull off test to evaluate the compressive strength of concrete: an alternative to Brazilian standard techniques. Rev Ibracon de Estrcturas Mater 2012;5(6):757–80.

[10] Su H, Yang J, Ling TC, Ghataora GS, Dirar S. Properties of concrete prepared with waste tyre rubber particles of uniform and varying sizes. J Clean Prod 2015;91:288–96.

[11] Elachalakani M. High strength rubberized concrete containing silica fume for the sustainable road side barriers. Structures 2015;1:20–38.