A Review Paper on Experimental Investigation of Crumb Rubber Concrete

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Abstract — Due to rapid development in automobile industries; production of vehicles increases which leads to increase in production of tires. Disposing the waste tires becomes worldwide problem. Environmental friendly procedures are not available for disposing the waste tires. These waste tires must used in different forms in various industries for achieving environmental sustainability. One form of application is in the form of crumb rubber. Different types of researches have been made by taking crumb rubber as replacement material. In this review paper, it is attempted to take review of previous experimental work on crumb rubber concrete. It is attempted to study the completed research, existing research and scope of this research in construction industry.

Keywords **—Crumb rubber concrete, Microstructure, Impact energy, Waste tires, Durability.**

I. INTRODUCTION

In construction industry concrete plays vital role as it is the heart of construction industry. But for production of concrete and its ingredients like cement, aggregates lots of natural resources are depleted and more energy is spent for its production. The demand of these materials is increasing day by day. So it is needful to find alternatives. Utilization of industrial and agricultural waste is widely accepted because of their ability to improve the strength and durability properties of concrete. So it is desirable to use industrial and agricultural waste as replacement in construction industry after considering its impacting cost and material property. Rapid growth in automobile industry leads to huge scrap tires generation worldwide. This resulted in the big problem of disposing the waste tires. Many attempt made to reuse the waste tires in the form of crumb rubber which is obtained by ambient grinding in mills in the form of partial replacement of aggregates and asphalt. Ground rubber is used as fuel in industry boilers, cement kilns, sports ground surfacing, sub-grade of roads, landfills construction, septic tank construction, embankment construction but is not assured environment friendly disposal.

Figure -1: Actual photo of crumb rubber in size 2.36-4.75 mm

II. LITERATURE REVIEW

Alireza Kashani et al (2018)[1] :- In this paper, it is attempted to overcome the decreased test results when used only crumb rubber by surface treating the crumb rubber. Various coatings used are surface cement coating, surface chemical coating, surface potassium permanganate ($KMnO_4$) coating, surface sodium hydroxide (NaOH) coating and surface sulphuric acid (H_2SO_4) coating. Various tests like slump cone test, compressive test, and density were performed on five different coated crumb rubber concrete and compared with normal concrete. According to these results silica fume coating gives best results.

Priyanka Asutkar et al, (2017)[2] It revealed the study on behaviour of rubber aggregates concrete beams using analytical approach. In this study an attempt on partially replace the rubber aggregates by coarse aggregates in concrete & to study its impact on properties of concrete. A modified concrete was prepared by replacing coarse aggregates in concrete with rubber aggregates by varying the replacement are casted & tested after 28th days of curing. The physio-mechanical

properties like density, compressive strength & elastic properties of modified concrete are determined from concrete cubes experimentally & further stresses & displacement at every 50 mm depth of beams are determined analytically by method of initial functions (MIF). MIF is an analytical method in which elastic properties & theoretical loads are used to analyse the beams without conducting any experimental program. The analytical results by MIF are compared with bending theory.

M K Haridharan et al, (2017) [3] It revealed the study on influence of waste tyre crumb rubber on compressive Strength, Static Modulus of Elasticity and Flexural Strength of Concrete. In this paper, the experimental investigations was carried out to find the compressive strength, static modulus of elasticity and flexural strength of concrete mixtures, in which natural sand was partially replaced with Waste Tyre Crumb Rubber (WTCR). River sand was replaced with five different percentages (5%, 10%, 15%, 20% and 25%) of WTCR by volume. The main objective of the experimental investigation is to find the relationship between static modulus of elasticity and flexural strength with compressive strength of concrete with WTCR. The experimentally obtained static modulus of elasticity and flexural strength results comparing with the theoretical values. The concrete cubes and cylinder compressive strength were decreased with increasing in WTCR content. Flexural strength of concrete was increased up to 15% of WTCR replacement. It the percentage of WTCR replacement increases over 15% the flexural strength was decreased. The measured flexural strength was more than the predicted flexural strength by various country codes for all the percentage replacements of sand by WTCR. Static modulus of elasticity of WTCR mixed concrete was less than control concrete, but there was withstanding large deformation and displacement due to the properties of rubber. Normally rubber having more ductile or flexible in that it has the ability to withstand larger deformation. The experimentally obtained modulus of elasticity of control and WTCR mixed concrete was less than predicted from the theoretically obtained values.

Roman Chylík et al, (2017) [4] It revealed the study on mechanical properties and durability of crumb rubber concrete. This paper is focused on concrete with admixture of rubber powder, generally called crumb rubber concrete (CRC). The inspiration was found in Arizona, where one of the first CRCs has been created. However, Arizona has completely different climates than Central Europe. Could we use the crumb rubber concrete on construction applications in the Central European climate too. 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, and resistance of concrete to water with 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. 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. The results indicated that the incorporation of rubber powder to concrete mixes had significant effect on the properties of fresh and hardened concrete. Laboratory tests included slump test, air content test, compressive strength, splitting tensile strength tests and test of resistance to water with de-icing chemicals. As the content of rubber powder increased, compressive strength and splitting tensile strength decreased. In mixes containing 40 kg/m3 of rubber powder, the compressive strength generally decreased with increasing ratio of fine rubber powder to coarse rubber powder in earlier stages, After 45 days, and the strength of all the mixes was almost the same. Fine rubber particles were significantly more efficient in increasing the air content than the coarse ones. The effect of the total amount of added rubber powder was less significant than the effect of fineness. Incorporating of rubber powder to concrete mix has also influence on workability. Workability decreased, as the amount of fine rubber increased. Microscopic analysis performed for two selected mixes confirmed that fine rubber particles contributed more efficiently than coarse rubber particles to creation of optimal size and spacing of air voids in hardened concrete. This is a reason why the mix containing fine rubber particles had better resistance to water with de-icing chemicals.

Hanbing Liu et al, (2016) [5] It revealed the study on Experimental Investigation of the Mechanical and Durability Properties of Crumb Rubber Concrete. In this study, the effect of the volume content of crumb rubber and pre-treatment methods on the performances of concrete was evaluated. Firstly, the fine aggregate and mixture were partly replaced by crumb rubber to produce crumb rubber concrete. Secondly, the mechanical and durability properties of crumb rubber concrete with different replacement forms and volume contents had been investigated. Finally, the crumb rubber after pre-treatment by six modifiers was introduced into the concrete mixture. Corresponding tests were conducted to verify the effectiveness of pre-treatment methods as compared to the concrete containing untreated crumb rubber. It was observed that the mechanical strength of crumb rubber concrete was reduced, while durability was improved with the increasing of crumb rubber content. 20% replacement of fine aggregate and 5% replacement of the total mixture exhibited acceptable properties for practical applications. In addition, the results indicated that the modifiers had a positive impact on the mechanical and durability properties of crumb rubber concrete. It avoided the disadvantage of crumb rubber concrete having lower strength and provides a reference for the production of modified crumb rubber concrete. Adding

crumb rubber into concrete resulted in a significant decrease of the mechanical properties, but increased the durability. The effect caused by replacing the mixture with crumb rubber was higher than that caused by fine aggregate replacement. Compressive strength, splitting tensile strength, axial compressive strength and the modulus of elasticity were reduced with the increasing percentage content of crumb rubber, while freezing-thawing resistance and sulphate resistance were improved. A 20% replacement of fine aggregate and a 5% replacement of the total mixture with crumb rubber met the safety strength requirements of concrete and had excellent durability. The negative effect of crumb rubber on mechanical strength could be minimized and avoided by pre treatment of the crumb rubber using modifiers. These pre-treatments enhanced the adherence between the rubber and cement paste and achieved the uniform distribution of rubber particle in mixture. Synthetic resin significantly improved the mechanical and durability properties of crumb rubber concrete as compared to the other modifiers. The compressive strength, splitting tensile strength and axial compressive strength of crumb rubber concrete prepared with pre-treated rubber using synthetic resin increased 12%, 40% and 5%, respectively. Additionally, the strength loss ratio after 25 cycles of freezing-thawing was reduced to 1.2%.

Jinhua Xu et al, (2017) [6] It revealed the study on Crumb Rubber Concrete Deterioration Caused by Sulphate Attack. An exhaustive study should be carried on Crumb Rubber Concrete deterioration caused by sulphate attack in this paper. The crumbed tire rubber powder was used to replace fine aggregates of concrete, whose grain size is 0.28mm. The replacement levels were 5%, 10%, 15% and 20 % by volume of the fine aggregates. It is evaluated to effect of sulphate attack on appearance and compressive strength of crumb rubber concrete. The research shows that appropriate proportional fine aggregate replaced by rubber powder can improve resistance to sulphate attack of concrete, especially mixing 5% and 10% rubber powder. But too much rubber content results in decreasing its performance. Based on this study, the following conclusions can be drawn as the 5 and 15 % in volume replacements with rubber powder in concrete can obviously improve resistance to sulphate attack. But too much rubber content results in decreasing its performance. Mixture proportion with rubber content of 5% will achieve larger compressive strength and better resistance to sulphate attack of crumb rubber concrete. Mixture proportion with rubber content of 20% will be unfavourable to mechanical performance of crumb rubber concrete.

S.Selvakumar et al, (2018) [7] It revealed the study on strength Properties of Concrete Using Crumb Rubber with Partial Replacement of Fine Aggregate. this project have aimed to study the effectiveness of rubber as substitute for fine aggregate and utilize the crumb rubber tyres in concrete, to minimize global warming. Aggregate properties viz., specific gravity, water absorption, acid resistance were to be conducted to ascertain the properties concrete specimens were to be casted and tested for concrete mix with various percentage of replacement (5%,10%,15% &20%) and its viability for replacement are discussed in this project. From this study the effective utilization of rubber tyre waste as been developed and it made to used in the concrete mixture as fine aggregate. At present the crumb rubber production in the south India is very less than north. So the material availability was less, because of less knowledge about that. Based on the test results the following conclusions were made. These can also include non primary structural applications of medium to low strength requirements, benefiting from other features of this type of concrete. Even if rubber tyre aggregate was used at relatively low percentages in concrete, the amount of waste tyre rubber could be greatly reduced due to the very large market for concrete products worldwide. Therefore the use of discarded tyre rubber aggregates in concrete shows promise for developing an additional route for used tyres. The compressive strength of crumb rubber concrete with 5% replacement is 38.66 N/mm2; it is higher than the strength of normal concrete (36.73N/mm^2) on 28th day. The compressive strength of crumb rubber concrete with 10% replacement, it gives acceptable strength of 33.47 N/m^2. In splitting tensile strength the strength of crumb rubber concrete is lower than the strength of normal concrete. In the flexural strength test conducted on crumb rubber concrete it shows a decrease in strength when compared to the strength of normal concrete. From the test results, it is found that the crumb rubber posses less bonding ability which has affected on the strength of the concrete.

D.S.Q. Abg Adenan et al, (2017) [8] It revealed the study on durability Performance of Polymeric Waste Crumb Rubber as Fine Aggregates Replacement in Concrete. This paper presents a study on durability performance of polymeric waste crumb rubber as partial fine aggregates replacement in concrete grade 30. The use of aggregates as constituent in concrete production commonly lead to a question about the sources of natural aggregates since concrete consumption has been increasing nowadays. Rubberized concrete has been introduced whereby natural fine aggregates are being replaced with crumb rubber in concrete since there are problems with availability of natural sand as fine aggregate material. Besides, polymeric waste materials production has been increasing. Crumb rubber used in this study was manufactured by special mill where scrap tire rubber is grinded and screened into smaller size of particles. Rubberized concrete is produced by mixing with different percentages of 10, 20 and 30% of crumb rubber as fine aggregates replacement. Water cement ratio of 0.53 and curing periods for 28 days and 60 days were considered in this study. The water absorption test was conducted to determine the percentages of water absorption, while water permeability test was conducted to determine the coefficient of permeability in concrete. Absorption and permeability are governed by the capillary pores in the cement paste. Pores that are too large resulted in high absorption and permeability, while pores that are small resulted in a low

absorption and permeability. The durability performance in term of water absorption and water permeability in concrete was improved by introducing crumb rubber as polymeric waste materials to replace fine aggregates in concrete. The recycling and reusing of polymeric waste materials in concrete attract the interest worldwide which can promote sustainability and reduce the high environmental impact of the concrete technology. Concrete workability in term of slump value increases with the increased of crumb rubber percentages indicating that the workability of fresh concrete was improved by using crumb rubber in concrete. Water absorption of concrete increases with the increased of crumb rubber percentages in rubberized concrete.

Prof M R Wakchaure et al, (2017) [9] It revealed the study on waste tyre crumb rubber particle as a partial replacement to fine aggregate in concrete. In this study, the performance of waste waste material crumb rubber as partial replacement for aggregates in M25 grade of concrete mix at different percentages & its effect on concrete properties like compressive strength, flexural strength & split tensile strength were investigated. The waste tyre crumb rubber particles was used to replace fine aggregate in concrete of size passing through 1.18 mm IS sieve & retaining on 600 microns IS sieve at ratios 0.5%, 1%, 1.5%, 2% & also in combination with glass fibre at ratios 0.4%, 0.5% addition to the weight of cement are used to regain the reduced strength of concrete due to use of waste tyre crumb rubber particle. Results indicated that replacement of waste tyre crumb rubber particles to fine aggregates in concrete at ratios 0.5% & 1% there was no effect on the concrete properties would occur, but for replacement ratios 1.5% , 2% considerable changes were observed as compare to similar normal concrete.

III. CONCLUSION

In most of the researches impact energy is increased in crumb rubber concrete, so it has application where impact loads are applied such as industries base slab, pavements etc. In most of the researches compressive strength, workability, density is increased but percentage increase is not satisfactory in cost to application concern. New approaches of using crumb rubber by surface treating and surface coating getting popularity in researches due to its firm binding to the concrete mix. New researches should be carried out by these coating together by applying it as multi-stage coating and surface treating. It is needful to carry out the experiments with application oriented approach.

REFERENCES

[1] Alireza Kashani, Tuan Duc Ngo, Prashastha Hemachandra, Ailar Hajimohammadi (2018), Effects of surface treatments of recycled tire rubber on cement-rubber bonding in concrete composite foam, Construction and building material journal 171(2018)467-473.

[2] Priyanka Asutkar, S.B.Shinde, (2017), Study on behaviour of rubber aggregates concrete beams using analytical approach, Engineering science and technology at international journal.

[3] M K Haridharan, R Bharathi Murugan, (2017), **Influence** of Waste Tire Crumb Rubber on Compressive Strength, Static Modulus of Elasticity and Flexural Strength of Concrete, IOP conference series.

[4] Roman Chylík, Tomas Trtik, (2017), Mechanical properties and durability of crumb rubber concrete, IOP conference series.

[5] Hanbing Liu, Xianqiang Wang, Yubo Jiao, Tao Sha (2016), Experimental Investigation of the Mechanical and Durability Properties of Crumb Rubber Concrete.

[6] Jinhua Xu, Sili Chen, He Yu, Ying Wang, (2015), Crumb Rubber Concrete Deterioration Caused by Sulphate Attack, international conference on material, mechanical & manufacturing engineering.

[7] S.Selvakumar, R Venkatakrishnaiah (2015), strength Properties of Concrete Using Crumb Rubber with Partial Replacement of Fine Aggregate, International Journal of Innovative Research in science engineering and technology.

[8] D.S.Q. Abg Adenan, K Kamaruddin (2017), Durability Performance of Polymeric Waste Crumb Rubber as Fine Aggregates Replacement in Concrete, Advanced material research Tech.

[9] Prof M R Wakchaure, Prashant Chavan (2014), waste tyre crumb rubber particle as a partial replacement to fine aggregate in concrete, International journal of engineering research & technology, ISSN:2278-2014.