A REVIEW ON USE OF CRUMB RUBBER AS FINE AGGREGATE IN CONCRETE

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Abstract: Incorporating rubber aggregates generally has a detrimental effect on the mechanical strength, but gives improved strain capacity resulting in significant reductions in the flexural Crack Mouth Open Displacement (CMOD), compared to the reference mix. Structural grade SCRC (fc > 17 MPa; q > 2000 kg/m3) can be obtained with up to _260 kg/m3 (equivalent to 15 wt%) in all forms of crumb rubber aggregate substitution. Substituting recycled rubber for natural aggregates gives plain rubberized concrete (PRC) and is typically for non-structural applications. Several studies have also focused on self-compacting rubberized concrete (SCRC). This paper summarizes, compares and draws general conclusions from the findings of more than 70 independent studies, in terms of the fresh and hardened state properties of rubberized concrete to highlight and confirm the key characteristics of the material.

Keywords- pavement, crumb rubber, concrete, hardness

1. INTRODUCTION

The use of rubber aggregate (from scrap vehicle tyres) in concrete has become increasingly popular generating significant research interest over the past 20 years. Owing to the large increase in number of cars worldwide, the accumulation of huge volumes of scrap tyres has become a major waste management problem. Approximately 37 million tyres were used annually in the UK in 2002 and this number continues to grow. In the USA this figure is closer to 275 million scrap tyres per year. A modest quantity of unprocessed scrap tyres are used to provide shock protection for marine platforms against impact from waves or ships, whilst in some parts of the world people still resort to burning them which produces unacceptable levels of pollution.

2. CLASSIFICATION OF THE SCRAP TYRES

Tyres may be divided into two types: car and truck tyres. Car tyres are different from truck tyres with regard to constituent materials, especially natural and synthetic rubber contents. Considering the high production volume of car tyres as compared to truck tyres, the former is usually of more interest to researchers. In most of the researches performed, usually three broad categories of discarded tyre rubber have been considered such as chipped, crumb and ground rubber:

1. Shredded or chipped rubber to replace the gravel. To produce this rubber, it is needed to shred the tyre in two stages. By the end of stage one, the rubber has length of 300– 430 mm long and width of 100–230 mm wide. In the second stage its dimension changes to 100–150 mm by cutting. If shredding is further continued, particles of about with 13– 76 mm in dimensions are produced and are called ‘‘shredded particles”.
2. Crumb rubber that replaces for sand, is manufactured by special mills in which big rubbers change into smaller torn particles. In this procedure, different sizes of rubber particles may be produced depending on the kind of mills used and the temperature generated. In a simple method, particles are made with a high irregularity in the range of 0.425– 4.75 mm.
3. Ground rubber that may replace cement is dependent upon the equipment for size reduction. The processed used tyres are typically subjected to two stages of magnetic separation and screening. Various size fractions of rubber are recovered in more complex procedures. In micro-milling process, the particles made are in the range of 0.075–0.475 mm.

3. EXISTING RESEARCH WORK

Mark Belshe, vice president of FNF Construction, was also brought to the mix. Then, in 2003, Zhu accepted to be a professor in a university in China, and the crumb rubber concrete project was then handed over to ASU’s Dr. Kamil Kaloush. To date, the project dealt majorly with poured concrete, but the group was also more excited about the possibilities for precast applications. Residential housing can also be benefitted. “In the Southwest there are a lot of homes with roofs of clay tile,” said Carlson, explaining that, strength for the most of part, is not that big concern because of the lack of snow there. “we could create a precast roof with a very high percentage of crumb rubber that will be lightweight, will help control noise going both ways.

Carlson was trying to convey the fact that Kaloush, and Zhu before him, have performed tests that seem to suggest that the crumbed rubber concrete is comparatively cooler than its regular counterpart concrete. “These studies concludes at this time and support the theory that it is cooler,” said Kaloush. “I took some photos with an infrared camera, and from those at least it was observed that the crumbed rubber is cooler. ”The thought of a “cooler” concrete, that’s one of the things that caught the attention of FNF Construction’s. The use of crumbed rubber concrete could very well open one another major area to the precast industry and that is “green” buildings.

3.1 Factors to Consider Using Natural Frequencies for Damage Detection in Prototypes

Some factors to consider when using vibration testing for integrity assessment and for successful utilization of vibration data in assessing structural condition, measurements should be taken at points where represented. The simplest way of achieving this is to conduct a theoretical vibration analysis of the structure prior to testing. The best positions would be those points where the sum of the magnitudes of the mode shape vectors is maximized.

3.2 Low frequency Technique

Low frequency techniques are based on the analysis of structural dynamic response measurements, typically made by subjecting the structure to low frequency vibrations. By this analysis, a suitable set of parameters is identified, and any variation in these parameters is an indication of the changing state of the structures. Damage in a structure alters its modal parameters, namely the stiffness matrix and the damping matrix .In these techniques, the structure is excited by appropriate means and the response data is processed to obtain a quantitative index or a set of indices representative of the condition of the structure.

Like every other innovation, crumbed rubber concrete will have to, undoubtedly, face its share of sceptics. The experts do believe, however, that end-users will be impressed by the fact that this process is so environmentally sound. While we still need to gather the real evidence to verify that the advantages will outweigh the possible increase in cost of producing crumbed rubber panels.

Concrete, by its basic nature have low tensile strength and which causes cracking [4]. Cracksin concrete generally are interconnected flow paths. Advancement in concrete technology over past years have resulted in development of several new types of concrete and mortar which has incorporated rubber particles as fine and/or coarse aggregates.

1. Eldin et.al found that Rubcrete possess good aesthetics, acceptable workability, and comparatively a smaller unit weight than normal concrete. Unlike normal concrete, rubcrete had the ability to absorb a huge amount of plastic energy under compressive loads and tensile loads. It did not show the typical brittle failure, but rather a ductile one, plastic failure kind of mode was obtained.
2. Karahan et.al made experiments and fresh concrete properties test ingrevealed that the use of crumbed rubber in concrete as a fine aggregate eliminated the filling and passing-ability. No significant reduction was observed in the freezing-and-thawing properties and corrosion resistance properties of concrete with 10% crumbed rubber. Beyond that level, however, the durability performance was significantly affected.
3. Wai Ching Tang suggested that the coefficients of water permeability of concrete were found increased with increase of chipped tyres percentage in the mix. Ki et al (2011) concluded after his research work that the rubcrete can offer a good energy dissipation capacity and ductility which will make it suitable for seismic applications.
4. Benazzouk et al suggested that the presence of rubber particles have reduced absorptive nature and hydraulic diffusivity by causing a decrease in water absorption. Similarly, air permeability was significantly reduced due to the presence of these additives. Further, The cellular character of rubber improves behavior of such concrete when comes in contact with fluid.
5. Bignozzi et.al found it during their experimentation that self –compacting rubberized concrete (SCRC) will require slightly higher amount of super-plasticizer than the conventional self-compacting concrete. Moreover, the compressive strength and stiffness of (SCRC) self-compacting rubberized concrete decreased with increase in amount of rubber percent in the mixture, and significant deformability in concrete was also measured before failure.
6. Hameed et.al concluded after their extensive research work on rubcrete that damage and brittleness Index causes a decrease in permeability. The increased permeability of concrete due to the progression of cracks allows more water to pass through or aggressive chemical ions to penetrate in the concrete which facilitates deterioration. Efforts have been made in past to decrease the brittleness of concrete by adding rubber percentage in prescribed quantity.
7. Schimizze et al. developed two rubberized concrete mixtures using fine rubber crumbs in one mixture and coarse chipped rubber in the second. While these two mixtures were not optimized and their mixture proportioning parameters were selected arbitrarily, their results indicated a reduction in compressive strength of about 50% with respect to the control mixture. The elastic modulus of the mixture containing coarse chipped rubber was reduced by about 72% of that of the control mixture, whereas the mixture containing the fine rubber crumbs showed a reduction in the elastic modulus by about 47% of that of the control mixture.
8. Khatib et.al studied the influence of adding two kinds of rubber, crumb (very fine to be replaced for sand) and chipped (at the size of 10–50 mm to be replaced for gravel). They made three groups of concrete mixtures. In group A, crumb rubber to replace fines, in group B, chipped rubber to replace coarse aggregate, and in group C both types of rubber were used in equal volumes. In all, the three groups had eight different rubber contents in the range of 5–100% were used. They found that the compressive strength of concrete would decrease with increasing rubber content. For example, replacing 100% gravels by chipped rubber would decrease the compressive strength of concrete up to 90%. Meanwhile, they showed that the rubberized concrete made with chipped rubber has less strength than concrete made with crumb rubber.
9. Topcu et.al investigated the particle size and content of tyre rubbers on the mechanical properties of concrete. He found that, although the strength was reduced, the plastic capacity was enhanced significantly.
10. Serge et.al in their study, added rubber particles in cement paste (rubber particles had a size with maximum 500 lm). In order to decrease hydrophobic nature of rubber surface, NaOH was chosen. At first, the surface of rubber particles were modified by saturated NaOH for 20 min. They concluded that the rubber particles treated by NaOH show better cohesion with cement paste. Their results indicated that there was an improvement in flexural strength by this procedure, but a 33% decrease occurred in compressive strength.
11. Naik et al. studies concluded that among the surface treatments tested to enhance the hydrophilicity of the rubber surface, a sodium hydroxide (NaOH) solution gave the best result. The particles were surface-treated with NaOH saturated aqueous solutions for 20 min before using them in concrete. Then, scanning electron microscopy (SEM) and measurements of water absorption, density, flexural strength, compressive strength, abrasion resistance, modulus of elasticity, and fracture energy tests were performed, using test specimens (water-to-cementations materials ratio of 0.36) containing 10% of powdered rubber or rubber treated with 10% NaOH. The test results showed that the NaOH treatment enhances the adhesion of tyre-rubber particles to cement paste, and mechanical properties such as flexural strength and fracture energy were improved with the use of tyre-rubber particles

4. CONCLUSION

The main potential for SCRC in civil engineering applications is in rapid construction, multistory buildings, in structural members or partitions as well as in roofs and ground works. SCRC could provide an attractive solution for shrinkage cracking and strain failure as a result of incorporating the waste rubber particles which leads to more deformability under pre-failure loads, as well as increased toughness, impact resistance and ductility compared with standard SCC. Finally, there is a clear need to define rubberized concrete mix design approaches and to integrate these with current standards and procedures. According to the research, the following generalizations can be made. Tensile strength of concrete was reduced with increased percentage of rubber replacement in concrete. The most important reason being lack of proper bonding between rubber and the paste matrix, as bonding plays the key role in reducing tensile strength. Tensile strength of concrete containing chipped rubber (replacement for aggregates) is lower than that of concrete containing powdered rubber (for cement replacement). In the case of 5–10% aggregate replacement by chipped tyre rubber, the reduction in tensile strength was about 30–60% where for 5–10% cement replacement by powdered rubber the reduction was about 15–30%. 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 reduction was about 37% for coarse aggregates replacement and 29% for cement replacement.

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