ICM11

The effects of polypropylene fibers and rubber particles on mechanical properties of cement composite containing rice husk ash

Ali sadr momtazi\textsuperscript{a}, Romina zarshin zanoosh\textsuperscript{b}

\textsuperscript{a} Associate professor /Faculty of engineering, university of Guilan/Rasht/Iran
\textsuperscript{b} Phd student/ Faculty of engineering, university of Guilan/Rasht/Iran

Abstract

People around the world rely on concrete as a safe, durable, and simple building material. Portland cement is a primary material in concrete construction. The increasing use of concrete in construction especially in the developing countries is becoming a problem due to Portland cement’s high cost. That is why there is a need for alternative materials. Accordingly, many developing countries are attempting to develop substitutes for cement from locally available raw materials like agricultural and industrial wastes. The main objective of this study was to investigate use of rice husk in cement composite contained of waste rubber tire. Tires are discarded without control and deposited in inadequate way in the environment increasing the environmental, pollution and favouring the proliferation of insects that causes tropical diseases. Rice husk used in the present work was replaced of 10\% of cement weight. And five designated rubber contents varying from 10\% to 50\% by volume and 0.3 \% polypropylene fibre were used. The 28-days properties of the cement composite were determined. Analyses included compressive strength, flexural strengths, velocity of ultrasonic wave, water absorption and SEM. Test results indicated that the increase in rubber content decreases the sample unit weight. Results have shown that the introduction of rubber particles significantly increases the strain capacity of the materials. Also use of rice husk decreased the mechanical properties in early age. But it helps to environmental problems.

Keyword : ductile cement composite; light weight cement composite; rice husk ash; waste rubber tire

1. Main text

The growing amount of waste rubber, produced from tires, has resulted in an environmental problem. Waste rubber is not easily biodegradable even after a long period of landfill treatment, material and energy recovery are alternatives to disposal. The important contaminant effect of tyres waste is well known. Some people propose to use it as fuel material for cement industries. Other construction products are based rubber powder obtained from the cryogenic milling of tyres, mixed with asphalt or bituminous materials [1-9].

Also Agricultural by products are emerging as new and inexpensive materials with commercial viability and environmental acceptability. One of the agricultural residues which can be potentially used is rice husk [10]. The research was undertaken to determine the feasibility of using rice husk as a pozzolanic material and to determine the percentage of rubber particles allowable replacement when blended with ordinary Portland cement in a cement composite mix [11-13].

Also fibers are increasingly being used for the reinforcement of cementations matrix to enhance the toughness and energy absorption capacity and to reduce the cracking sensitivity of the matrix [14-17].
In this work, the idea is to use rubber waste particles and rice husk, as a raw material, to develop construction materials. An experimental test program was conducted to investigate the effect of rubber particles and rice husk addition on the physical-mechanical and water absorption properties of the composites. The material was manufactured by reinforcing varying volume fraction of rubber particles in cementations matrix. The tested properties of composite were dry unit weight, elasticity dynamic modulus, compressive and flexural strengths, strain capacity, water absorption and SEM, all of them measured at 28 days.

2. Materials

Rubber particles used in this study have been obtained from mechanical shredding of rubber automobile industry waste. This waste comprises rubber particles of less than 1mm in size. The absolute density of these rubber waste particles is 506 kg/m³. Fig. 1 shows the picture of rubber waste particles and Fig. 2 shows the picture of rice husk ash. The cement used was CEM I (425 mazandaran of IRAN), the rubber particles and rice husk and cement were initially dry-mixed. The volume ratio of rubber ranged from 0% to 50% by volume as replacement to cement in mixtures and 0.3 % polypropylene fiber were used. the weight ratio of rice husk ash 10% by weight as replacement to cement in mixtures.

To achieve constant workability for all composites (slump on the order of 90–100 mm), water was added according to the empirical formula for deriving total mixing water, i.e.: w =0.27C + 0.3R, where C and R are weights of the cement and rubber particles in the mix. Also Super plasticizer is use in this study. Recommended content from the manufacturer is from 0.8 to 1.1 liter per 100 kg cement. For each mixture, three prismatic (50× 50×200 mm) and (50×50×50 mm) samples were prepared and moist-cured, for 28 days at 20 ± 2 °C and 98% relative humidity.

3. Experimental results and discussion

3.1. Dry unit weight

The dry weight of composite with respect to rubber volume content is displayed in Fig.2. Values decrease from approximately 2200 kg/m³ for cement paste to 1920 kg/m³ for specimen containing 50% of rubber particles. A reduction of up to 13% was recorded.

It was observed that, in addition to a low rubber specific gravity, the increase in rubber particle tends to heighten the level of air-entrainment. The higher air entrainment may be due to the capability of rubber particles to entrap air...
at their rough surface due to their no polar nature. When rubber is added to mixture, it may attract air as it has the tendency to repel water. The lightening of cement composite is very attractive particularly in both building renovation works and design of lightweight structural elements.

Also replacement of Rice Husk for rubberized cement results in reductions of density of cement composite. This is due to specific density of the Rice husk is much lower than that of cement. And utilization of polypropylene fiber decrease dry unit weight too.

![Graph showing dry unit weight of cement composite contained of rice husk ash, waste tire rubber, and polypropylene fiber](image1)

**3.2. Compressive strength**

The increase of rubber content reduces compressive strength. Value decreases from 54.5 MPa for cement paste to 21.8 MPa, for composite with 50% of rubber particles. The reduction is about 60%. Results of compressive strength are given in Fig. 4. The decrease in compressive strength is attributed to physical properties if rubber particles, since they are less stiff than the surrounding cement paste. Under loading cracks are initiated around the particles, with accelerates the failure in matrix. It is assumed that mechanical strength of composite is opposite to its unit weight. In addition, the decrease in compressive strength is relative to air-entainment. When the air-voids ratio increases, it cases the lighter the specimen and the lower its mechanical strength.

![Graph showing compressive strength of cement composite contained of rice husk ash, waste tire rubber, and polypropylene fiber](image2)

Also when Rice husk added, it shown that at the age of 28 days there is no big different between compressive strength of rubberized samples contained of Rice husk and sample with only rubber particles. However, the use of Rice husk leads to a reduction of compressive strength. These could be due to that Rice husk does not act as a
cement replacement because of its coarse particle size and low reactivity. From these data it is designed that 10% Rice husk is an acceptable percentage of Rice husk as cement replacement. The rate of increase of compressive strength tends to rise up continuously after the designed age (e.g. 28 days).

Also can use polypropylene fiber and increase the compressive strength in cement composite contained of waste rubber tire and rice husk ash.

### 3.3. Flexural strength

Fig.5. shows the flexural loading, velocity of loading is 3mm/s. Fig.6. Shows curve of flexural strength. With varying rubber content, the curves first shows reduction in 0% to 10% and the n it shows maxima at volume ratio of 20%. The decrease in flexural strength is possibly due to reduction of the cement content in matrix and the lack of bond between rubber particles and cement paste. In addition time of rupture increases from 0.65S for specimens containing 10% to 1s for specimens containing 50%. Increasing is about 3%.

Also in samples contained Rice Husk flexural strength in early age is lower than samples without it and increase of flexural strength tends to rise up continuously after the designed age (e.g. 28 days).

The use of polypropylene fibers has successfully increased the toughness of concrete. It is quite apparent that the load carrying ability of a structure under flexural loading is considerably increased.

---

*Fig. 5. Flexural loading*

*Fig. 6. Flexural strength of cement composite contained of rice husk ash, waste tire rubber, polypropylene fiber*
3.4. Ultrasonic wave

Fig. 7. shows the ultrasonic devise. The time duration for an acoustic wave to propagate through the longitudinal direction of the specimen was recorded in this study. The ultrasonic wave bypasses air-voids in order to propagate within the cement matrix. Incorporation of rubber particles into cement matrix reveals the ability of composites to both reduce sound intensity and dampen vibrations, which serves to provide a high level of sound insulation. The velocity-values decrease from 4170 m/s for cement paste to 3500 m/s, for composite with 50% of rubber particles. The reduction is about 15%. Results of velocity of ultrasonic wave are given in Fig. 8. Also in samples with Rice Husk, velocity of ultrasonic wave is decreased. In samples with polypropylene decrease are shown too.

![Ultrasonic devise](image)

Fig. 7. Ultrasonic devise

![Velocity of ultrasonic wave](image)

Fig. 8. Velocity of ultrasonic wave of cement composite contained of rice husk ash, waste tire rubber , polypropylene fiber

3.5. Water absorption

The change in composite water absorption is displayed in Fig. 9. This figure indicates that percent of water absorption decrease from 5% for cement paste to 0.1% for composite with 50% of rubber particles. This may be due both to the capability of rubber to repel water (non-sportive nature) and to the increase of air-entrainment, as manifested by closed empty pores, which are not accessible to water. This phenomenon serves to reduce the volume accessible in water absorption. The results reveal that higher substitution amounts results in lower water absorption values, this occurs due to the Rice Husk being finer than cement. And in samples with polypropylene water absorption decreased too, because polypropylene fiber do not absorb water.
3.6. SEM

The SEM micrographs of cement composite contained of rubber particles after compressive rupture are shown in Fig. 10. Adhesion between cement and rubber particles is good in this picture because materials are good mixed. And the SEM of cement composite contained of Rice Husk and rubber particles are shown in Fig. 11. The SEM of polypropylene fiber in cement composite contained of waste rubber particles and rice husk are shown in Fig. 12. In rupture zone polypropylene fiber do not let crack increased. The major inherent factor that affects the properties of the fiber reinforced is the bond strength of the polypropylene fiber with cement composite. The effectiveness of the polypropylene fiber as concrete reinforcement depends on the bond between fiber and the matrix. The bundles of polypropylene fibers added to cement composite are separated into millions of individual strands due to the abrasive action. The fibers are distributed throughout the entire matrix, providing support to cement composite in all possible directions.
4. conclusion

1. Rubberized cement composite with increasing rubber concentrations present lower unit weights compared to cement paste. Workability of rubberized cement composite is reduces with increasing rubber. Addition of Rice Husk is decreased compressive strength in early age but with spend time it is simply rubberized composite.

2. Flexural strength is improved for rubber volume ratio comprises 20%. Addition of Rice Husk is decreased flexural strength in early age but with spend time it is simply rubberized composite.

3. Adding tire-rubber particles to cement paste results in large reductions in ultimate strength.

4. More ductile behavior is observed for rubberized cement composite compared to cement paste under loading. Unlike cement paste, the failure state in rubberized cement composite does not occur quickly. Crack weight in rubberized cement composite is smaller than that of cement paste. The failure state in tire-rubber cement composite compared to cement paste is characterized by more deformation.

5. Rubberized cement composite is an effective absorber of sound and shaking energy. Also Addition of Rice Husk is increase absorber of sound and shaking energy.

6. The addition of rubber particles reduces composites sensitivity to water. This water absorption resistance offers a better protection against corrosion. Also water absorption is better with addition Rice Husk.

7. Addition polypropylene fiber does better mechanical properties of cement composite contained of rubber particles and rice husk.

References

[1] HUYNH, H., RAGHAVAN, D. "Durability of Simulated Shredded Rubber Tire in Highly Alkaline Environments”. Advn Cem Bas Mat, (1997), pp.138-143.

[2] HERNÁNDEZ-OLIVARES, F., BARLUENGA. " Static and dynamic behaviour of recycled tire rubber-filled concrete". Cement and Concrete Research, 32, 2002, pp.1587–1596.

[3] TOUTANJI, H. A. “The Use of Rubber Tire Particles in Concrete to Replace Mineral Aggregates”. Cement and Concrete Composites . 18, 1996, pp.135-139.
[4] N.Sergo, J.Joeke, [2000]. "Use of rubber particles as addition to cement paste". Cement and Concrete Research 30 (2000) 1421-1425

[5] Rafat Siddique, Jamal Khatib, Inderpreet Kaur. "Use of recycled plastic in concrete: A review". Waste Management 28 (2008) 1835–1852.

[6] D. García a, J. López a, R. Balart a, R.A. Ruseckaitė b, P.M. Stefan "Composites based on sintering rice husk–waste tire rubber mixtures". Materials and Design 28 (2007) 2234–2238.

[7] Malek Batayneh, Iqbal Marie, Ibrahim Asi. "Use of selected waste materials in concrete mixes" Waste Management 27 (2007) 1870–1876.

[8] M.C. Bignozzi, F. Sandrolini. "Tyre rubber waste recycling in self-compacting concrete". Cement and Concrete Research 36 (2006) 735–739.

[9] Malek K. Batayneh a, Iqbal Marie b, Ibrahim Asi "Promoting the use of crumb rubber concrete in developing countries" Waste Management 28 (2008) 2171–2176.

[10] D. Garcia, J. Lopez. "Composites based on sintering rice husk–waste tire rubber mixtures". Materials and Design 28 (2007) 2234–2238.

[11] B. Chatveera, P. Lertwattanaruk "Evaluation of sulfate resistance of cement mortars containing black rice husk ash" Journal of Environmental Management 90 (2009) 1435–1441.

[12] Dao Van Dong, Pham Duy Huu. "EFFECT OF RICE HUSK ASH ON PROPERTIES OF HIGH STRENGTH CONCRETE" The 3rd ACF International Conference-ACF/VCA 2008.

[13] Mauro M. Tashima, Carlos A. R. Silva, "Influence of Rice Husk Ash in Mechanical Characteristics of Concrete". Supplementary cement materials, Paper XII.08 - p. 780-790 ISBN 85-98576-08-5.

[14] Burak Felekoglu, Kamile Tosun, Bulent Baradan, "A comparative study on the flexural performance of plasma treated polypropylene fiber reinforced cementitious composites". Journal of Materials Processing Technology (2009).

[15] A. Noumowe, "Mechanical properties and microstructure of high strength concrete containing polypropylene fibres exposed to temperatures up to 200°C". Cement and Concrete Research 35 (2005) 2192 – 2198.

[16] A. García Santos a, J.Ma. Rinconon, "Characterization of a polypropylene fibered cement composite using ESEM, FESEM and mechanical testing". Construction and Building Materials 19 (2005) 396–403.

[17] R.D. Toledo Filho, M.A. Sanjuán, "Effect of low modulus sisal and polypropylene fibre on the free and restrained shrinkage of mortars at early age". Cement and Concrete Research 29 (1999) 1597–1604.