Experimental Investigation of Concrete Using Waste Tyre Rubber as Aggregates

Kulwinder Srowa[1], Vikram Dhillon[2]

[1]Student, Dept. of Civil Engg., JCDMCOE, Sirsa, Haryana
[2]Asst. Prof., Dept. of Civil Engg., JCDMCOE, Sirsa, Haryana

ABSTRACT

Concrete is the most commonly used construction material in the world after water. Concrete is a composite material made of cement paste and aggregates. Aggregates occupy around 70% volume of concrete. The natural aggregates are depleting day by days. To minimise this, natural aggregates should be replaced with the waste materials so that the waste materials can also be utilized and their environmental issue can be minimized. In the present study, rubber aggregates were used in the development of rubberized concrete. The coarse aggregates were replaced with the rubber aggregates by 0%, 10%, 20%, 30% and 40%. The different properties of rubberized concrete of M 25 grade was studied in the present work. The quantity of super plasticizer was 0.50%. Fresh i.e. workability by slump flow test and hardened properties i.e. compressive strength, split tensile strength and flexural strength at 7, 28 and 56 days of curing was studied. Compressive strength, split tensile strength and flexural strength decreased with the increase in rubber aggregates content.

INTRODUCTION

Concrete is the most commonly used construction material in the world after water. Concrete is a composite material made of cement paste and filler materials. Cement paste had portland cement and water and filler materials contains aggregates. Aggregates occupy around 70% volume of concrete. The natural aggregates are depleting day by days. To minimise this, natural aggregates should be replaced with the waste materials so that the waste materials can also be utilized and their environmental issue can be minimized. The remarkable increase in number of vehicles worldwide and lack of both technical and economical mechanism make that waste tire are considered a serious pollution problem in term of waste disposal. Research efforts have been made to match society`s needs for economic and safe disposal of waste materials. The use of waste materials saves natural resources and dumping spaces and helps to maintains clean environment.

Discarded vehicle tires constitute the important part of solid waste which were historically disposed into landfills. These waste had an emerging use on the concrete production in which they are being replaced with natural fine or coarse aggregates. This has the additional advantage of saving natural aggregates used in the production of concrete. Recycled waste tire has been used in different application. It has been used as a fuel for cement kiln, in production of carbon black as feedstock and in marine environment as artificial reef. Recycled waste tire rubber is a promising material in the construction industry because it has lightweight, elasticity, energy absorption, sound and heat insulating properties. Rubber can be used in the form of chip or crumb. Rubberized concrete can be used for nailing concrete, as false facades, stone backing, interior construction, in the production of concrete kerb and paving block, in road construction as shock absorber, in sound barrier as sound absorbers as well as in building as an earthquake shock wave absorber, in sidewalks, in flowable fill as bridge abutments fills, trench fills and foundation supports fills. Rubberized concrete can be used where resistance to impact is required such as in railway buffers and pavements. It can also be used in the light weight concrete block.

In the present study, rubber aggregates were used in the development of rubberized concrete. The rubberized concrete consists of cement, fine aggregates, coarse aggregates, water and rubber aggregates. Rubberized concrete had higher crack resistance, sound insulation and thermal resistance but decreased the chloride ion penetration. Rubberized concrete can be used in road construction as shock absorber, in sound barriers as sound absorbers as well as in building as an earthquake shock wave absorber and in sidewalks. Rubber waste is a highly durable material and it is highly resistant to most natural environments.

Lv Jing et.al. (2015) investigated the slump value, compressive strength, flexural strength, static modulus of elasticity and unit weight of rubber light weight aggregates concrete with sand replacement with rubber particles from 10% to

100%. Rubber particles had detrimental effect on the slump and mechanical strength while unit weight dropped. **Agampodi S.M Mendis et.al. (2017)** compared the mechanical behaviours of various crumbed rubber concrete (CRC) mixes of similar strength. Shredded scrap truck tyre was used as crumbed rubber for CRC mixes. Mechanical properties and stress-strain relationships of the developed mixes were experimentally measured and compared. The results showed that CRC mixes exhibited similar mechanical properties regardless of rubber contents. **Nelson Flores Medina et.al. (2016)** studied the influence of high volume of recycled rubber aggregates on acoustic properties of lightweight concrete containing. Concrete specimens were designed with 0–100% substitution of coarse aggregate by two different rubber aggregates from recycled tires. The results showed that combination of steel and textile fibers contaminated with rubber powder increased sound absorption in comparison ordinary or rubberized concrete. **Shah S. F. A. et.al. (2014)** investigated the performance of concrete using rubber waste from scrap tires. Replacement ratio of scrap tire was 5%, 10% and 15% with coarse aggregates. There was no significant changes in concrete properties up to 5% substitution were observed. Beyond 5%, concrete properties change appreciably.

2. EXPERIMENTAL PROGRAMME

Material used

Ordinary portland cement (consistency 30% ,initial setting time 120 min. and final setting time 200 min, fineness 4 and compressive strength of cement at 3, 7 and 28 days was 31.3, 36.56 and 45.23 MPa respectively) was used in the present work.

Natural sand with fineness modulus 2.65, specific gravity 2.58 and zone III was used. Coarse aggregates of size 10mm and 20 mm Of broken stone of specific gravity 2.64 and 2.58 and fineness modulus 6.05 and 6.89 respectively were used. Tap water was used for mixing and curing.

Rubber Aggregates

Rubber aggregates were taken from truck tyres which were manually shredded in the regular size of 15mm. Complast SP430, super plasticizer was used in the present study.

In the present manual mixing was done. The different materials were weighed on the weighting machine. The materials were mixed first when they dry and water was added to the mix and uniformly mixed manually. The mixing time was about 5-6 minutes. The compaction was done by vibratory tables in this work. After mixing and compaction of the concrete mix, the mix was poured into the mould and casted into cubes, cylinders and beams. After 24 hours specimens were withdrawn from the moulds and the specimens were kept in the curing tanks for curing. Casting of moulds for compressive strength test, splitting tensile strength and flexural strength test were done. Three moulds were casted for each mix and cured for 7, 28 and 56 days and then they were tested.

After curing the specimens were taken out from the curing tank and then dried at the room temperature. Then the specimens were tested destructively in the testing machine as per the specification. One controlled mix proportion was prepared without use of recycled aggregates. The coarse aggregates were replaced with 0%, 10%, 20%, 30% and 40% of rubber aggregates. M25 grade of concrete was casted in the present work. The aggregates of size 10 mm and 20 mm and water cement ratio of 0.45 were taken constant for all the mix proportions in the present study. The ratio of 10mm and 20mm aggregates in the concrete mixture was kept 50%-50%. The batch specification is given in the table 3.1.

Table 2.1 Mix proportion of rubberized concrete

Sr. No.	Mix Number	Natural Coarse aggregates (%)	Rubber Content (%)
1	M1	100	0
2	M2	90	10
3	M3	80	20
4	M4	70	30
5	M5	60	40

3. RESULTS AND DISCUSSION

3.2.1 WORKABILITY

Workability of the rubberized concrete was determined by the slump test. The effect of rubber aggregates on the workability of rubberized concrete is shown in fig 3.1 and table 3.1

Table 3.1 Workability of rubberized concrete

Mix Number	Slump Value(mm)
M1	45
M2	55
M3	65
M4	75
M5	90

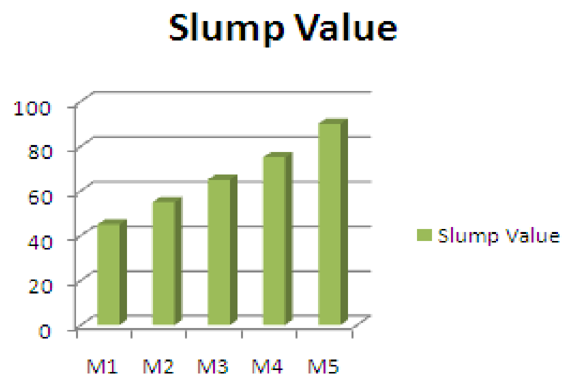

Fig. 3.1 Workability of Rubberized Concrete

3.2.2 COMPRESSIVE STRENGTH

The compressive strength of the different concrete mixes is given in the tabular form in table 3.2 and in fig. 3.2

Table 3.2 Compressive strength of Rubberised concrete

Mix Number	7 days	28 days	56 days
M1	20.45	29.76	36.55
M2	16.32	25.23	31.48
M3	15.21	24.81	30.55
M4	13.98	23.66	29.45
M5	12.78	22.12	28.10

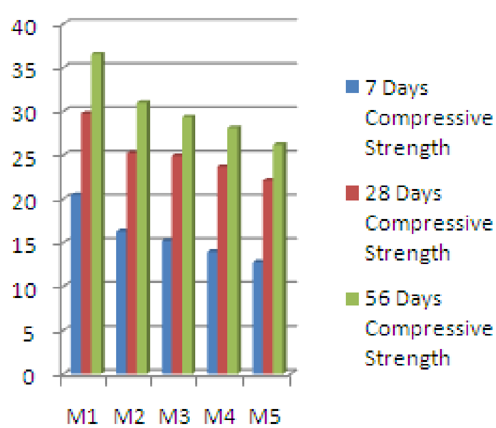

Fig. 3.2 Variation in compressive strength at 7, 28 and 56 days

The compressive strength of rubberized cubes decreased with the increase in rubber aggregates. The compressive strength of rubberized concrete decreased by 20%, 26%, 32% and 38% in comparison to control mix at 7 days due to addition of rubber content in the concrete mixtures. The flexural strength of rubberized concrete decreased by 15%, 17%, 20% and 26% at 28 days and 13%, 16%, 19% and 23% at 56 days with respect to control mix i.e. 0% rubber aggregates in the concrete mixtures.

3.2.3 SPLIT TENSILE STRENGTH

The split tensile strength of different mix proportions are given in table 3.3 and their variation is shown in the fig. 3.3

Table 3.3 Split tensile strength of rubberized concrete

Mix Number	7 days	28 days	56 days
M1	2.3	3.7	4.5
M2	1.86	3.21	3.85
M3	1.75	3.10	3.76
M4	1.63	2.98	3.66
M5	1.55	2.88	3.57

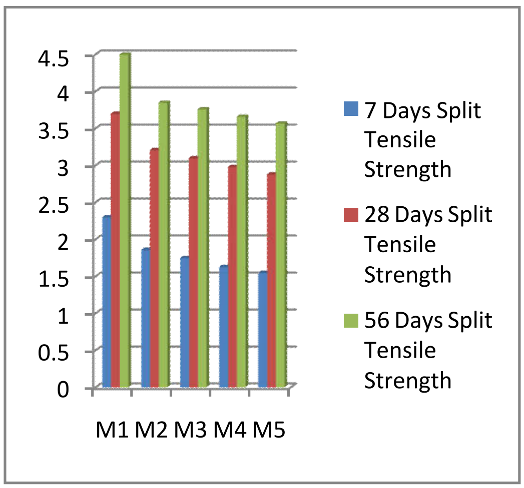

Fig 3.3 Variation in split tensile strength at 7, 28 and 56 days

The split tensile strength of the control mix was highest and it decreased with the increase in rubber aggregates. The split tensile strength of rubber concrete decreased by 19%, 24%, 29% and 33% in comparison to control mix at 7 days due to addition of rubber content in the concrete mixtures. The split tensile strength of rubberized concrete decreased by 13%, 16%, 19% and 22% at 28 days and 14%, 16%, 18% and 21% at 56 days with respect to control mix i.e. 0% rubber aggregates in the concrete mixtures.

3.2.4 FLEXURAL STRENGTH

The flexural strength of the rubber reinforced concrete of beam of different mix proportions are given below in the table 3.4 and the variation of the flexural strength of various mix proportions is shown in fig. 3.4

Table 3.4 Flexural strength of rubberized concrete

Mix Number	7 days(flexural)	28 days	56 days
M1	3.45	4.05	4.50
M2	2.82	3.45	3.91
M3	2.69	3.33	3.8
M4	2.51	3.21	3.69
M5	2.38	3.10	3.57

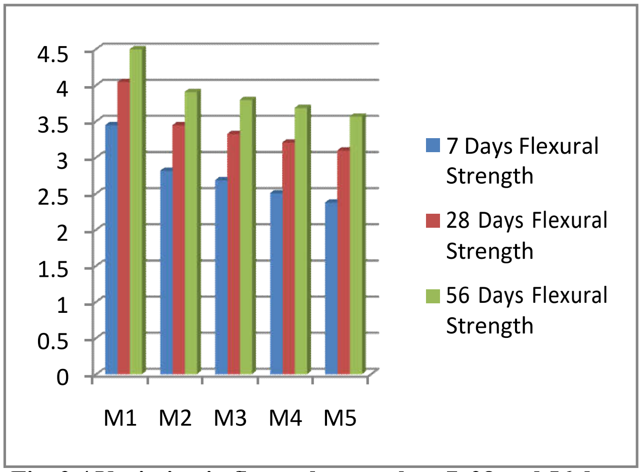

Fig. 3.4 Variation in flexural strength at 7, 28 and 56 days

The flexural strength of rubber concrete decreased by 18%, 22%, 27% and 31% in comparison to control mix at 7 days due to addition of rubber content in the concrete mixtures. The flexural strength of rubberized concrete decreased by 15%, 18%, 21% and 23% at 28 days and 13%, 16%, 18% and 21% at 56 days with respect to control mix i.e. 0% rubber aggregates in the concrete mixtures.

CONCLUSIONS

Rubberized concrete (RC) is a concrete containing cement, aggregates and rubber. In the present study the fresh and hardened properties of rubberized concrete such as compressive strength, split tensile strength and flexural strength at 7, 28 and 56 days with constant water cement ratio of 0.45 and the aggregate was replaced by 0%, 10%, 20%, 30%, 40% rubber aggregates and compared with conventional concrete. The following points were observed from the discussion of the result obtained from this study

- The compressive strength of rubberized concrete decreased by 20%, 26%, 32% and 38% at 7 days, 15%, 17%, 20% and 26% at 28 days and 13%, 16%, 19% and 23% at 56 days respectively for M2, M3, M4 and M5.
- The split tensile strength of rubberized concrete of mix M2, M3, M4 and M5 decreased by 19%, 24%, 29% and 33% at 7 days, 13%, 16%, 19% and 22% at 28 days and 14%, 16%, 18% and 21% at 56 days as compared to mix M1.
- The flexural strength of rubberized concrete decreased in comparison to control mix by 18%, 22%, 27% and 31% at 7 days, 15%, 18%, 21% and 23% at 28 days and 13%, 16%, 18% and 21% at 56 days when 10%, 20%, 30% and 40% rubber aggregates were used in place of coarse aggregates.

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