Reuse of scrap tyre as partial replacement of fine aggregate in concrete and its impact on properties of concrete
Pravin A. Shirule, Mujahid Husain
1Civil Engineering Department, S.S.B.T’s College of Engineering & Technology, Jalgaon, 425001, India
pashirule@gmail.com
doi: 10.6088/ijcser.2014050032

ABSTRACT
This paper will suggests a safe and environmentally consistent method of disposal of tyre waste material. The fine rubber particles obtained during remolding process of tyre at State Transport workshop, Jalgaon are used for replacement of fine aggregate (sand) in certain percentage in concrete. The blends are prepared by replacing 0%, 3%, 6%, 9%, 12%, 15% and 18% of fine aggregate (sand) by fine rubber particle by weight. The mechanical property of wet concrete like compaction factor is test for workability. The mechanical properties of hardened concrete like density, compressive strength, split tensile strength and flexural strength are test for strength of concrete.

Keyword: Sand, Tyre waste, Fine rubber, environmentally consistent, Mechanical properties.

1. Introduction

“Energy cannot be created, it cannot be destroyed”; it is the base of all intellectual and spiritual thoughts of human beings. Energy is always subjected to cycles. Thus nothing as such is a waste. The so called waste of one process is in fact a raw material for some other process. Globally the tyre production is estimated to be 1 billion per year. With the exponential growth in number of automobiles in India during recent years, the demand of tyres as original equipment and as replacement has also increased. In India an annual cumulative growth rate of 8% is expected in buses, trucks, cars/jeep/taxis. Considering the average life of the tyres used in these vehicles as 10 years after rethreading twice, the total number of waste disposable tyres will be in the order of 112 million per year. Approximately, one tire is discarded per person per year. These tires are among the largest and most problematic type of waste, due to the large volume produced and their durability. Those same characteristics, which make waste tires such a problem, also make them one of the most re-used waste materials, as the rubber is very resilient and can be reused in other products. Accumulations of discarded waste tires have been a major concern because the waste rubber is not easily biodegradable even after a long-period landfill treatment. Thus it gets accumulated and creates variety of problems. It creates unsightly appearance. If burnt under conventional uncontrolled fashion it creates harmful vapors. If dumped in land fill sites, in rainy seasons it accumulates water and harbors mosquito and fly breeding. In landfill sites methane is generated by other sources and bulk of tyre waste fetches fire. It creates hazards in land fill sites.

However, recycling of waste tire rubber is an alternative. Recycled waste-tire rubbers have been used in different application. It has been used as a fuel for cement kiln, as feedstock for making carbon black, and as artificial reefs in marine environment. It has also been used as a playground matt, erosion control, highway crash barriers, guard rail posts, noise barriers, and...
Reuse of scrap tyre as partial replacement of fine aggregate in concrete and its impact on properties of concrete

Pravin A. Shirule, Mujahid Husain

in asphalt pavement mixtures. Other construction products are also based on rubber powder obtained from the cryogenic milling of tires mixed with asphalt or bituminous materials. Over the past two decades, research had been performed to study the availability of using waste tire rubber in concrete mixes. In order to prevent the environmental problem from growing, recycling tire is an innovative idea or way in this case.

2. Methodology

Owing to the prolonged use of tyre in vehicle grip area of tire become plain. Remoulding of tyre is done for its further use. During the process of remoulding, fine rubber particle are obtained. These waste fine particles of rubber are used as replacement of locally available natural sand obtained from Girna River.

2.1 Materials used for casting of specimen

Natural Aggregate: Gravels are obtained by crushing natural basalt stone obtain from quarries nearby Jalgaon. They are hard, strong, tough, clear and free from veins, alkali, vegetable matter and other deleterious substances. Aggregates are free from such material, which will reduce strength or durability of concrete. Sand: Natural sand free from silt, veins, alkali, vegetable matter and other deleterious substances, obtained from Girna River Jalgaon.

Cement: Aditya Ultratech 53 Grade Ordinary Portland Cement having Batch W3 M01 Y13 is used for all mixes. Fine Scrap tyre rubber: Fine Scrap tyre rubber Obtained from Remolding section, S. T. workshop, Jalgaon. Water: Water used for drinking purpose in College of Engineering & Technology, Jalgaon is used for mixing and curing.

2.2 Quantity of materials used for each blend

The blends are prepared by replacing 0%, 3%, 6%, 9%, 12%, 15% and 18% of fine aggregate (sand) by fine rubber particle by weight. Each blend is prepared for casting of one set of 3 cubes, 3 beams and 3 cylinders each. Quantity of materials used for each blend is estimated.

2.3 Mixing of Concrete

Hand mixing of concrete is done as per IS code

2.4 Tests on Fresh Concrete

To measure workability of concrete compaction factor test carried on fresh concrete.

2.5 Casting of Test Specimen

Three specimen of each blend of Cube, Cylinder and Beam are casted as per IS code.

2.6 Curing of Specimen

Curing of the specimen is done for 28 days after casting of specimen as per IS code.

2.7 Testing of Concrete Specimen
Reuse of scrap tyre as partial replacement of fine aggregate in concrete and its impact on properties of concrete

Pravin A. Shirule, Mujahid Husain

Testing for hardened concrete is also done as per the IS codal provisions

3. Results and Discussions

The test conducted on materials used like Aggregate, Sand and Cement qualify all tests as per IS codes. Results of the test carried on fresh concrete and hardened concrete are described below.

3.1 Compaction factor test for fresh concrete

Compaction factor test is carried out on fresh concrete for each blend for measurement of workability of concrete.

![Compaction Factor of Fresh Concrete](image)

Figure 2: Compaction Factor of Fresh Concrete

3.2 Discussion

The maximum value of compaction factor of concrete is 99.83% for 9% blend. As increase in the % replacement of fine scrap tyre rubber decreases the compaction factor from 3% to 9% replacement of fine scrap tyre rubber aggregate compaction factor of concrete gradually decreases at the rate of 2.5%. After 9% up to 12% Replacement of fine scrap tyre rubber aggregate compaction factor of concrete is suddenly decrease by 3.9%. From 12% to 18%
reuse of scrap tyre as partial replacement of fine aggregate in concrete and its impact on properties of concrete

Pravin A. Shirule, Mujahid Husain

replacement fine scrap tyre rubber aggregate compaction factor of concrete gradually decreases at the rate of 2.4%.

3.2 Density of modified concrete

Density of concrete is found by measuring of weight of concrete cube and then by diving it by volume of cube.

![Figure 3: Density of Modified Concrete](image)

% Replacement by fine rubber

3.2.1 Discussion

The density of concrete reduces as the proportion of rubber tyre increases. The rate of decrease is nearly equal to 0.3% per 3% replacement of fine aggregate by rubber tyre.

3.3 Compressive Strength of Concrete

After 28 days curing of concrete cube, compressive test carried on each concrete cube of each blend. Average of three cubes of each blend is calculated and graph is plotted.

![Figure 4: Compressive Strength of Concrete Cube Specimen Tested After 28 Days of Curing](image)
3.3.1 Discussion

1. The maximum compressive strength is 40.66 N/mm$^2$ at 6% replacement of fine scrap tyre rubber aggregate. It is 6.58% greater than the compressive strength of traditional concrete.
2. Up to 6% replacement of fine scrap tyre rubber aggregate compressive strength is more than the compressive strength of traditional concrete.
3. For 9% replacement of fine scrap tyre rubber aggregate the compressive strength is nearly equal to the compressive strength of traditional concrete.
4. At 18% replacement of fine scrap tyre rubber aggregate compressive strength is decreased by 20.80% as compared with the maximum compressive strength of concrete at replacement of 6% and by 13.34% of compressive strength of traditional concrete.
5. Compressive strength from 9% to 18% replacement of fine scrap tyre rubber aggregate is reduced at an average rate of 2.82% for every addition of 3% of fine rubber aggregate.

3.4 Split Tensile Strength of Concrete

After 28 days curing of concrete cylinder, split tensile strength test carried on each concrete cylinder of each blend. Average of three split cylinder of each blend is calculated out and graph is plotted.

![Graph showing split tensile strength](image)

**Figure 5:** Spilt tensile strength of concrete cylinder specimen tested after 28 days of curing

3.4.1 Discussion

1. The maximum Split tensile strength of concrete is 3.65 N/mm$^2$ at 6% replacement of fine scrap tyre rubber
2. The maximum Split tensile strength at 6% replacement of fine scrap tyre rubber aggregate is 3.99% greater than the split tensile strength of traditional concrete.
3. For 9% replacement of fine scrap tyre rubber aggregate split tensile strength is nearly equal to the split tensile strength of traditional concrete.
Reuse of scrap tyre as partial replacement of fine aggregate in concrete and its impact on properties of concrete 
Pravin A. Shirule, Mujahid Husain

4. At 12% replacement of fine rubber aggregate the split tensile strength is decreased by 14.78% as compare with maximum split tensile strength at 6% replacement fine rubber aggregate and by 10.38% for traditional concrete.
5. For 15% replacement of fine rubber split tensile strength is nearly equal to split tensile strength for 12% replacement of fine rubber.
6. At 18% replacement of fine scrap tyre rubber aggregate split tensile strength is decreased by 23.31% as compared with the maximum split tensile strength at 6% replacement of fine scrap tyre rubber aggregate and by 22.29% than traditional concrete.

3.5 Flexural Strength

After 28 days curing of concrete beam, flexural strength test carried on each concrete beam of each blend. Average of three beam of each blend is finding out and graph is plot.

Figure 6: Flexural strength of concrete beam specimen tested after 28 days of curing

3.5.1 Discussion

1. The maximum flexural strength of concrete is 63.75kg/cm² at 6 % replacement of fine rubber aggregate.
2. The maximum flexural strength at 6% replacement of fine rubber aggregate is 14.69% greater than the flexural strength of traditional concrete.
3. At 18 % replacement of fine rubber aggregate flexural strength of concrete is decrease by 22.73% as compared with maximum flexural strength at 6% replacement of fine rubber aggregate and by 14.70% than traditional concrete.
4. For 9% replacement of fine rubber aggregate the flexural strength of concrete is nearly equal to flexural strength of traditional concrete.
5. There is not much difference between flexural strength of concrete from 12% to 15% replacement of fine rubber aggregate so by replacing 9% of fine rubber aggregate in concrete saves natural material.
6. Flexural strength of concrete from 9% to 18% replacement of fine rubber aggregate is gradually reduced at an average rate of 2.07% for every addition of 3% of fine rubber aggregate.
4. Conclusion

Use of the waste rubber tyre in concrete is a techno- economically feasible and environmentally consistent method of waste disposal. The addition of rubber tyre under certain proportion of rubber tyre for an specific property. Further higher proportion of rubber tyre degrades the concrete properties. The optimum values for specific concrete properties are presented in the previous section. (Results and Discussions). The proportion of rubber tyre, higher than the optimum can also find application in uses like partition walls etc. Where low density is the major requirement. Thus there is great potential to use rubber tyre waste in concrete.

Acknowledgement

We acknowledge to the All India Council of Technical Education for financial assistant under Modernization & Removal of Obsolesces Scheme. We are also acknowledging to Principal and Management of SSBT’s College of Engineering and Technology, Jalgaon (India) for their permission to use laboratory facilities. We acknowledge our colleague Ms Snehal Sawant for assisting in experimental work and drafting manuscript.

5. References


