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Effect of Waste Rubber Tyres on the Behavior of Concrete with Its Partial Replacement by 20mm Coarse Aggregates

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Abstract: In this research, firstly I have studied all the previous research studies in literature form to examine the issue of the problem (Waste Tyre Problem) & to study the behavior of these tyres on the performance of Concrete. For this purpose, I have adopted a Design Mix of M-30. The specimens are filled in the form of Cubes & Beams for testing of Compressive Strength & Flexural Strength. Using M-30 design Mix, I have casted 6 Samples (3 for 7 Day Testing & 3 for 28 Day Testing) of each varying proportion of replacement of coarse aggregates. The samples are prepared at different % of replacement at 1%, 2%, 3%, 5%, 8%, 10%. These are the % of replacement of Coarse Aggregates by Rubber Tyre Aggregates by Volume. Normal samples are also prepared without any replacement for Comparison purpose.

Laboratory Testing had been carried out on these prepared concrete samples. Compressive Strength & Flexural Strength tests are performed in this study. All the testing data is collected from testing of all Samples& then analyzed in respective manner in comparison with Conventional Concrete (Normal concrete). The results of Compressive Strength & Flexural Strength showed that a Continuous reduction occurs in both the Strengths with increase in the % of replacement of Coarse Aggregates with Rubber Tyres. However Compressive Strength is acceptable upto a replacement of 1%, 2%, 3% and slightly upto 5% also. This study has shown that this type of technique can be adopted in future scope as this will provide a significant strength upto a replacement of 3 - 5% & also cost analysis shows that a feasible cost is maintained. Thus waste tyres which are dangerous to environment if disposed off or burnt openly in air & causes pollution, can be used in the production of Concrete.

Introduction:

Cement and Aggregate are one of the basic materials used in concrete production, are obtained as the products of natural materials, for need of construction industry. It requires continuous supply of these natural materials for production of concrete. This utilization of natural resources for continuous need will lead to main concern of conserving the natural resources & to meet the demands of environment preserving also. This may be adopted by the use of any recycled, used of wasted materials for the production of concrete.

With the change in the constituents of its composition, concrete strength will show a dramatic change in its behavior. Aggregate is the major constituent of the bulk of the concrete mix, its properties will affect the end product results. An Aggregate is generally treated as the inert filler of the concrete. But now days the use of Aggregates is replaced by a number of advanced techniques to overcome its inert behavior. Initially Aggregate was supposed to use for maintaining the economical concern but now this is used with cement paste as cohesive material like in masonry structures. So the chemical, thermal or all other physical properties will affect the behavior of the concrete. Being cheaper than Cement, Aggregate is preferred to put in the concrete mix to make it economical. On the other hand, Aggregate is not only used for the economical purpose, it is used due to its some better qualities & technical advantages such as higher stability in volume aspect and better durability in comparison to hydrated paste of cement alone.

As we know, the continuous use of the natural aggregate will give rise to the risk of depletion of natural resources like coarse aggregate. This may be replaced by one of the vital waste material that is waste rubber tyres. These waste rubber tyres are one of the major threat to the any nation, because being non-biodegradable in nature. In INDIA alone, 10-12 million waste tyres are produced every year & this figure will keep on increasing day by day due to advancement in automobile technology. If we will talk about whole world, studies by U.S.A. based scientist named Blackwell S.G. has revealed that about more than 2 billion waste tyres are produced every year. So about 3-4% of the whole world waste tyres are produced only in INDIA (10-12 million per year).

Now, the main concern is about dumping of these waste tyres. When these waste tyres are dumped openly in the free land, they would provide a ground for many serious health issues. Basic of all is the collection of water in these waste tyres during the days of monsoon (raining days), the mosquitoes got reproduce there. They will cause Malaria or other serious diseases like Dengue etc. On the same hand, when these waste tyres are disposed in the soil , they will not decompose due to being non- biodegradable & cause toxicity to the soil.

If these waste tyres are burned openly in the air, they will produce a large number of toxic gases in the air. Thus environment get polluted & when humans breath in this polluted environment, they would got affected by some of the serious respiratory problems such as Asthma, Tuberculosis etc. Apart from it, many of the natural living species of the birds got affected by this pollution. The protective Ozone layer also got some serious damage due to carbonates produced in the burning process of these waste tyres. So dumping & dispose off the waste tyres is one of the major problem.

Moreover, the sustainability has a main goal of the permanent future and basically three components are responsible for this sustainability that are environment, society and the economy. To meet its target, sustainable development has to ensure all these components should remain safe and balanced. Apart from it, this will be adopted throughout the planet and all upto future and present. Environment is one of the prominent factor among all of these & any engineer should keep this in mind that this should not be affected at any cost. Along all the dangers which may affect the environment, includes waste materials which are produced after the use of any material or product which ends its life cycle or produced during the process of production of any product. Depending on the state these are solid, liquid or gaseous in state. Liquid or gaseous wastes can be disposed off by many of the ways but difficult for solids. Some of the solids can be recasted like steel, plastic or papers without any effect on the environment. Studies are performed to dispose off the threatening solid wastes like rubber tyres.

Being a thermoset material, tyre contains molecules of sulphur and some other chemicals in cross linked shape. The process of its mixing, rubber with some other chemicals for manufacturing of this thermoset material is known as vulcanization. This process makes tyres very safe and difficult to degrade under normal conditions. As a result, this leads to a great problem of disposal & becomes the issue of worldwide researches. On same side, its disposal has become a vulnerable issue for all the means. Every year, number of vehicles keep on increasing and this causes a major problem for tyres disposal. This is one of the main environmental problem.

So all of the studies suggest that reuse & recycling of the waste tyres has utmost need in current era. So that these tyres can be used in the environment friendly way. For this purpose, concrete construction technology is one of the best way to adopt.

Results & Discussions:

General:

The results of Compressive Strength & Flexural Strength of all specimens of different mix proportions are discussed below in this chapter. Different identification Marks were used for all specimens of Cubes & Beams. They are designated as following :-

1. CS-0 = Cube Specimens with 0 % replacement of Coarse Aggregates.
2. CS-1 = Cube Specimens with 1 % replacement of Coarse Aggregates.
3. CS-2 = Cube Specimens with 2 % replacement of Coarse Aggregates.
4. CS-3 = Cube Specimens with 3 % replacement of Coarse Aggregates.
5. CS-5 = Cube Specimens with 5 % replacement of Coarse Aggregates.
6. CS-8 = Cube Specimens with 8 % replacement of Coarse Aggregates.
7. CS-10 = Cube Specimens with 10 % replacement of Coarse Aggregates.
8. BS-0 = Beam Specimens with 0 % replacement of Coarse Aggregates.
9. BS-1 = Beam Specimens with 1 % replacement of Coarse Aggregates.
10. BS-2 = Beam Specimens with 2 % replacement of Coarse Aggregates.
11. BS-3 = Beam Specimens with 3 % replacement of Coarse Aggregates.
12. BS-5 = Beam Specimens with 5 % replacement of Coarse Aggregates.
13. BS-8 = Beam Specimens with 8 % replacement of Coarse Aggregates.
14. BS-10 = Beam Specimens with 10 % replacement of Coarse Aggregates.

These identification marks were provided to all the samples for their unique identity. 3 Samples each of Cubes & Beams were casted for 7 Days Testing and 3 Samples each of Cubes & Beams were casted for 28 Days Testing. A total of 42 Specimens of Concrete Cubes were casted & 42 Specimens of Concrete Beams were casted for experimentation of this research.

1. Compressive Strength of CS-0 Mix After 7 Days & 28 Days:

Formula Used:

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days:

1. Cube CS-0/1 = 430 X 1000/150 X 150 = 19.11 N/mm^2
2. Cube CS-0/2 = 410 X 1000/150 X 150 = 18.22 N/mm^2
3. Cube CS-0/3 = 420 X 1000/150 X 150 = 18.66 N/mm^2

Average Compressive Strength = (CS-0/1 + CS-0/2 + CS-0/3) / 3
Average Compressive Strength = (19.11 + 18.22 + 18.66) / 3
= **18.66** N/mm^2

Compressive Strength After 28 Days:

1. Cube CS-0/4 = 710 X 1000/150 X 150 = 31.55 N/mm^2
2. Cube CS-0/5 = 698 X 1000/150 X 150 = 31.02 N/mm^2
3. Cube CS-0/6 = 708 X 1000/150 X 150 = 31.46 N/mm^2

Average Compressive Strength = (CS-0/4 + CS-0/5 + CS-0/6) / 3
Average Compressive Strength = (31.55 + 31.02 + 31.46) / 3
= **31.34** N/mm^2

2. Flexural Strength of BS-0 Mix After 7 Days & 28 Days:

Formula Used:

Flexural Strength = $P.L/bd^2$

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days:

1. Beam BS-0/1 = 39.5 X 1000 X 400/150 X 150^2 = 4.68 N/mm^2
2. Beam BS-0/2 = 38.5 X 1000 X 400/150 X 150^2 = 4.56 N/mm^2
3. Beam BS-0/3 = 38.5 X 1000 X 400/150 X 150^2= 4.56 N/mm^2

Average Flexural Strength = (BS-0/1 + BS-0/2 + BS-0/3) / 3
Average Flexural Strength = (4.68 + 4.56 + 4.56) / 3
= **4.60** N/mm^2

Flexural Strength After 28 Days:

1. Beam BS-0/4 = 86.5 X 1000 X 400/150 X 150^2 = 10.25 N/mm^2
2. Beam BS-0/5 = 84 X 1000 X 400/150 X 150^2= 9.95 N/mm^2
3. Beam BS-0/6 = 92.5 X 1000 X 400/150 X 150^2= 10.96 N/mm^2

Average Flexural Strength = (BS-0/4 + BS-0/5 + BS-0/6) / 3
Average Flexural Strength = (10.25 + 9.95 + 10.96) / 3
= **10.39** N/mm^2

3. Compressive Strength of CS-1 Mix After 7 Days & 28 Days:

Formula Used:

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days:

1. Cube CS-1/1 = 420 X 1000/150 X 150 = 18.66 N/mm^2
2. Cube CS-1/2 = 390 X 1000/150 X 150 = 17.33 N/mm^2
3. Cube CS-1/3 = 420 X 1000/150 X 150 = 18.66 N/mm^2

Average Compressive Strength = (CS-1/1 + CS-1/2 + CS-1/3) / 3
Average Compressive Strength = (18.66 + 17.33 + 18.66) / 3
= **18.22** N/mm^2

Compressive Strength After 28 Days:

1. Cube CS-1/4 = 698 X 1000/150 X 150 = 31.02 N/mm^2
2. Cube CS-1/5 = 687 X 1000/150 X 150 = 30.53 N/mm^2
3. Cube CS-1/6 = 710 X 1000/150 X 150 = 31.55 N/mm^2

Average Compressive Strength = (CS-1/4 + CS-1/5 + CS-1/6) / 3
Average Compressive Strength = (31.02 + 30.53 + 31.55) / 3
= **31.03** N/mm^2

4. Flexural Strength of BS-1 Mix After 7 Days & 28 Days :

Formula Used :

Flexural Strength = $P.L/bd^2$

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days :

1. Beam BS-1/1 = 39 X 1000 X 400/150 X 150^2 = 4.62 N/mm^2
2. Beam BS-1/2 = 38.5 X 1000 X 400/150 X 150^2 = 4.56 N/mm^2
3. Beam BS-1/3 = 38 X 1000 X 400/150 X 150^2= 4.50 N/mm^2

Average Flexural Strength = (BS-1/1 + BS-1/2 + BS-1/3) / 3
Average Flexural Strength = (4.62 + 4.56 + 4.50) / 3
= **4.56** N/mm^2

Flexural Strength After 28 Days :

1. Beam BS-1/4 = 81 X 1000 X 400/150 X 150^2 = 9.60 N/mm^2
2. Beam BS-1/5 = 83 X 1000 X 400/150 X 150^2= 9.83 N/mm^2
3. Beam BS-1/6 = 85.5 X 1000 X 400/150 X 150^2= 10.13 N/mm^2

Average Flexural Strength = (BS-1/4 + BS-1/5 + BS-1/6) / 3
Average Flexural Strength = (9.60 + 9.83 + 10.13) / 3
= **9.85** N/mm^2

5. Compressive Strength of CS-2 Mix After 7 Days & 28 Days :

Formula Used :

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days :

1. Cube CS-2/1 = 400 X 1000/150 X 150 = 17.77 N/mm^2
2. Cube CS-2/2 = 380 X 1000/150 X 150 = 16.88 N/mm^2
3. Cube CS-2/3 = 390 X 1000/150 X 150 = 17.33 N/mm^2

Average Compressive Strength = (CS-2/1 + CS-2/2 + CS-2/3) / 3
Average Compressive Strength = (17.77 + 16.88 + 17.33) / 3
= **17.33** N/mm^2

Compressive Strength After 28 Days :

1. Cube CS-2/4 = 688 X 1000/150 X 150 = 30.57 N/mm^2
2. Cube CS-2/5 = 660 X 1000/150 X 150 = 29.33 N/mm^2
3. Cube CS-2/6 = 692 X 1000/150 X 150 = 30.75 N/mm^2

Average Compressive Strength = (CS-2/4 + CS-2/5 + CS-2/6) / 3
Average Compressive Strength = (30.57 + 29.33 + 30.75) / 3
= **30.22** N/mm^2

6. Flexural Strength of BS-2 Mix After 7 Days & 28 Days :

Formula Used :

Flexural Strength = $P.L/bd^2$

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days :

1. Beam BS-2/1 = 38 X 1000 X 400/150 X 150^2 = 4.50 N/mm^2
2. Beam BS-2/2 = 37.5 X 1000 X 400/150 X 150^2 = 4.44 N/mm^2
3. Beam BS-2/3 = 36.5 X 1000 X 400/150 X 150^2= 4.32 N/mm^2

Average Flexural Strength = (BS-2/1 + BS-2/2 + BS-2/3) / 3
Average Flexural Strength = (4.50 + 4.44 + 4.32) / 3
= **4.42** N/mm^2

Flexural Strength After 28 Days :

1. Beam BS-2/4 = 78 X 1000 X 400/150 X 150^2= 9.24 N/mm^2
2. Beam BS-2/5 = 78.5 X 1000 X 400/150 X 150^2= 9.30 N/mm^2
3. Beam BS-2/6 = 80 X 1000 X 400/150 X 150^2= 9.48 N/mm^2

Average Flexural Strength = (BS-2/4 + BS-2/5 + BS-2/6) / 3
Average Flexural Strength = (9.24 + 9.30 + 9.48) / 3
= **9.34** N/mm^2

7. Compressive Strength of CS-3 Mix After 7 Days & 28 Days :

Formula Used :

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days :

1. Cube CS-3/1 = 380 X 1000/150 X 150 = 16.88 N/mm^2
2. Cube CS-3/2 = 390 X 1000/150 X 150 = 17.33 N/mm^2
3. Cube CS-3/3 = 390 X 1000/150 X 150 = 17.33 N/mm^2

Average Compressive Strength = (CS-3/1 + CS-3/2 + CS-3/3) / 3
Average Compressive Strength = (16.88 + 17.33 + 17.33) / 3
= **17.18** N/mm^2

Compressive Strength After 28 Days :

1. Cube CS-3/4 = 660 X 1000/150 X 150 = 29.33 N/mm^2
2. Cube CS-3/5 = 680 X 1000/150 X 150 = 30.22 N/mm^2
3. Cube CS-3/6 = 645 X 1000/150 X 150 = 28.66 N/mm^2

Average Compressive Strength = (CS-3/4 + CS-3/5 + CS-3/6) / 3
Average Compressive Strength = (29.33 + 30.22 + 28.66) / 3
= **29.40** N/mm^2

8. Flexural Strength of BS-3 Mix After 7 Days & 28 Days :

Formula Used :

Flexural Strength = $P.L/bd^2$

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days :

1. Beam BS-3/1 = 36 X 1000 X 400/150 X 150^2 = 4.26 N/mm^2
2. Beam BS-3/2 = 34 X 1000 X 400/150 X 150^2 = 4.02 N/mm^2
3. Beam BS-3/3 = 35.5 X 1000 X 400/150 X 150^2= 4.20 N/mm^2

Average Flexural Strength = (BS-3/1 + BS-3/2 + BS-3/3) / 3
Average Flexural Strength = (4.26 + 4.02 + 4.20) / 3
= **4.16** N/mm^2

Flexural Strength After 28 Days :

1. Beam BS-3/4 = 72.5 X 1000 X 400/150 X 150^2= 8.59 N/mm^2
2. Beam BS-3/5 = 73 X 1000 X 400/150 X 150^2= 8.65 N/mm^2
3. Beam BS-3/6 = 74.5 X 1000 X 400/150 X 150^2= 8.82 N/mm^2

Average Flexural Strength = (BS-3/4 + BS-3/5 + BS-3/6) / 3
Average Flexural Strength = (8.59 + 8.65 + 8.82) / 3
= **8.69** N/mm^2

9. Compressive Strength of CS-5 Mix After 7 Days & 28 Days :

Formula Used :

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days :

1. Cube CS-5/1 = 340 X 1000/150 X 150 = 15.11 N/mm^2
2. Cube CS-5/2 = 360 X 1000/150 X 150 = 16.00 N/mm^2
3. Cube CS-5/3 = 350 X 1000/150 X 150 = 15.55 N/mm^2

Average Compressive Strength = (CS-5/1 + CS-5/2 + CS-5/3) / 3
Average Compressive Strength = (15.11 + 16.00 + 15.55) / 3
= **15.55** N/mm^2

Compressive Strength After 28 Days :

1. Cube CS-5/4 = 580 X 1000/150 X 150 = 25.77 N/mm^2
2. Cube CS-5/5 = 562 X 1000/150 X 150 = 24.97 N/mm^2
3. Cube CS-5/6 = 548 X 1000/150 X 150 = 24.35 N/mm^2

Average Compressive Strength = (CS-5/4 + CS-5/5 + CS-5/6) / 3
Average Compressive Strength = (25.77 + 24.97 + 24.35) / 3

= **25.03** N/mm^2

10. Flexural Strength of BS-5 Mix After 7 Days & 28 Days :

Formula Used :

Flexural Strength = $P.L/bd^2$

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days :

1. Beam BS-5/1 = 33.5 X 1000 X 400/150 X 150^2 = 3.97 N/mm^2
2. Beam BS-5/2 = 36 X 1000 X 400/150 X 150^2 = 4.26 N/mm^2
3. Beam BS-5/3 = 33.5 X 1000 X 400/150 X 150^2= 3.97 N/mm^2

Average Flexural Strength = (BS-5/1 + BS-5/2 + BS-5/3) / 3
Average Flexural Strength = (3.97 + 4.26 + 3.97) / 3
= **4.06** N/mm^2

Flexural Strength After 28 Days :

1. Beam BS-5/4 = 61 X 1000 X 400/150 X 150^2= 7.22 N/mm^2
2. Beam BS-5/5 = 62.5 X 1000 X 400/150 X 150^2= 7.40 N/mm^2
3. Beam BS-5/6 = 63 X 1000 X 400/150 X 150^2= 7.46 N/mm^2

Average Flexural Strength = (BS-5/4 + BS-5/5 + BS-5/6) / 3
Average Flexural Strength = (7.22 + 7.40 + 7.46) / 3
= **7.36** N/mm^2

11. Compressive Strength of CS-8 Mix After 7 Days & 28 Days :

Formula Used :

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days :

1. Cube CS-8/1 = 280 X 1000/150 X 150 = 12.44 N/mm^2
2. Cube CS-8/2 = 270 X 1000/150 X 150 = 12.00 N/mm^2
3. Cube CS-8/3 = 280 X 1000/150 X 150 = 12.44 N/mm^2

Average Compressive Strength = (CS-8/1 + CS-8/2 + CS-8/3) / 3
Average Compressive Strength = (12.44 + 12.00 + 12.44) / 3
= **12.29** N/mm^2

Compressive Strength After 28 Days :

1. Cube CS-8/4 = 538 X 1000/150 X 150 = 23.91 N/mm^2
2. Cube CS-8/5 = 548 X 1000/150 X 150 = 24.35 N/mm^2
3. Cube CS-8/6 = 518 X 1000/150 X 150 = 23.02 N/mm^2

Average Compressive Strength = (CS-8/4 + CS-8/5 + CS-8/6) / 3
Average Compressive Strength = (23.91 + 24.35 + 23.02) / 3
= **23.76** N/mm^2

12. Flexural Strength of BS-8 Mix After 7 Days & 28 Days :

Formula Used :

Flexural Strength = $P.L/bd^2$

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days :

1. Beam BS-8/1 = 31 X 1000 X 400/150 X 150^2 = 3.67 N/mm^2
2. Beam BS-8/2 = 35 X 1000 X 400/150 X 150^2 = 4.14 N/mm^2
3. Beam BS-8/3 = 31 X 1000 X 400/150 X 150^2= 3.67 N/mm^2

Average Flexural Strength = (BS-8/1 + BS-8/2 + BS-8/3) / 3
Average Flexural Strength = (3.67 + 4.14 + 3.67) / 3
= **3.83** N/mm^2

Flexural Strength After 28 Days :

1. Beam BS-8/4 = 49.5 X 1000 X 400/150 X 150^2= 5.86 N/mm^2
2. Beam BS-8/5 = 53 X 1000 X 400/150 X 150^2= 6.28 N/mm^2

3. Beam BS-8/6 = 52.5 X 1000 X 400/150 X 150^2= 6.22 N/mm^2

Average Flexural Strength = (BS-8/4 + BS-8/5 + BS-8/6) / 3
Average Flexural Strength = (5.86 + 6.28 + 6.22) / 3
= **6.12** N/mm^2

13. Compressive Strength of CS-10 Mix After 7 Days & 28 Days :

Formula Used :

Compressive Strength = Maximum Load in KN/Cross Sectional Area in mm^2 = P/A

Compressive Strength After 7 Days :

1. Cube CS-10/1 = 220 X 1000/150 X 150 = 9.77 N/mm^2
2. Cube CS-10/2 = 190 X 1000/150 X 150 = 8.44 N/mm^2
3. Cube CS-10/3 = 230 X 1000/150 X 150 = 10.22 N/mm^2

Average Compressive Strength = (CS-10/1 + CS-10/2 + CS-10/3) / 3
Average Compressive Strength = (9.77 + 8.44 + 10.22) / 3
= **9.48** N/mm^2

Compressive Strength After 28 Days :

1. Cube CS-10/4 = 482 X 1000/150 X 150 = 21.42 N/mm^2
2. Cube CS-10/5 = 498 X 1000/150 X 150 = 22.13 N/mm^2
3. Cube CS-10/6 = 505 X 1000/150 X 150 = 22.44 N/mm^2

Average Compressive Strength = (CS-10/4 + CS-10/5 + CS-10/6) / 3
Average Compressive Strength = (21.42 + 22.13 + 22.44) / 3
= **22.00** N/mm^2

14. Flexural Strength of BS-10 Mix After 7 Days & 28 Days :

Formula Used :

Flexural Strength = P.L/bd^2

Here,

P = Maximum Load in KN.
L = Span of Supports.
b = width of specimen.
d = depth of specimen.

Flexural Strength After 7 Days :

1. Beam BS-10/1 = 32.5 X 1000 X 400/150 X 150^2 = 3.85 N/mm^2
2. Beam BS-10/2 = 31.5 X 1000 X 400/150 X 150^2 = 3.73 N/mm^2
3. Beam BS-10/3 = 30 X 1000 X 400/150 X 150^2= 3.55 N/mm^2

Average Flexural Strength = (BS-10/1 + BS-10/2 + BS-10/3) / 3
Average Flexural Strength = (3.85 + 3.73 + 3.55) / 3
= **3.71** N/mm^2

Flexural Strength After 28 Days :

1. Beam BS-10/4 = 46.5 X 1000 X 400/150 X 150^2= 5.51 N/mm^2
2. Beam BS-10/5 = 48.5 X 1000 X 400/150 X 150^2= 5.74 N/mm^2
3. Beam BS-10/6 = 46.5 X 1000 X 400/150 X 150^2= 5.51 N/mm^2

Average Flexural Strength = (BS-10/4 + BS-10/5 + BS-10/6) / 3
Average Flexural Strength = (5.51 + 5.74 + 5.51) / 3
= **5.59** N/mm^2

15. Overall Comparison of Results of Compressive Strength :

The comparison of the results of all the specimens of the Concrete Cubes with different % of Rubber Tyres Aggregates are mentioned in table below :

Table 4.15 Results of Compressive Strength (After 7 Days & 28 Days)

Identification Mark	7 Days Average Compressive Strength **(N/mm^2)**	28 Days Average Compressive Strength **(N/mm^2)**
CS-0 (0 % replacement)	18.66	31.34
CS-1 (1 % replacement)	18.22	31.03
CS-2 (2 % replacement)	17.33	30.22

CS-3 (3 % replacement)	17.18	29.40
CS-5 (5 % replacement)	15.55	25.03
CS-8 (8 % replacement)	12.29	23.76
CS-10 (10 % replacement)	9.48	22.00

16. Overall Comparison of Results of Flexural Strength :

The comparison of the results of all the specimens of the Concrete Beams with different % of Rubber Tyres Aggregates are mentioned in table below :

Table 4.16 Results of Flexural Strength (After 7 Days & 28 Days)

Identification Mark	7 Days Average Flexural Strength **(N/mm^2)**	28 Days Average Flexural Strength **(N/mm^2)**
BS-0 (0 % replacement)	4.60	10.39
BS-1 (1 % replacement)	4.56	9.85
BS-2 (2 % replacement)	4.42	9.34
BS-3 (3 % replacement)	4.16	8.69
BS-5 (5 % replacement)	4.06	7.36
BS-8 (8 % replacement)	3.83	6.12
BS-10 (10 % replacement)	3.71	5.59

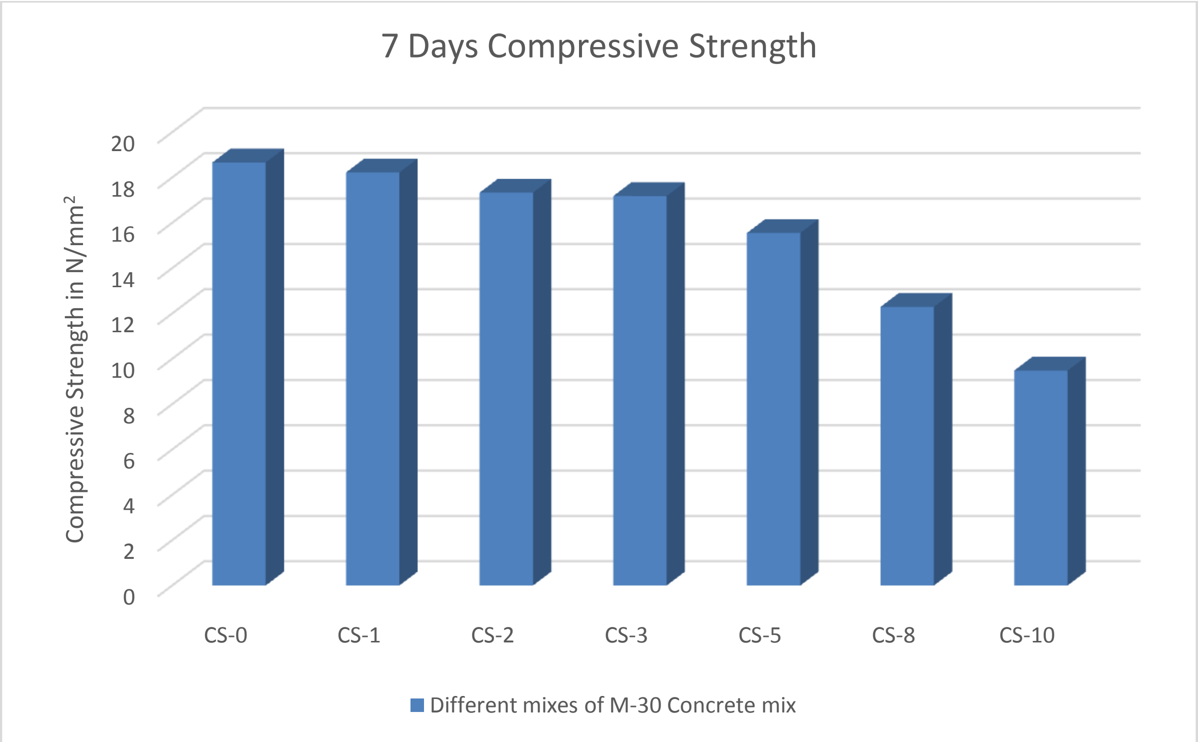

Fig. 1 - 7 Days Compressive Strength Graph

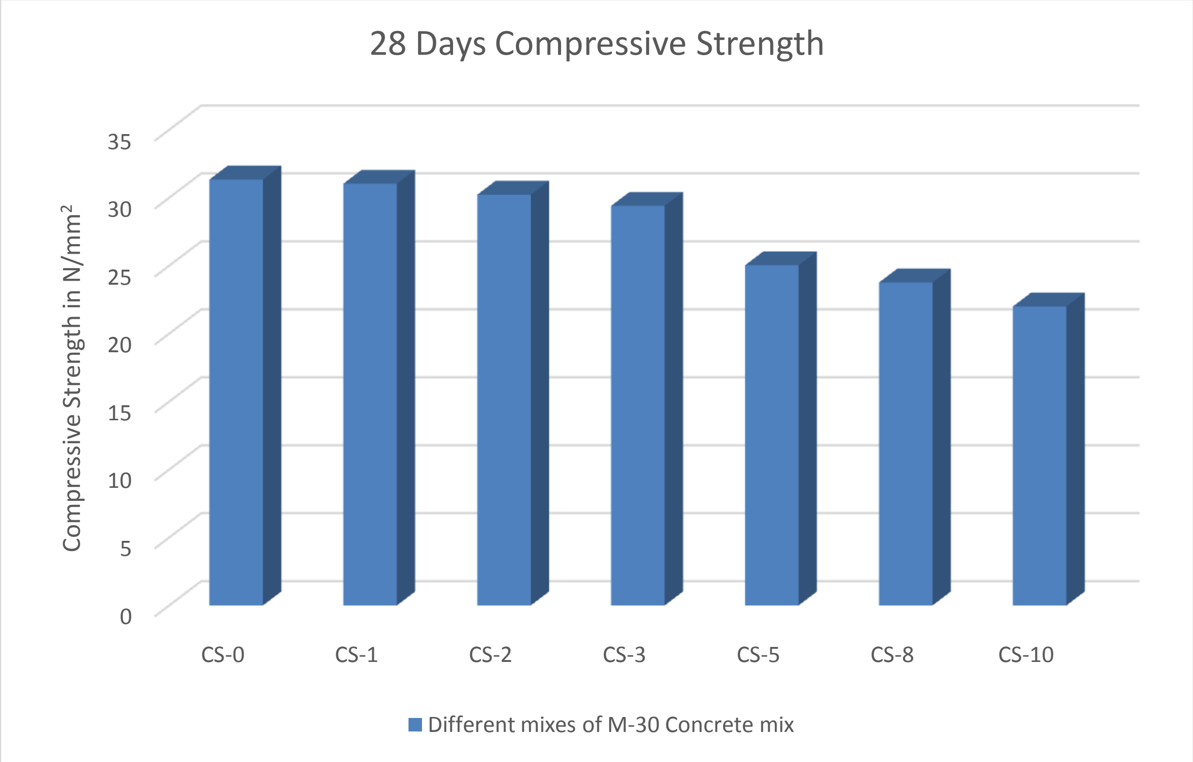

Fig. 2 - 28 Days Compressive Strength Graph

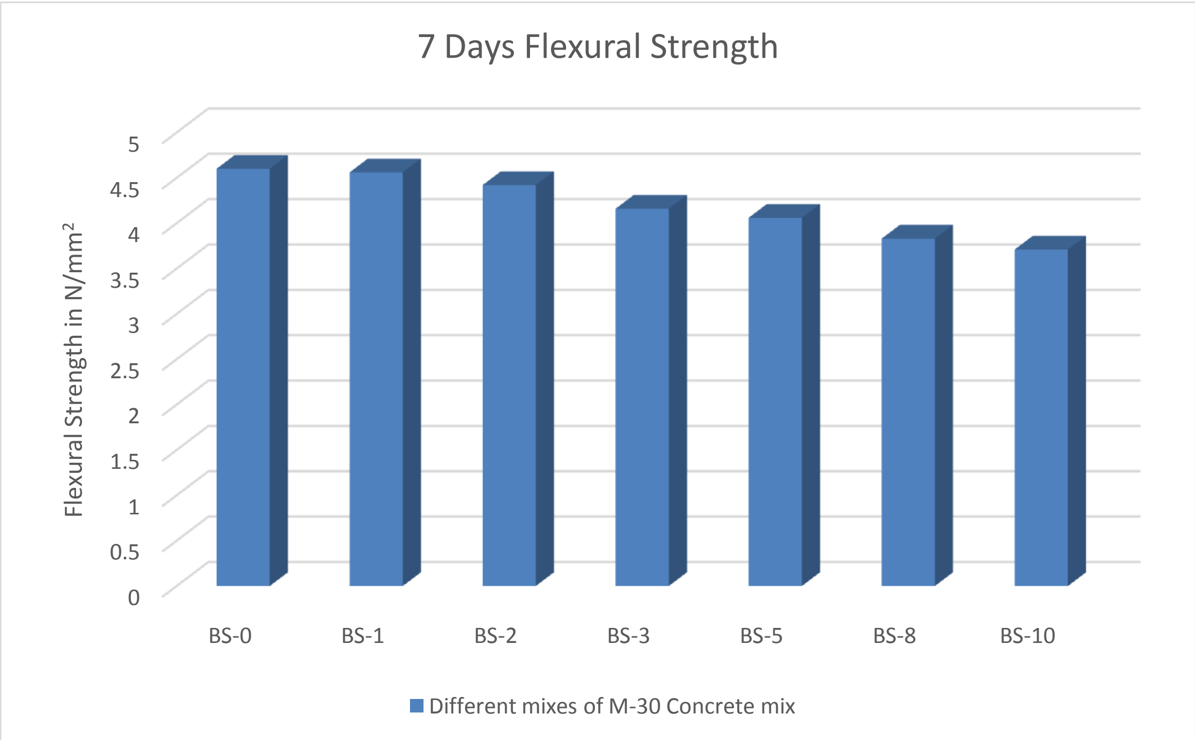

Fig. 3 - 7 Days Flexural Strength Graph

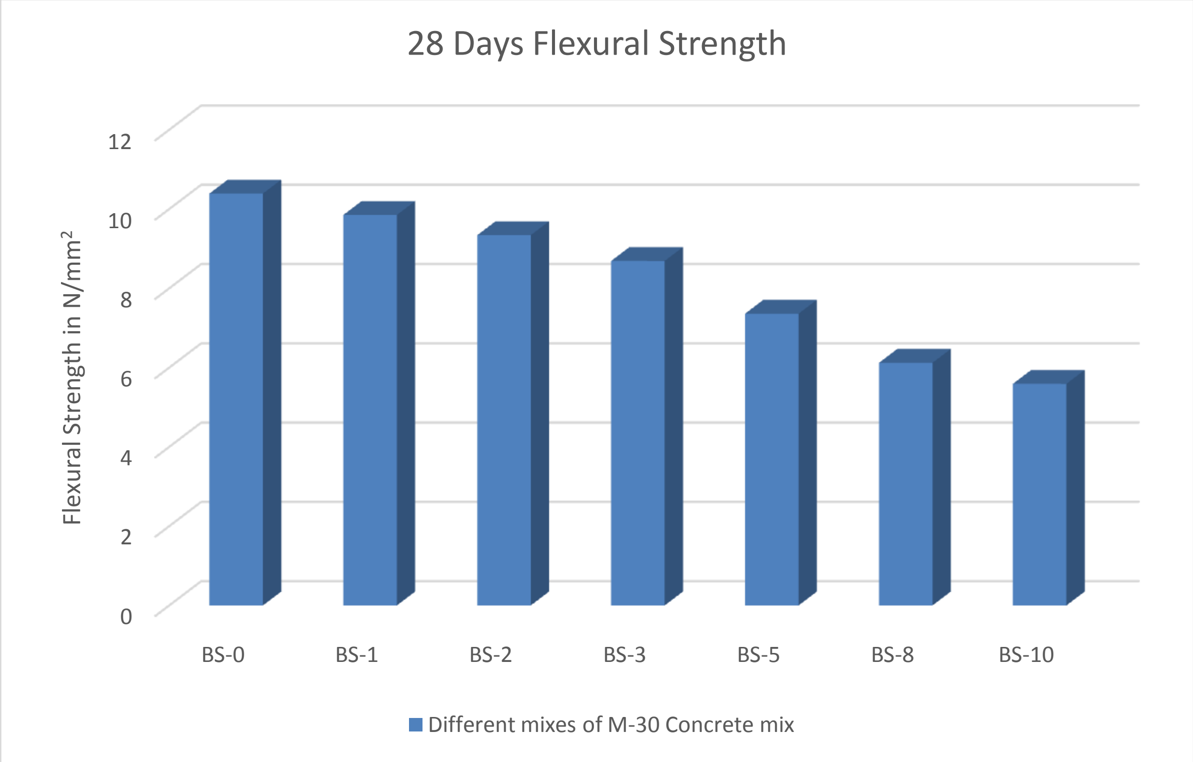

Fig. 4 -28 Days Flexural Strength Graph

Conclusions:

Conclusion of Compressive Strength

The results of the Compressive Strength were showing a continuous reduction in the strength. This was clear from the research that on increasing the % of waste rubber tyre aggregate, the Compressive Strength kept on decreasing. The 7 Day & 28 Day testing's results were displayed above. These both testing results were showing that a definite reduction would occur with any amount of Rubber Tyre Aggregate Replacement. But this had shown that this reduction will be acceptable upto replacement 1%, 2% & 3% without any dubious thinking because upto 3% this reduction will not affect the required strength. We had used M-30 grade and upto 3%, the final compressive strength at 28 Days was above or approximate equal to 30 N/mm^2. If we talk about the acceptance of this M-30 grade as alternative of M-25 grade, then upto 5% replacement could be done. This would fulfill two tasks, one is the acceptance of M-30 as alternative of M-25 & secondly this would waste tyres in it, which are a major threat to environment when burn openly in the air due to non decomposable nature.

Conclusion of Flexural Strength:

The results of the Flexural Strength were also showing a continuous reduction in the strength. As like compressive strength, it was clear from the research that on increasing the % of waste rubber tyre aggregate, the Flexural Strength would also kept on decreasing. The 7 Day & 28 Day testing's results were displayed above. These both testing results were showing that a definite reduction would occur with any amount of Rubber Tyre Aggregate Replacement. But this also had shown that this reduction will be acceptable upto replacement 1%, 2%, 3% & slightly upto 5% as upto this level significant strength was obtained. We had used M-30 grade and upto 3 - 5%, the final flexural strength at 28 Days was above or approximate the acceptable value. Like as Compressive Strength, this would fulfill two tasks, one is the acceptance of M-30 as alternative of M-25 & secondly this would waste tyres in it, which are a major threat to environment when burn openly in the air due to non decomposable nature.

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