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Performance of Hybrid Rubberized Concrete Slabs Under Impact Loads

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ABSTRACT
The dumping of waste tyres is the major environmental problem the world faces today. It is estimated that only 4% of the dumped tyre is used in Civil Engineering Applications. At the same time there is an acute shortage of natural aggregates. The concrete produced by replacing natural aggregates by scrap rubber is called as Rubberized concrete, which will be the suitable solution for the above problems. Here an investigation is done to find the impact load behaviour of Hybrid Rubberized concrete slabs. In this project three concrete grades namely M25, M30, and M35 were considered for investigation. Rubberized concrete slabs of two categories for a size of 300 mm x 300 mm with 50mm thickness were cast along with normal concrete slabs .Then these specimens were subjected to Drop Hammer test to find its performance against the impact loads. The number of blows required for the first crack and complete failure of the slabs were found out from the impact test and the failure characteristics of the specimens were studied

Keywords
Rubberized concrete slabs, Hybrid rubberized concrete slabs, Impact test, Energy absorption, Ductility Index.

1. INTRODUCTION
In recent years waste handling and management is the primary issue faced by the countries all over the world. It is very challenging and hectic problem that has to be tackled in an indigenous manner. On the basis of statistical data provided by the Environmental Protection Agency (EPA) 270,000,000 millions waste tyres are produced each year. The disposal of the waste tyres in the landfills is the major issue handled by the local municipalities and government sectors. The statistical study gives an estimate that within the next decade the majority of the landfills used for the waste tyre disposal shall be closed and this poses the problem of need for lands for waste dumping. This new problem gave an idea of recycling of waste tyres instead of filling them in bare lands. Some of the alternatives are: reuse of ground tyre rubber in a variety of rubber and plastic products, tyre retreading applications, highway crash barriers, and breakwaters but after this usage the material become scrap and the search of recycling draw out. Concrete Structure is designed for service life 50 to 100 years which promotes us to use waste tyre rubber as a constituent material in concrete which gives sustainable solution to the problem faced.

On the other hand the infrastructure development is resulted in excessive use of natural aggregate. To cope up with the increasing demand of natural aggregates the rate of extraction are also being increased. Extraction of natural aggregates from river beds, lakes and other water bodies have resulted in huge environmental problems such as flooding, landslides. Moreover the filtration of rain water achieved by deposits of natural sand is being lost, thereby causing contamination of water reserves used for human consumption.

To mitigate the above problems it is proposed to use rubber as a partial replacement for natural aggregates. The concrete produced by replacing natural aggregates by scrap rubber is called as Rubberized concrete. If suitability of such material is identified by various research, then it becomes possible to make wealth out of waste.

Hybridized rubber concrete consists of two layers with rubberized concrete on the top layer and plain concrete on the bottom layer. Since rubberized concrete has greater potential to absorb impact load, it is kept on the top layer and simultaneously plain concrete which has greater resistance to tension (when compared with rubberized concrete) is kept in the bottom layer to get better results.

2. MATERIALS AND MATERIAL TESTING

2.1 Concrete
In the work 53 grade OPC is used for casting. The physical properties of cement are obtained by conducting following tests as per the IS standards namely IS 1727:1967 and IS 4031(Part – 5):1988

Table 1. Physical Properties of Cement

S.No	Properties	Values
1	Specific gravity of cement	3.01
2	Fineness of cement	4%
3	Standard consistency of cement	30%
4	Initial setting time	35 min
5	Final setting time	512 min
6	Compressive strength of cement mortar in 28 days	53.80 MPA

2.2 Fine Aggregate

The sand used for the experimental works was locally procured and conformed to grading zone II. Sieve Analysis of the Fine Aggregate was carried out in the laboratory as per IS383-1970. The following tests are carried out on fine aggregate as per IS:2386 (Part3)- 1963 to find out its physical properties.

Table 2. Properties of Sand

S.No	Properties	Values
1	Specific gravity of sand	2.62
2	Water absorption	2%

Table 3. Fineness Modulus of Fine Aggregate

Sieve Size (mm)	Weight Of Retained Sand (g)	% Weight Retained	Cumulative % Of Weight Retained	Cumulative % Weight Passed
4.75mm	24	2.4	2.4	97.6
2.36mm	48	4.8	7.2	92.8
1.18mm	132	13.2	20.4	79.6
600µm	208	208	41.2	58.8
300 µm	356	356	76.3	23.2
150 µm	196	196	96.4	3.6
Pan	36	36	100	0.0
Total Cumulative % Of Weight Retained = 355.6				
Fineness Modulus Of Fine Aggregate = 356/100 = 3.56				

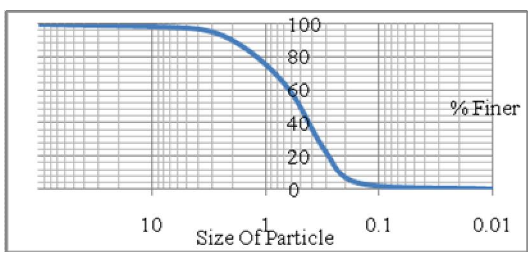

Figure 1. Particle Size Distribution of Sand

2.3 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 20 mm was used in the work. The following tests are carried out on coarse aggregate as per IS:2386 (Part3)- 1963

Table 4. Properties of Coarse Aggregate

S.No	Properties	Values
1	Specific gravity of coarse aggregate	2.72
2	Water absorption	1%
3	Fineness modulus	4.72
4	Aggregate Impact test value	13.58%
5	Aggregate Crushing value	18.24 %

2.4 Water

In the investigation, tap water was used for both mixing and curing purposes. The pH value of water is 6.5.

2.5 Crumb Rubber

Crumb rubber is recycled rubber from automotive and truck scrap tires. In this project the crumb rubber of size passing 2.36 mm sieve is used as replacement for fine aggregate.

Table 5. Properties of Coarse Aggregate

S.No	Properties	Values
1	Specific gravity of Rubber	1.3
2	Water absorption	1.3%

2.6 Chemical Solutions

Acetic acid (systematically named ethanoic acid) is an organic compound with the chemical formula CH_3COOH. Crumb rubber was immersed in acidic solution for 24hrs and then rinsed with water before using it in concrete.

Figure 2. Crumb Rubber

3. EXPERIMENTAL INVESTIGATION

3.1 Mix Proportion

The mix proportions are made for the M25, M30, and M35 grades of concrete. The following table shows the calculated mix proportions.

Table 6. Mix Proportions of Concrete

Grade Of Concrete	Mix Proportion (Cement: Fine Agg : Coarse Agg.)	Water Cement Ratio
M25	1:1.46:2.57	0.45
M30	1:1.15:2.12	0.38
M35	1:1:1.93	0.35

3.2 Treatment for Rubber

The rubber which is to be used in the manufacture of concrete was immersed in the Acetic acid (5% concentration) and kept undisturbed for 24 hours. After 24 hours it is taken out, rinsed with water, dried and used for manufacture of concrete.

3.3 Casting and Curing

A total of 27 slabs (9- Rubberized slabs, 9-Hybrid Rubberized slabs, 9-Ordinary Concrete slabs) were cast. Normal water curing is done on the slabs for 28 days. The following table shows the slab details that were casted.

Table 7. Slab Details

S.No	Slab Series	Slab ID	Type Of Slab	Grade of Concrete
1		A11		
2	A1	A12	Ordinary Concrete Slabs	
3		A13		
4		A21		
5	A2	A22	Rubberized Concrete Slabs	M25
6		A23		
7		A31		
8	A3	A32	Hybrid Rubberized Concrete Slabs	
9		A33		
10		B11		
11	B1	B12	Ordinary Concrete Slabs	
12		B13		
13		B21		
14	B2	B22	Rubberized Concrete Slabs	M30
15		B23		
16		B31		
17	B3	B32	Hybrid Rubberized Concrete Slabs	
18		B33		
19		C11		
20	C1	C12	Ordinary Concrete Slabs	
21		C13		
22		C21		
23	C2	C22	Rubberized Concrete Slabs	M35
24		C23		
25		C31		
26	C3	C32	Hybrid Rubberized Concrete Slabs	
27		C33		

Figure 3. Wet mix

Figure 4. Specimens after casting

Figure 5. Specimens after curing

3.4 Rebound Hammer Test

Rebound hammer test is used to find the compressive strength of the concrete slabs. The rebound hammer has a plunger which has to be pressed perpendicular against the concrete slab, and the pressure is applied gradually until the hammer impacts. Before the test on specimens the hammer was tested against the test anvil, to get reliable results.

3.5 Drop Hammer Test

The specimens are tested for impact loads by the well known Drop Hammer test. The drop hammer test apparatus consisted of a rigid welded steel frame square in plan and supported by short columns. The drop hammer having a mass of 3.5 kg (34.335 N) was used for applying repeated impact on the specimen from a constant height (1.20m). The test setup consists of a cylindrical ball of 90mm dia and 80mm height with hemispherical blunt tip to a height of 20mm, which acts as a plunger. For each specimen, the hammer is dropped repeatedly and the number of blows required for the first visible crack and the blows required for final failure were recorded

Figure 6. Drop Hammer apparatus

4. Experimental Results and Discussions

The specimens after curing are tested for its compressive strength and energy absorption. The results are tabulated below:

4.1 Compressive Strength Results

Table 8. Compressive Strength Results

S. No	M25		M30		M35	
	Slab ID	Compressive Strength (MPA)	Slab ID	Compressive Strength (MPA)	Slab ID	Compressive Strength (MPA)
1	A11	28	B11	31	C11	33
2	A12	26	B12	30	C12	35
3	A13	26	B13	31	C13	35
4	A21	22	B21	24	C21	27
5	A22	23	B22	26	C22	29
6	A23	22	B23	26	C23	27
7	A31	24	B31	28	C31	31
8	A32	24	B32	29	C32	33
9	A33	22	B33	28	C33	32

4.2 Impact Load Test Results for M25

Table 9. Impact load Test Results for M25

S. No	Slab Id	No.Of Blows Required To Create (n)		Initial Energy Disspiation (E_i) joules	Final Energy Disspiation (E_p) joules	Ductility Index E_p / E_i
		First Crack	Final Failure			
1	A11	2	4	82.404	164.81	2
2	A12	2	3	82.404	123.61	1.5
3	A13	2	5	82.404	206.01	2.5
4	A21	5	34	206.01	1400.87	6.8
5	A22	6	34	247.21	1400.87	5.7
6	A23	5	32	206.01	1318.46	6.4
7	A31	6	24	247.21	988.85	4
8	A32	5	26	206.01	1071.25	5.2
9	A33	6	23	247.21	947.65	3.8

Table 10. Impact load Test Results for M30

S. No	Slab Id	No.Of Blows Required To Create (n)		Initial Energy Disspiation (E_i) joules	Final Energy Disspiation (E_p) joules	Ductility Index E_p / E_i
		First Crack	Final Failure			
1	B11	2	6	82.404	247.212	3
2	B12	2	5	82.404	206.01	2.5
3	B13	2	7	82.404	288.414	3.5
4	B21	6	33	247.212	1359.666	5.5
5	B22	6	35	247.212	1442.07	5.8
6	B23	5	32	206.01	1318.464	6.4
7	B31	5	29	206.01	1194.858	5.8
8	B32	4	28	164.808	1153.656	7
9	B33	5	28	206.01	1153.656	5.6

Table 11. Impact load Test Results for M35

S. No	Slab Id	No.Of Blows Required To Create (n)		Initial Energy Disspiation (E_i) joules	Final Energy Disspiation (E_p) joules	Ductility Index E_p / E_i
		First Crack	Final Failure			
1	C11	3	8	123.606	329.616	2.7
2	C12	3	9	123.606	370.818	3
3	C13	2	7	82.404	288.414	3.5
4	C21	7	43	288.414	1771.686	6.1
5	C22	8	45	329.616	1854.09	5.6
6	C23	9	45	370.818	1854.09	5
7	C31	6	36	247.212	1483.272	6
8	C32	6	38	247.212	1565.676	6.3
9	C33	5	38	206.01	1565.676	7.6

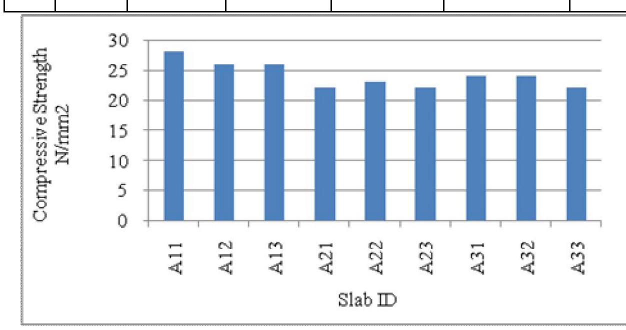

Figure 7. Compressive Strength for M25 Slabs

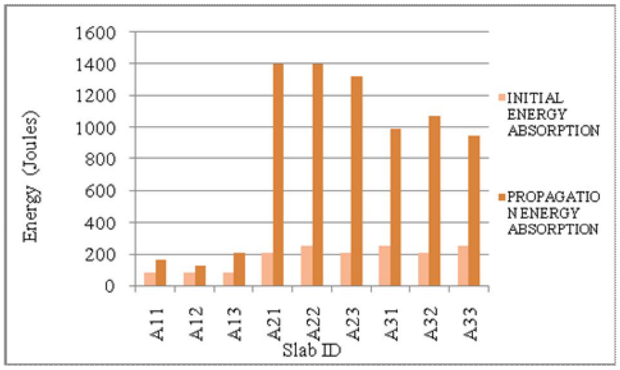

Figure 8. Energy Absorption for M25 Slabs

Figure 9. Ductility Index for M25 Slabs

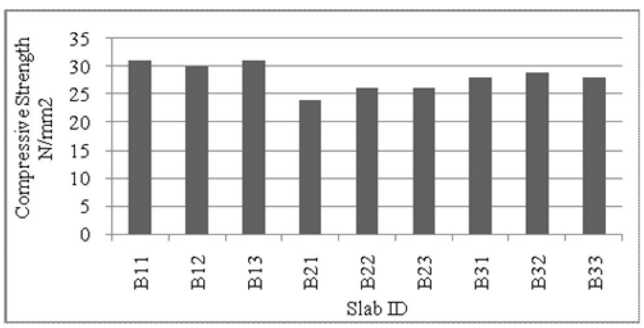

Figure 10. Compressive Strength for M30 Slabs

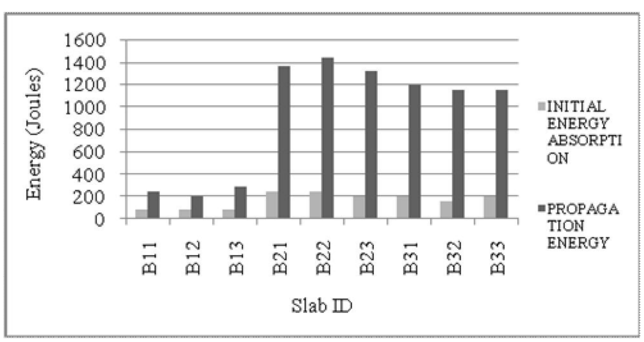

Figure 11. Energy Absorption for M30 Slabs

Figure 12. Ductility Index for M30 Slabs

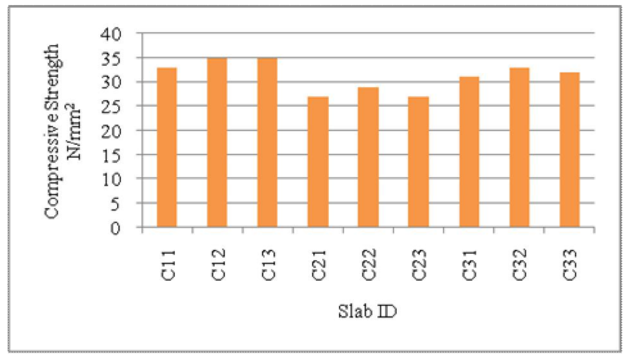

Figure 13. Compressive Strength for M35 Slabs

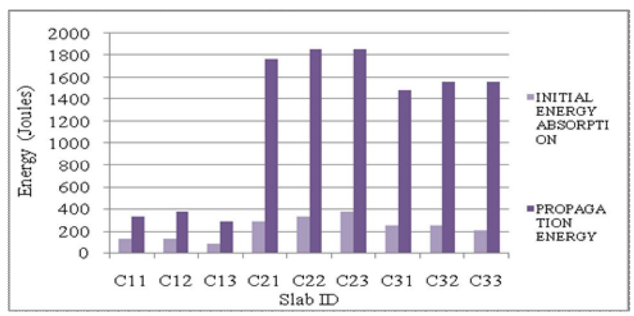

Figure 14. Energy Absorption for M35 Slabs

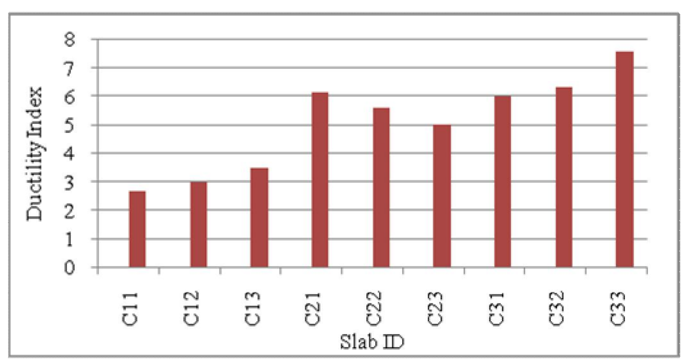

Figure 12. Ductility Index for M35 Slabs

The experimental results revealed that the Hybrid rubberized concrete slabs shows better compressive and impact resistant where as other two slabs showed weakness either in compressive strength or in impact resistant. The rubberized concrete showed greater resistance to impact loads but it fails to show good compressive strength, when compared with other slabs.

5. CONCLUSION

Based on the performance of Hybrid rubberized concrete slabs and the experimental results, the following conclusions were arrived

- The tyres which are polluting the land by dumping can be efficiently used in Civil engineering applications in the form of hybrid rubberized concrete.
- The Hybrid rubberized concrete slabs shows better compressive strength than rubberized concrete and better impact resistance and energy absorption than ordinary concrete.
- Hybrid concrete acts as material which blends the advantages of ordinary concrete and rubberized concrete and at the same time it nullify the disadvantages of both the above concretes.
- The Hybrid rubberized concrete which shows better results can be used in places where the concrete surfaces are subjected to impact loads and should also take care of the compressive stresses to certain limit.
- The rubberized concrete shows greater resistance to impact load, so they can be used where impact load is more and compressive strength can be low.

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