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Experimental Study on Shear Performance of Rubberized Concrete Panel under Diagonal Tensional Stresses

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ABSTRACT

The rapid industrialization and urbanization in the country leads to the lot of infrastructure development. This process leads to the several problems like shortage of construction materials, increased productivity of wastes and other products. The traditional method of disposal of waste tires have been stockpiling or illegally dumping or land filling, all of which are short-term solution. One of the possible solutions for the use scrap tire rubber is by adding into the concrete, to replace some of the natural aggregate. The aim of this project is to study on shear performance of rubberized concrete panel under diagonal tensile stresses using treated crumb rubber of M30 concrete. The treated crumb rubber will be done by using Sodium hydroxide (NaOH). The fine aggregate will be partially replaced by treated crumb rubber of 5%, 10% & 15%. Addition of fiber material such as polypropylene fibre as volume fraction of concrete is 0%, 0.25%, 0.50%& 0.75%. Different mix of rubberized concrete cube and cylinder will be cast and tested to failure under compressive and spilt tensile test. The achieved strength of correct mix combination will be taken and the panel will be casted for that mix combination. The parametric testing program included diagonal tension test of concrete panel built with shear reinforcement.

Keywords: Concrete panels, Reinforced Cement Concrete, Shear Strength, Diagonal Tension, Crumb Rubber, Polypropylene Fiber.

1. Introduction

As the world population grows, the various types of waste are being generated. The creation of non-biodegradable waste materials, combined with the growing consumer population has resulted in waste disposal disaster. One of the most critical environmental issues all around the world disposal of the waste material. The discarded waste tires have been a major concern, because the waste rubber is not easily biodegradable. According to the estimate 1.2 million of waste tire rubber has produced around the world in a year. By the year 2030, there would be about 5 million tyres used, which would have outlived their use full age, to be disposed or discarded. Many Governments agencies, private organizations and individuals are completed or in the process of completing different types of studies and research projects about the feasibility, environmental suitability and performance of using crumb rubber in construction field which needs better and use of crumb rubber and save the world from environmental pollution. The purpose of this project is to evaluate the possibility of using crumb rubber to addition for the fine aggregate in concrete composites. India is a developing country has grown in the field of infrastructure and development leading to large number of vehicles used i.e. much road construction and as a result is large number of used tires is produced. More researches are going on various departments to reducing the scrap tire wastes. The construction field, the many structure are constructed by the concrete only. In construction field, more than 90% of the structure is constructed by the concrete only. Because, the concrete having enough strength, durability, impermeability, sound and Heat.Insulation, wear & corrosion resistance and fire resistance and having more versatility and mould ability. Concrete is a mixture of homogenous materials such as cement (bending material), fine aggregate (sand), coarse aggregate and water in specified proportions. This crumb rubber is replaced in concretes is having low compressive, tensile and flexural strength. But ductility, durability, reduces crack formation and surface toughness of the rubberized concrete is slightly higher than the normal conventional concrete.

Treatment processes for the crumb rubber particles are useful for increasing the bonding between the rubber particles and cement paste. So many rubber treatment methods are used in this process. To increase the efficiency of concrete to adding some fiber materials like polypropylene fiber. These fiber materials even reduce the early plastic shrinkage cracking by augment the tensile capacity of the concrete to resist the tensile stresses caused by the typical volume changes. In this project, to increase the effectiveness of the concrete, the crumb rubber treated by use of Sodium hydroxide (NaOH). Washed crumb rubber is mixing with the sodium hydroxide (NaOH). The treated crumb rubber is the partial replacement of fine aggregate. Polypropylene fiber is replacement to the total volume of concrete to enhance the performance of rubberized concrete.

In this research, the shear diagonal tension of 4 concrete panels was experimentally evaluated in universal testing machine UTM-100. The experimental program includes casting of different types of concrete with reinforcement for all specimens. Reinforcement was provide as TMT bars = 8mm diameter Fe550D. The crackingpatterns, Load & Deflection and Stress & Strain were registered and compared.

2. Experimental Program

The experimental program includes casting of different types of concrete panels, cube and cylinder. A concrete panel was casted with reinforcement for all specimens. The first concrete type was casted as conventional concrete and the second concrete type was casted by adding rubber content with different percentage in the concrete and the third type was casted by adding crumb rubber including the polypropylene fiber with different percentage in the concrete. The crumb rubber was two different particles as Rubber powder (FCR) and coarse rubber (CCR) was used in the concrete. The compressive strength (f_c) & split tensile strength (f_t) were calculated for mechanical properties of concrete. Totally 4 panels were casted to measured their diagonal tension capacity. In those 4 panels, 1 is conventional concrete panel and remaining 3 panels casted by using admixtures. The letters symbolized the type of concrete such as CC for conventional concrete and CR 0% & PPF 0% adding Crumb rubber and polypropylene fiber in the concrete. The percentage includes volume of the admixtures.

2.1. Material & Concrete mixtures ratio.

In this study, Portland- pozzolana cement was used as cementitious material for the fabrication of concrete. The physical properties of polypropylene fiber were shown in the Table 1. Polypropylene fiber have thermoplastic, resilient, light weight and resistant to mildew and many various chemicals. The chemical resistances are generally excellent and tensile strength is 3.5 to 5.5. The relative density of fiber is 0.91. As per study, the fiber content is incorporating as 0.25%, 0.50% & 0.75% of total volume fraction of concrete. Concrete mixture was design for the M30 grade concrete. The coarse aggregate were added the sizes 20mm aggregate. The fine aggregate were used as river sand in 2.36mm sieve passing. The rubber particle was added as partially replacement of fine aggregate. The FCR were added as 60% and CCR as 40% its depends on the fine modulus of sand as shown in Fig 1. In order to increase the workability of concrete, the conplastsp 430 DIS superplastizer were used in the concrete. Tap water is used to mix the concrete.

The mass ratio of concrete between cement, fine aggregate and coarse aggregate is 1:1.8:3.8. The concrete combination of polypropylene fiber and crumb rubber was shown in Table 2. The adding percentage of polypropylene fiber & crumb rubber was shown in Table 2. The crumb rubber was before adding in concrete, the treatment process was taken for the crumb rubber.

Table 1: e Properties of polypropylene fiber:

Material	Relative Density	Tensile strength (gf/den)	Elongation %	Thermal Conductivity
Polypropylene fiber	0.91	3.5 to 5.5	40 to100	6.0 (with air as 1.0)

Table 2 Combinations of concrete mixture ratio:

Specimen	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF	CR& PPF
Rubber	0%	5%	5%	5%	5%	10%	10%	10%	10%	15%	15%	15%	15%
Fiber	0%	0%	0.25 %	0.5%	0.75 %	0%	0.25 %	0.5%	0.75 %	0%	0.25 %	0.5%	0.75 %

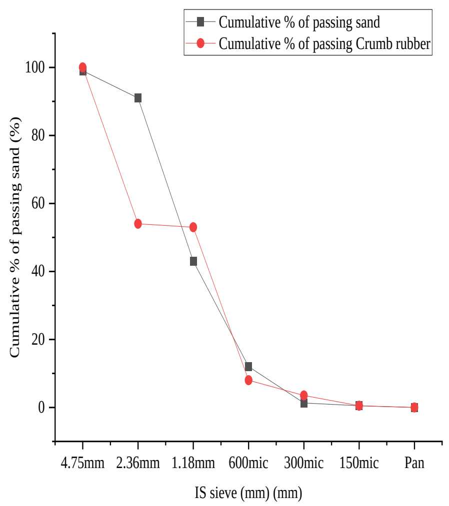

Fig 1- Grain size distribution of cumulative % of sand and Crumb Rubber

2.2 Pre – Treatment of Crumb rubber

In this paper,an important step in producing effective CRC mixes is to pre-treat the rubber particles using Sodium Hydroxide (NaOH) solution to improve the rubber/cement adhesion. For this purpose, the first step rubber particle was added in 10% of sodium hydroxide (NaOH). Then rubber was washed vigorously and continuously to remove the NaOH.And the end finally the treated rubber was dried in the room temperature. The **2.3 Mechanical properties of materials**

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chemical properties of Sodium hydroxide (NaOH) and Crumb rubber were shown in the Table 3 and 4 respectively. The two various crumb rubber particles are show in Fig 2 and 3 respectively.

Table 3:
Chemical Properties of Sodium Hydroxide (NaOH)

Property	Information
Chemical Formula	NaOH
Acidity	Very low (13-14pH)
Basic type	Caustic metallic Base
Corrosive	High
Reactivity	Medium
Hygroscopic	Yes
Solubility (20°C)	1110g/L

Table 4:
Chemical Properties of Crumb Rubber

Crumb Rubber components	Test Data (%)
Acetone extract	10.0
Rubber Hydrocarbon	25.0
Carbon Black Content	30.0
Natural Rubber Content	31.0
Ash Content	4.0

Fig-2

Fig- 3

A total of 82 specimens were casted and tested in this paper. In those 82 specimens, Cube is casted as 39 specimens with size of 150mm x 150mm x 150mm. Then cylinder is casted as 39 specimens with size of 150mm diameter and 300mm height. Then 4 reinforced concrete panels were casted in the size of 400mm x 400mm x75mm. The cubes are casted for the compression testing. Then cylinders are casted for the split tensile testing. Finally the high Combination were taken and casted the reinforced concrete panel. In the reinforced concrete panel, the details of reinforcement provide in panel is 8mm diameter bar with 110mm c/c spacing both vertical and horizontal the same diameter rod was provide. This detail was shown in the Fig 4 respectively. The reinforced concrete panel was casted for the diagonal tensile stress.

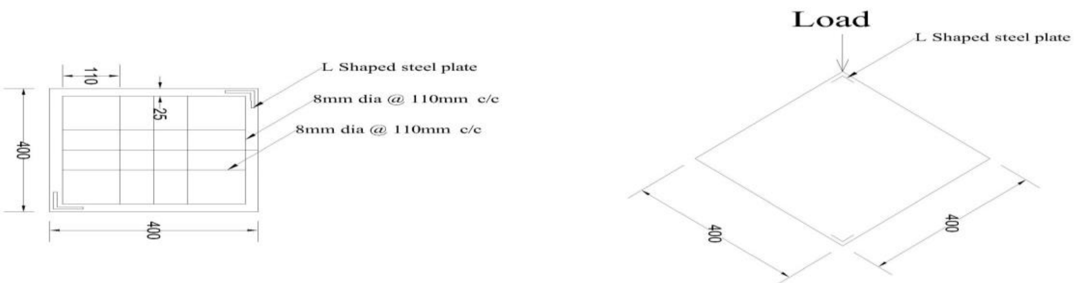


Fig – 4 Reinforcement details for panel

2.4 Test setup and instrumentation

The dimension of 4 reinforced concrete panel sizes are 400mm x 400mm x 75mm. It was tested at the age of 28 days. The test setup was performed as per ASTM E519-15 and IS14858-2000. This standard is intended for diagonal tension tests on masonry walls, the alternate were completed in this paper on extrapolate the assembly for concrete walls. The load was applied in the universal testing machine (UTM) with maximum capacity of 1000 kN. The test were displacement-controlled at a rate of loading in 0.03mm/s. L shaped steel plates of 75mm x 75mm x 75 mm was provide to guarantee a uniform force distribution (without eccentricities) in the corner of panel. The test step was shown in Fig 5. The two shoes are providing at the top and bottom while loading was applied in the machine for panel.

Fig-5 mould and machine step for panel

2.5 Compressive strength

The cube was casted in different combination and it was curing process has done for 28 days strength. The cube size was casted as 150mm x 150mm x150mm. The entire are cubes are tested under the Compressive Testing Machine (CTM). The cubes are loading in the Capacity of 3000KN hydraulic by using compression testing machine. The loading on the cubes are increased gradually and load was obtained and the load value was measured using digital display gauge. Cube compressive strength was determine using the IS 516-1959 code book.

Table 5

Compressive strength for 28 days (Mpa).

Property	Sample	CC	Cr5%& Ppf 0%	Cr5%& Ppf 0.25%	Cr5%& Ppf 0.5%	Cr5%& Ppf 0.75%	Cr10%& Ppf 0%	Cr10%& Ppf 0.25%	Cr10%& Ppf 0.50%	Cr10%& Ppf 0.75%	Cr15% & Ppf 0%	Cr15% & Ppf 0.25%	Cr15%& Ppf 0.50 %	Cr15% & Ppf 0.75%
Compressive strength	S1	38.7	36.03	43.78	38.04	37.32	34.16	33.47	36.1	37.25	33.71	35.47	36.15	37.27
	S2	36.10	36.17	31.76	39.4	39.12	31.97	36.30	36.23	37.03	31.25	35.65	35.78	37.10
	S3	39.58	36.68	36.08	36.49	37.78	37.64	36.11	35.83	36.93	33.24	35.97	36.45	36.069
	Avg	38.1	36.29	37.21	37.96	38.07	34.59	35.29	36.01	37.07	32.73	35.70	36.13	37.02

2.6 Split Tensile strength

The cylinder was casted in different combination and it was curing process has done for 28 days strength. The cylinder size was casted as 150mm diameter and 300mm height. The sample reading has shown in the table 6. The average split tensile strength was plot in graph shown in Fig 7. Split tensile strength for cylinder was determining using theIS5816-1999codebook

Table 6 Split Tensile strength for 28 days (Mpa).

Property	Sample	CC	Cr5 %& Ppf 0%	Cr5 %& Ppf 0.25 %	Cr5 %& Ppf 0.5 %	Cr5 %& Ppf 0.75 %	Cr10 %& Ppf 0%	Cr10 %& Ppf 0.25 %	Cr10 %& Ppf 0.50 %	Cr10 %& Ppf 0.75 %	Cr15% & Ppf 0%	Cr15% & Ppf 0.25%	Cr15%& Ppf 0.50 %	Cr15% & Ppf 0.75%
Split tensile strength	S1	4.11	3.75	3.75	3.66	3.70	3.30	3.50	3.56	3.68	3.18	3.36	3.55	3.55
	S2	3.68	3.52	3.47	3.60	3.62	3.44	3.29	3.51	3.66	3.26	3.47	3.50	3.63
	S3	3.47	3.39	3.56	3.70	3.77	3.26	3.45	3.44	3.58	3.24	3.39	3.53	3.59
	Avg	3.75	3.55	3.59	3.65	3.70	3.33	3.41	3.50	3.64	3.23	3.41	3.51	3.59

2.7 Cracking patterns

The damaged state of the tested panels and a zoom in on the final cracks are shown in the fig 8 and 9 respectively. The exact instant when the diagonal shear tension test had ended were taken are shown in fig 9. The crumb rubber panels are shown a wide diagonal crack and other minor negligible cracks. In the conventional concrete the greater damage was observed in the specimen and main diagonal crack was characterized and adjacent cracking pattern was well defined. Rubberized concrete panels damage was observed and comparable to the cracking patterns of conventional concrete panel.

Fig 6 Tested Panels

Fig 7 Zoom cracking patterns

2.8 STIFFNESS

The stiffness was obtained from the load and displacement curve. It was calculated and shown in the table 7 respectively. As per the research the stiffness is calculated for the 4 reinforced concrete panel. From the graph the stiffness was higher in rubberized concrete panel by adding 5% of rubber and 0.75% of polypropylene fiber content compared with the conventional concrete panel. The remaining two percentage of rubberized concrete panel stiffness was decrease by comparing the conventional and 5 % rubber and 0.75% fiber respectively.

Table 7

Stiffness

S.No	Sample	Stiffness (KN/mm)
1	Conventional Concrete	9.33
2	CR 5% & PPF 0.75%	16.79
3	CR 10% & PPF 0.75%	8.055
4	CR 15% & PPF 0.75%	3.22

3. Result and discussion

The response of the panels result was discussed in the terms of cracking pattern, stress and strain curve, load and displacement and the compressive spilt tensile strength for each type of concrete.

3.1 Compressive strength

The average compressive strength was plot in graph shown in Fig 8. The ultimate load of the specimen can be taking before to failure. In the ultimate load stage the permanent deformation was occurred. The strength of the specimen denotes by the ultimate load. Graphical presentations of ultimate load for cubes are given below. The compressive strength of the cubes of CR specimen without adding PPF is less than the conventional cube concrete. While adding PPF with the CR, specimen is having higher strength than the CR specimen without adding PPF cube concrete compressive strength.

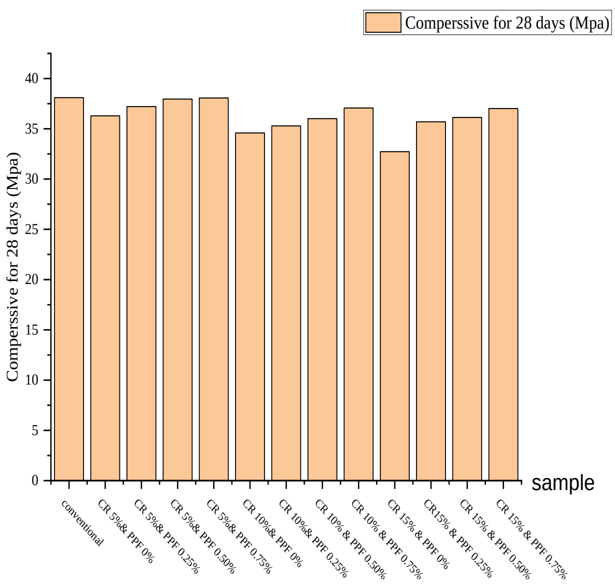


Fig 8- Compressive strength

3.2 Split tensile strength

The average Split tensile strength was plot in graph shown in Fig 9. The ultimate load of the specimen can be taking before to failure. In the ultimate load stage the permanent deformation was occurred. The strength of the specimen denotes by the ultimate load. Graphical presentations of ultimate load for Cylinder are given below. The Split tensile strength of the cubes of CR specimen without adding PPF is less than the conventional Cylinder concrete. While adding PPF with the CR, specimen is having higher strength than the CR specimen without adding PPF Cylinder concrete split tensile strength.

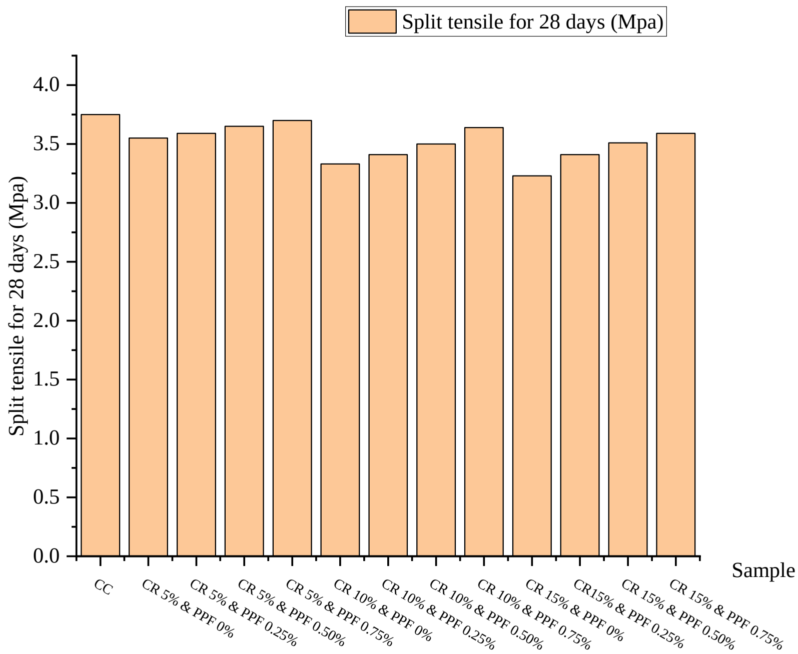
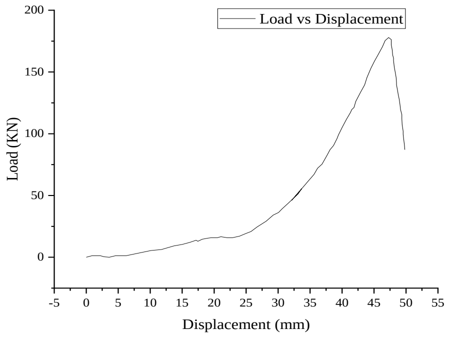


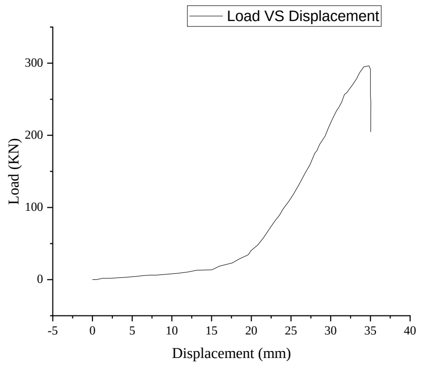
Fig 9- Split Tensile strength

3.3 Shear strength of concrete panels

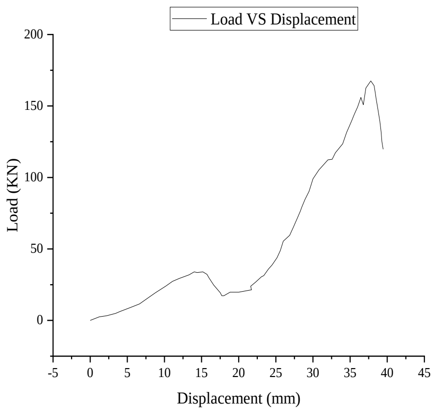
The panels were casted 4 numbers, in that 4 panels one conventional and remaining three are rubber with polypropylene fiber. In that panel, the maximum load and displacement, stress vs. displacement and stress vs. strain were calculated in this paper. The load and displacement was shown in the fig 10. In the figure the specimen was named as D1, D2, D3, and D4. The D3 is named as conventional concrete panel. The D1 is named as CR 5% and PPF 0.75%. The D2 is named as CR 15% and PPF 0.75%. The D4 is named as CR 10% and PPF 0.75%. The maximum load was appeared in the CR 5% and PPF 0.75% respectively. The maximum displacement was appeared in the CR 15% and PPF 0.75% respectively. For the about 4 panels the stress and displacement was plot in the graph and show in fig 11 respectively. The work has undergoes deformation and displacement and develops the internal forces. Stress is otherwise known as intensity of internal forces. Strain is defined as the measurement of the deformation. The casted panels stress vs. strain was calculated and plot in the graph shown in the fig 12 respectively. Using the universal testing machine the load and displacement, stress and strain and stress and displacement was calculated respectively.



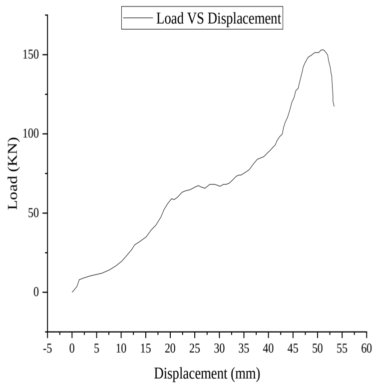
D3 – Conventional



D1 – CR 5% & PPF 0.75%

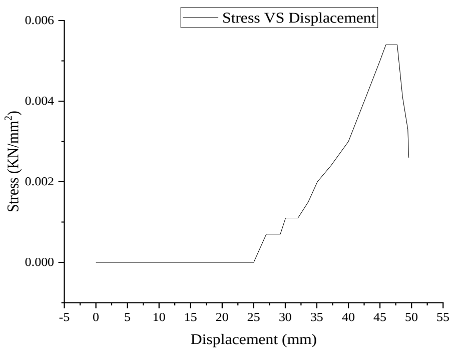


D4 – CR 10% & PPF 0.75%

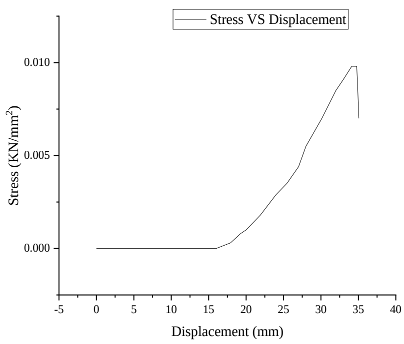


D2 – CR 15% & PPF 0.75%

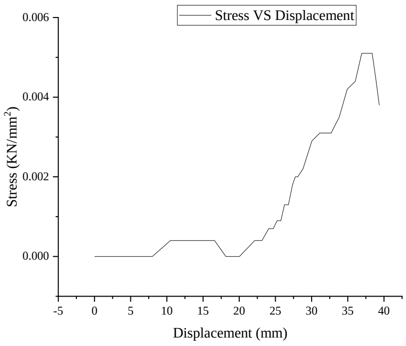
Fig- 10 Load and Displacement



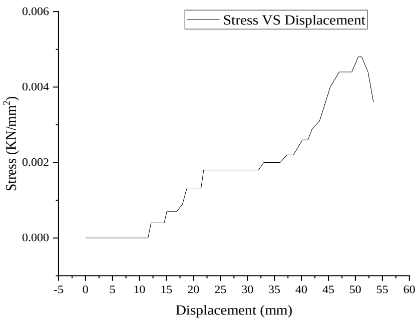
D3 – Conventional



D1 – CR 5% & PPF 0.75%

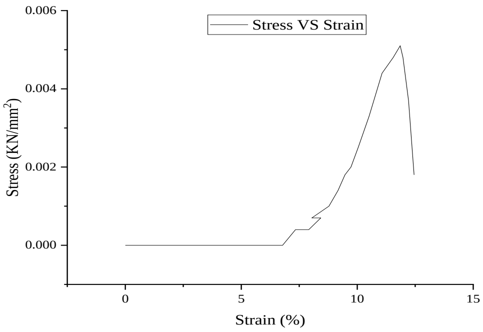


D4 – CR 10% & PPF 0.75%

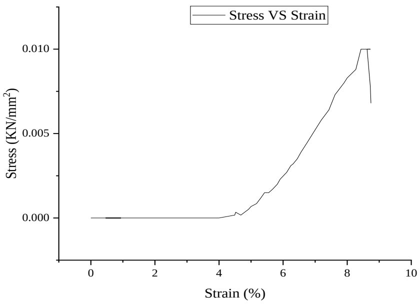


D2 – CR 15% & PPF 0.75%

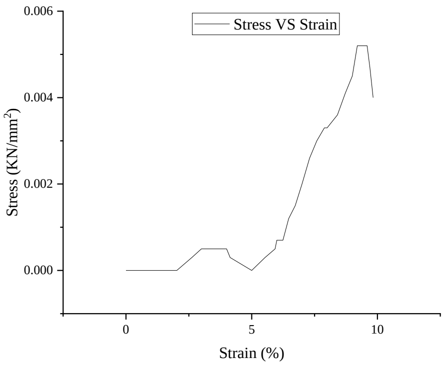
Fig-11 Stress and displacement



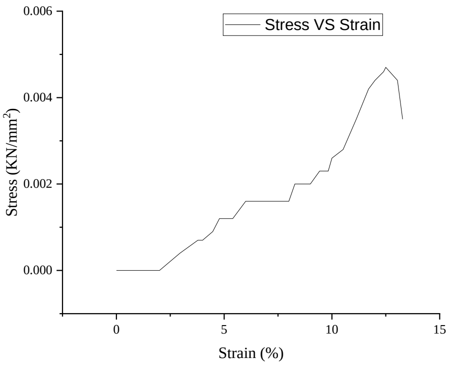
D3 – Conventional



D1 – CR 5% & PPF 0.75%



D4 – CR 10% & PPF 0.75%



D2 – CR 15% & PPF 0.75%

Fig -12 Stress and Strain

3.4 Stiffness

The Stiffness was plot in graph shown in Fig 13.. Graphical presentations of maximum stiffness for panel are given below. The Stiffness of the Panel for CR 5% specimen with adding PPF 0.75% is more than the conventional Cylinder concrete. Remaining two specimen as CR 10% & PPF 0.75% and CR 15% & PPF 0.75% is less than the conventional concrete.

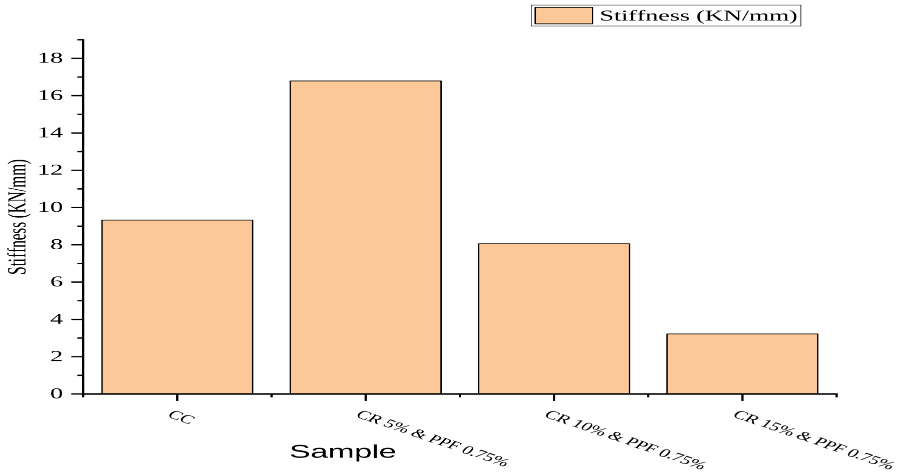


Fig – 13 Stiffness for panels

4. Conclusion

In this research paper, the shear diagonal tension of rubberized concrete panel. In the concrete, by adding treated crumb rubber and polypropylene fiber. The specific conclusion was drawn from this research paper are as follows:

1. The compressive strength and split tensile strength was decrease by increasing of content in the concrete as partially replacement of fine aggregate.
2. By adding polypropylene fiber content, the strength was increasing by the increase of fiber content in the concrete.
3. By adding 5% to 15% are show the good mechanical properties strength for the concrete.
4. The result of diagonal tension test for panel, the maximum load was occurred in the 5% of crumb rubber and 0.75% polypropylene fiber content adding in concrete panel.
5. The maximum displacement was occurred in the CR 15% & PPF 0.75% adding in the concrete panels.
6. For each reinforced concrete panel, stress and displacement curve & stress and strain curve was plot in the graph by digitally.
7. Stiffness for the rubberized reinforced concrete panel by adding 5% of CR and 0.75% of PPF was increased by the conventional concrete panel respectively.

Using crumb rubber which obtained from the scrap tires was incorporating in the concrete in civil engineering application provides on effective technique to get rid of large volume of waste material.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

References

[1]. Xiaoyin Sun, Shuyin Wu, Jun Yang et al, “Mechanical properties and crack resistance of crumb rubber modified cement-stabilized macadam”Elsevier. Construction and Building materials 259(2020)119708.
[2]. Jinxu Mo, Lei Zeng et al, “Mechanical properties and damping capacity of polypropylene fibre reinforced concrete modified by rubber powder”Elsevier. Construction and Building materials 242(2020)118111.
[3]. Tuqawaleedahmeed et al, “Properties of high strength polypropylene fibre concrete containing recycled aggregate”Elsevier. Construction and Building materials 241(2020)118010.
[4]. Jhoncardenas-pulido, Juan C. Reyes et al, “Shear behavior of geopolymer concrete panel under diagonal tensile stresses”Elsevier. Engineering structures 212(2020)110518.
[5]. Aminal-Fakih et al, “Experimental study on axial compressive behaviour of rubberize interlocking mansonry wall” Elsevier. Journal of Building Engineering 29(2020)101107.
[6]. I.A. Sharaky, Heba A. Mohamed, L. Torres, Mohamed Emara, “Flexural behaviour of rubberized concrete beams strengthened in shear using welded wire mesh” Elsevier. Composite structure 247 (2020)112485.

[7]. Hang T.N. Ngugen, Kang Hai Tan, "Effects of polypropylene fibers and steel fibers on web shear resistance of deep concrete hollow-core slabs" Elsevier. Engineering Structure 210(2020)110273.

[8]. Mohamed Thameem Ansari, N.Sakthieswaran, O. Ganesh Babu, "Experimental study of an eco-friendly concrete by inbuilt with treated crumb rubber" Elsevier. Material today: Proceeding (2020).

[9]. AntonicConforti et al, "Enhancing the shear strength of hollow- core slab by using polypropylene fibre" Elsevier. Engineering Structure 207(2020)110172.

[10]. Agampodi S.M. Mendis, Safat Al-Deen, "Flexural shear behaviour of reinforced crumb rubber concrete beam" Elsevier. Construction and Building Materials 166(2020)779-791.

[11]. FarshadAmeri, Parham Shoaei, Hamid Reza Musaeei, SeyedAlirezaZareei, CheahChee Ban, , "partial replacement of copper slag with treated crumb rubber aggregate in alkali slag mortar" Elsevier. Construction and Building material 256(2020)119468.

[12]. Z.H. Mohebi, A.B. Bahnamiri, M. Dehestani, "Effect of polypropylene fibers on bond performance of reinforcing bars in high strength concrete" Elsevier. Construction and Building material 215(2019)401-409.

[13]. Jhoncardenas-pulido, Juan C. Reyes et al, "Shear behavior of geopolymer concrete panel under diagonal tensile stresses"Elsevier. Engineering structures 212(2020)110518.

[14]. Hang T.N. Ngugen, Kang Hai Tan, "Effects of polypropylene fibers and steel fibers on web shear resistance of deep concrete hollow-core slabs" Elsevier. Engineering Structure 210(2020)110273.

[15]. Chalermpholchaikaew, "Properties of concrete pedestrian blocks contenting crumb rubber from recycle waste tyres reinforced with steel fibres" Elsevier. Case studies in construction material (2019).

[16]. AymanAbdelmonem, M.S. El-Feky, El-Sayed A.R. Nasr, Mohamed Kohail, "Performance of high strength concrete containing recycled rubber" Elsevier. Case studies in construction material 227(2019)116660.

[17]. SeyedAmidTahami et al, "The use of high content of fine crumb rubber in asphalt mixes using dry process" Elsevier. Case studies in construction material 227(2019)643-653.

[18]. Rong Wang, PeiweiGao, "Experimental study on mechanical and waterproof performance of lightweight foamed concrete mixed with crumb rubber" Elsevier. Case studies in construction material 209(2019)655-653.

[19]. FarnooshJokar, Mohammad Khorram, "Experimental investigation of mechanical properties of crumbed rubber concrete containing natural zeolite" Elsevier. Case studies in construction material 208(2019)651-658.