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STUDY ON BEHAVIOUR PARTIAL ADDITION OF RECYCLED RUBBER TYRES AS REPLACEMENT FOR AGGREGATES IN CONCRETE

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Abstract:
In this report, we have conducted an experimental technique for the partial replacement of recycled rubber tyres as ground aggregates to produce concrete tyres. The pre-treatment is conducted in Hyderabad to adjust the surface and the crossfade region for the rubber to bind to its concrete paste using a sodium hydroxide solution. The cycle pneumatics were taken, and their surface washed in running water and let air dry for 20 minutes with a saturated aqueous solution. Then the coarse aggregates were substituted partly by rubber tyres, which is 5%, 10%, 20% and 30% of the overall volume is traditional concrete and rubber mixed concrete. Several studies have been conducted for specimens such as compression, break tensile, bending strength and attack sulphate (NaCl) and the result was the SEM examination of the concrete specimen with a rubber tyre, partly replaced 0 per cent by 1,0%, 3% by 4,5%. The results drawn from this analysis are as follows

Key words: Recycled rubber tyres compressive, split tensile and flexural strength, sulphate's (NaCl) attack SEM analysis, recycled rubber tyres

1.0 INTRODUCTION

The rubber product received enormous demand worldwide every day. The most frequently used rubber in cars improves automotive use, but in recent years there has been a significant waste of rubber tyres. If the use of rubber by incineration and landfill increases, environmental problems such as air pollution, soil infertility and mass piles of stocks of used tyres can be created. The use of rubber tyres shows the record alone in Thailand in 2000, with around 250,000 metric tonnes. The vehicles alone accounted for 38 percent of the total. In India, about 811 lakh metric tonnes, 35% were vehicle pipelines alone, is made. High strength silica concrete with varying quantities of solid particles recycled from used crumbed truck pneumatic tyres Tyre rubber is graded primarily according to its size. It can be used as a modification on the road surface asphalt, plastics modification and soil processing, etc. Many applications are made with the application of this scrap tyre into rubber Pulver. This rubber can be substituted in a concrete, which in the present scenario are scarce, as natural aggregates. Tyre rubber can be partially but not completely replaced, which can have an influence on the power. Tyre rubber is commonly referred to as recycled car- and camion scrap rubber. From the experimental study it demonstrates how a concrete mix uses tyre rubber particles as fine aggregates to know the engineering properties and to bind them by using a SEM analysis. The power of the rubberized concrete mix and its comparisons are explained in this study at different replacement percentages.

BACKGROUND OF THE STUDY

A wide range of wastes materials, including many useful additives to concrete, are considered possible. Cellulose, ash flying, silica fumes and wood particles are some of these materials. The rubber collected from discarded tyres, because its critical use in the building industry, is considered to be the latest waste material examined. Each year, worldwide rubber production is increasing. Various countries in the world have different production rates of rubber, such as the 3.6 million tonnes of rubber produced in the United States each year. Similarly, Iran produces 100,000 tonnes, annually. Malaysia generates about 200,000 tonnes of rubber annually. With the increased production of vehicles these figures are increasing. More than a billion scrap tyres are produced every year in India, roughly one tyre per human.

Classification of Waste Tyre Rubber:

The waste rubber pneumatic tyres in the construction industry are not classified or specified. They are graded as following classes, depending on the scale they are reduced after they withdraw from their primary demand for a vehicle to move. This is not a very precise or strict classification as they are simultaneously only used as one category at some stages.

Figure 1.1: Manual cutting of tyre rubber to the size of coarse aggregates

Scrap tyres:
This can be described as a full shape waste pneumatic without being cut or shredded. A average car tyre weighs approximately 9.07 kilogrammes. The weight of a truck tyre is often generally considered to be approximately 45.35 kilogrammes. The following table shows the usual weight composition of the car and truck pneumatics.

Table: 1.1 Composition by weight

Composition by percent weight	Automobile tyre	Truck tyre
Natural rubber	14	27
Synthetic rubber	27	14
Carbon black	28	28
Steal	14-15	14-15
Fabric, filler, accelerators	16-17	16-17

Slit tyres:
This is called the waste pneumatic, resulting in the cutting of a whole pneumatic in two or three parts. For this work, different pneumatic cutting machines are used. These are made in pneumatic cutting machines. These machines cut these tyres into pieces and can also remove the pneumatic lateral walls from their tread.

Figure: 1.2 Slit tyres

The Need for Recycling of Waste Tires
Scrap neumes are not serious environmental issues when properly treated. But if treated unsuccessfully, scrap tyres can be a significant environmental problem. Tires which are exposed to the elements may contain water and provide a breeding ground for mosquitoes carrying disease. Tires usage, especially the fuel used to overcome the rolling resistance of tyres, is associated with a great use of resources. Consequently, the highest outputs result from combustion of fuel are emissions (CO2 and H2O). Therefore, recycling and use of waste pipes in a more functional form is currently mandatory. Post-consumers and/or use tyres are the ones whose useful lives have come to an end.

Application of tyre rubbers in concrete:
Many authors have mentioned concrete properties with the rubber used. Their findings show that the size, proportion and surface texture of particulate matter affects the strength of the rubber used in concrete experiments to assess the strength and durability of rubberized concrete blends. They used two kinds of pneumatic rubbers with different material of the pneumatic. The results showed around an 85% reduction in compressive strength, while the divisive strength of the tensile decreased by approximately 50% when the ground component was fully replaced with chiped tyre-rubber. When the sand was replaced with fine rubber, a smaller compressive force decrease (65%) was observed. Rubber-containing concrete was not fragile under stress compression or cracking and was capable of absorbing a great deal of energy under pressure and tensile loads.

- Where damping vibration, such as machinery base pads and stations, is required.
- For filling of trenches and tubes, pile heads and plywood plates.
- Where impact or explosion resistance is required, for example in rail buffers, jersey barriers and bunker systems.

Objective of the study:
Used tyre rubber is much of the time not noticed for useful use. It is instead becoming a waste and environmental pollutant. Furthermore, in comparative to extraction or manufacture of mineral aggregates used in normal concrete, collecting waste tyres is not very expensive. This study is therefore designed to demonstrate the feasibility of using partial substitution of crumb rubber concrete for coarse concrete aggregates. The overall aim of this study is to assess the fresh and hardened properties of concrete produced by substituting part of the natural coarse aggregate for an aggregate produced from local recycled tyre rubber.

Scope of the study:
1) This research was based on the achievement of a single crumb rubber gradation. The waste pipes from local sources are collected and cut into pieces by hand to achieve a uniform size of 20 mm, the maximum total size for the blend design.
2) In this analysis, the effect on concrete properties of different gradations of a rubber aggregate was not evaluated, but in future studies.

3) In this analysis, the impact of use in high-performance concrete of recycled tyres was not covered. Cossy compounds were partly substituted by a different percentage of rubber pipes, say 5%, 10%, 20%, and 30% is traditional and rubber-mixed concrete total volume. Different tests were conducted and results obtained for samples such as compression, break tensils, flexural strength and sulphate (NaCl) attack tests There were no different effects seen in various percentages of replacements in this sample.

2.0 LITERATURE REVIEW

Ali, A.M. and D.G. Goulias [1] Concluded that RPCC blends can be made in partial substitution with CA and FA by ground tyre. Depending on the working capacity, a higher amount of 50% of the gross total volume can be used. Strength data (compressive and flexural) produced in their research show a systematic reduction in strength by increasing the rubber content. In practise, due to extreme strength reduction rubber content does not exceed 20% of the aggregate volume

Amirkhanian, S.N. and L.C. [2] Examinations of chips and fibres were performed. The surfaces of the pneumatic tubes are processed with a saturated NaOH solution, while the anchorage of the holes at the centre of the chips has been examined and it is concluded that fibres function more effectively than chips. Additional attempts would be made to expand the size of the hole.

Garrick [3] Analysis of waste-tire modified concrete using the volume of a coarse aggregate of 15 percent was calculated by replacing waste pneumatic materials as pneumatic fibre and concrete mixed chips. Determined As a consequence, tightness, plastic deformation, impact strength and cracking resistance are increased. However, rubberised samples decreased their strength and rigidity.

Schimizze [4] In one combination, produced two rubberized mixtures of concrete with fine granular rubber and coarse granular rubber in the next. Although both blends have not been optimised and design parameters have been arbitrarily chosen, their findings suggest that their compressive force was reduced in control mix by approximately 50 per cent

Mavroulido and Figueiredo [5] The conclusion that, considering the observed lower mechanical value of concrete, there is a potential broad demand for the concrete goods in which the inclusion of rubber aggregate is viable, can be inferred by the discarded tyre rubber as concrete aggregates, which are called potential production for used tyres. This may also involve not-primary structural applications that benefit from other features of this form of concrete and from the medium and low strength requirements.

3.0 METHODOLOGY

The general features of the concrete are checked and the basic characteristics of the concrete material meet the strength of the grade. The materials used are cement, sand, coarse aggregate, rubber, and water to substitute the sum of fine aggregates in the standard concrete with the waste material (tyre rubber powder), For this mission, sand passing from 4.75mm to 0.15mm is applied.

MATERIALS:

Aggregates:

'Aggregate' is a concept in which the substance of the particles is used. It contains the aggregates of rocks, crushed stones and sand, slag and recycled concrete. It can be normal, generated or recovered. Aggregates. Around 60%-80% of the concrete mix makes up aggregates.

Figure: 3.1 Aggregates

Coarse Aggregate:

Inert granular materials such as sand, gravel, or crushed stone are mainly naturally occurring. However, technology is expanding to include the use of recycled materials and goods manufactured by people. 12mm-sized aggregates for self-compacting concrete are used in this study.

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Figure: 3.2 Coarse Aggregate

Fine Aggregate:

Fine sand can be natural or processed, but it should be uniformly classified. The fineness of the particles is more than 150 by sieve. The overall content of fineness must be high, typically around 520 to 560kg/m3, in order to achieve the balance between deformations or fluidity and stability.

Figure: 3.3 Fine Aggregate

Natural Aggregates

Sand and gravel, stone and crushed stone constitute mineral aggregates. About 80 percent of the overall aggregate market are constructed aggregates, primarily intended for roads, rip rap, concrete and asphalt. In 1998, approximately 3,400 U.S. quarries produced about 1.5 billion tonnes, about 1.2 billion tonnes of which were used for construction purposes.

Figure: 3.4 Natural aggregates

All-natural particles in the aggregate form a larger parent mass initially. The result may have been fractured or artificially broken by natural processes of weathering and abrasion. Many properties of the aggregate depend, therefore, entirely on the characteristics of the parent rock, for example chemical and mineral composition, specific weight, durability, strength, physical and chemical stability, pores and paint structure

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Table: 3.1 Properties of water sample

S.No.	Parameter	Results	Limits as per IS 456 – 2000
1	pH	6.3	6.5 – 8.5
2	Chlorides (mg/l)	45	2000 (PCC) 500 (RCC)
3	Alkalinity (ml)	6	< 25
4	Sulphates (mg/l)	105	400
5	Florides (mg/l)	0.04	1.5
6	Organic Solids (mg/l)	43	200
7	Inorganic Solids (mg/l)	115	3000

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Rubber tyre:

After mechanical trituration of the post-combusted tyres from trucks, pneumatic rubber used in the present studies is obtained. Over the years, researchers have studied the use and efficacy of recycled tyre-rubber waste as a substitute for the aggregate in concrete. The product of this substitution is "Rubber concrete-Mix" that has many technical applications and has promises in future. Rubber concrete also has excellent mechanical characteristics and is seen as one of the safest and most economical recycled pneumatic methods.

Table: 3.2 Properties of rubber

Compacted density	2.3 to 4.8kN/cum
Compacted unit weight	1/3 of soil
Compressibility	3 times more compressible than soil
Density	1/3 to 1/2 less dense than the granular fill
Durability	Non-biodegradable
Modulus of Elasticity	1/10 of sand
Permeability	Less than 10cm/sec
Poisson's Ratio	0.2 to 0.3
Specific gravity	1.14 to 1.27
Thermal insulation	8 times more effective than the gravel
Unit weight	Half the unit weight of gravel

Methods of Recycling Tires

The following are various technologies and techniques available for postconsumer pneumatic processing.

- 1.Shredding and chipping: This mechanically shredding the pumps into larger sizes first, then into 20-30 mm particles.
- 2.Crumbing is the sorting of the tyre by mechanical or cryogenic processes into small granular or powdered particles. Also, during this process, the tyres' steel and fabric components are removed.
- 3.DeVulcanization: This is the heat and chemical treatment of tyres for the reverse phase of vulcanization in the original tyre making.
- 4.Pyrolysis and gasification: two processes under different conditions of thermal decomposition have occurred. The processes generate coal, oil, steel and black carbon (char).
- 5. Energy recovery: tyre combustion for the production of energy

EXPERIMENTAL PROCEDURE:

Concrete Mix Design as per IS: 10262 2009 (M30 Grade):

Table: 3.3 Mix Proportion for M30 grade of concrete

cement	Fine aggregates	Coarse aggregates	water	w/c ratio
Kg/m^3				
355	520	1035	175	0.5
1	1.5	3		

PROPERTIES OF FRESH & HARDENED CONCRETE:

Workability:

This test will assess the functionality of the concrete. In the beginning ingredients including cement, sand and ground aggregate have been taken. Connect to the ingredients the amount of water to be taken from the blend design and blend accordingly

Unit Weight

The test shows a specific gravity of 1.18 and 2.70 of the rubber tyres, respectively, and of mineral rough aggregates. The study states that the unit weight of rubberized concrete decreases as the rubber pneumatic aggregate increases

Table: 3.4 Unit weight of conventional concrete and various rubberized concrete mix

Specimen	% rubber	Unit wt. in Kg
A	0	8.541
A_1	5	8.345
A_2	10	7.979
A3	20	7.317
A4	30	6.989

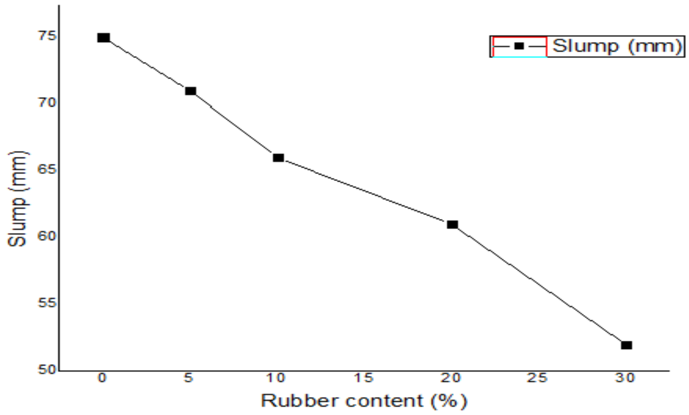
By improvements to the bond properties of rubber aggregates, rubberized concrete strength can be increased. Of the 36 tyre companies in India, the tyre recyclers are around 20, and only four or five of these M/S contributes. Gujarat Recovery has an annual turnover in its Haridwar tyre recycling plants of over 15 crores. With 20 tonnes of reclaim rubber produced each day. In the sizes of 10 to 10mm, 10 to 4.75mm and 4.75mm the tyre recycling factories should have quality rubber aggregates for use as concrete aggregates.

SLUMP test:

The method of determining the consistency of concrete is a slump test. The strength or rigidity shows how much water the mix has used. The rigidity of the concrete mix should be compliant with the finished product specifications. Table reveals the effects of slump tests on substitution percentage slumps

Table: 3.5 Slump performance for various percentage of rubber tyre content

Rubber content (%)	Slump (mm)
0	75
5	71
10	66
20	61
30	52



Graph: 3.1 Slump performance for various percentage of rubber tyre content

4.0 RESULTS AND DISCUSSIONS

The standard and rubber concrete have been measured to recognize the strength properties of the compressive strength, the tensile strength fracturing, bending strength at 7, 28 and 56 days.

Analysis of case study:

In the city's inland container depot (ICD) there has been no claim for three years for up to ten 40-feet containers stuffed with scrap rubber pipes. Although this reflects a great demand for scrap tyres, they are recycled and reused in some cases.

Figure:4.1 located area

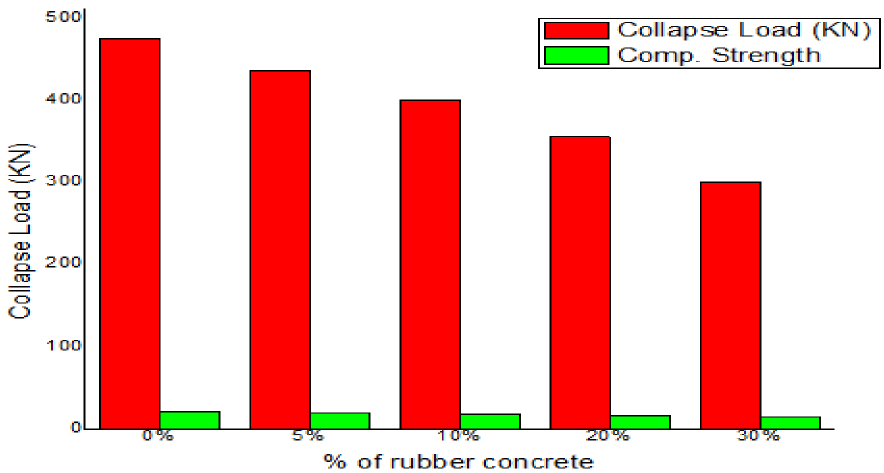
Carbonation and chloride were the most important aspects for durability to measure the concrete performances in use. These two are considered to reflect typical site environmental loads of the normal lifetime of a structure in hyderabad in durgamma cheruvu region to produce a structural rubberized concrete, although other durability aspects have been examined. The impact of ambient and cryogenic process crumb and chipped rubber aggregates on carbonate resistance of concrete has been examined.

COMPRESSIVE STRENGTH:

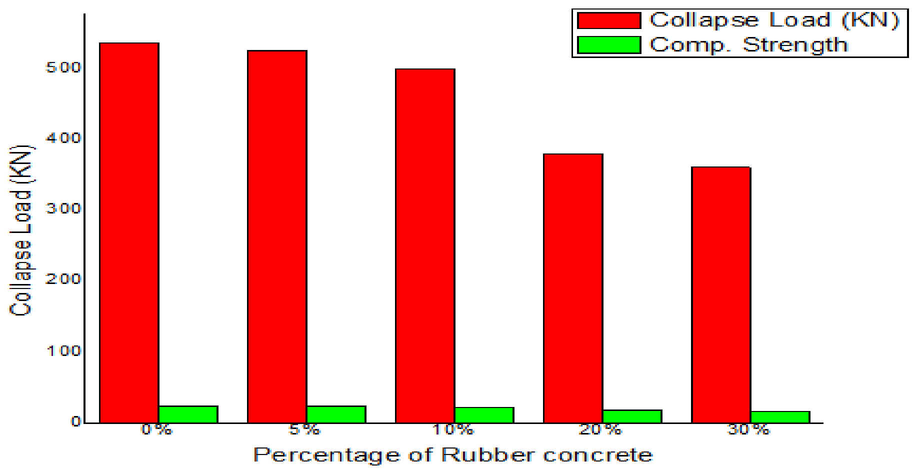
It had been observed that the compressive strength attained on replacing different percentages of the rubber content exhibited 26 Mpa at 56 days respectively

Table: 4.1 Compressive strength for M30 grade of concrete

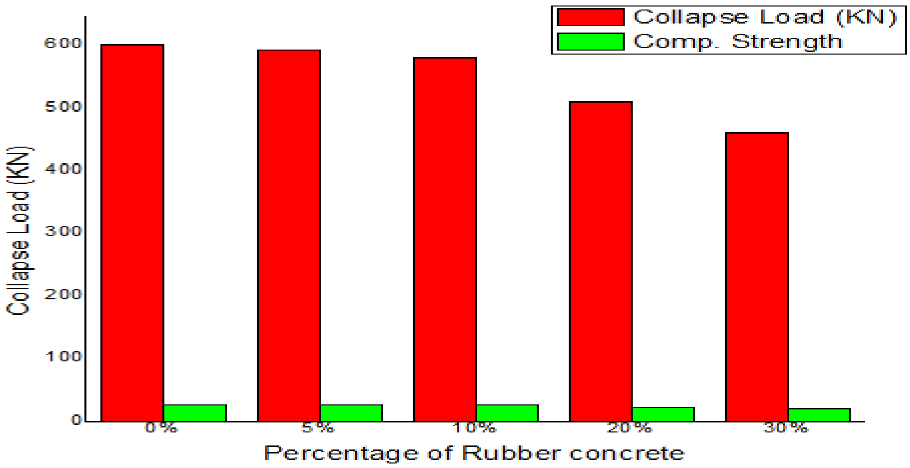
S.NO	Percentage of Rubber	7 days		28 days		56 days	
		Collapse Load (KN)	Comp. Strength ( )	Collapse Load (KN)	Comp. Strength ( )	Collapse Load (KN)	Comp. Strength ( )
1	0%	475	21.11	536	23.82	600	26.67
2	5%	435	19.33	525	23.33	592	26.30
3	10%	400	17.78	500	22.22	580	25.78
4	20%	355	15.78	380	16.89	510	22.67
5	30%	300	13.33	360	16.00	460	20.44



Graph: 4.1 Compressive strength for M30 grade of concrete with 7 days



Graph: 4.2 Compressive strength for M30 grade of concrete with 28 days



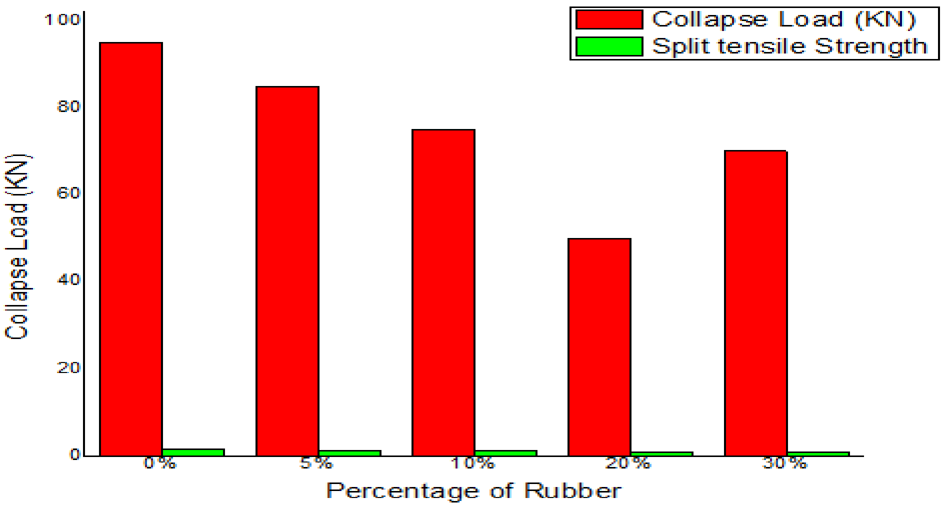
Graph: 4.3 Compressive strength for M30 grade of concrete with 56 days

SPLIT TENSILE STRENGTH

The split tensile strength achieved to replace different percentages of the material of rubber showed 2.1 Mpa was observed.

Table: 4.2 Tensile strength for M30 grade of concrete

S. No	Percentage of Rubber	7 days		14 days		28 days	
		Collapse Load (KN)	Split tensile Strength	Collapse Load (KN)	Split tensile Strength	Collapse Load (KN)	Split tensile Strength
1	0%	95	1.34	150	2.12	160	2.24
2	5%	85	1.2	135	1.9	150	2.1
3	10%	75	1.06	120	1.68	140	1.96
4	20%	50	0.7	100	1.4	130	1.82
5	30%	70	0.99	80	1.12	120	1.68



Graph: 4.4 Tensile strength for M30 grade of concrete with 7 days

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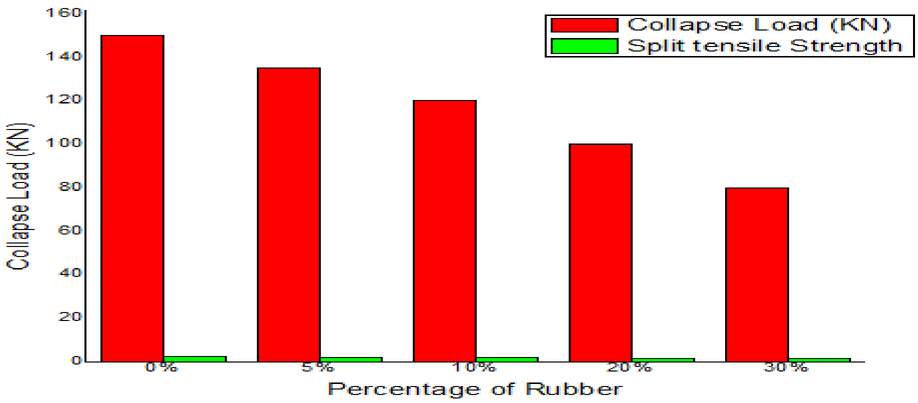
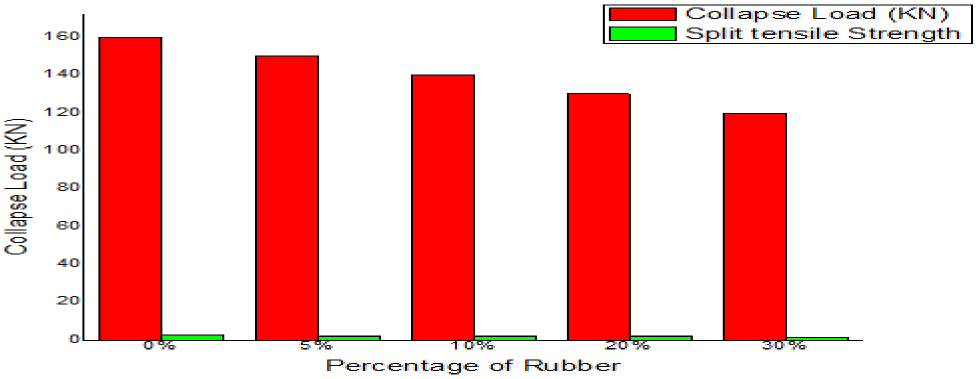


Graph: 4.5 Tensile strength for M30 grade of concrete with 28 days



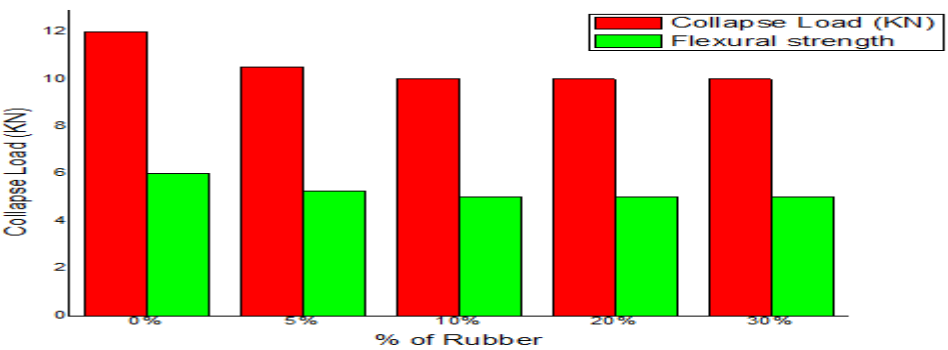
Graph: 4.6 Tensile strength for M30 grade of concrete with 56 days

FLEXURAL STRENGTH

The bending strength at a replacement of different rubber content percentages showed 7.5 Mpa respectively in 56 days had been observed.

Table: 4.3 Flexural strength for M30 grade of concrete

S.NO	% of Rubber	7 days		14 days		28 days	
		Collapse Load (KN)	Flexural strength ()	Collapse Load (KN)	Flexural strength ()	Collapse Load (KN)	Flexural strength ()
1	0%	12.0	6.00	14.0	7.00	16	8.00
2	5%	10.5	5.25	13.0	6.50	15	7.50
3	10%	10.0	5.00	12.0	6.00	13	6.50
4	20%	10.0	5.00	12.0	6.00	12	6.00
5	30%	10.0	5.00	10.5	5.25	10	5.00



Graph: 4.7 Flexural strength for M30 grade of concrete with 7 days

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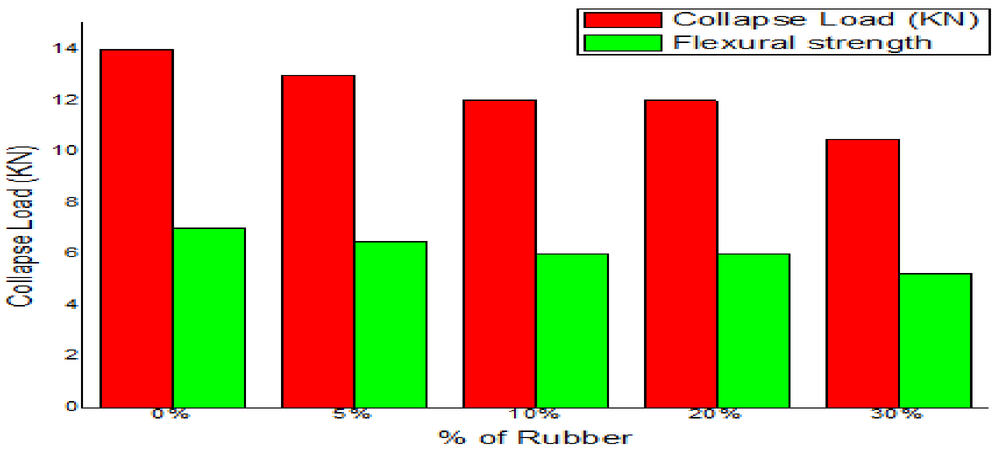
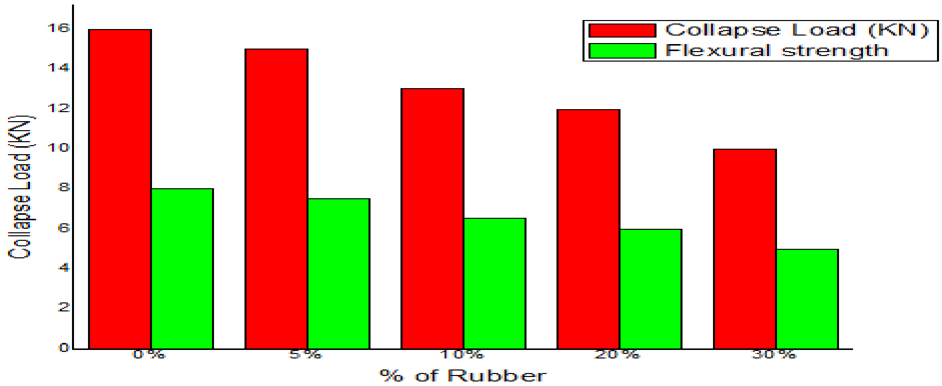


Graph: 4.8 Flexural strength for M30 grade of concrete with 28 days



Graph: 4.9 Flexural strength for M30 grade of concrete with 56 days

Microstructure study by SEM analysis:

SEM analysis is a magnification instrument for electrons that produces images through a committed emission of light. Up to 1 nano metre can be scanned by SEM. The samples which have several electrons around the parts, the electrons are precisely scanned by the scan-electron machine and it shows clearly how the sample structure would bind. In the scan microscopy, a picture is checked and specimens collected from various points of view that show a very clearly visible view. The numbers that follow are analysed by SEM with a different percentage of rubber powder replacement by SEM research.

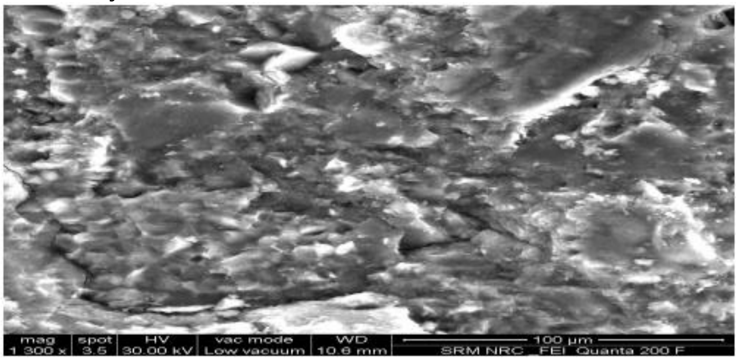


Figure: 4.1 SEM image of 1.5% replacement

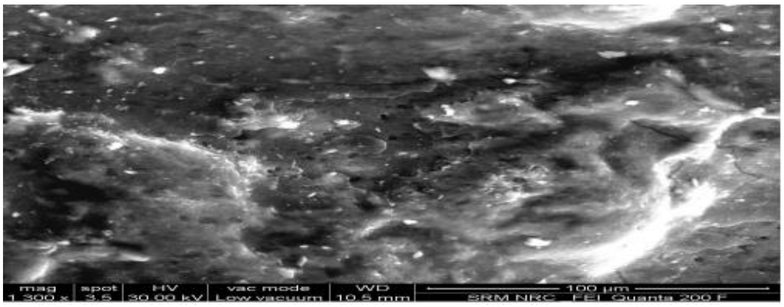


Figure:4.2 SEM image of 3 % replacement

The results of this SEM show clearly how the bonding happens within the sample of the concrete specimen. When the rubber content is increased, the bonding of the rubber with the other particles inside the specimen was not as good as 1,5% and 3%. Thus, when the rubber content is increased, the strength decreases, as this SEM analysis makes clear.

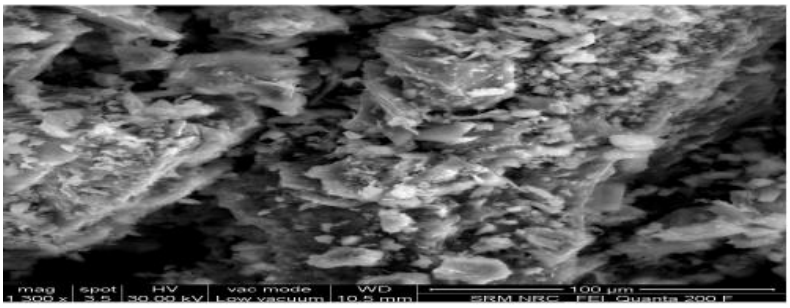


Figure: 4.3 SEM image of 3.5 % replacement

CONCLUSION:

- Clearly, the compressive strength decreases when the percentage of rubber replacement increases. Rubber substituted concrete performance in the M30 class appears to be very encouraging to nearly achieve the target mean compressive strength by up to 10 per cent substitution.
- The compressive strength of 5% rubber aggregate replacement is almost 10% and 20%. The substitution of a 20% aggregate of crumb rubber in 56 days is comparatively low compared with that of 85% of the content.
- The split tensile strength of more than 90% of traditional specimen strength is achieved in M30 grade concrete for all per cent of crumb rubber replacement. Whereas 5% of the substitution was exceptionally well carried out with higher strength than the conventional substitute and 10% equals the strength of 28-day conventional specimens.
- According to the above, 5%, 10 per cent replacement performance in compressive cadets has been demonstrated. 5%, 10% of replacement materials show good tensile strength performance. All proportional substitution has exceptionally improved efficiency when it comes to flexicurity. It is quite clear, according to the graphic representation, that the incremental and significant improvement of all the above-mentioned strength aspects of concrete was calculated by 5per cent replacing cough aggregates together with waste tyre aggregates.
- In this experimental study of the partial substitution of crumb-rubber tyres, the results have shown that strength parameters such as compressive strength, tensile split resistance and bending strength decreased if the percentage of substitution increases.
- By comparing all the parameters of strength of various mix proportions, like 5%, 10%, 20% and 30%. The results show that the 5% and 10% mix proportion show 90% of normal strength.
- Finally, it was concluded that a 5% substitution of the coarse aggregate with the rubber tyre substantially determined the best results that can be applied in low-cost structural aspects and dynamically loaded heavy concrete structures.

The utility of tyre rubber powder in concrete as a partial substitute of the finely aggregated was replaced by several experimental procedure. The M30-degree concrete has been engineered with the water-cement ratio 0,44, and the tyre rubber is substituted by 1.5%, 3% and 3,5%. The mix with the standard cement and the rubberized concrete is compared. Various tests have been carried out for the strength of the concrete such as compression, tensile cracking, bending strength tests. And SEM analyses were carried out to know how the bonding with the rubber is partly replaced in the concrete specimen by various percentages. The results drawn from this analysis are as follows:

• It is obvious that pneumatic powder can be used for the replacement of a fine aggregate of up to 1.5% if the percentage has not gone beyond that point.
• It is clear from the SEM study that the linking of cement to the rubber Pulver is good up to 1.5% and good bonding is not observed above that percentage. The results show that we can build structures such as pavements, agriculture purposes such as fences and poles using piping rubbers, which require a low strength.

Future Scope:

The easy availability of waste rubber and endless production of waste pneumatics from the pneumatic industry mean that it will still require a recycling of this waste product. On the basis of current research and other research on this issue, the use of tyre rubber in the construction industry has great potential. The use of the waste rubber means that concrete is cheaper and more environmentally friendly. Also, the strength properties would certainly improve if such treatments are made for rubber. If the current shortcomings shown by previous research find new and improved techniques for their use, it will provide greater possibility for waste rubber to be used in the construction industry.

RECOMMENDATIONS:

• It should be investigated the impact of the use of de-airing agents in rubberised concrete to reduce the entangled air. Therefore, the compressive force may be significantly increased.
• Any chemical reactions between the rubber aggregate and other components in the rubberized concrete must be studied in order to ensure that there are no adverse effects in natural aggregates that are close to alkali-silica and alkaline-carbonate reactions.
•This research was carried out through the development of single grades of 20 mm size rubber aggregates. In future, the impact of different sizes is to be investigated. In addition, the results in various replacements than those pertaining to this study must be examined

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