INVESTIGATION OF MECHANICAL AND DURABILITY PROPERTIES OF CRUMB RUBBER CONCRETE

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ABSTRACT: Rubberized concrete is a form of concrete in which discarded tyre rubber particles are used instead of natural aggregates. This sort of concrete provides an environmental alternative to the millions of discarded tires. The purpose of this study is to evaluate both the structural and durability behavior of crumb rubber concrete. In this M25 grade of concrete with a different target control strength is taken. Each M25 grade of concrete group had four different mixes, for a total of eight different mixes in which crumb rubber partially replaced coarse aggregates by 5%, 10%, 15%, 20% and 25% of volume. The effect of compressive strength, split tensile strength, flexural strength and acid attack HCL & H_2SO_4 and exposure to elevated temperatures of 200 °C and 400 °C were investigated for a period of 1 hour. Compressive strength was shown to be gradually decreasing after 15% of replacement. It is possible to identify that rubberized concrete is extremely resistant to aggressive environments based on the results of durability testing.

KEY WORDS: Crumb Rubber, M25 Concrete, Compressive Strength, Split Tensile Strength, Flexural Strength. Acid Attack HCL.

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I.INTRODUCTION

Concrete strength is greatly affected by the properties of its constituents and the mix design parameters. Because aggregates represent the major constituent of the bulk of a concrete mixture, its properties affect the properties of the final product. An aggregate has been customarily treated as inert filler in concrete. However, due to the increasing awareness of the role played by aggregates in determining many important properties of concrete, the traditional view of the aggregate as inert filler is being seriously questioned. Aggregate was originally viewed as a material dispersed throughout the cement paste largely for economic reasons [1]. It is possible, however, to take an opposite view and to look on aggregates a building material connected into a cohesive whole by means of the cement paste, in manner similar to masonry construction. In fact aggregate is not truly inert and its physical, thermal, and sometimes chemical properties influence the performance of concrete.

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid by mechanical means, reduces the size of the particles further. Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord are removed, leaving tire rubber with a granular consistency.

Crumb rubber is made up of 71% recoverable rubber, 14%steel, 3%fibre and 12% extraneous material. Rubberized asphalt is the largest market for crumb rubber in the United States, consuming an estimated 220 million pounds, or approximately 12 million tires annually. Crumb rubber is also used as ground cover under playground equipment, and as a surface material for running tracks and athletic fields. Crumb rubber usually consists of particles ranging in size from 4.75 mm to less than 0.075 mm. Most process that incorporate crumb rubber as an asphalt modifier use particle range from size 0.6 mm to 0.15mm [2].

Since its invention, concrete has been the most widely used building material and the most important component of any construction project. Durability of concrete could be described as the ability of concrete to retain its initial form, quality, and serviceability when exposed to different environmental conditions and to last a long time without any significant deterioration. Efforts are required by the modern world to take steps to save nature without compromising on the overall performance of concrete [3]. The use of recycled solid waste aggregates, plastic, glass, electronic waste in concrete are investigated in several studies with the aim of replacing natural aggregate with recycled aggregate.

Many tires are thrown or buried every year, posing a serious environmental threat. Worn tires are undesirable in landfills because of their high volume and fixed shape, which quickly consume valuable space. The exposed waste tires accumulate water, which can support the growth of bacteria, molds, insects, and mice. Besides, in the case of fire, they burn fast and emit toxic gases which can cause severe pollution problems [4]. Governments all over the world are working to find solutions to the rubber waste problem. As a result, various studies have been conducted to identify alternative uses for rubber waste. Rubber tires have a wide range of civil and non-civil engineering applications. Whole scrap tires can be used as a rain water runoff barrier, collision barriers around race tracks, boat bumpers at marines, and as artificial reefs. Rubber waste can also be used in asphalt mixtures for road construction, playground surfaces, sports fields, and pavements [5].

II.LITERATURE SURVEY

Abhay kumar (2017) .et.al [6], "use of crumb rubber as fine aggregate in concrete to increase the strength of concrete block"- In this study it concluded that the percentage of higher amount of rubber will affect its workability in a negative term. These were just fundamental rules for strength loss of privately delivered concrete compared to 20mpa targeted concrete. Rubbercrete can be a good insulator for heat and noise, so it can be helpful for decreasing the noise pollution. So it tends to be utilized as a protecting material in dividers in private just as buildings and as a noise protector in theatres, film lobbies, and assembly halls and so on.

Iman mohammadi (2014) .et.al [6], "In depth assessment of crumb rubber concrete (CRC) prepared by water soaking treatment method for rigid pavements"- introducing water soaking method for treatment was effective for gaining a homogenous mixture and for the proper distribution. If we direct add the rubber particles into concrete it will result in trapping air bubbles into it. Intense vibration will have applied to this during compaction, then disintegration of mixture will be quite hard. This study told that low w/c ratio was not workable and if we take high w/c ratio then it would be affecting the rodding effects. Strength did not reduced due to using water soaking method and it gave 8% hand 22% higher compressive and flexural strength. A positive effect was seen on fatigue behavior in concrete.

Yogender Antil (2014) .et.al [6], "Rubberized Concrete Made with Crumb Rubber" - This study was about testing of hardened and fresh concrete in terms of rubber-sand replacement ratio. Sand was replaced with treated and untreated rubber. Rubber was treated with NAOH solution and it effects it in positive ways. It was seen that compressive strength reduction percentage was reduced. Tensile strength was not decreased due to NAOH treatment. The ideal decrease was recorded at 10% rubber substitution proportion. Concrete slump was slightly reduced because of sand replacement and unit weight was also reduced.

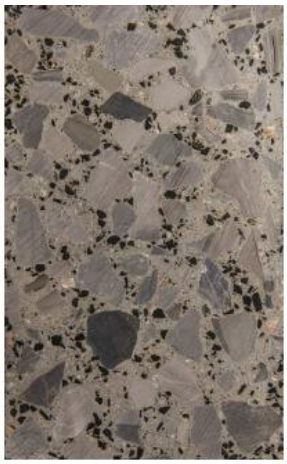
Reddy B D, Aruna J. S and Ramesh P. B, (2013).et.al [6], "Experimental Investigation on Concrete by Partially Replacement of Ware Aggregate with Junk Rubber"- The test assessment completed on CRC by substitution of FA/CA or both with rubber at various degrees by volume of concrete. The mould size was 150*150*150mm and compression and water absorption test were conducted w/c ratio was 0.40. when portion of crumb rubber was increased by time to time complexity was seen in their mixing pattern. Near about 10% of increase in compression strength and a change in water absorption properties was noticed.

M.S.H. Mohd Sani, F. Muftah (2012).et.al [6], "Assessment on Compressive Strength of Waste Rubber Tube Tyre (WRTT) Fibre in Concrete"- Among the characteristics of concrete compressive strength is most important. Increasing the quantity of crumb in concrete resulted the improvement in compressive strength as well as increased tensile strength. Due to the weakness of concrete in tension, rubber can do a great work to enhance it. Silica fume has been added and these can be used in colder areas. Properties like abrasion resistance and durability has been improved.

III. CRUMN RUBBER BRHAVIOUR

Crumb Rubber Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid by mechanical means, reduces the size of the particles further. Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord are removed, leaving tire rubber with a granular consistency. Crumb rubber is made up of 71% recoverable rubber, 14%steel, 3%fibre and 12% extraneous material. The crumb rubber used has sieve retaining at 500 microns. The specific gravity of crumb rubber is 1.12

(a)



(b)

Fig. 1: (a) Waste tires, and (b) Crumb rubber concrete.

Properties of Crumb Rubber

Physical properties

Crumb rubber usually consists of particles ranging in size from 4.75mm to less than 0.075mm. Most process that incorporate crumb rubber as an asphalt modifier use particle ranging from 0.6mm to 0.15mm.Three methods are currently used to convert scrap tires in crumb rubber. The cracker mill process is the most commonly used method.

Chemical properties

The principle chemical component of tires is a blend of natural and synthetic rubber, but additional component includes carbon black, sulfur, polymers, oil, paraffin's, pigments, fabrics and bead or belt material. Concerning the reuse of waste rubber in concrete, extensive studies had been conducted. Two major opposite effects existed when the rubber was introduced into the concrete mixture. The mechanical strength was reduced, while the durability, toughness, impact resistance, strain capacity and sound insulation properties were enhanced. Due to the compressive and flexural strengths being two major design criteria in concrete structures, the reduction in the strength of rubberized concrete limited its application. However, the desirable characteristics, including lower density, higher ductility, better sound insulation and resistance against cracking, made it a valid option for non-structural concrete with a low strength requirement.

IV. RESULTS AND DISCUSSION

MECHANICAL PROPERTIES

4.1 Compressive strength

The compressive strength of concrete is typically specified in building codes and standards, and different types of concrete are designed to achieve different levels of strength depending on their intended use. For example, high-strength concrete is used in applications where a high degree of durability and load-bearing capacity is required, while lightweight concrete is used in applications where weight reduction is a priority. The compressive strength of concrete with crumb rubber replacement depends on several factors, such as the particle size and volume fraction of rubber, the mixing procedure, the curing method, and the type and proportions of other materials used in the mix. While some studies have shown a reduction in compressive strength with the use of crumb rubber, others have reported similar or even improved compressive strength compared to traditional concrete.

Fig. 2: Compressive Strength of Cube Specimens

Table. 1: Compressive strength for 7 days

S.NO	CUBES	DAYS	COMPRESSIVE STRENGTH (N/mm*2)
1	CONVENTIONAL	7 days	25.78
2	5% REPLACEMENT	7 days	25.83
3	10% REPLACEMENT	7 days	25.89
4	15% REPLACEMENT	7 days	26.15
5	20% REPLACEMENT	7 days	16.14
6	25% REPLACEMENT	7 days	9.81

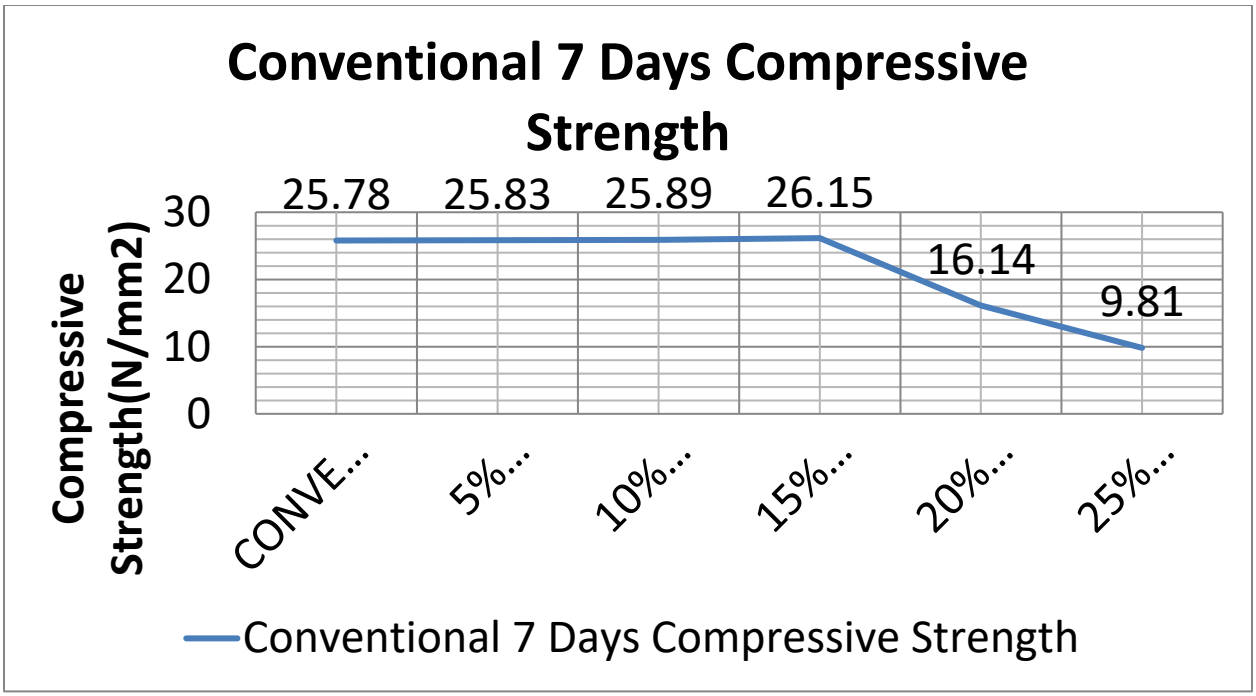


Fig. 3: Compressive strength for 7 days

Table. 2: Compressive strength for 28 days

Sl.NO	CUBES	DAYS	COMPRESSIVE STRENGTH (N/mm*2)
1	Conventional	28 days	32.89
2	5% Replacement	28 days	34.22
3	10% Replacement	28 days	34.87
4	15% Replacement	28 days	35.56
5	20% Replacement	28 days	24.08
6	25% Replacement	28 days	17.6

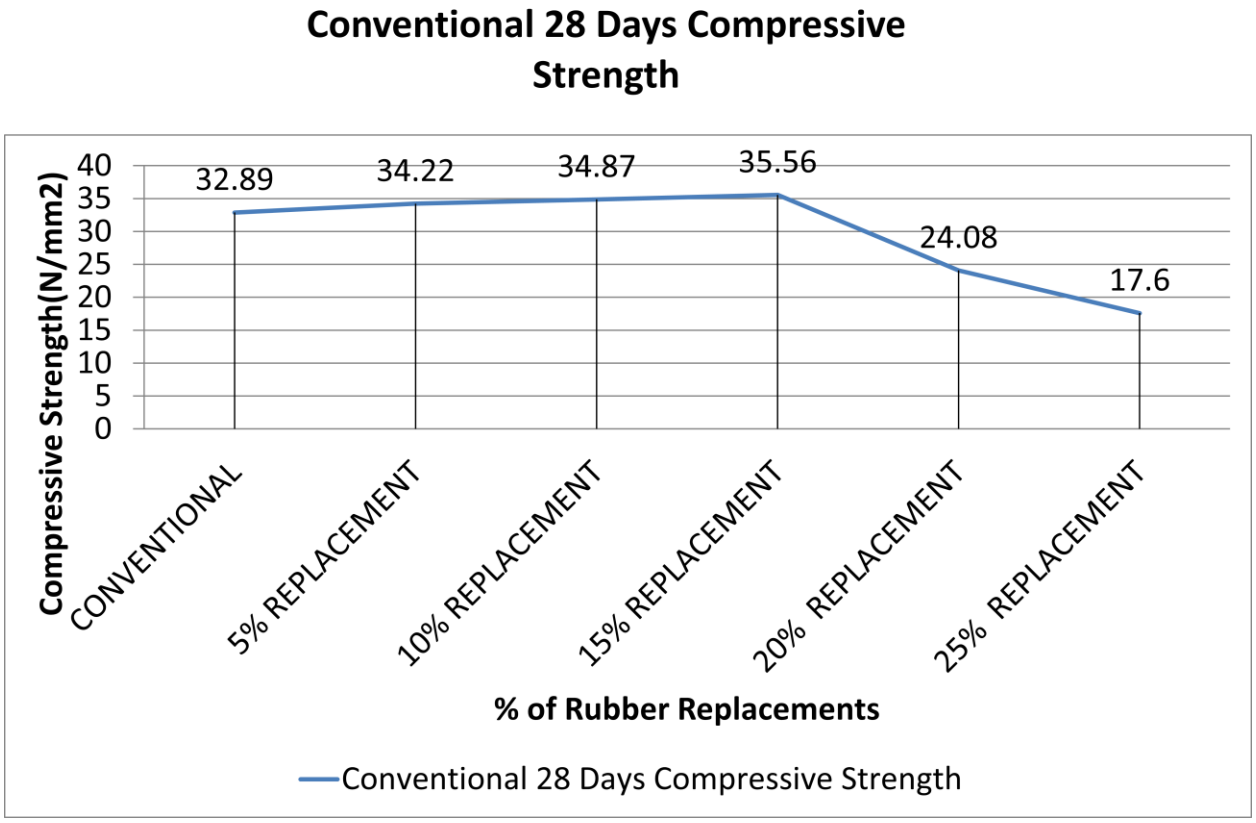


Fig. : Compressive strength for 28 days

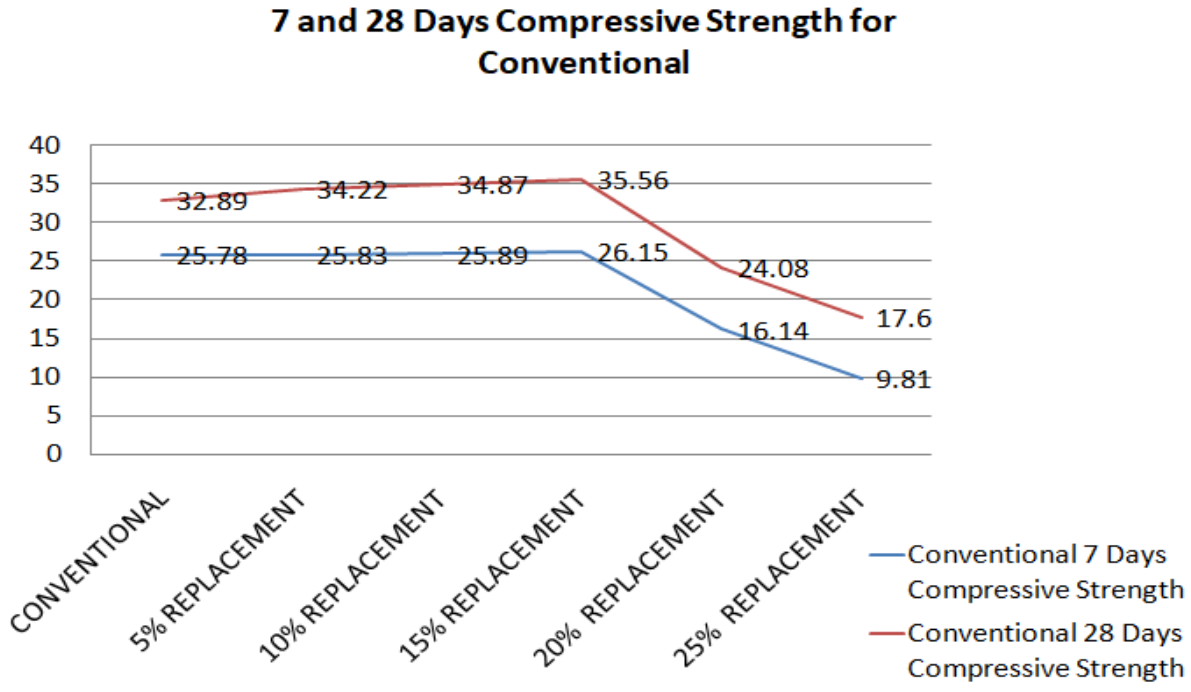


Fig. 5: 7 and 28 Days Compressive Strength for Conventional

4.2 Split Tensile strength

The Split tensile test was conducted according to IS Code 516-1999. The concrete is very weak in tension due to its brittle nature and is not accepted to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. Split tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. Split Tensile strength (MPa) = 2P / DL. The partial replacement of coarse aggregate with crumb rubber in concrete can also influence the tensile strength of the resulting concrete. In general, the addition of crumb rubber to the concrete mixture can lead to a reduction in the tensile strength of the concrete**.**

Fig. 6: Split tensile strength test

Table. 3: Split tensile strength

Material	Split Tensile Strength Of Cylinder(N/Mm^2)
Nominal Mix	2.75
5 % Rubber	2.83
10% Rubber	2.9
15% Rubber	3.04
20% Rubber	2.87
25% Rubber	2.76

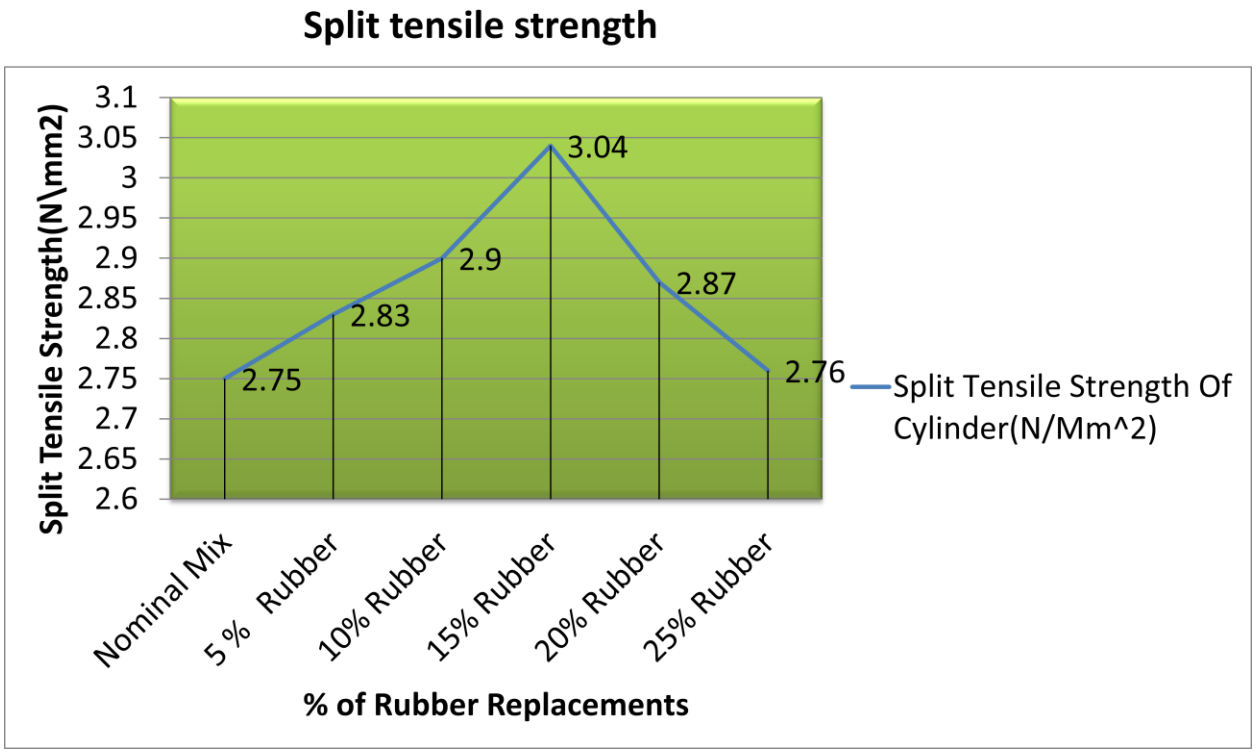


Fig. 7: Split tensile strength

4.3 Flexural strength

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property defined as the stress in a material just before it yields in a flexural test. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress. The Flexure strength of specimen was conducted as per IS Code 516-1959. The surface of the machine was cleaned and oiled, after that the specimen is put on the surface with contact to rollers. The axis of the specimen was carefully aligned with the axis of loading device. The load is applied gradually to the specimen until the specimen shows the signs of failure. The partial replacement of coarse aggregate with crumb rubber in concrete can have a significant effect on the flexural strength of the resulting concrete. In general, the addition of crumb rubber to the concrete mixture can lead to a reduction in the flexural strength of the concrete. This reduction in flexural strength is mainly due to the lower stiffness of crumb rubber compared to traditional coarse aggregate. The lower stiffness of crumb rubber can affect the load-carrying capacity of the concrete, which can result in a reduction in flexural strength

Fig .8: Flexural strength test

Table. 4: Flexural strength

MATERIAL	FLEXURAL STRENGTH (N/mm2)
Nominal	24
5% Rubber	24.8
10% Rubber	26
15% Rubber	25.6
20% Rubber	24.6
25% Rubber	22.8

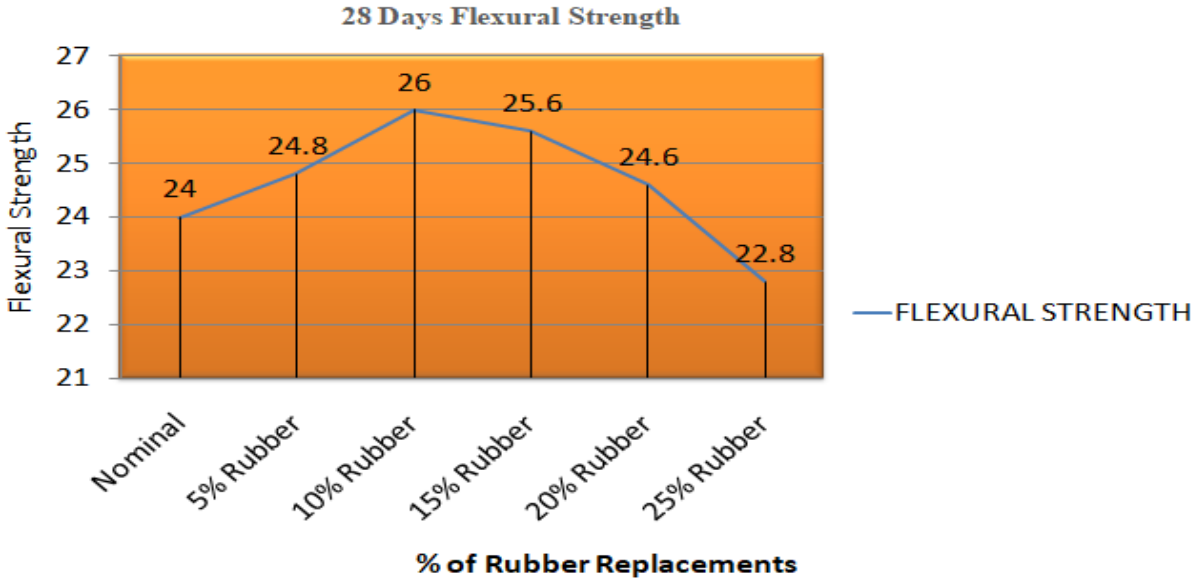


Fig. 9: 28 days Flexural strength

DURABILITY PROPERTIES

The durability of concrete in this experimental work was carried out by measuring acid resistance at different ages of curing. The concrete acid resistance was observed by two types of tests named as Acid attack factor test and Acid durability factor test. The concentrations of acids in water are 5%,10% HCL and 5%,10% of H_2SO_4.

HCL

Acid attack on crumb rubber concrete is a type of chemical degradation that can occur when concrete is exposed to acids. This can cause the concrete to lose strength and durability over time, which can compromise the structural integrity of the concrete. The susceptibility of crumb rubber concrete to acid attack depends on a number of factors, including the type of acid, the concentration and duration of exposure, and the specific properties of the crumb rubber and other components of the concrete. Overall, while acid attack is a potential concern for crumb rubber concrete, there are steps that can be taken to minimize the risk of degradation, such as careful selection of materials and protective coatings. As with any type of concrete, proper maintenance and monitoring are also important to ensure the long-term durability and performance of the material.

Fig.10: Immersion of cubes in 5% HCL AND 10 % HCL

Fig. 11: 5% Hcl And 10 % Hcl Subjected Specimens

5% HCL

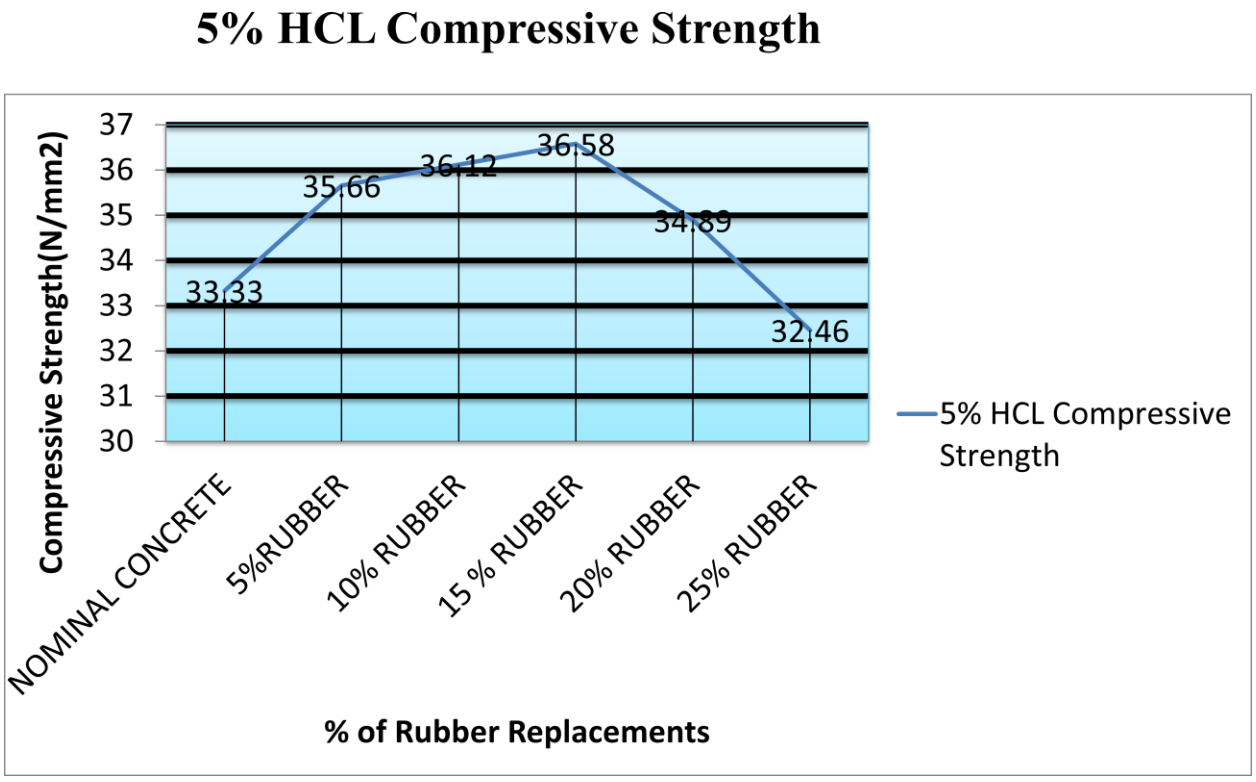


Fig. 12: 5% HCL Compressive strength

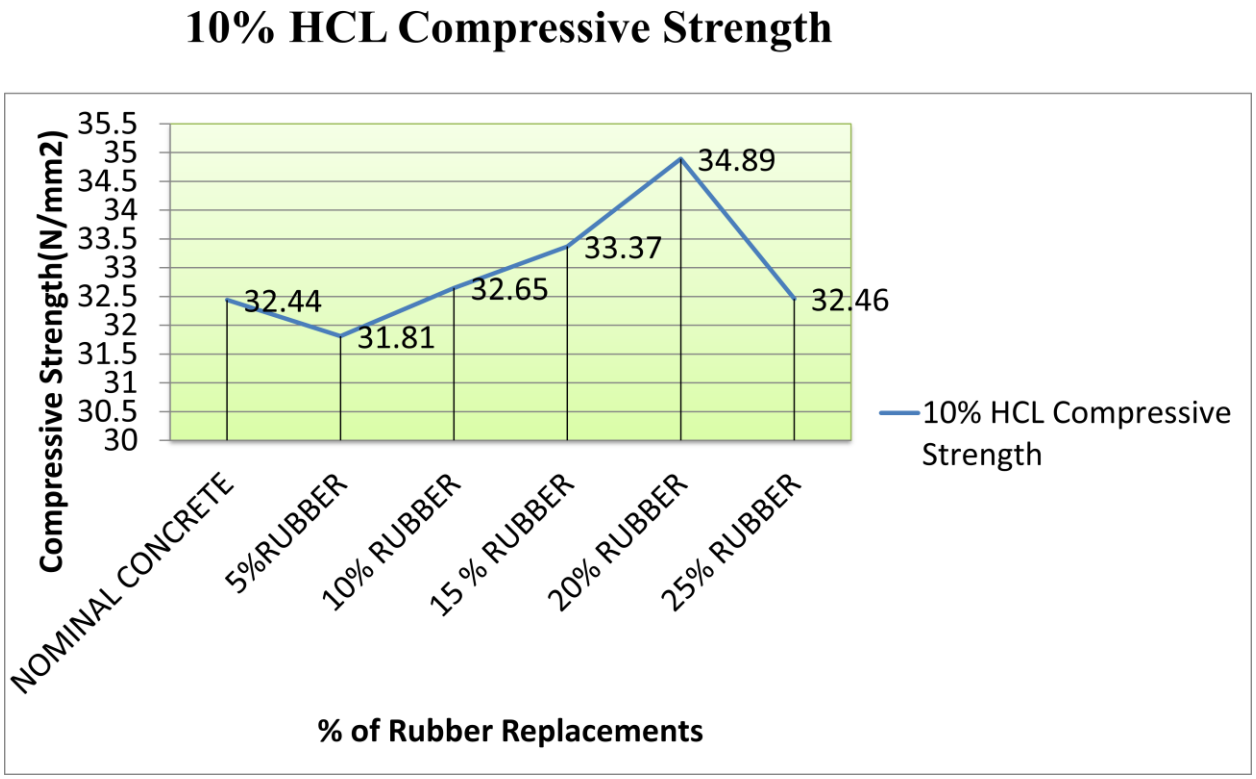


Fig. 13: 10% HCL Compressive strength

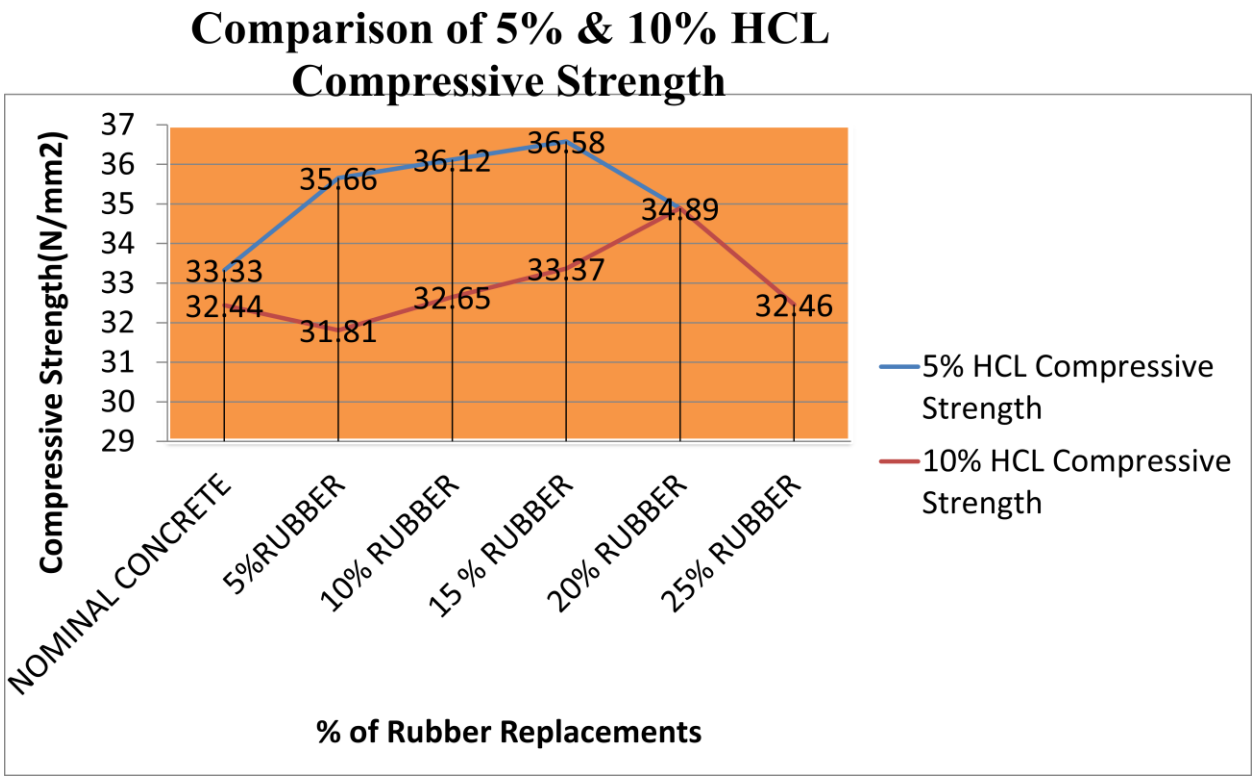


Fig. 14: Comparison of 5% & 10% HCL compressive strength

H_2SO_4 SULPHURIC ACID

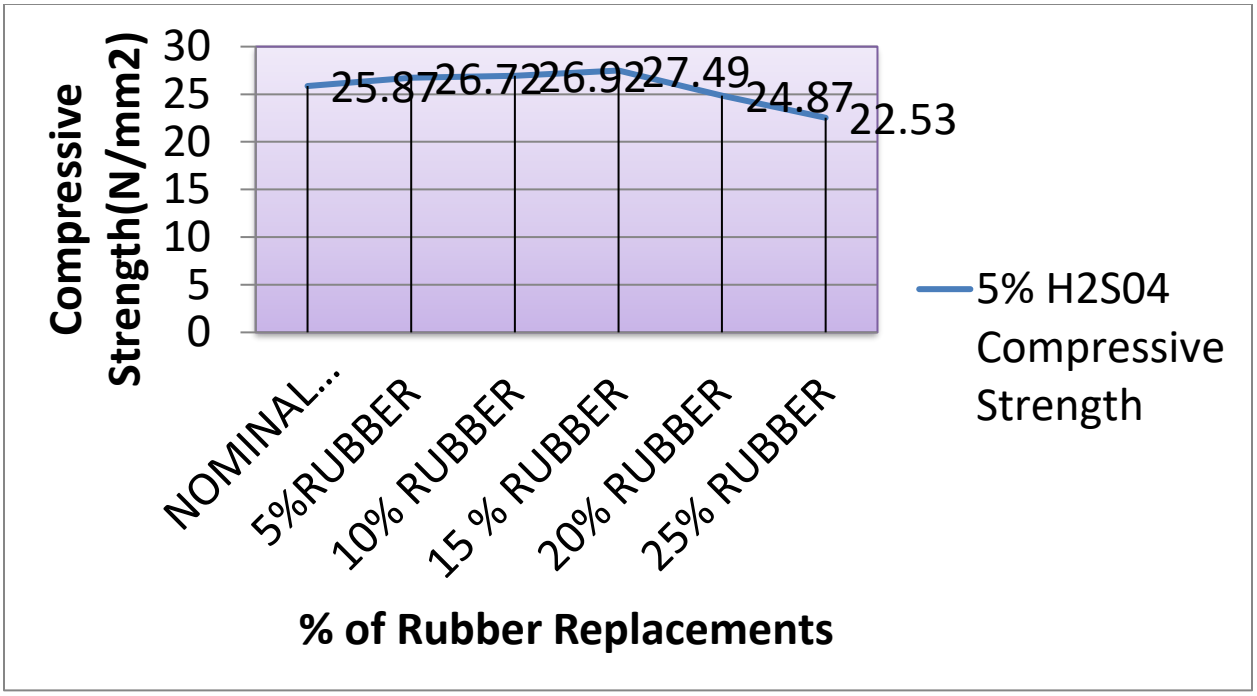


Fig. 15: 5% H2S04 Compressive strength

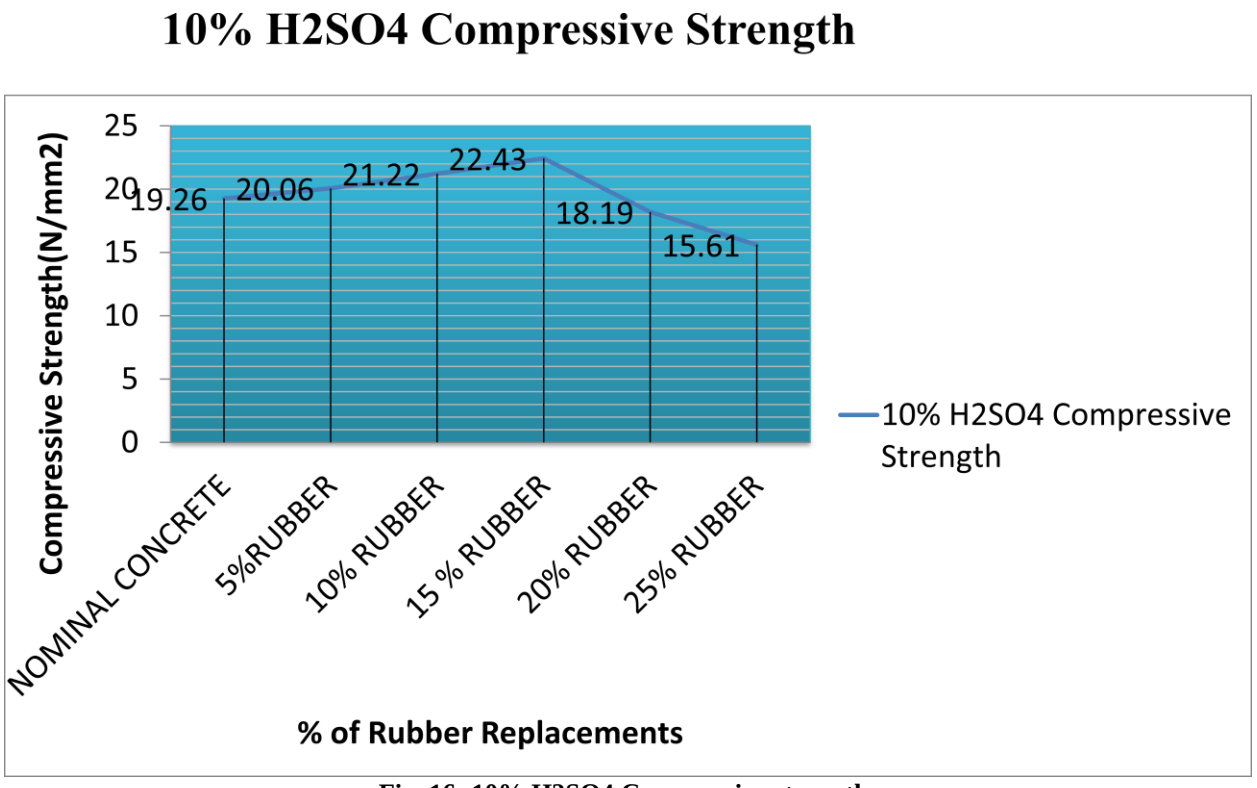


Fig. 16: 10% H2SO4 Compressive strength

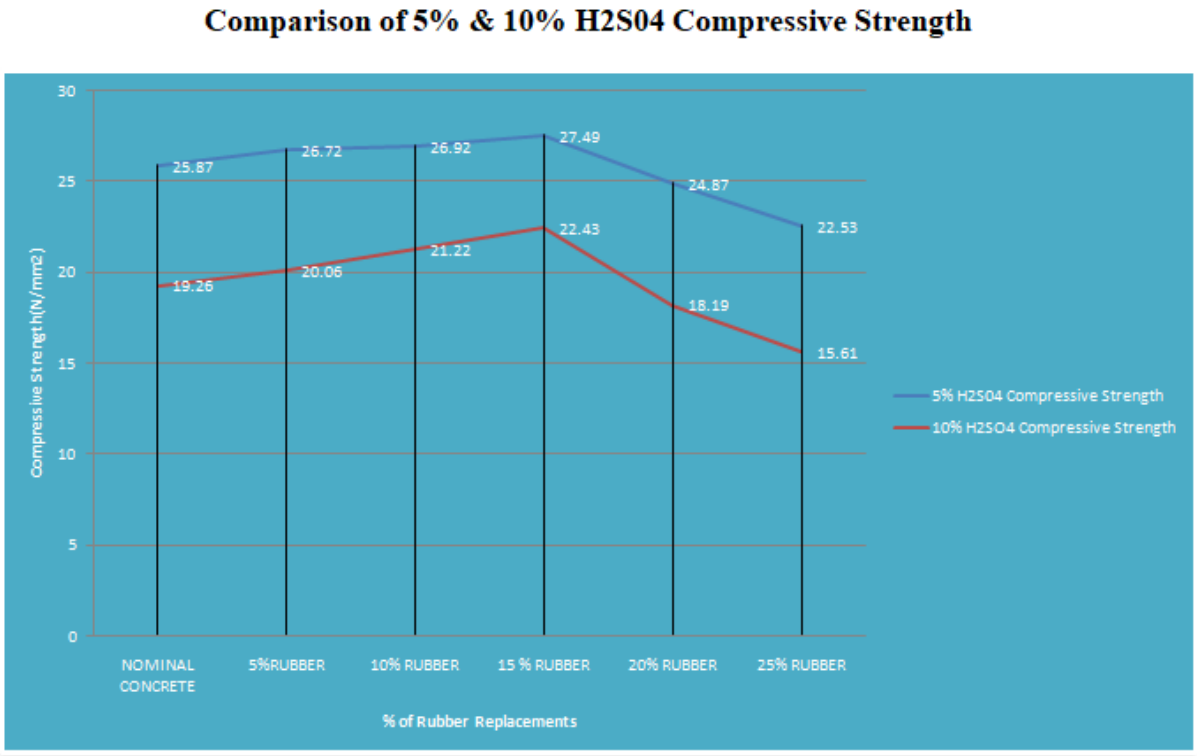


Fig. 17: Comparison of 5% & 10% H2SO4 compressive strength

4.5 Temperature effect

Here are some findings from studies that have used ovens to observe the temperature effect on crumb rubber concrete:

1. Reduction in compressive strength: Concrete with crumb rubber can experience a reduction in compressive strength when exposed to high temperatures. For example, a study found that concrete with 10% crumb rubber by volume experienced a 15% reduction in compressive strength after being exposed to a temperature of 80°C for 24 hours.
2. Increase in permeability: Concrete with crumb rubber can experience an increase in permeability when exposed to high temperatures, which can reduce its durability. For example, a study found that concrete with 10% crumb rubber by volume experienced a significant increase in permeability after being exposed to a temperature of 100°C for 24 hours.
3. Improved freeze-thaw resistance: Concrete with crumb rubber has been shown to have improved freeze-thaw resistance compared to traditional concrete, even when exposed to high temperatures. For example, a study found that concrete with 20% crumb rubber by weight of cement had better freeze-thaw resistance than traditional concrete after being exposed to a temperature of 100°C for 7 days.

Table. 5: Temperature Exposure At 200^0 C

Temperature Exposure (200 C)	Conventional	5%	10%	15%	20%	25%

STRENGTH(N\mm2)	33.09	34.46	35.25	36.45	34.89	32.46

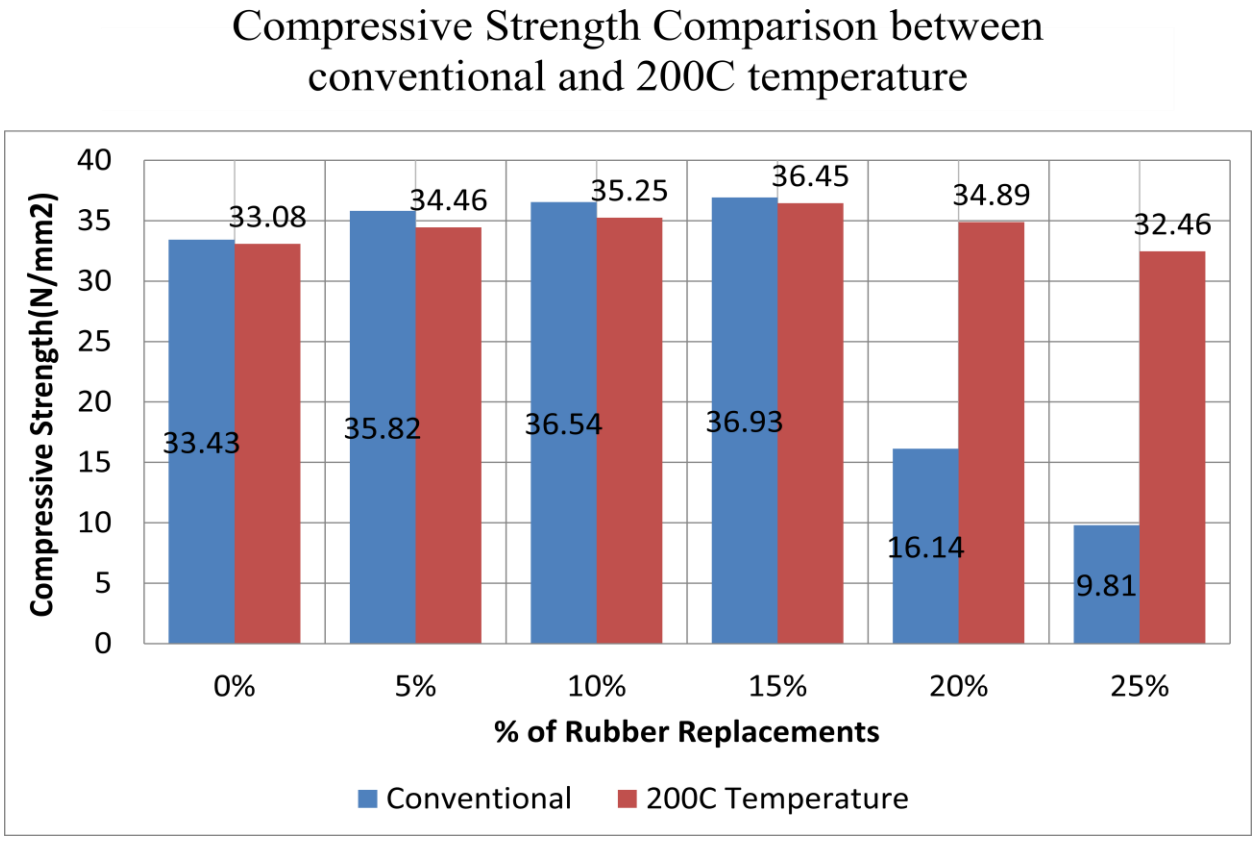


Fig. 18: Compressive strength of sample after Temperature effect At 200^0 C

Table. 5: Temperature Exposure At 400^0 C

Température Exposure (400 C)	Conventional Concrete	5%	10%	15%	20%	25%
Strength	32.94	34.24	35.08	36.12	32.2	30.67

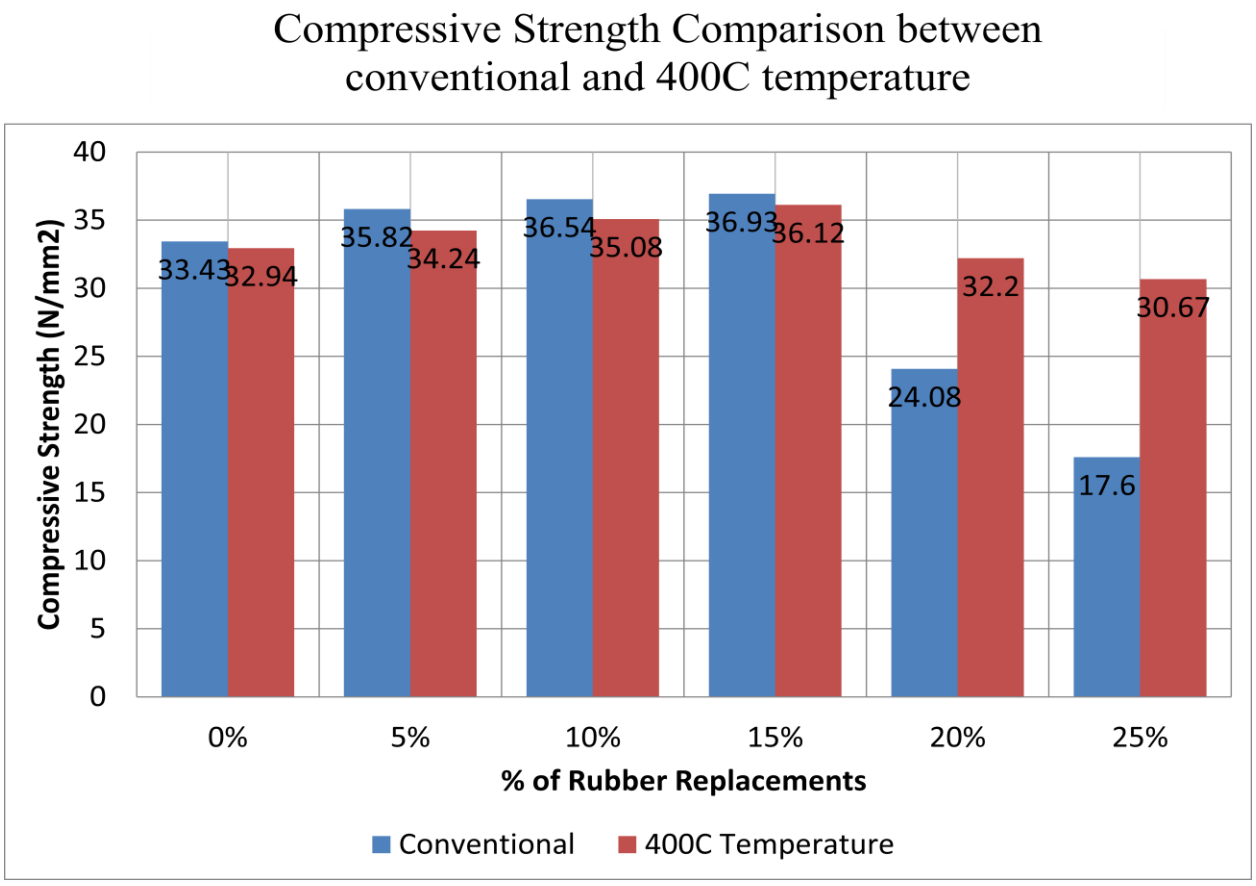


Fig. 19: Compressive strength of sample after Temperature effect At 400^0 C

V. CONCLUSION

Overall, studies evaluating the properties of crumb rubber concrete (CRC) have shown that the addition of crumb rubber can potentially improve various mechanical and durability properties of concrete. However, the effectiveness of CRC may depend on various factors such as the mix design, the type and size of crumb rubber used, and the environmental conditions in which the concrete is placed. In terms of mechanical properties, the addition of crumb rubber can potentially improve the compressive, split tensile and flexural strengths of concrete, particularly at lower replacement levels. However, the effect on each of these properties may vary depending on the specific conditions of the experiment.

With regards to durability, studies have shown that the addition of crumb rubber can improve the resistance of concrete to various types of degradation such as abrasion, freeze-thaw cycles, and chloride ion penetration. However, the impact of crumb rubber on the durability of concrete may depend on the specific environmental conditions in which the concrete is placed. The purpose of this study was to determine if waste materials such as rubber enhances the characteristic properties of concrete. The data presented in this project shows that there is great potential for the utilization of waste rubber. It is considered that the waste rubber form would provide much greater opportunities for value adding and cost recovery, as it could be used as a replacement for expensive materials such as coarse aggregate. In this project, the performance of concrete made rubber aggregates was studied.

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