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Evaluation of Interlocking Brick

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Abstract: ***The main aim of this project is to evaluate mechanical properties of interlocking bricks using coir fiber powder as a substitute of cement and rubber tire waste as a substitute of fine aggregate (sand) with varying percentages of 0%, 1%, 2% & 3% and 0%, 5%, 10% & 15% in concrete and to help in solving environmental problem produced from disposing of waste tires and coir husk partially. Additionally fly ash was also added with varying percentages of 5%, 10% and 15% as a substitute to cement in a concrete mix. Several laboratory tests such as compressive strength test, flexural strength test, split tensile strength test, water absorption test and density of concrete etc., were conducted on hardened concrete specimen to achieve the optimum usage of crumb rubber tire waste and coir fiber powder in mix proportion of concrete. It is found that the maximum compressive strength value of coir fiber based crumb rubber interlocking brick was obtained at 1%CF + 5%FA + 5%CR, flexural strength value and split tensile strength value of coir fiber based crumb rubber concrete block was obtained at 1%CF + 5%FA + 5%CR. From the final conclusion or outcome of the project, optimum usage of coir fiber powder is 3% and crumb rubber is 5%.***
Keywords: coir fiber powder, crumb rubber tire waste, mechanical properties, interlocking bricks & optimum usage.

I. INTRODUCTION

Due to enormous growth in population, increases urbanization, because of urbanization rate of construction also increases. Now-a-days construction industry plays an important role in the world. Cement and fine aggregate (sand) are one of the main ingredients in concrete preparation. For manufacturing one ton of cement 900kg of carbon dioxide are emitted. Carbon dioxide is one among the greenhouse gases which leads to global warming which effects environment as well as human life. Natural fine aggregate (sand) using in construction industry by collecting natural sand from rivers itself or flood plain. Because of this, now-a-days the use of river sand has been reduced with depletion of many small rivers and exploitation of natural resources. It causes many harmful environmental and social impacts. To overcome these issues, some alternatives for fine aggregate (sand) and ordinary Portland cement is necessary to determine. But now we are trying to evaluate mechanical properties of interlocking bricks by replacing sand with crumb rubber and cement with coir husk ash with varying percentages. If rubber tires are dumped in a landfills it occupies more than 70% of space, it can damage caps and liners by coming up to the top of landfill. It effects environment and natural soil also. Coir fiber powder is a fine grounded powder of natural fiber extracted from the outermost shell of coconut. By using rubber tire waste as sand and coir fiber powder as a cement partially in concrete mix, it helps in promoting safe environment and safe disposal of this waste materials. Interlocking bricks are one of the new innovative techniques in construction industry. These bricks are rectangular in shape with varying sizes (starts with actual size of conventional clay brick).By using interlocking bricks, cost of construction is reduced, it consumes less time, requirement of labor is also less, and it is easy to place and does not require skilled labor.In this project, interlocking bricks are prepared using crumb rubber and coir fiber powder as a partial replacement of sand and cement in concrete. By using these bricks, it requires low maintenance, self-weight of wall reduces, it provides eco-friendly environment.

A. Objectives of the Study

1) To achieve maximum compressive strength of interlocking bricks, fly ash is used in preparation of concrete mix.
2) To study the effects of coir husk and crumb rubber waste as a replacement of cement and sand.
3) To determine the compressive strength, flexural strength and split tensile strength of crumb rubber based coir fiber powder interlocking concrete brick at various ages of curing such as 3days, 7days and 28days of curing.
4) Cost analysis was done on conventional concrete brick and crumb rubber based coir fiber interlocking brick.

II. METHODOLOGY OF PROJECT WORK

A. Literature Review

Based on previous research papers, a comparative study on strength parameters of coir fiber concrete is done with respect to conventional concrete and influence of size and shape on strength properties, a comparative study on strength parameters of rubberized concrete is done with respect to conventional concrete.

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B. Raw Materials Collection

1) *Ordinary Portland cement (OPC):* Alpha cement traders Cement is also one of the most important raw materials which are used in construction industries. Ordinary Portland Cement (OPC) is one of the most widely used cement. Mainly cement is used in construction to get excellent binding property which gives strength to structural elements.
2) *Fine Aggregate:* Fine aggregate is also one of the most essential raw materials which are used in concrete preparation. 70 to 80 % of volume of concrete is occupied by aggregates only. According to IS 383 – 1970 code, aggregates passing through 4.75mm IS sieve are used as fine aggregates. In this project work, a fine aggregate passing through 2.36mm IS sieve is used.
3) *Coir Fibre Powder (Coconut Husk waste):* Dr. S. Bond Construction chemicals near ECIL. It was kept for drying in sunlight and it was sieved to avoid impurities present in this material. Coir fiber powder passing through 90micron IS sieve was used as partial replacement of cement. 1%, 2% and 3% of cement was partially replaced by using coir fiber powder.
4) *Crumb Rubber (Rubber Waste):* Diamond Rubber Industries near Bahadurpura. Particle size of rubber tire waste which is less than 1mm size is specified as crumb rubber. Before adding this material in concrete, it was sieved to avoid impurities and other unessential materials. Crumb rubber of size 1mm (passing through 600microns IS sieve which is retained on 1.18mm IS sieve) was used as partial replacement of fine aggregate.
5) *Coarse Aggregate:* According to Indian Standard code of 383 – 1970, aggregates which are retained on 4.75mm IS sieve is used as coarse aggregates. In these project work, coarse aggregate of 20mm size (retained on 10mm IS sieve which is passing through 20mm IS sieve).
6) *Fly Ash:* Class of fly ash used was class 'F' Particle size of rubber tire waste which is less than 1mm size is specified as crumb rubber. Before adding this material in concrete, it was sieved to avoid impurities and other unessential materials. Crumb rubber of size 1mm (passing through 600microns IS sieve which is retained on 1.18mm IS sieve) was used as partial replacement of fine aggregate.
7) *Water:* Locally available water from nearby water source.

Table (2.2): Properties of Coir Fiber

Properties	Values
Diameter	16micron (0.10 to 0.40mm)
Length	6 to 8inches (50 to 100mm)
Colour	Light Brown
Specific Gravity	1.130

Table (2.3): Properties of Crumb Rubber

Properties	Values
Fineness Modulus	0.950
Specific Gravity	01
Moisture Content	1.10
Water Absorption	00

Table (2.4): Properties of Fly Ash

Properties	Values
Fineness	45microns sieve retained
Particle Size	10 to 100microns
Specific Gravity	1.190 to 2.960
Colour	Grey

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C. Mix Design

Selection of required and suitable raw materials for production of concrete, estimation of proportions related to concrete mix of desired minimum strength and durability as economically as possible. As per Indian Standard code of IS 10262 – 2019 mix design of concrete is done for M30. Mix proportion obtained for M30 concrete was 1: 1.5: 2.5.

Table (2.5): Quantity of Ingredients Required for Each Mix

Raw Materials	Weight of raw materials (kg/m^3)			
	Mix (1) (Conventional concrete)	Mix (2) (5%FA+1%CF + 5%CR)	Mix (3) (10%FA+2%CF + 10%CR)	Mix (4) (15%FA+3%CF + 15%CR)
Cement	201.9	189.8	176.2	165.6
Coir Fiber (CF) Powder	0	2.01	4.03	6.05
Fly Ash (FA)	0	10.09	20.19	30.2
Fine Aggregate	304.2	289.03	273.8	257.8
Crumb Rubber (CR)	0	15.2	30.4	45.6
Coarse Aggregate	505.7	505.7	505.7	505.7
Water	90.8 lit	90.8 lit	90.8 lit	90.8 lit

D. Mixing Of Concrete

First, the materials used in this concrete mix are weighed and mixing of concrete was done manually on a waterproof platform, care should be taken while adding water to the mix to avoid bleeding in concrete mix.

E. Casting And Curing

Casting of specimens has done immediately after mixing of concrete mix. Before casting, first cleaning of mould and oil was applied to mould, then casting of specimen was done in three layers for each specimen and compacted with tamping rod for each layer of 25 to 30 blows. After casting specimen kept undisturbed for 24 hours and after 24hours specimen was demoulded and placed it under water for immersion curing for 3days, 7days and 28days.

F. Testing Of Specimen

After completion of curing period, specimens have been tested for various ages of curing of 3days, 7days and 28days. Compressive, flexural, split tensile strength test and water absorption test was performed on a specimen.

1) Compressive strength test was conducted on interlocking brick of size 190 X 90 X 90mm specimen each for conventional concrete and coir fibre based crumb rubber concrete with fly ash were casted with varying percentages of coir fibre (1%, 2%, 3%) , crumb rubber (5%, 10%, 15%) and fly ash (5%, 10%, 15%). For each mix 3days, 7days and 28days compressive strength values were obtained by testing under compression testing machine with gradually applied load.

2) Flexural strength test was conducted on beam specimen of size 750 X 150 X 150mm each for conventional concrete and coir fiber based crumb rubber concrete with fly ash were casted with varying percentages of coir fiber (1%, 2%, 3%) , crumb rubber (5%, 10%, 15%) and fly ash (5%, 10%, 15%). For each mix 3days, 7days and 28days flexural strength values were obtained by testing under universal testing machine with gradually applied load.

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3) Split tensile strength test was conducted on cylinder specimen of size 300mm length and 150mm diameter each for conventional concrete and coir fibre based crumb rubber concrete with fly ash were casted with varying percentages of coir fibre (1%, 2%, 3%) , crumb rubber (5%, 10%, 15%) and fly ash (5%, 10%, 15%). For each mix 3days, 7days and 28days split tensile strength values were obtained by testing under universal testing machine with gradually applied load.

4) Water absorption of conventional concrete should be less than or equal to 10% (from IS 2185 (part1)) but not more than that. For conventional concrete block, water absorption value is 3.61 & 3.50 % for sample 1 and 2. For coir fibre based crumb rubber interlocking concrete brick, water absorption value is 2.25 & 2.05 at 3%CF +1 5%FA +1 5%CR for sample 1 and 2 which has less water absorption rate when compare other mixes.

G. Cost Analysis

1) Cost for conventional concrete block (for 10 blocks)

a) Total cost of 10 conventional concrete block = 92.3 /-

b) Cost of conventional concrete block per each block = 9.23 /-

2) Cost of coir fibre based crumb rubber interlocking concrete brick (for 10 blocks)

a) For mix (1) (for 3%CF + 15%CR + 15%FA)
Total cost of 10 interlocking brick for mix (1) = 80.8 /-
Cost of interlocking brick per each brick for mix (1) = 8.08 /-

b) For mix (2) (for 5%CF + 20%CR + 20%FA)
Total cost of 10 interlocking brick for mix (1) = 76.07/-
Cost of interlocking brick per each brick for mix (1) = 7.6

3) Comparison of cost: Cost of conventional concrete block per each block is 9.2 /- and cost of interlocking brick per each brick for mix (1) and mix (2) is 8.08 /- and 7.6 /-. Cost of interlocking bricks is cost effective when compare to solid concrete blocks. Sometimes cost of interlocking bricks depends on two things in concrete mix

a) Percentage of partial replacement of coir fibre powder and fly ash with cement and

b) Percentage of partial replacement of crumb rubber with fine aggregate

H. Results and Conclusion

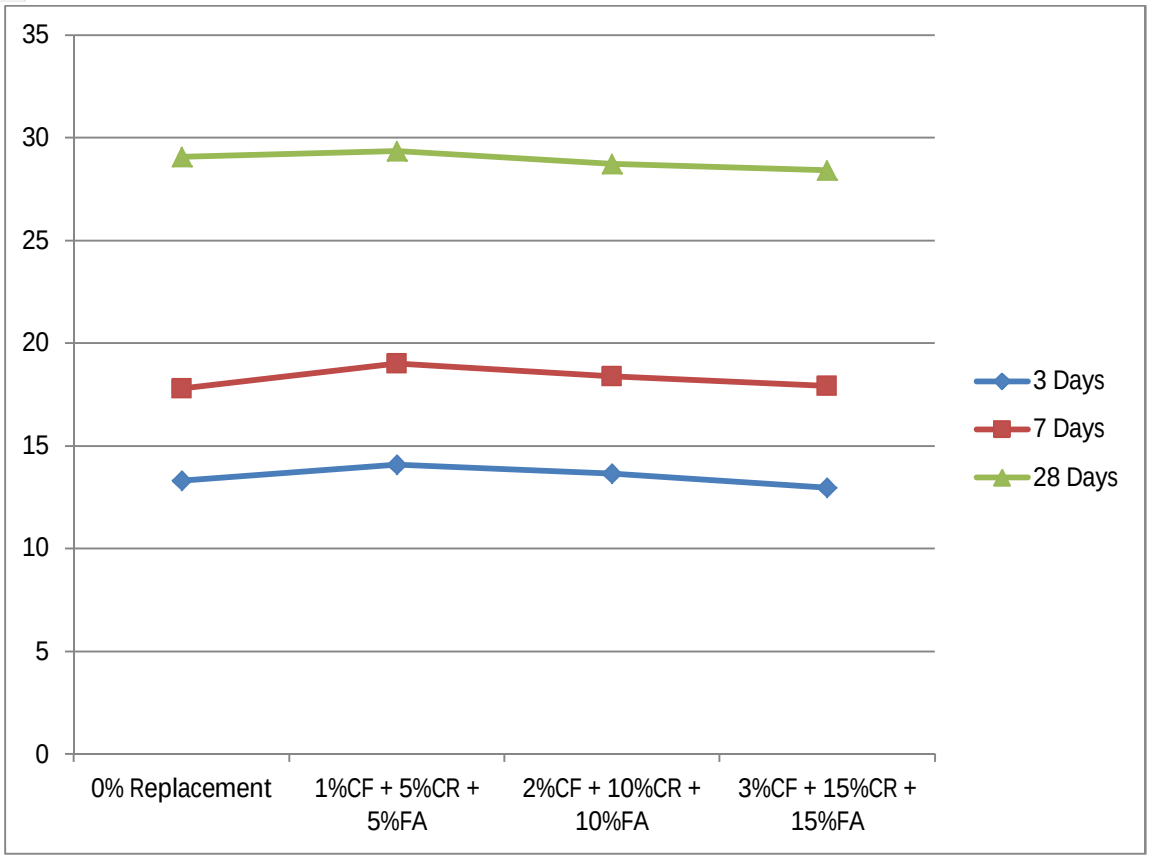
1) *Compressive Strength:* For coir fibre based crumb rubber interlocking concrete brick, maximum compressive strength value is 14.65, 19.55 & 29.55 N/mm^2 at the age of 3, 7 & 28days of curing obtained at 1%CF + 5%FA + 5%CR for specimen one and 12.85, 16.95 & 28.88N/mm^2 at the age of 3, 7 & 28days of curing obtained at 2%CF + 10%FA + 10%CR for specimen two and 13.62, 18.32 & 29.46N/mm^2 at the age of 3, 7 & 28days of curing obtained at 3%CF + 15%FA + 15%CR for specimen three. Slightly strength decreases with increasing the percentage of coir fibre and crumb rubber in concrete mix. Results have been shown in table 3.6.

2) *Flexural Strength:* For coir fibre based crumb rubber interlocking concrete brick, maximum flexural strength value is 1.85, 2.78 & 4.54 N/mm^2 at the age of 3, 7 & 28days of curing obtained at 1%CF + 5%FA + 5%CR for specimen one and 1.98, 2.86 & 4.62N/mm^2 at the age of 3, 7 & 28days of curing obtained at 2%CF + 10%FA + 10%CR for specimen two. When compare to flexural strength of conventional concrete block, flexural strength of coir fibre based crumb rubber interlocking brick is lesser. Results have been shown in table 3.7.

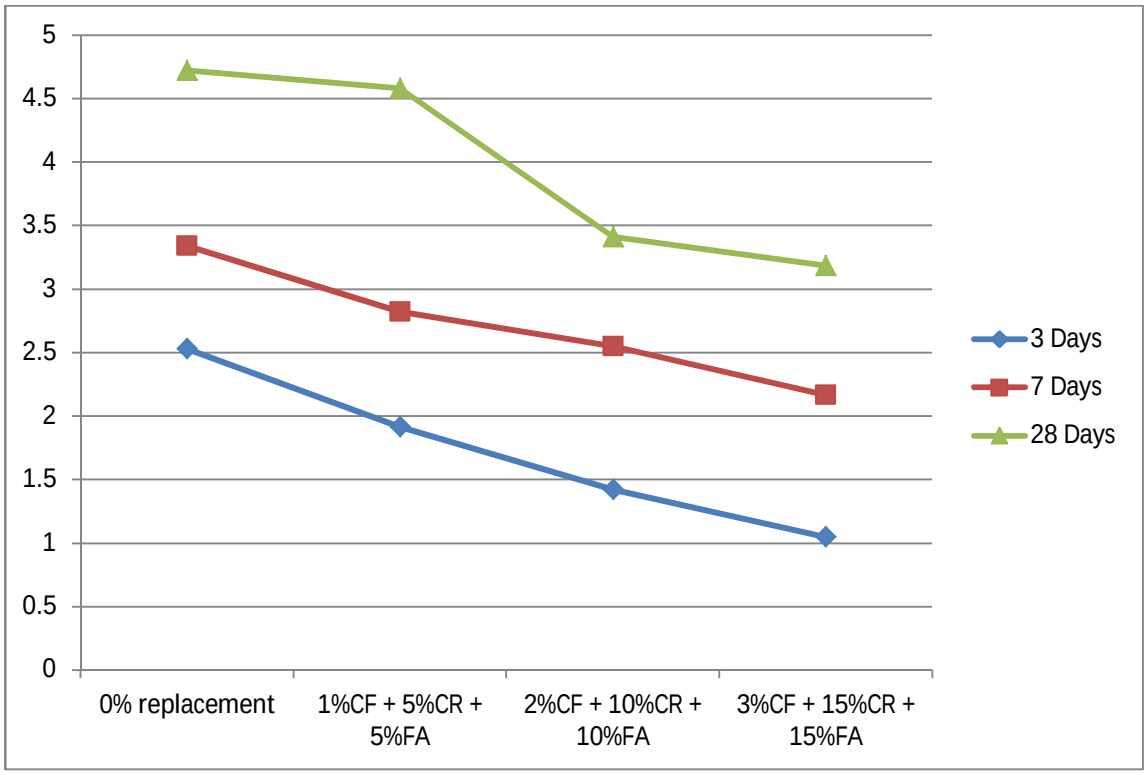
3) *Split Tensile Strength:* For coir fibre based crumb rubber interlocking concrete brick, maximum split tensile strength value is 1.12, 1.58 & 2.62N/mm^2 at the age of 3, 7 & 28days of curing obtained at 1%CF + 5%FA + 5%CR for specimen one and 1.18, 1.62 & 2.88N/mm^2 at the age of 3, 7 & 28days of curing obtained at 2%CF + 10%FA + 10%CR for specimen two. When compare to split tensile strength of conventional concrete block, split tensile strength of coir fibre based crumb rubber interlocking brick is lesser. Results have been shown in table 3.8.

4) *Water Absorption:* For conventional concrete block, water absorption value is 3.61 & 3.50 % for sample 1 and 2. For coir fibre based crumb rubber interlocking concrete brick, water absorption value is 2.25 & 2.05 at 3%CF +1 5%FA +1 5%CR for sample 1 and 2 which has less water absorption rate when compare other mixes.

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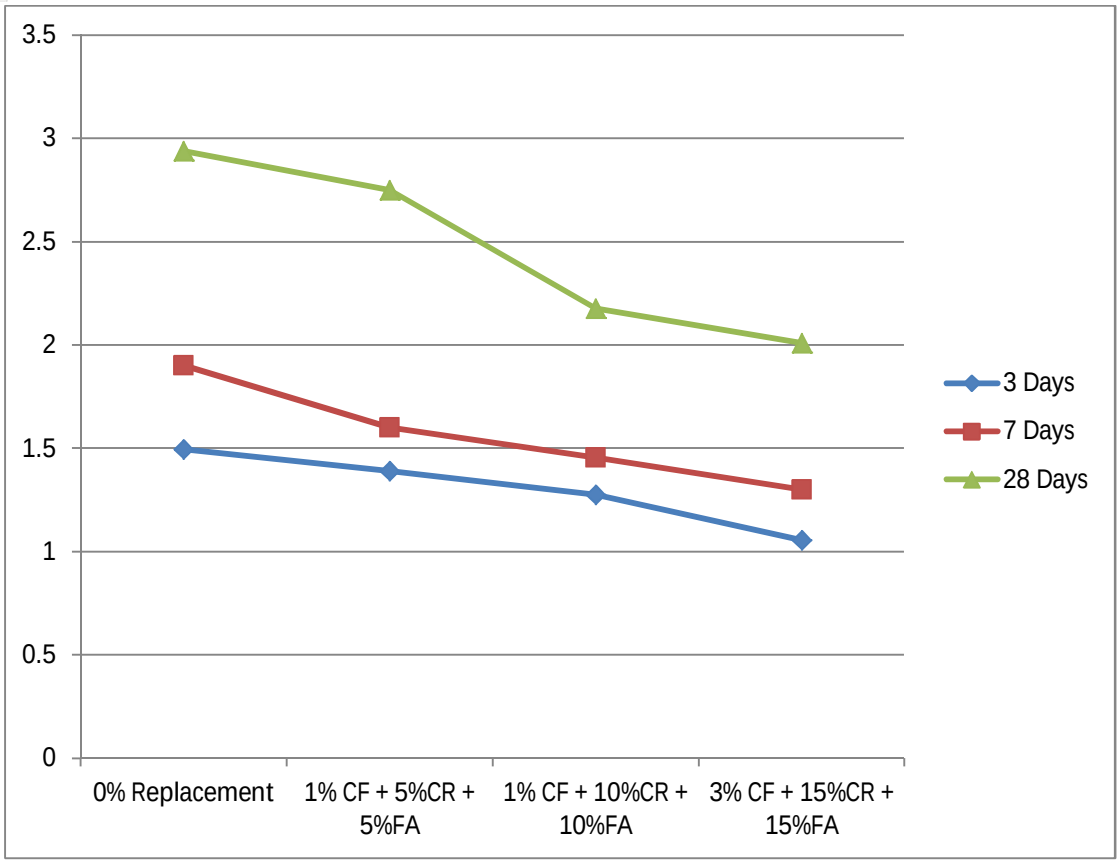
Graph (1) shows variations in compressive strength



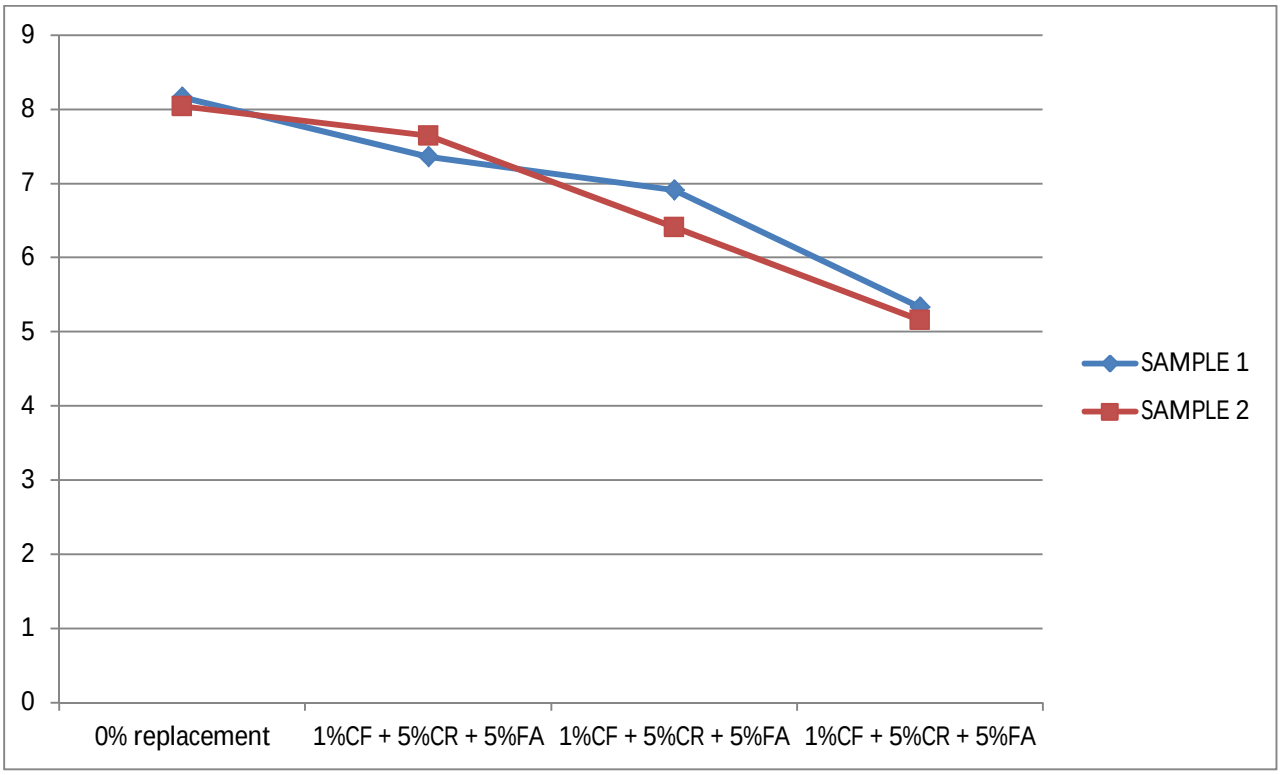
Graph (2) shows variations in Flexural strength

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Graph (3) shows variations in Split tensile strength



Graph (4) represents variation in water absorption

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III. FINAL CONCLUSION

A. When compare to compressive strength of conventional concrete block, the compressive strength of coir fibre based crumb rubber interlocking brick was increased by adding coir fibre and crumb rubber with combination of fly ash. The maximum compressive strength was attained at mix (1) (1%coir fibre + 5%crumb rubber + 5%fly ash) is 14.086, 19.003 and 29.353N/mm^2 for 3days, 7days and 28days of curing.

B. Maximum flexural strength was attained at mix (1) (1%coir fibre + 5%crumb rubber + 5%fly ash) was 1.915, 2.82 and 4.58N/mm^2 for 3, 7 and 28days of curing. But when compare to flexural strength of conventional concrete block, the flexural of coir fibre based crumb rubber concrete specimen was decreasing by adding coir fibre and crumb rubber content.

C. Maximum split tensile strength attained at mix (1) (1%coir fibre + 5%crumb rubber + 5%fly ash) was 1.38, 1.58 and 2.62 for 3, 7 and 28days of curing. But when compare to split tensile strength of conventional concrete block, the split tensile strength of coir fibre based crumb rubber concrete specimen was decreasing with further increase in coir fibre and crumb rubber content.

D. Water absorption of coir fibre based crumb rubber interlocking brick was less when compare to conventional concrete block. The percentage of water absorption is decreasing with increase in coir fibre and crumb rubber percentage in concrete mix.

E. From the results obtained/ finally concluded that the optimum percentage of coir fibre is 3% and crumb rubber is 15% in concrete mix. Further increase in percentage of coir fibre and crumb rubber decreases the strength of interlocking brick.

F. Since maximum strength is obtained at a lower mix design of concrete. It can be used in manufacturing of interlocking bricks economically when compare to conventional concrete block thus making it preferable for low cost housing, boundary walls around the building, parapet walls and partition walls of the building.

Future Scope of the Study

1) Properties of fresh concrete used for manufacturing of coir fibre based crumb rubber interlocking concrete brick should be studied.

2) Durability and shrinkage of coir fibre based crumb rubber interlocking concrete brick should be studied.

3) The properties of thermal and acoustic insulation should be studied.

4) Effect of various curing methods on coir fibre based crumb rubber interlocking concrete brick should be studied.

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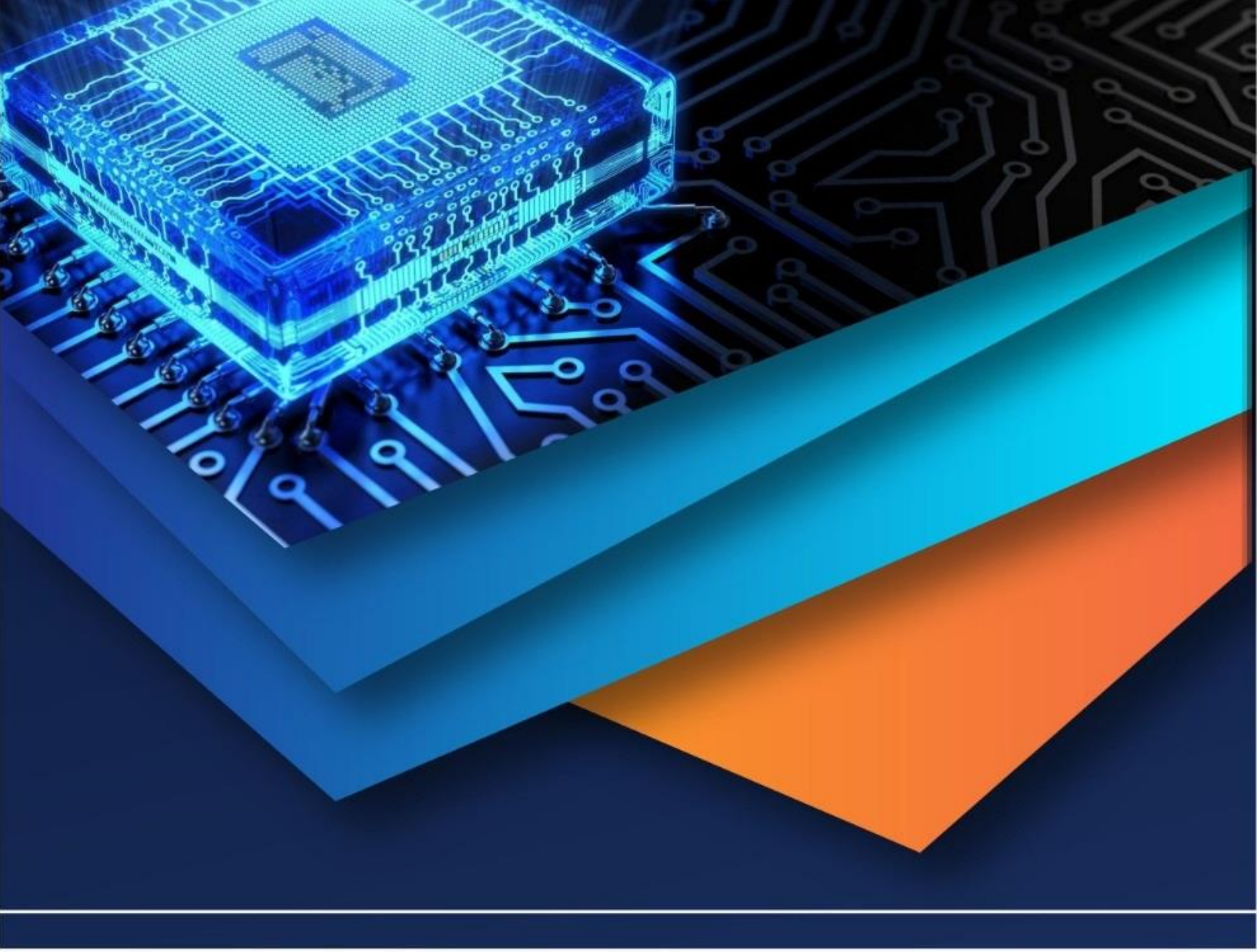
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