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AN EXPERIMENTAL STUDY ON CONCRETE OF GRADE M20, M25 AND M60 BY USING OF RICE HUSK ASH AND WASTE GRANITE POWDER

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1 ABSTRACT

Concrete is one of the most widely used construction materials, but its production requires significant amounts of cement and fine aggregate, which contribute to environmental issues. In this study, we aimed to explore the feasibility of partially replacing cement and fine aggregate in concrete with sustainable alternatives, namely rice husk ash (RHA) and waste granite powder (WGP).The experimental investigation involved the preparation of concrete specimens with varying proportions of RHA and WGP. Five different mix ratios with 10%, 20%, 30%, 40% and 50% replacement levels were considered for both cement and fine aggregate. The physical and mechanical properties of the produced concrete were evaluated and compared with those of conventional concrete. The results showed that the RHA and WGP exhibited pozzolanic properties, enhancing the strength and durability characteristics of the concrete. The compressive strength, flexural strength, and split tensile strength of the concrete specimens increased significantly with the increase in RHA and WGP content. This indicates that partial replacement of cement and fine aggregate with RHA and WGP can provide a potential solution for reducing the environmental impact of concrete production without compromising on its mechanical properties. Furthermore, the durability properties of the concrete, such as water absorption, chloride ion penetration resistance, and carbonation resistance, were found to improve with the addition of RHA and WGP. This suggests that the use of RHA and WGP can contribute to enhancing the longevity and sustainability of concrete structures. In conclusion, our experimental study provides evidence that partial replacement of cement and fine aggregate with RHA and WGP can be an effective and sustainable approach in concrete production. It not only reduces the consumption of natural resources but also improves the strength and durability properties of concrete. Further research is warranted to explore the long-term performance and economic feasibility of this approach.

Keywords: Concrete, rice husk ash, waste granite powder, partial replacement, sustainable construction, strength, durability.

I. Introduction

Cement included in concrete is a blend of intricate of compounds. Cement being a considerable industrial artifact and is made in about 120 countries. Cement when mixed with water and aggregates, makes omnipresent concrete that is utilized in the raising of buildings, roads, bridges, and other structures. Producing concrete by incorporating portland cement is on the top priority to many countries due to the low cost of materials and construction besides, loss cost of preservation for concrete structures. But an enormous levels of energy is essential for cement production which spits carbon dioxide (CO_2) and is very deleterious to the environment. Specifically, this issue by employing the concept of supplementary cementitious material.

1. Rice Husk Ash

Rice husk ash (RHA) is the by-product obtained from the burning of rice husks, which are the outer layer of rice grains. It is a highly valued agricultural waste material that has various applications due to its unique properties. RHA is rich in silica, which makes it an excellent source of amorphous silica with high chemical reactivity. This silica content contributes to its pozzolanic properties, meaning it can react with calcium hydroxide to form cementitious compounds. As a result, RHA is widely used as a sustainable alternative to traditional materials in construction and building materials, such as cement, concrete, and mortar. In addition to its pozzolanic properties, RHA also possesses thermal insulation and sound absorption characteristics. This makes it an excellent material for the production of insulation boards, ceiling tiles, and acoustic panels. Furthermore, RHA is also utilized in various industries such as agriculture, refractories, ceramics, and waste water treatment. It can improve soil fertility, act as a refractory material in furnaces, serve as a raw material in ceramics, and even remove heavy metals from contaminated water. Overall, rice husk ash is a versatile and sustainable material that offers multiple applications across different industries, promoting waste reduction and environmental sustainability.

2. Waste Granite Powder

Waste granite powder, also known as granite sludge or granite dust, refers to the by product generated during the cutting and polishing of granite stone. This powder is typically fine-grained and can be used in various applications as a replacement for conventional materials. The content of waste granite powder in a particular application can vary depending on the desired properties and performance requirements. In some cases, it can be used as a partial replacement for cement in concrete mixes, typically ranging from 10% to 30% by weight. This can help to reduce the consumption of cement, lower CO_2 emissions, and improve the durability of the concrete. Similarly, waste granite powder can also be used as a replacement for fine aggregates in concrete or as a filler material in asphalt mixes. The content of the powder in these applications can vary depending on the specific requirements of the project. It's important to note that the optimal content of waste granite powder can vary based on factors such as the quality of the powder, the type of application, and the desired performance characteristics. It is recommended to conduct thorough testing and analysis to determine the appropriate content for a specific project.

Table 1 Chemical composition of Granite powder

S. No	Chemical compound	Weight (%)
1.	SiO_2	64.5
2.	Al_2O_3	12.01
3.	Na_2O_3	5.92
4.	Fe_2O_3	5.77
5.	K_2O	5.26
6.	CaO	4.80
7.	TiO_2	0.67
8.	MgO	0.57
9.	MnO	0.39
10.	P_2O_5	0.07

Objectives of the study

- To study the strength of the concrete with partial substitution of fine aggregate with waste granite powder and cement with rice husk ash.
- Compensate the scarcity of natural sand.
- To economize the cost of construction works.
- Deciding suitable percentage of waste granite powder as an alternate for conventional sand
- Strength comparison of Conventional and Non-conventional concrete.

II.MATERIALS

1. Cement: - Cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Ordinary Cement OPC 53 Grade was used in the present experimental investigation.

2. Rice husk ash (RHS):- Rice husk ash (RHA) is a fine powder left over after burning rice husks, which is high in silica, carbon, and other minerals. RHA is a versatile material that can reduce waste.

3. Fine Aggregates: - Locally available natural river sand is used. It is naturally available. The Aggregates which are passing from 4.75 mm to 150 microns are termed as fine aggregate.

4. Coarse Aggregates: - The crushed stone aggregates were collected from the local quarry. The aggregate which are passing from 80mm sieve to 6.3mm sieve is termed as coarse aggregate.

5. Water: - The water which is suitable for drinking can be used for construction.

2.1 Mix Proportions

M20:- The mix proportion for M20 grade concrete is done using the Indian standard code 10262:2019. For whose the water cement proportion is kept as the least value of 0.45 for the slump value is 150mm, the coarse aggregate of 20mm size and below. The proportion for the mix is 1:1.51:2.95

M25: The mix proportion for M25 grade concrete is done using the Indian standard code 10262:2019. For whose, the water-cement proportion is kept as the least value of 0.45 (0.55 maximum according to code IS 10262:2019) for the slump value is 150mm, the coarse aggregate of 20mm size and below. The proportion for the mix is 1:1.2:2

M60: The mix proportion of M60 grade concrete is done by utilizing the Indian standard code 10262:2019. For whose the water-cement proportion is kept as the minimal estimation of 0.35 for the slump value is 150mm, an admixture named Master Glenium sky 8777 is utilized to minimize the workability and increase the strength, the coarse aggregate of size 20mm and below. The proportion for the mix is 1:1.07:3.40.

2.2 Tests Conducted on Concrete

a) Compressive strength test

The compressive strength tests on concrete are carried out on a compression testing machine accompanied by a range of 2.5 KN/s. The specimen utilized is a 150 mm cube and is cast and cured for 7, 14 and 28 days. The specimens are tested after taking the cubes from the curing tank in surface dry condition.

b) Split tensile strength test

The split tensile strength test is executed on a universal testing machine accompanied by a range of 2.5KN/s. A cylinder specimen of 150mm dia and 300 mm height are cast and cured for 7,14 and 28 days. The specimens are tested after taking out from curing tank.

c) Flexural strength test

The flexural strength test is executed on a flexural strength testing machine with a load rate of 1KN/s. Beam specimens of 500*150*150mm dimensions are cast and cured for 7 and 28 days. The specimens are tested after taking out from curing tanks.

2.3 Durability tests on concrete

Durability tests are conducted to expose a chemical attack that gives change in volume, fissure of concrete which results in the deformation. Under a chemical attack the following tests are carried out:

i. Acid Attack
ii. Sulphate Attack
iii. Alkaline Attack

Acid Attack

For the acid test, a liter of distilled water is combined with 5% of HCL to obtain the HCL solution. Casted cubes are cured in the hydrochloric acid solution for 28 days. Once done with curing, the cubes are lifted off from the solution, and then the compression test is conducted.

Sulphate attack

For the Sulphate test, a liter of distilled water is combined with 5 % of Magnesium Sulphate ($MgSO_4$)to obtain the $MgSO_4$ solution. Then cubes are immersed within the $MgSO_4$ solution for 28 days. Oncedone with curing, the cubes are pulled off, and then the compression test is completed to seek out itscompression strength.

Alkaline attack

For the alkaline test, a liter of distilled water is combined with 5 % of NaOH pellets to obtain caustic soda (NaOH) solution. Then cubes are immersed within the prepared caustic soda solution for 28 days. Once done with curing, the cubes are pulled off and the compression test is completed to seek out its compressionstrength.

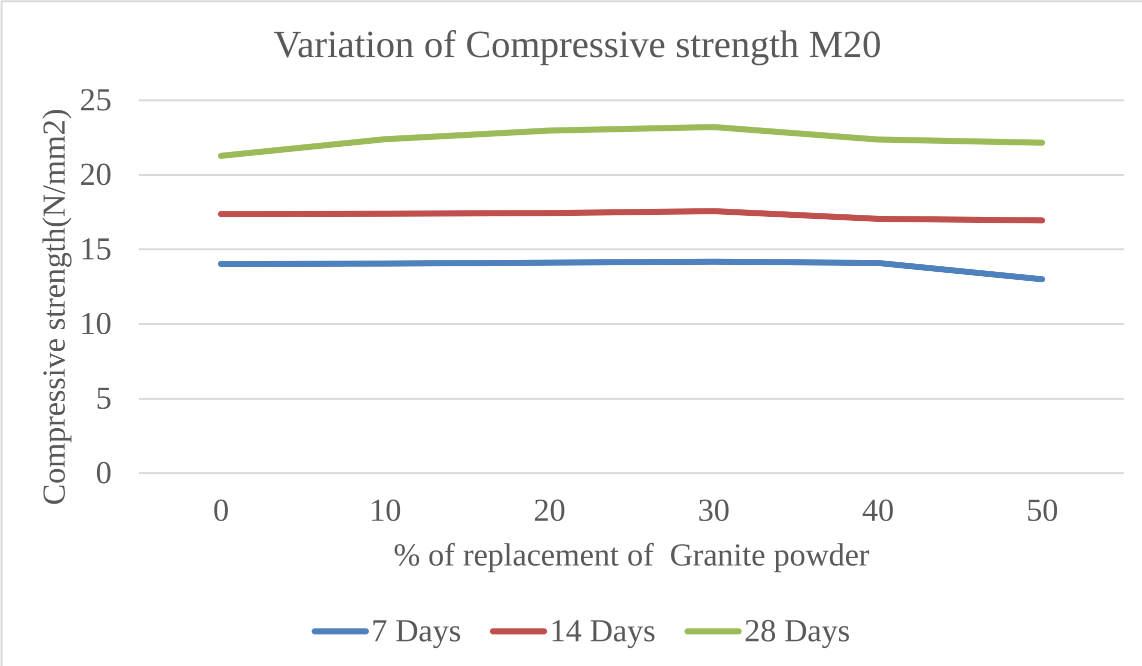
III. Experimental Results

The following table 2 and graph 1 illustrates the compressive strength of concrete of grades of M20 with 25% weight replacement of cement with RHA and (0%, 10%, 20%, 30%, 40 % and 50%) fine aggregate with granite powder not subjected to chemical attack.

Table 2 Average Compressive Strength of M20

M20		Compressive strength (N/mm^2)		
% ofRHA	% of Granite powder	7 days	14 days	28 days
0	0	14.02	17.37	21.27
25	10	14.05	17.40	22.40
25	20	14.12	17.45	22.98
25	30	14.18	17.57	23.20
25	40	14.09	17.05	22.37
25	50	13.01	16.95	22.15

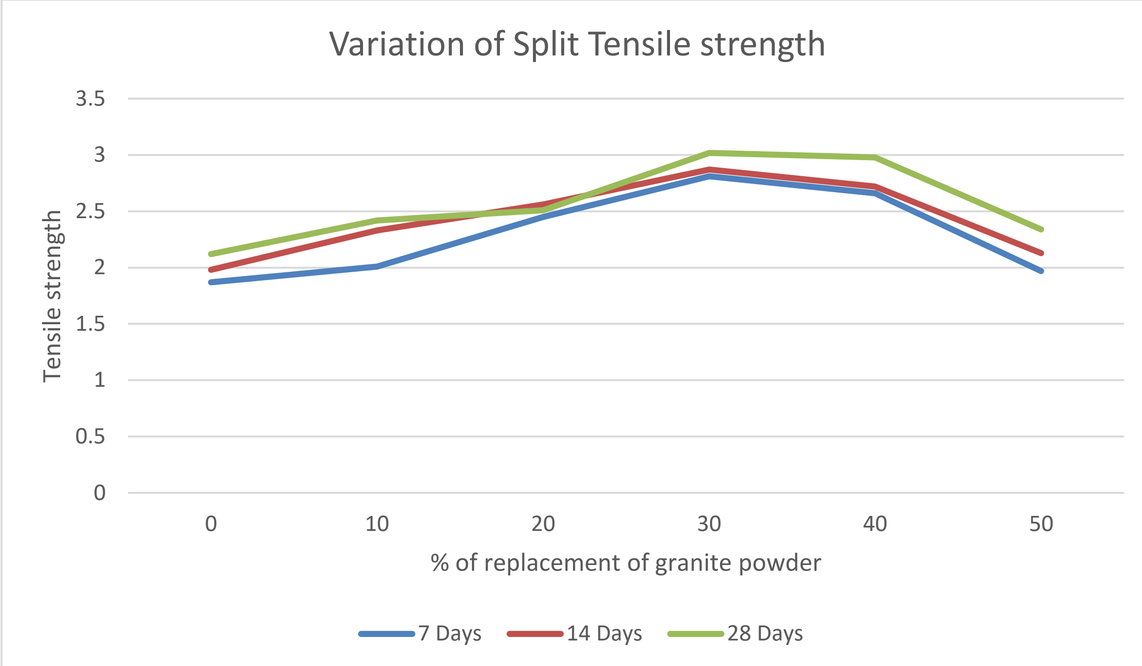
Graph-1: Compressive strength of M20 Concrete (N/mm^2)



The following table 3 and graph 2 illustrates the Split tensile strength of concrete of grades of M20 with 25% weight replacement of cement with RHA and (0%, 10%, 20%, 30%, 40 % and 50%) fine aggregate with granite powder not subjected to chemical attack.

Table 3 Average Split Tensile Strengths of Cylinders (M20)

% of Replacementof RHA	% of Replacement of Granite powder	Tensile strength (N/mm^2)(M20)		
		7days	14days	28days
0	0	1.87	1.98	2.12
25	10	2.01	2.33	2.42
25	20	2.45	2.56	2.51
25	30	2.81	2.87	3.02
25	40	2.66	2.72	2.98
25	50	1.97	2.13	2.34

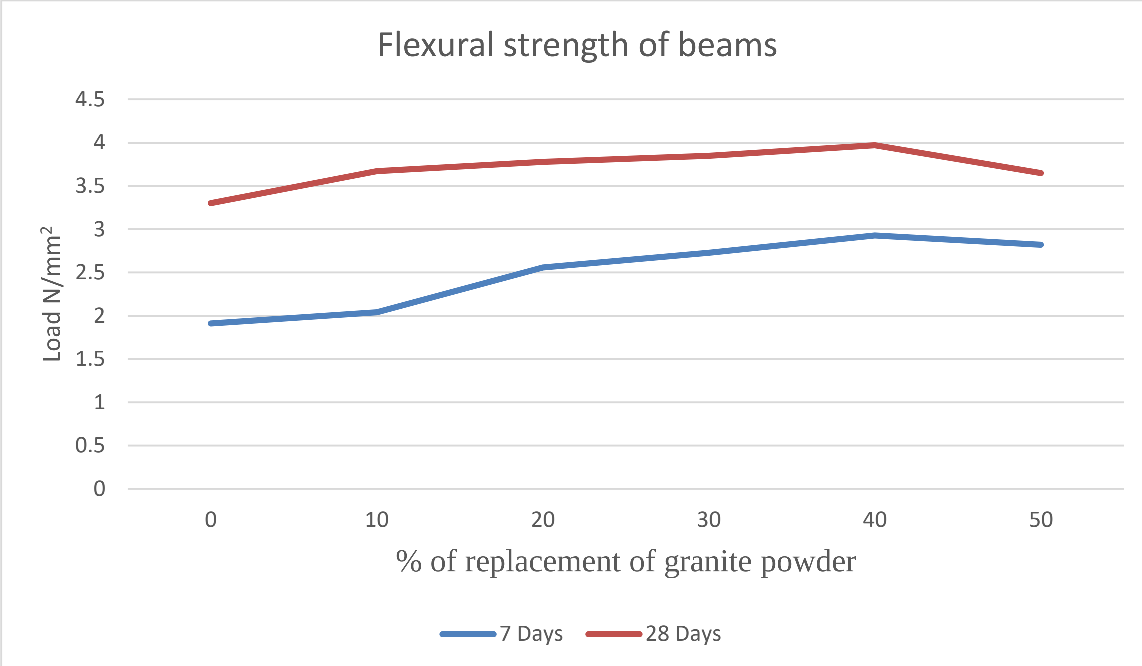


Graph -2: Split tensile strength of M20 Concrete (N/mm2)

The Table 4 and graph 3 illustrates the flexural strengths of concrete of grades M20 with 25% weight substitution of cement with RHA and (0%, 10%, 20%, 30%, 40%, and 50%) fine aggregate with granite powder, not subjected to chemical attack.

Table 4 : Average Flexural Strengths of Beams (M20)

% of substitutionof RHA	% of substitutionof Granite powder	Flexural strength (N/mm^2) (M20)	
		7days	28days
0	0	1.91	3.30
25	10	2.04	3.67
25	20	2.56	3.78
25	30	2.73	3.85
25	40	2.93	3.97
25	50	2.82	3.65

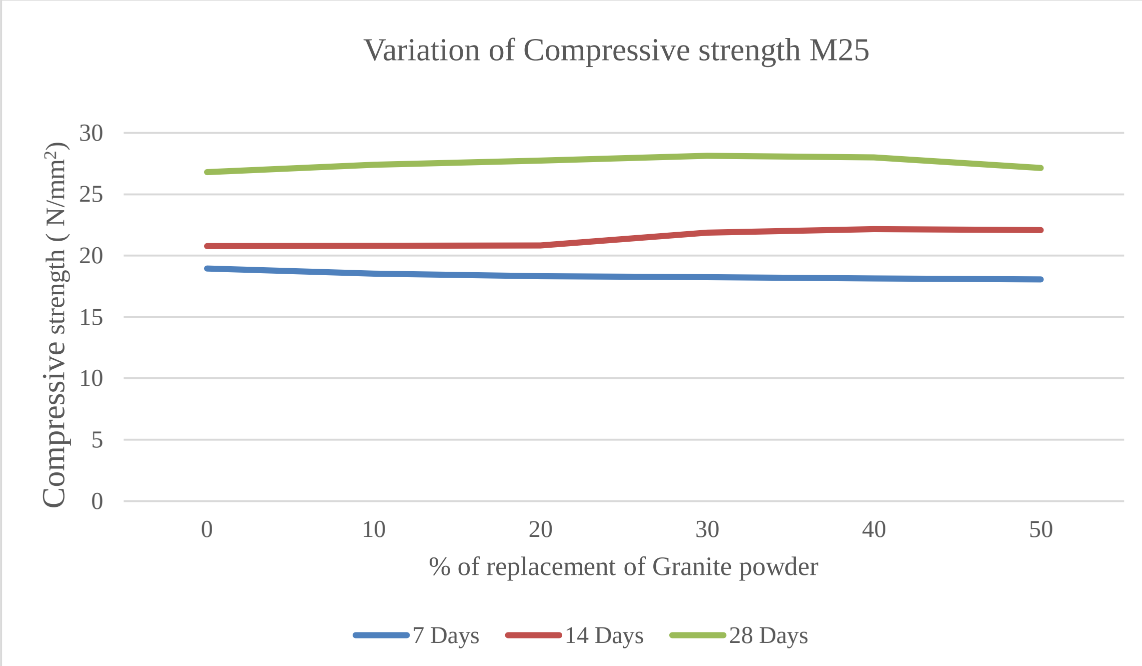


Graph 3: Flexural strength of M20 Concrete (N/mm2)

The following table 5 and graph 4 illustrates the compressive strength of concrete of grades of M25 with 25% weight replacement of cement with RHA and (0%, 10%, 20%, 30%, 40 % and 50%) fine aggregate with granite powder not subjected to chemical attack.

Table 5: Average Compressive Strength of M25

M25		Compressive strength (N/mm^2)		
% ofRHA	**% of Granite powder**	**7 days**	**14 days**	**28 days**
0	0	18.95	20.77	26.8
25	10	18.53	20.80	27.42
25	20	18.32	20.82	27.75
25	30	18.25	22.88	28.15
25	40	18.13	22.15	28.01
25	50	18.06	22.09	27.15

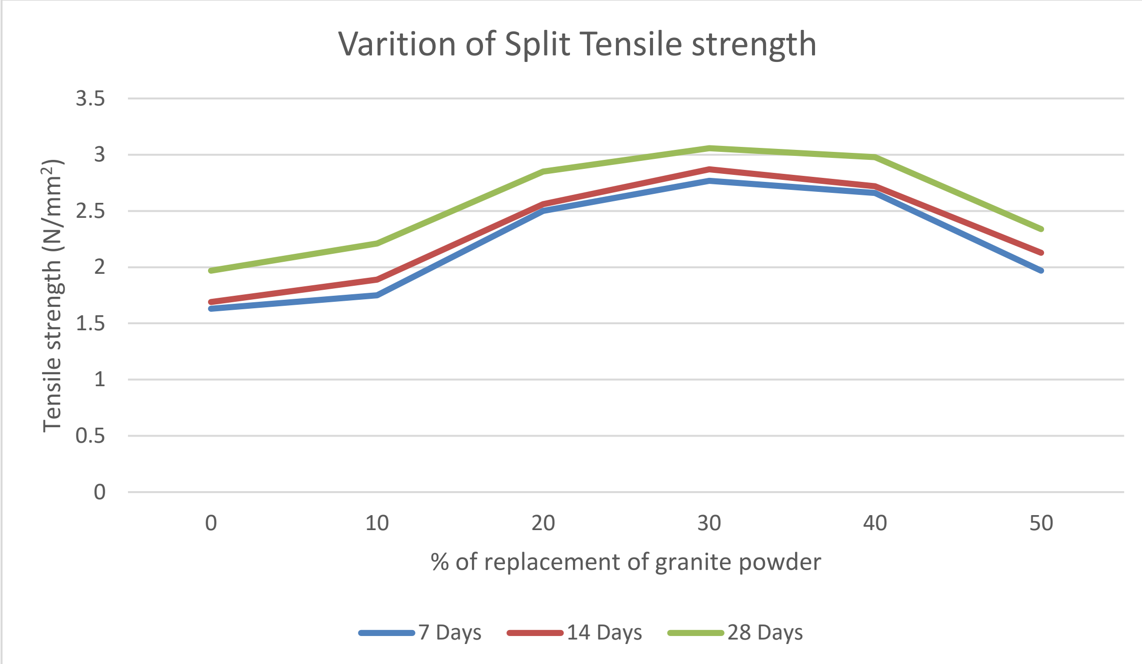


Graph 4: compressive strength of M25

The following table 6 and graph 5 illustrates the Split tensile strength of concrete of grades of M25 with 25% weight replacement of cement with RHA and (0%, 10%, 20%, 30%, 40 % and 50%) fine aggregate with granite powder not subjected to chemical attack.

Table 6 Average Split Tensile Strengths of Cylinders (M25)

% of Replacementof RHA	% of Replacement of Granite powder	Tensile strength (N/mm^2)(M25)		
		7days	14days	28days
0	0	1.63	1.69	1.97
25	10	1.75	1.89	2.21
25	20	2.50	2.56	2.85
25	30	2.77	2.87	3.06
25	40	2.66	2.72	2.98
25	50	1.97	2.13	2.34

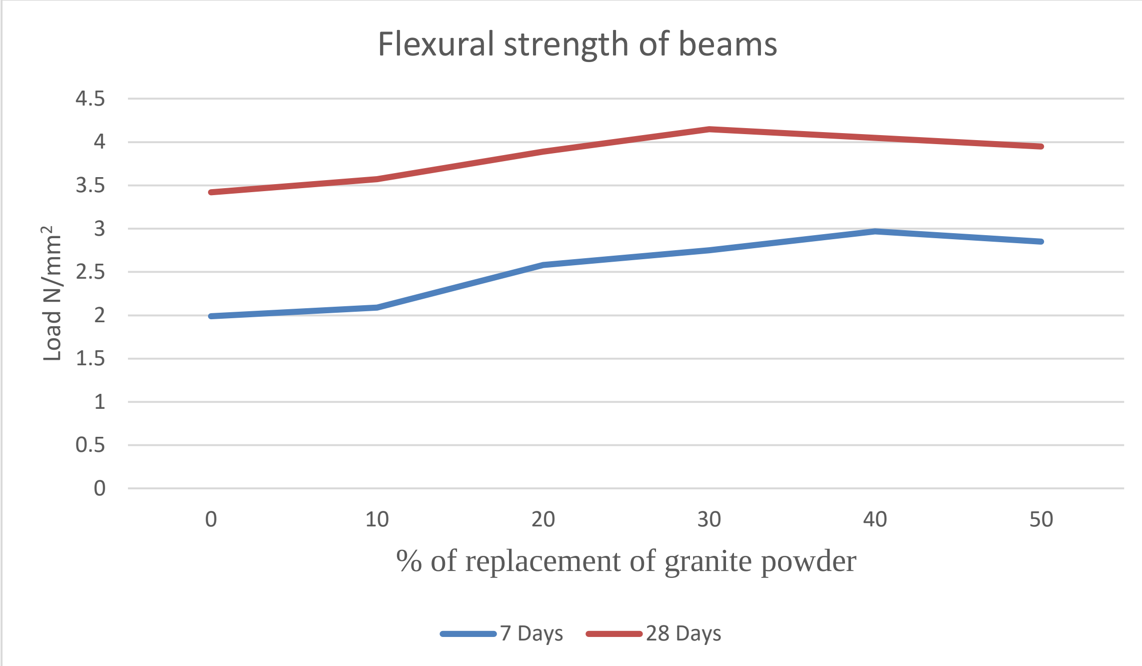


GRAPH-5: Split tensile strength of M25 Concrete (N/mm2)

The Table 7 and graph 6 illustrates the flexural strengths of concrete of grades M25 with 25% weight substitution of cement with RHA and (0%, 10%, 20%, 30%, 40%, and 50%) fine aggregate with granite powder, not subjected to chemical attack.

Table 7 Average Flexural Strengths of Beams (M25)

% of substitutionof RHA	% of substitutionof Granite powder	Flexural strength (N/mm^2) (M25)	
		7days	28days
0	0	1.99	3.42
25	10	2.09	3.57
25	20	2.58	3.89
25	30	2.75	4.15
25	40	2.97	4.05
25	50	2.85	3.95

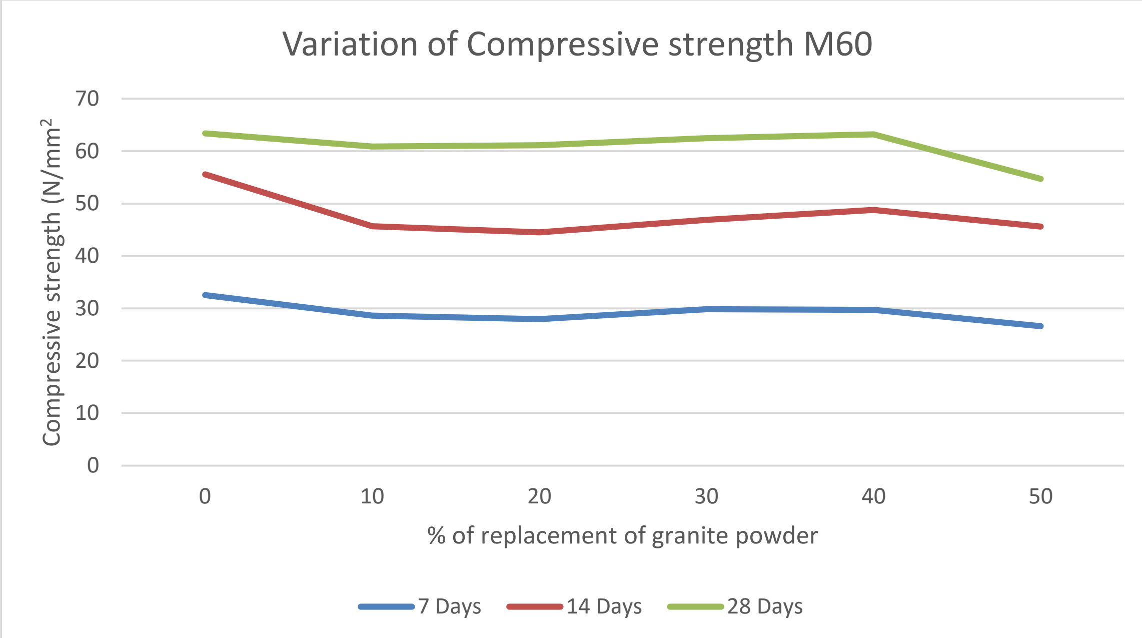


Graph 6 Flexural strength of M25 Concrete (N/mm2)

The Table 8 and graph 7 illustrates the compressive strengths of concrete of grades M60 with 25%weight substitution of cement with RHA and (0%, 10%, 20%, 30%, 40%, and 50%) fine aggregate with granite powder, not subjected to chemical attack.

Table 8 Average Compressive Strengths of Cubes (M60)

% of Replacement of RHA	% of Replacement of Granite powder	Compressive strength (N/mm^2)(M60)		
		7days	14 days	28days
0	0	32.52	55.6	63.4
25	10	28.60	45.65	60.90
25	20	27.93	44.50	61.12
25	30	29.81	46.92	62.5
25	40	29.70	48.8	63.20
25	50	26.62	45.60	54.71

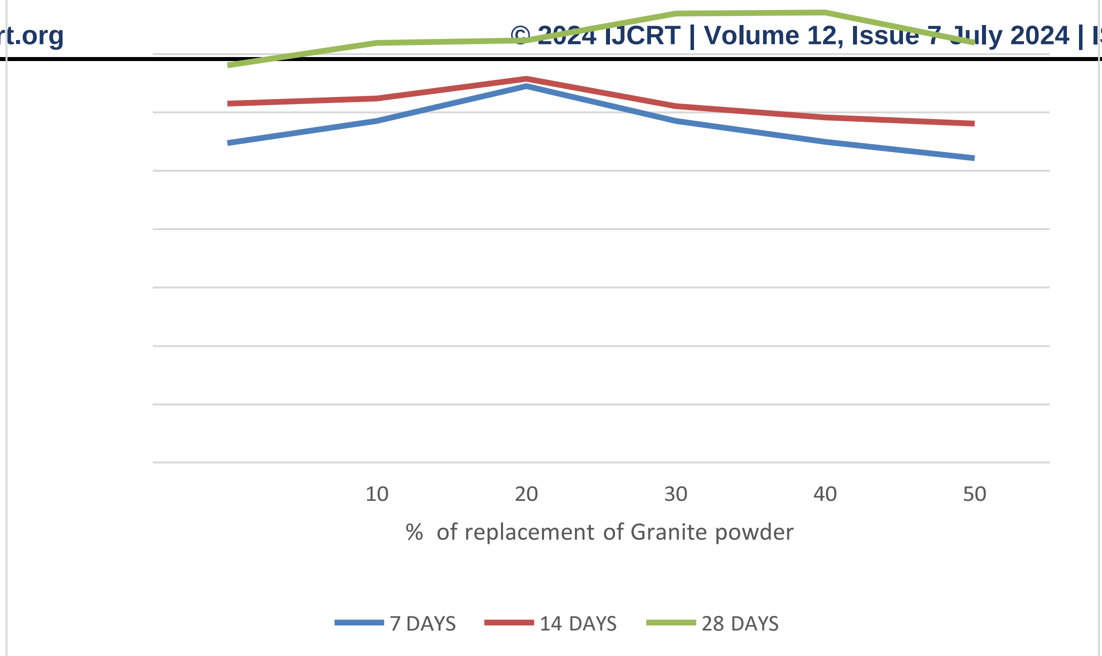


GRAPH-7: Compressive strength of M60 Concrete (N/mm^2)

The following table 9 and graph 8 illustrates the Split tensile strength of concrete of grades of M60 with 25% weight replacement of cement with RHA and (0%, 10%, 20%, 30%, 40 % and 50%) fine aggregate with granite powder not subjected to chemical attack.

Table 9 Average Split Tensile Strengths of Cylinders (M60)

Replacement of RHA in %	Replacement of Granite powder in %	Split Tensile strength (N/mm^2)		
		7days	14days	28days
0	0	2.737	3.076	3.403
25	10	2.928	3.119	3.595
25	20	3.225	3.288	3.616
25	30	2.928	3.055	3.866
25	40	2.752	2.958	3.854
25	50	2.609	2.906	3.598

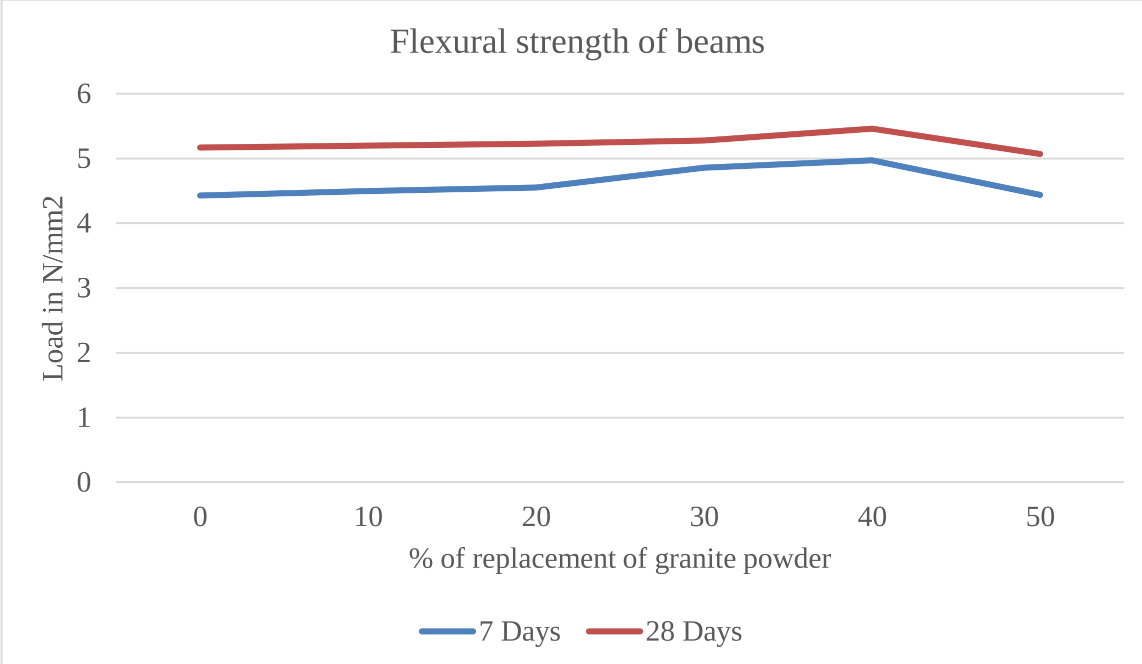


GRAPH-8: Split Tensile strength of M60 Concrete (N/mm2)

The Table 10 and graph 9 illustrates the flexural strengths of concrete of grades M60 with 25% weight substitution of cement with RHA and (0%, 10%, 20%, 30%, 40%, and 50%) fine aggregate with granite powder, not subjected to chemical attack.

Table 10 Average Flexural Strengths of Beams (M60)

% of replacement of RHA	% of replacement of Granite powder	Flexural strength (N/mm^2)	
		7days	28days
0	0	4.43	5.17
25	10	4.50	5.20
25	20	4.55	5.23
25	30	4.86	5.28
25	40	4.97	5.46
25	50	4.44	5.07



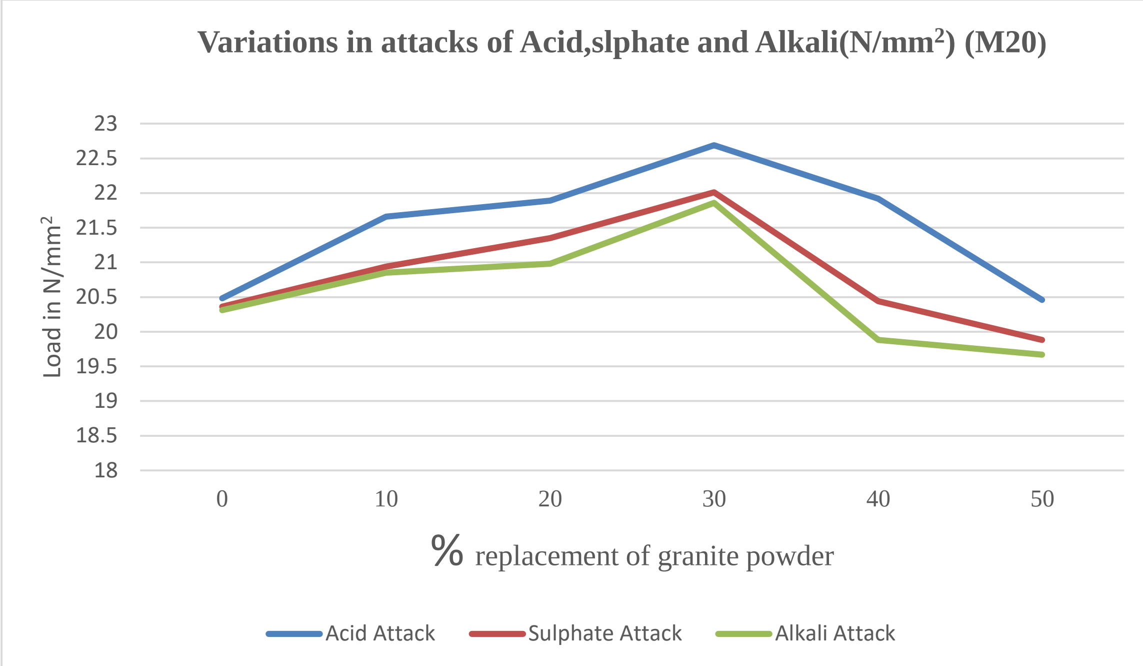
Graph 9: Flexural strength of M60 Concrete (N/mm2)

The following Table 11 and graph 10 illustrates the compressive strengths of concrete of grades M20 with25% weight substitution of cement with RHA and (0%,10%,20%, 30%, 40%, and 50%) fine aggregate with granite powder, subjected to chemical attack.

Table 11

Average Compressive Strengths of Cubes Subjected to Chemical Attack: (M20)

% of replacement of RHA	% of replacemnt of Granite powder	Compressive strength (N/mm^2) after 28days subjected to chemical attack(M20)		
		Acid Attack	Sulphate Attack	AlkaliAttack
0	0	20.84	20.36	20.31
25	10	22.66	20.94	20.85
25	20	21.98	21.35	20.98
25	30	22.89	22.01	21.86
25	40	22.92	20.44	19.88
25	50	20.66	19.88	19.67



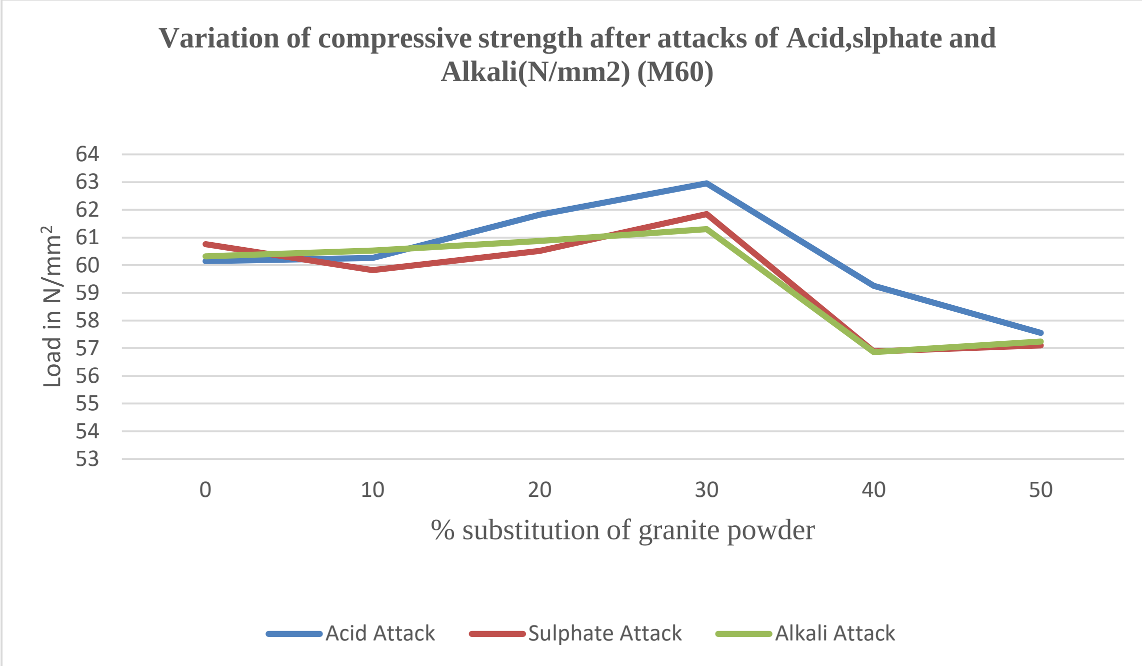
Graph 10: Compressive strength of M20 Concrete (N/mm2)

The table 12 and graph 11 illustrates the compressive strengths of concrete of grades M60 with 25% weight substitution of cement with RHA and (0%, 10%, 20%, 30%, 40%, and 50%) fine aggregate with granite powder, subjected to chemical attack.

Table 12

Average Compressive Strengths of Cubes Subjected to Chemical Attack: (M60)

% of replacement of RHA	% of replacementof Granite powder	ıpressive strength (N/mm^2) after 28 dayssubjected to chemical attack(M60)		
		Acid Attack	Sulphate Attack	Alkali Attack
0	0	60.14	60.76	60.32
25	10	60.26	59.82	60.53
25	20	61.82	60.52	60.87
25	30	62.95	61.85	61.3
25	40	59.26	56.88	56.86
25	50	57.55	57.1	57.24



Graph 11: Compressive strength of M60 Concrete

IV. DISCUSSION

The cube compressive strength results are obtained after the curing process of 7, 14, and 28 days for different replacement levels of 0%, 25% weight replacement of cement with RHA and 0%, 10%, 20%, 30%, 40%, and 50% of fine aggregate with granite powder. The Strength thus developed for the given different mixes is plotted as a graph and is shown in Figures. From the test results, it is noticed that the strength increased up to 30% of Replacement of sand with waste granite powder and then decreases, while it is more than 30% for M20, M25 and M60 mixes, but in the case of flexural strength, the strength increased till 40% replacement and then decreased, at 25% replacement of cement with RHA. Thus, the maximum strength is obtained for a mixture of 25% of RHA and 30% of granite powder replacement at the water-binder ratio of 0.45 for M20 and 0.35 for M60 mixes in case of compressive and split tensile strengths, and 40% replacement will be optimum for flexural strength.

CONCLUSION

1) Replacement of fine aggregate with granite powder is found to improve the strength ofconcrete.

2) The optimal dosage of replacement is found to be 30%.

3) Utilization of granite powder will reduce the usage of river sand and conserve natural resources.

4) The compressive strength of concrete cured in normal water for 28 days have reached the targetmean strength.

5) Utilization of rice husk ash and its applications are used for the development of construction industry, material science.

6) It is possible alternative solution of safe disposal of rice husk ash.

7) At 25% replacement of rice husk ash gives maximum strength and shows good resistance.

8) The concrete mixture containing RHA and granite powder presented higher tensile strength.

FUTURE SCOPE

1) The future study can be carried out by fixing the substitution percentage of thegranite powder as 30% and varying the RHA substitution percentage and conductingthe strength and durability tests on concrete.
2) The same experimental study can be carried out with adopting other grades.
3) The same experimental study can be carried out with partial substitution of fine aggregate with similar ingredients like Fly ash, silica fume etc.,
4) Chemical attacks may be calculated using this mixture of concrete.

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