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EXPERIMENTAL INVESTIGATION ON CONCRETE WITH PARTIAL REPALCEMENT OF PEBBLES SAND AS A FINE AGGREGATE

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ABSTRACT:

Concrete is the main building material used in construction today. It consists of cement, fine aggregate, coarse aggregate and water. Fine aggregates are needed in large quantities to produce concrete. Generally, river sand is used as fine aggregate. Due to the increase in the use of concrete in the construction industry, the demand for river sand has increased significantly. This scenario demonstrates how environmental concerns and the high price of natural river sand interact. As a civil engineers, we have intended to employ an alternate material to replace the river sand, which is frequently used in construction sector. One of the finest solutions for this issue is pebble sand which is grained version of pebbles stone. The pebbles sand has been tested in accordance with the code for fineness modulus, specific gravity and water absorption test. This study examines the mechanical properties of concrete grade M30 using pebbles sand as a fine aggregate. The six categories of concrete were each replaced with 20% incremental increase of pebble sand by weight to obtain the concrete's fresh and hardening behavior. According to the results of this investigation, river sand might replace with 60% of the Pebbles sand in concrete which is performed well in all aspects, compared to conventional concrete. In this study, it was concluded that the Concrete's behaviour was noticeably reduced when Pebbles sand was replaced more than 60% into river sand.

Key words: Pebbles sand, Chemical Composition, Workability, Strength, Optimum content.

INTRODUCTION:

Concrete, the most popular building material in the world is a heterogeneous composite made of a variety of frequently available regular materials, such as cement, water, coarse and fine aggregate, and depending on the situation, admixtures, fibres, or other additions. When these components are combined, a fluid mass is shaped that is easy into any form. When the cement has adequately dried, it eventually creates a tough matrix that holds the other materials together to create strong matter are known as concrete. Since ancient times, humans have used concrete to create innovative structures. Concrete consumption is rising extremely day to day around the world as a result of the current housing explosion and other growth activities in the construction industry. According to a research released by the United Nations Environment Program, 12 billion tones of concrete are produced annually throughout the world. Concrete is widely used in the construction industry due to its adaptability, dependability, and sustainability as well as its strength, stiffness, durability, mold ability, effectiveness, and affordability.

In general, the volume of the concrete is made up of 60% to 75% of the fine and coarse aggregates. Since the aggregate forms the primary matrix of concrete, it is crucial to obtain the proper type and high quality aggregate on site. The most popular coarse aggregates used in concrete are crushed stone and gravel, whereas river sand or natural sand is utilized as the fine aggregate. The predicted need for sand in the upcoming several years would be between 500 and 550 Mt, based on the ratio of sand to the anticipated cement consumption in the nation. River sand has historically served as the primary source of supplies, but the Green Tribunal's current limits due of worries about environmental deterioration have prompted research into alternative sources. Whereas quarry dust, M sand, and industrial wastes have been actively explored and are being used to a large amount, it has become vital to look for other sources as well because demand is tremendous and merely a few alternatives will not be sufficient to meet demand over the long term. One such substitute with considerable availability could be Pebbles sand (P-sand) which is prepared by crushing the pebbles stone into fine grains. In this study, the engineering characteristics and behaviour of concrete made with partially replaced by pebbles sand will be discussed.

Materials Used in Concrete:

The choice of each component is crucial to the concrete's strength. This study examines the physical and chemical characteristics of a variety of substances, including cement, fine aggregate, coarse aggregate, pebble sand, water, and superplasticizer, which are used to create concrete. Figure 1 depicts the materials used in this study.

Fig 1 Materials Used in Concrete.

1. **Cement**

In this investigation, ordinary Portland cement (OPC) of grade 53 was utilised. Cement is typically used in concrete as a binding agent to bind all of the solid elements. To determine the physical qualities, testing were conducted in accordance with Indian Standard codes; the findings are listed in table 1.

Table 1 Properties of Cement

S.No	Physical Property	Result
1	Specific Gravity	3.14
2	Consistency	34%
3	Initial Setting Time	30 Min
4	Final Setting Time	320 Min

2. River Sand

Typically, river sand is employed as the fine aggregate in concrete. In this experiment, concrete was partially replaced with river sand. In this experiment, concrete was partially replaced with river sand. The river sand used for concrete is sharp-grained, chemically static, free of clay, and clean. The river sand's particle size ranges from 4.75 to 150 microns.

3. Pebbles sand

Pebbles sand is obtain from crushing and grinding of pebbles stones. The advantageous of pebbles sand doesn’t contain impurities like silt, clay and any other organic matters. Pebbles sand has proper gradation of fine aggregates and thus voids are filled completely. When compared to other materials, like river sand, the cost is inexpensive. Table 2 displays the physical characteristics of river sand and pebbles sand.

Fig 2 Pebbles Sand

Table 2 Physical Properties of Fine Aggregate

S.No	Physical Properties	River Sand	Pebbles Sand
1	Specific Gravity	2.67	2.74
2	Fineness Modulus	2.78	2.92
3	Zone	II	III
4	Water Absorption	0.15%	0.17%
5	Bulk Density	1582 kg/m^3	1620 kg/m^3

4. **Coarse aggregate**

From a nearby quarry, crushed granite stone aggregate has been obtained. The largest coarse aggregate size is 20 mm. According to Indian Standard (IS 2386 Part III). The fineness modulus, specific gravity, and water absorption of coarse aggregate were measured. Crushed stone has a 2.74 specific gravity and a 6.72 fineness modulus. Aggregates that were rounded and lengthy were eliminated. Because they might cause the concrete's bond to collapse. When the concrete was being mixed, the coarse aggregate was saturated.

5. **Water**

The hydration process in concrete is sparked by a reaction between water and cement. This process ultimately results in the creation of C-S-H gel. For the purpose of this experiment, concrete was made in the laboratory tap water. For this study, a water cement ratio of 0.45 was chosen. 186 kg/m3 of water in total was consumed.

6. **Superplasticizer**

Water reducer Superplasticizer (SP) has a 30% water reduction capacity. It was included to make freshly laid concrete easier to deal with. Sulfonated Naphthalene Formaldehyde Condensate CONPLAST SP 430, which complies with IS: 9103-1999 and is a high performance superplasticizer with a specific gravity of 1.18 at 25°C, was utilised in this work. Following numerous trials of mixing the concrete, 0.2% of Binder was selected as the optimal SP proportion.

EXPERIMENTAL INVESTIGATIONS:

In this investigation Pebbles sand was replaced with river sand. There are six different mixing proportions at 20% incremental of pebbles sand by weight replacement of River sand. Concrete mixtures were determined according to the specification of IS 10262-2019. With a w/c ratio of 0.45, the intended compressive strength is 30 MPa. The 50-75mm slump of the concrete mixture was maintained. The reference concrete mix ratio was determined to be 1:1.48:2.9. Table 3 provides the particular details for six concrete compositions.

Table 3 Details of Materials Quantity per m^3

Sl. No	Mix ID	Cement kg/m^3	River Sand kg/m^3	Pebbles Sand kg/m^3	Coarse Aggregate kg/m^3	Water kg/m^3	SP ml/m^3	Slump
1	CC	413	612	-	1198	186	826	65
2	R-80% + P-20%	413	489.6	122.4	1198	186	826	69
3	R-60% + P-40%	413	367.2	244.8	1198	186	826	62

4	R-40% + P-60%	413	244.8	367.2	1198	186	826	67
5	R-20% + P-80%	413	122.4	489.6	1198	186	826	74
6	R-0% + P-100%	413	-	612	1198	186	826	78

a. Mechanical Properties of Concrete:

1. Compressive Strength Test

The Concrete cube specimens of 150 x 150 x 150 mm were used in the test, which was conducted in accordance with IS 516-1959, to ascertain the compressive strength of concrete at ages 7 and 28. Figure 3 depicts the concrete cube specimen testing setup. A total of 36 cube specimens were cast, and for one sample, three specimens underwent testing in order to estimate the average compressive strength. Compression testing equipment with a 3000 kN maximum capacity was used for the testing. The failures of concrete cube specimens as a result of ultimate load are depicted in Figure 4. The results of concrete's mean compressive strength are displayed in Table 4

Table 4 Compressive Strength

Fig 3 Compressive Strength test setup

Fig 4 Failure Pattern of Concrete Cube Specimens

2. Split Tensile Strength Test

At the age of 28 days, the universal testing machine performed the Split Tensile strength test for concrete on a cylinder specimen with a 150 mm diameter and 300 mm height. Between the loading surfaces, a cylinder specimen was positioned horizontally, and the load was applied continuously until the specimen failed. Table 5 contains the results, and Figure 5 displays the cylinder specimen test system.

Table 5 Split Tensile Strength

Mix ID	Size of the Specimen in mm	Mean Split Tensile Strength in N/mm2
CC	150 Dia. x 300 Ht.	4.88
R-80% + P-20%	150 Dia. x 300 Ht.	4.46
R-60% + P-40%	150 Dia. x 300 Ht.	4.49
R-40% + P-60%	**150 Dia. x 300 Ht.**	**5.48**
R-20% + P-80%	150 Dia. x 300 Ht.	3.93
R-0% + P-100%	150 Dia. x 300 Ht.	3.93

Fig 5 Split Tensile Strength test setup

3. Flexural Strength Test

Total of 18 prism specimens sized 100 x 100 x 500 mm were cast and allowed to cure for 28 days. Flexural strength tests were performed in accordance with Indian code provisions. The experimental setup and several failure mechanisms for the flexural strength test are depicted in Figures 6 and 7, respectively. Table 6 lists the test results.

Fig 6 Flexural test setup

Fig 7 Failures of Prisms

Table 6 Flexural Strength Test

4. Modulus of Elasticity Test

When considered as elastic, concrete's modulus of elasticity assumes substantial significance. In these studies, the modulus of elasticity of concrete was ascertained using cylindrical specimens with dimensions of 150 mm in diameter and 300 mm in height. The samples are analysed using a 3000 kN AIMIL digital compression testing machine in accordance with IS: 516-1959 following a 28-day curing time. Figure 8 and Table 7 depict the testing setup and outcomes.

Fig 8 Modulus of Elasticity test setup

Table 7 Modulus of Elasticity test

RESULT AND DISCUSSION

In this study, six variations of concrete, including reference concrete, were tested in this study utilizing various combinations of fine aggregate ingredients. The concrete samples were examined in terms of their strength and durability.

Compressive Strength:

The most frequent test is the compressive strength test because it determines the majority of mechanical attributes. In order to compare the cube compressive strengths of five different pebble-sand concrete types and ordinary concrete, The test results were reported in table 4 and the compressive strength of pebbles and sand concrete was assessed after 7 and 28 days of curing. High strength concrete made with a combination of river sand and pebble sand (40 percent and 60 percent, respectively) was attained. At 60% replacement of fine aggregate with pebble sand, the compressive strength of concrete improves, and the strength reduces in subsequent concrete mixes.

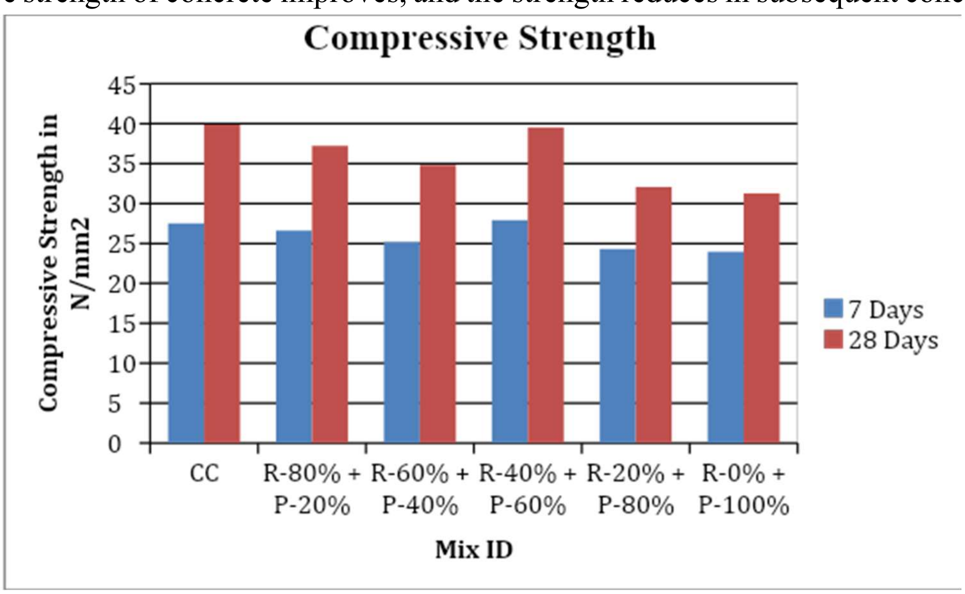

Fig 12 Compressive Strength

Split Tensile Strength:

To ascertain the tensile strength of cylindrical specimens, do a split tensile strength test. Figure 13 demonstrates that a concrete mixture with 60% pebbles and 40% sand has nearly identical strength to standard concrete in terms of split tensile strength. When compared to normal concrete, the remaining mixtures that are 80% and 100% replacement of pebbles and sand exhibit poorer split tensile strength.

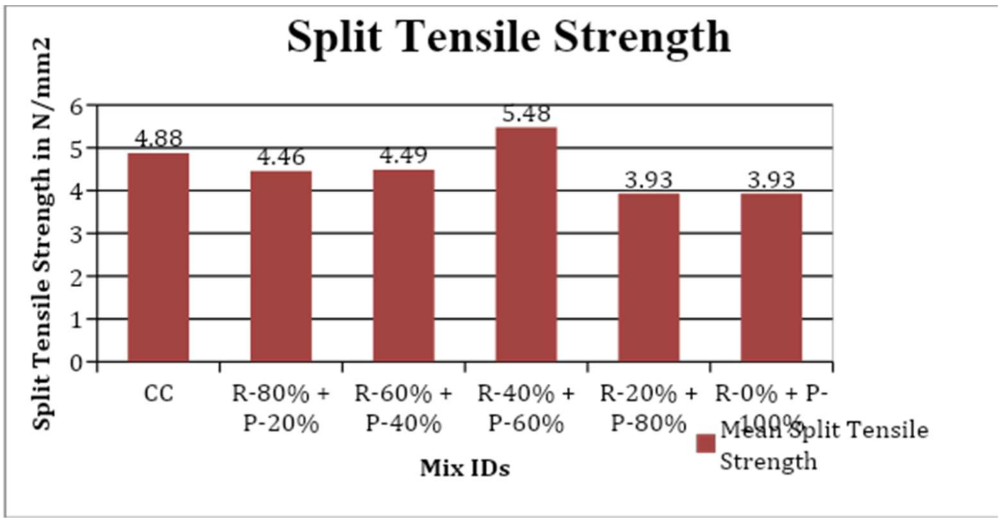

Fig 13 Split Tensile Strength

Flexural Strength:

To analyse the bending behaviour of prisms under two-point static loading conditions, flexural strength tests are used. When compared to traditional concrete prisms, the combination four, or 60% pebble sand concrete, fared well. When more pebbles sand is substituted for river sand, the flexural strength of pebble sand concrete somewhat declines. It demonstrates how many pores there are in concrete mixtures. The firm matrix of the concrete is made up of 40% river sand and 60% pebble sand.

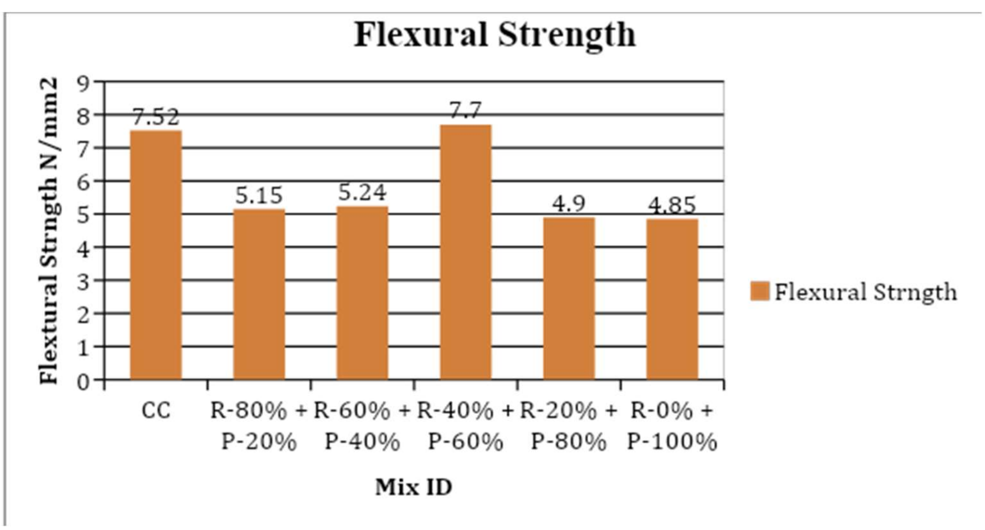

Fig 14 Flexural Strength

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Modulus of Elasticity

At 60% replacement of pebbles with river sand, the M30 grade of concrete has reached its maximum elastic modulus value. 33.84x103 Mpa is the appropriate number for the modulus of elasticity. This number is marginally higher than that of regular concrete. The stress stain curve for all types of concrete is shown in Figure 16. Figure 15 presences comparisons between theoretical and experimental values for the modulus of elasticity.

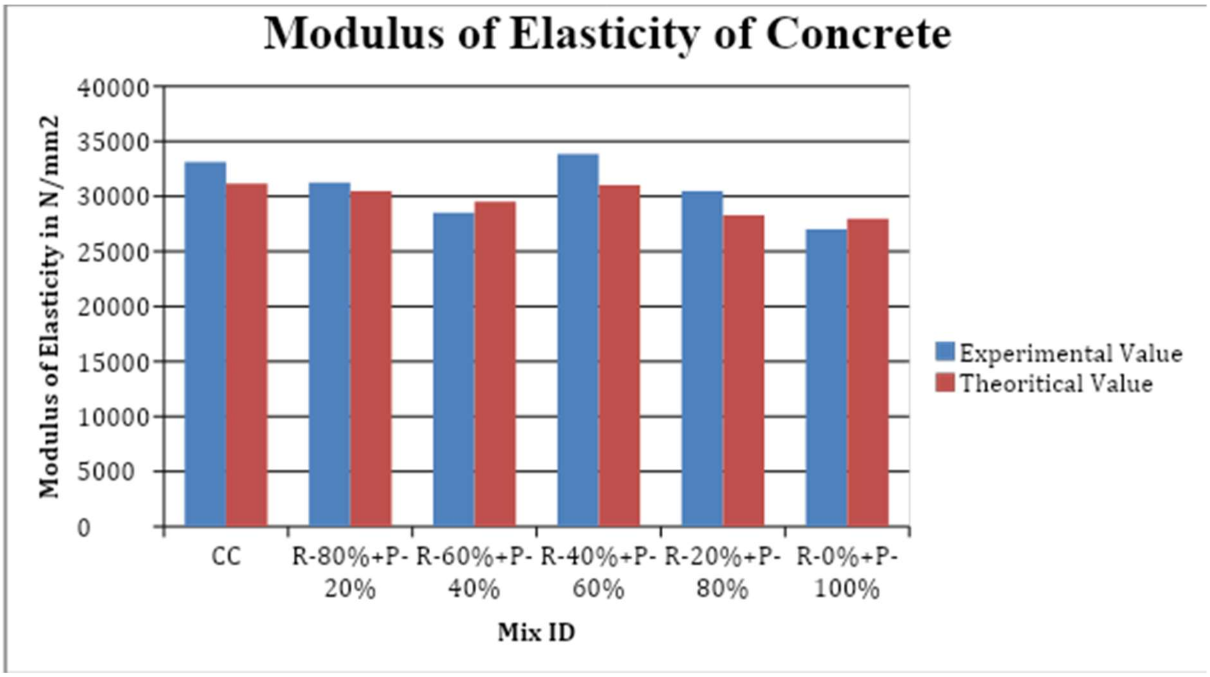

Fig 15 Modulus of Elasticity of concrete

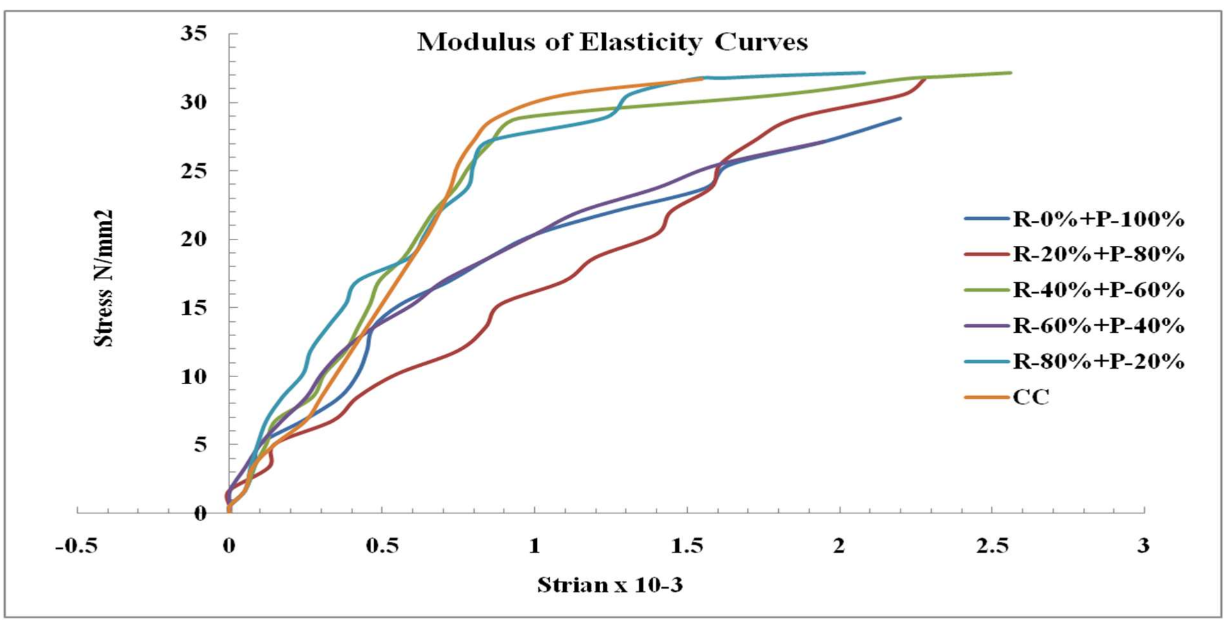

Fig 16 Stress – strain Curve of concrete

CONCLUSION

Based on the findings, the following conclusions are drawn.

1. All six of the fresh concrete mixtures have workability characteristics that fall between 50 to 75 mm. The fourth mixture, which consists of 60% pebbles and 40% river sand, has a slump value of 67mm.
2. The gradual substitution of fine aggregate at rates of 20%, 40%, 60%, 80%, and 100% 60% of the maximum replacement is discovered, giving the compressive strength values that are almost comparable. The compressive strength of conventional concrete is 39.89 N/mm^2, while that of pebbles sand concrete is 39.56 N/mm^2.
3. 5.48 N/mm2 was discovered to be the split tensile strength of cylinders made of pebble sand. It was 22.32 percent more than regular concrete.
4. It was discovered that standard concrete and pebble-and-sand concrete have flexural strengths of 7.52 N/mm^2 and 7.70 N/mm^2, respectively, for prisms. It was 2.39 percent more than regular concrete.
5. A combination of 60% pebble sand and 40% river sand was found to have a 33848 N/mm^2 modulus of elasticity for cylinders. It was 8.27 percent more than regular concrete.

Hence from the study, it was discovered that pebble sand 60% can effectively replace in river sand as a substitute material.

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