

Utilisation of Granite Chips as a Supplementary Coarse Aggregate Material

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Abstract

Background/Objectives: Concrete mixture consists of cement, fine and coarse aggregates. India possesses a wide variety of stones such as granite, marble, stone, sandstone, limestone and many others. Here, the properties of granite chips are studied and compared with the conventionally used aggregate material. Since granite is a lighter material compared to aggregates, its use in concrete will lead to reduced self weight on members and hence reduced dead load on columns and eventually, the foundation system. **Methods/Statistical Analysis:** Concrete cubes and cylinders of standard dimensions of M20 grade are cast. Four mix ratios are adopted, ranging from fully conventional concrete to concrete with coarse aggregate completely replaced with granite chips. Compressive strength and split tensile strength tests were conducted on all the test specimens at 7-days, 21-days and 28-days time periods. **Findings:** Based on the compressive strength test and split tensile strength test in the laboratory on various proportions with granite chips as coarse aggregate and it is compared with the conventional concrete. **Applications/Improvements:** It is concluded that concrete with 10% replacement of granite chips possesses great strength and since granite chips, considered here are recycled materials, this usage is not only beneficial stability-wise, but also cost-wise.

Keywords: Concrete, Granite, Mixed Aggregate, Recycled, Strength

1. Introduction

Concrete is a man-made construction material that is widely used. It is obtained by mixing cement, water and aggregates (and sometimes admixture) in required proportions. Aggregates provide higher volume, stability and better durability than cement paste in concrete and provide around 75 per cent of the body of concrete¹. The aggregates are obtained from natural sources. But in regions where natural rock deposits are scarce, burnt-clay bricks are used as an alternative source of coarse aggregate. Since granite is a lighter material compared to aggregates, its use in concrete will lead to reduced self weight on members and hence reduced dead load on columns and eventually, the foundation system². Concrete that has a mixture of coarse aggregate and granite chips in certain

proportion will have more strength than the sum which has coarse aggregate completely replaced with granite chips. Hence, this study on the replacement of coarse aggregate by granite chips in concrete, will be carried out through studying the properties of the mixed aggregate concrete mix.

2. Materials Used

2.1 Aggregates

Fine aggregates are the aggregates whose size are less than 4.75 mm. Example sand is used as fine aggregate in the preparation of concrete and cement mortar. Fine aggregate is the inert or chemically inactive material, most of which passes through a 4.75 mm IS

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sieve and contains not more than 5 percent coarser material. Properties of aggregates are presented in Table 1.

Table 1. Properties of aggregates

Properties	Fine aggregate	Coarse aggregate	
		Stone chips	Granite chips
Bulk specific gravity	2.65	2.61	2.6-2.7
Water absorption	2.05	0.35	0.27
Fineness Modulus	1.60	7.28	7.35
Unit weight, kg/m ³ (dry, compacted)	---	1653.4	1650

2.2 Cement

Cement is the main binder that coats the aggregate developing a good bonding between them, thereby inducing strength characteristics of pervious concrete. After concluding all the tests for cement the various physical parameters are evaluated and indicated in Table 2. In short, the cementitious content, maintains the void structure, maintains point to point aggregate contact and maintains the paste thickness.

It is recommended for various research studies to adjust the cementitious content to coat the aggregate with 3.75 mm thickness. The cement content is most important as an excessive cement separates aggregate with paste. Also, lower strength, shrinkage and warp and curl are the main frailties of the past. Portland Pozzolana Cement containing the pozzolanic materials like fly ash, blast furnace slag and silica fume can also be used. However, use of pozzolanic materials will affect setting time, strength, porosity and permeability of the resulting concrete.

Table 2. Properties of cement

Test conducted	Observed values
Specific gravity of cement	3.15
Consistency	35%
Initial setting time	28 min
Final setting time	60min

2.3 Granite as an Aggregate Material

Granite is the material, traditionally used in the construction of monuments. It is one of the hardest and most durable of substances. It can withstand extreme weather conditions. It is in fact, one of the main reasons

it is used in the construction of monuments³. Different varieties of granites are available from specific regions of the world. Chemical composition for the material are listed in Table 3.

Table 3. Chemical composition

Name	Percentage
SiO ₂	72.04%
Al ₂ O ₃	14.42%
K ₂ O	4.12%
Na ₂ O	3.69%
CaO	1.82%
FeO	1.68%
Fe ₂ O ₃	1.22%
MgO	0.71%
TiO ₂	0.30%
P ₂ O ₅	0.12%

2.3.1 Physical Properties

- Co-efficient of Expansion: This parameter for granite vary from 4.8×10^{-6} to 9.0×10^{-6} .
- Porosity/Permeability: Granite has very less porosity and it ranges between 0.1 to 0.4%.
- Variegation: Granite shows consistency in color and texture.
- Thermal Stability: Granite is a thermally sound material and hence it shows no change with the variations in temperature. Granite has high resistance to chemical erosion that makes it useful for making tanks to store highly reactive substances⁴.

2.3.2 Uses of Granite

Granite has been extensively used as a dimension stone and as flooring tiles in public and commercial buildings and monuments. Engineers make use of polished granite surface plates to create a plane of reference, since they have very less perviousness and flexibility. Sand blasted concrete with a heavy aggregate content appears similar to rough granite and is often used as a substitute when use of real granite is not practical.

3. Results and Discussion

The specimens are casted as per IS Standards and they have decribed in Table 4.

Table 4. Dimensions of specimens

Material Properties	Shape	Dimensions of theSpecimens
Compressive Strength(7,21 and 28 days)	Cube	150x150x150 mm
Split Tensile Strength(7,21 and 28 days)	Cylinder	150x300mm

3.1 Adopted Mix Design

Proper mix design is selected and as per IS codes the design procedure is calculated and tabulated in Table 5.

Adopted Grade	:	M20 (1:1.5: 3).
Water Cement Ratio	:	0.45.
Volume	:	0.15 x 0.15 x 0.15 m.

Table 5. Adopted mix ratio

Material	100% Replaced	10% Replaced	20% Replaced	30% Replaced
Cement	1.35 Kg	1.35 Kg	1.35 Kg	1.35 Kg
Sand	2.025 Kg	2.025 Kg	2.025 Kg	2.025 Kg
Gravel	0	3.645 Kg	3.24 Kg	2.835 Kg
Granite Chips	4.05 Kg	0.405 Kg	0.810 Kg	1.215 Kg
Water	0.675 Lt.	0.675 Lt.	0.675 Lt.	0.675 Lt.

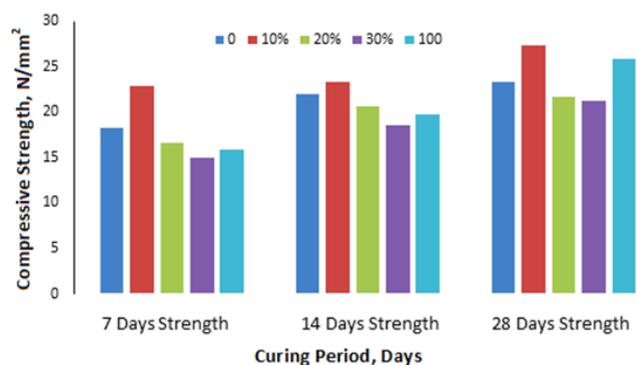
3.2 Preparation and Testing of Specimens

It is essential that the coarse aggregates are saturated at their surfaces before mixing with other ingredients. The aggregates and cement are first subjected to dry mixing for about 2 minutes. Then water is added into the mix and the mixing operation is continued for about 2 minutes to produce a uniform mix. Additional water, taking into account the water absorption properties of aggregate materials are added to the mix. Slump test is carried out to observe the workability of the mix. The slump values are checked to see if the workability is sufficient. The cubic moulds are filled with this mix into 3 layers, giving 25 blows for each layer with a tamping rod. The moulds are removed 24 hours after casting. It is essential that the specimens are kept out after demoulding before curing them.

3.3 Compressive Strength Test

This is one of the most important test that is used to study the strength of hardened concrete⁵. After curing the specimen is taken out from the curing tank and excess water is wiped out from the outer surface of the specimen.

The dimension of the specimen is noted down to compute the strength of the concrete. Clean the testing surface of the compressive strength test machine. place the specimen in the machine in such a manner that the load shall be constantly applied to the opposite sides of the cube cast. Align the specimen to the centre of the testing pad of the strength test machine. Rotate the arm portion gently so that it should contact with the top surface of the specimen. The load is gradually applied without shock and continuously at the rate of 140 kg/cm²/minute till the specimen fails and the percentage of variation is shown in Figure 1. Record the maximum load and note down any unusual pattern in the type of failure and the compressive strength is tabulated in Table 6.

**Figure 1.** Compressive strength test result.**Table 6.** Compressive strength results

Percentage of Granite	Compressive Strength		
	7-Days	21-Days	28-Days
0	16.6	19.5	21.7
10	20.32	23.88	30.3
20	17.15	22.5	25.6
30	15.7	22	24
100	10.18	18.4	19

3.4 Split Tensile Strength Test

Split tensile strength test knowledge of tensile strength of concrete is of great importance. Take the specimen has been taken out from water after specified days of curing. The water is wiped out from the surface of specimen, the weight and dimension of the specimen is recorded. Set the compression testing machine for the required range. Plywood strip has kept on the lower and upper plate of the surface and the specimen is placed between them.

Figure 2 represents the split tensile strength of concrete. Apply the load gradually without shock at a rate of approximately 14-21 kg/cm²/minute (which corresponds to a total load of 9900 kg/minute to 14850 kg/minute). The corresponding load has been noted and the strength is calculated and tabulated in Table 7.

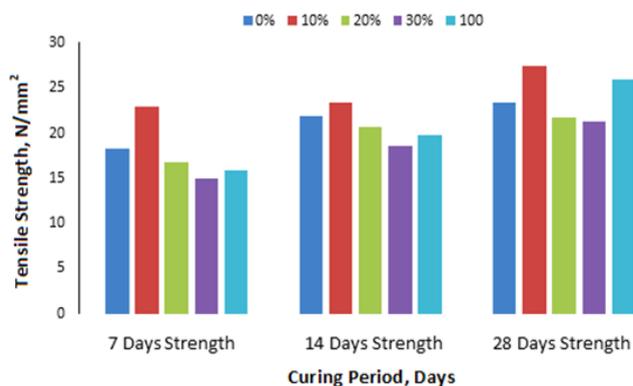


Figure 2. Split tensile strength.

Table 7. Split tensile strength results

Percentage of Granite	Split Tensile Strength		
	7-Days	21-Days	28-Days
0	18.3	21.93	23.36
10	22.9	23.4	27.4
20	16.7	20.6	21.70
30	15	18.5	21.3
100	14.9	17.8	20.9

4. Conclusion

Based on the compressive strength test and split tensile

strength test in the laboratory on various proportions with granite chips as coarse aggregate. The authors obtain optimum strength on replacing 10% of granite chip with granite chips. The compressive strength of the specimens increases in the percentage of the granite which results to increases in strength. The split tensile strength of the five different percentage of granite is added and the day wise the strength get increased, when the percentage of granite increases the strength get decreases.

5. References

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