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Compressive Strength and Durability Properties of M35 Grade Concrete by Replacing Sand Partially with Vermiculite and Granite Powder and Coarse Aggregate by Re-Cycled Aggregate

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Abstract. The Construction Industry is one of the industries contributing highest GDP in Indian economy. The material that is most chosen in construction Industry is concrete. Concrete is a material made with Cement, Fine aggregate in the form of sand, Coarse aggregate in the form of gravel and water. With increasing scarcity of sand, construction works are coming to jolt and thereby increasing the need for choosing an alternative material. Vermiculite is a material which after exfoliation can be used as a filler material replacing sand partially without affecting strength much. One more material Granite (by product which is a waste is causing lot of environmental Issues), produced from granite industry, is available in India in several million tons. Coarse aggregate generally used is a crushed aggregate obtained from rocks like granite, basalt and soon. Recycled aggregate is an aggregate which is obtained after demolishing of an existing building, which is a waste causing economical in balance and which if put into use can not only decrease the construction cost but also make this waste into a better use. In the present study, for a M35 grade of concrete, Vermiculite (0, 5%, 10% and 15% of weight of sand) and granite powder (fixed at 10% of weight of sand used) is used to replace sand partially and in the place of normal coarse aggregate, recycled aggregate is used which is 20 mm passing and 12 mm retained After preparation of Mix-Design(1:1.83:2.69 with w/c ratio of 0.38) the concrete cubes are casted to test for compressive strength after curing for 28 days, 56 days and 90 days. Forsec brand super plasticizer is used to take care of workability requirements. Durability test in the form of resistance to attack of sulphuric acid was conducted along with compressive strength. The test results were promising at 10% replacement levels of Vermiculite.

1. Introduction

The construction industry is consisting of unorganized companies working as subcontractors making significant contribution to national economy both by increased GDP as well as in providing employment. In construction sector there are three segments like real estate combined with residential and commercial constructions. In the construction industry, in the presence of concrete elements

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depending on work inherent nature of the infrastructure or capital formation industry, capital goods are used directly and indirectly with all other types of resources.
Concrete is combination of material made from sand, gravel and cement. The cement is a mix of various minerals which when mixed with water, hydrate and roughly become strong binding the sand and gravel into a solid mass. Cement, normally in powder form, acts as a binding agent when mix with water and aggregates. This combination, or concrete mix, will be dipped and harden into the durable material.
Workability is the most important one of these properties. The workability is necessary in a concrete mix and it is totally depends upon the purpose for which is used and the equipment and methods used in placing and handling it in work. The concrete strength is the next important attribute to be considered. Unit volume of concrete with a fixed amount of cement, the hardened and most impermeable concrete is one that has the greatest density, i.e., the given unit volume is that which has the largest percentage of solid materials.

2. Review of literature

According to Lakshmi Kumar Minapu et.al (2014), an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M30 using the light weight aggregate. Pumice stone is used as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume are adopted. By using 20% of light weight aggregate as a partial replacement to natural coarse aggregates the compressive strength results are promising. Syed Abdul Rahman et.al (2016) in their study on structural light weight aggregate concrete revealed that the 10% replacement of vermiculite of fine aggregate when compared to control mix yielded better results.

According to Dr D.V. Prasad Rao(2017), this study combined influence of Ston dust and Metakaolin on compressive strength, split tensile strength, flexural strength and modulus of elasticity of M30 grade of concrete is investigated. Finally they found that the various strength characteristics of concrete can be improved by the addition of 15% of Metakaolin and 60% of quarry dust content.

According to study conducted by Dr.K.Chandrasekhar Reddy and G.Ashok (2017) on " A study of durability properties of concrete using Geo cement and Vermiculite", he revealed that for M35 grade concrete after experimentation that at 10% replacement of Vermiculite the water absorption is very less when compared with other mixes and conventional samples after soaking for 28 days.

According to Gumma Soumya(2018),this work intended to study the impact of concrete by partially replacement of cement with silica fume and fine aggregate with quartz sand. The optimum percentages of substitution of silica fume and quartz sand in concrete was found to be 10% and 60%.

According to study of C.Sangeetha and S.Manikandan (2018), on 'Performance of Concrete using Dolomite and Vermiculite as Partial Replacement of Cement and Fine Aggregate', for M30 grade concrete with 20% replacement of Vermiculite has given slightly better compressive strength when compared with Conventional concrete.

2.1 From the literature review, the objectives drafted are:

To find whether any improvement of compressive strength is there with partial replacement of Natural sand with fixed percent of Granite and variable percentages of Vermiculite when recycled coarse aggregate is used.

Further this study also aims to compare weights of various mixes of vermiculite with Conventional Concrete when recycled coarse aggregate is used.
This study also aims in studying the ability of Vermiculite based mixes in resisting Acid attack when prepared with recycled coarse aggregate.

3. Materials and methods

In this study Ordinary Portland cement (with fineness as retained on 90 micron sieve) of 53 grade was used as per IS code. In the production of concrete, River sand of size of that is 4.75mm and less is used as Fine Aggregate. The Re-Cycled coarse aggregate an important material of concrete with size of 20mm is used in this concrete. Water used in this study is free from acid, dust, suspended materials and having PH value ranging between 6 to 8.

Vermiculite material is a low density material of phyllo-silicate mineral group and good in insulating and acoustic properties. Even though Vermiculite is a costlier material, it has superior properties of thermal insulation and good acoustic behavior and can be adopted.

Granite powder is Quartz sand that is recently weathered from granite or gneiss quartz crystals will be angular. It is called Grus in geology or *sharp sand* in the building trade where it is preferred for concrete, and in gardening where it is used as a soil amendment to loosen clay soils. The properties of Cement, Fine aggregate (Natural Sand, Vermiculite and Granite) and Coarse aggregate are shown in Table 1to Table 3.

Table 1: Properties of cement

S.NO	Properties	Results	Permissible Limits as per IS 12269-1987
1	Specific gravity	3.15	3.10-3.25
2.	Fineness of modulus	2.1%	<10%
3.	Normal consistency	27%	-
4.	Initial setting time	32 minutes	30 minutes (minimum)
5.	Final setting time	271 minutes	600 minutes (maximum)

Table 2: Properties of fine aggregate

Properties	Results			Permissible Limits as per IS 383-1970
	Natural Sand	Vermiculite	Granite	
Specific gravity	2.48	2.55	2.6	2.5-3.0
Bulking	18 at 6%	20 at 6.5%	21 at 6.5%	-
Fineness of modulus	3.48	3.5	2.35	2-3.5
Grade	Zone-I			
Size	< 4.75mm			

Table 3: Properties of Recycled Coarse aggregate (RCA)

S.NO	Properties	Results	Permissible Limits as per IS 383-1970
1	Specific gravity (20mm)	2.9	2.5-3.0
2	Flakiness index	21.96%	35% maximum
3	Elongation index	19.19%	35% maximum
4	Aggregate impact value	14.98%	45% maximum
5	Fineness modulus	2.65	
6	Shape	Angular or flaky	

The granite fines at 10% of weight of fine aggregate is fixed and vermiculite at 5%, 10%, and 15% of weight of Natural sand is fabricated and Tested as depicted in Table 4 as Mix Proportions .

Table 4: Mix Proportions

Mix	Cement	Fine Aggregate	Coarse Aggregate
Conventional Concrete	100% Cement	100% Fine Aggregate	100% Normal Aggregate
M1	100% Cement	90% FA+10% Granite+ 0%	100% Recycled Aggregate
M2	100% Cement	85% FA+10% Granite+ 5%	100% Recycled Aggregate
M3	100% Cement	80% FA+10% Granite+ 10%	100% Recycled Aggregate
M4	100% Cement	75% FA+10% Granite+ 15%	100% Recycled Aggregate

After preparation of Mix-Design(1:1.83:2.69 with w/c ratio of 0.38) the concrete cubes are casted and cured for 28 days, 56 days and 90 days. Forsec brand super plasticiser is used to take care of workability requirements. The tests conducted on concrete cubes include Compressive strength, water absorption and durability test (Resistance to Acid attack).

4. Results and discussions

The Vermiculite is a special material which not only decreases structural weight but also exhibits inertness and is good thermal insulator. When compared with Weight of Conventional Mix and all other Mixes M1, M2, M3, the M4 exhibited fewer weights, as shown in Table 5. This study is in accordance to that study results of Dr. K. Chandra Sekhar Reddy and G. Ashok at 10% of Vermiculite replacing Fine Aggregate. They achieved the results using Geo cement but instead in this study along with Vermiculite, Granite powder is used to replace partially natural sand and Recycled coarse aggregate is used in the Place of Gravel. Results shown that at 10% of Vermiculate (M3) is effective in

improving compressive strength of Concrete cubes prepared.

Table 5: Weight of concrete mixes

S.No	Mix	Weight of Concrete at 28 Days (KG)
1	CC	8.71
2	M1	8.20
3	M2	7.94
4	M3	7.68
5	M4	7.17

From Table 5, it is clear that Weight of Concrete when compared with conventional sample is less. The compressive strength of cubes of 15 cm x 15 cm x 15 cm made with M35 grade both with conventional concrete and with Mixes of M1, M2, M3 and M4 are conducted using compression testing machine.

Table 6: Compressive strength of Concrete Cubes

Concrete Mix	End of 7 Days	End of 14 Days	End of 28 Days	End of 56 Days	End of 90 Days
Conventional Concrete	29.86	32.71	38.73	40.91	41.87
M1	30.84	33.92	39.77	41.38	42.89
M2	31.70	34.55	40.14	41.92	43.02
M3	32.83	35.61	40.53	42.41	43.96
M4	31.45	34.39	39.04	40.92	42.85

Here M3 is giving better results as depicted in Table 6 when compared with other mixes as well as

conventional mixes. The reason may be attributed to reduction in voids at 10% of vermiculite replacing the Fine aggregate at fixed 10% of Granite Fines. The test results are supported by the results of study of Sangeetha et.al and Abdul Rahman et.al. However unlike them, in this present study Recycled aggregate along with fixed percentage of Granite Fines is used.

Table 7: Durability of Concrete Cubes (Resistance to Acid Penetration)

Mix	Weight of Cubes after 28 days before immersing in Acid (KG)	Weight of Cubes after 28 days After immersing in Acid (KG)	% Loss	Compressive Strength of Cubes after 28 days before immersing in Acid	Compressive Strength of Cubes after 28 days before immersing in Acid	% Loss
Conventional Concrete	8.71	8.12	6.78	38.73	37.62	2.87
M1	8.20	7.73	5.73	39.77	38.87	2.26
M2	7.94	7.57	4.65	40.14	39.35	1.94
M3	7.68	7.37	4.03	40.53	39.76	1.89
M4	7.17	6.62	7.67	39.04	38.21	2.04

From the Table 7, it is clear that M3 mix is absorbing less water content and also showing less reduction in compressive strength when compared with Other Mixes and conventional samples. The reason may be attributed to improved resistance to Acid attack due to usage of Recycled aggregate at an appropriate usage of Vermiculite content in filling the air voids and improving the Compressive strength.

5. Conclusion

From the Study it can be inferred that there is an improvement in Compressive strength at 10% replacement of Natural sand with Vermiculite and at Fixed 10% replacement of Natural sand with Granite fines. By increasing the vermiculite content in Natural sand at a fixed 10 percentage of Granite, the weight of concrete cubes decreased and recorded lowest at 10% replacement levels. Vermiculite based mixes exhibited better durability when compared with conventional mixes, even though Recycled aggregate is used in the place of normal aggregate. The reason may be attributed to improved texture at later dates thus improving compressive strength of specimens.

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