Comparison of Mechanical Properties of M35 and M40 Grade Concrete after Percentage Replacement of River Sand with Vermiculite

M. Uma[1] P. Balakrishna[2]
[1]PG Student
[1,2]Department of Civil Engineering
[1,2]KMM Institute of Technology & Sciences, Tirupati, India

Abstract— To determine the influence of application Geo Cement and different proportions of Vermiculite as replacement of sand. To produce an acidic resistance concrete with good workability and better strength to withstand harsh environmental conditions. Grades of Concrete tested are M35 & M40. To inquire effectiveness of partial replacement of sand by its weight with 10%, 15%, 20% of vermiculite. Proportions of Vermiculite is maintained constant (10%, 15% & 20%) for both the Grades (M35 & M40) of Concrete. To investigate the compressive force, split tensile strength, water absorption and Acid resistance test with various proportions of vermiculite which holds in the concrete. Comparison of test results obtained with conventional Geo cement concrete.
Key words: Reinforced Geopolymer Concrete; Tensile Strength; Water Absorption; Vermiculite; River Sand

I. INTRODUCTION

Concrete is the most widely used construction material after water in the world and ordinary Portland cement (OPC) is the major ingredient used in concrete. The production of cement releases large amount of carbon dioxide (CO2) to the atmosphere that significantly contributes to greenhouse gas emissions. It is estimated that one ton of CO2 is released into the atmosphere for every ton of OPC produced [1]. . In this field, a thermal insulated tile has been prepared with exfoliated Vermiculite. The vermiculite cement tiles have low water absorption, better strength properties and low thermal conductivity compared with conventional tiles. In this study water absorption, Flexural strength, compressive strength, Thermal conductivity tests is limited

The mechanical properties of Geo-polymer concrete(GPC) mixes with different aggregates blending and also combination of sodium hydroxide and sodium silicate solution was used as alkaline activator and conclude that optimum fine aggregate blending and also all Splitting Tensile Strength (STS) and Flexural Strength(FS) of all mixes were compared with ACI 363R, CEB-FIP and ACI 318R predicted equations [2]. The mechanical properties of Geo-polymer concrete(GPC) using granite slurry(GS) as sand replacement at different levels and cured at room temperature and concluded that optimum replacement level of GS used in place of sand and can solve the natural resources [3]. The load deflection relationships, crack pattern, ultimate load was obtained and compared with the experimental results available in literature and obtained results shows good agreement with the experimental results for comparative study of experimental and analytical results of FRP strengthened beams in flexure [2]. A study on the unretrofitted RC beam designated as control beam, RC beams retrofitted with CFRP composites in uncracked and precracked beams were studied in Ansys and The results obtained was in good agreement with the experimental plots [3]. The dynamic analysis of the composite beam was studied and values of Young Modulus, Poisson's ratio and shear modulus were determined by using Ansys [4]. Beams strengthened with Carbon Fiber Reinforced Polymer and the beams were modelled using ANSYS and the obtained results were compared with the experimental one and was found to be in good agreement [5]. The load deflection relationship, crack pattern and ultimate load were obtained and also comparison were done for the CFRP and GFRP and reported that the performance of beams with retrofitting with CFRP was better than the beams with retrofitting with GFRP by using Ansys[6]. An Analytical Investigation of Bonded Glass Fiber Reinforced Polymer Sheets with Reinforced Concrete Beam Using Ansys which has been used to study the strengthened behavior of the beam and gave the conclusion as the Deflections in the beams retrofitted with GFRP are less than RCC beam and for the same load the RCC beam with GFRP have the less stresses and strains. In the comparison cases both experimental and analytical results are coinciding [7]. The models which are analyzed has shown the same structural response and failure modes as found in the experimental investigation [8]. The modelling of RC beams with and without openings by using Ansys and were investigated on beam strength, stiffness, deformed shape, and cracked patterns by the experimental and theoretical results were concluded that the both results were showed satisfactory [9]. A theoretical and experimental study on mechanical properties and flexural strength of fly ash-geo polymer concrete using young's modulus, Poisson's ratio stress-strain relation and indirect tensile strength with four-point loading and as FEM and concluded after the results there were approximate values by comparing both the theoretical and experimental study [10].

II. EXPERIMENTAL STUDY

In the development of M35, M40 grade of concrete mix, it is necessary to select proper ingredients, evaluate their properties and understand the interaction among the different material for optimum usage. The ingredients used for this experimental investigation are Geo cement, fine aggregate (FA), Vermiculite, coarse aggregate, water. The following parameters involves the performance requirements of concrete to enhance

- Ease of placement and compaction without segregation
- Volume stability
- Early strength
- Long-term mechanical properties
- Long-term durability properties
- Toughness
- Longer service life

A. Materials

Geocement is a promise to reduce global warming by reducing carbon dioxide emission using a proprietary liquid Geo-binder with various industrial bye products viz. Flyash, Blast furnace slag etc. In the present investigation, two types of fine aggregates were used. One is the natural sand which is brought from the locally available river source and the other is Vermiculite. Natural sand is a weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. The sand particles consist of smaller grains of silica (SiO2). Now-a-days good sand is not readily available, which is transported from a long distance. Those available resources are also exhausting very rapidly. So it is a need of the time to find an alternative to natural river sand. The physical properties of vermiculite are shown in table 1

Melting point (°C)	1330
Specific heat(kj/kg)	1.08
Specific gravity (crude)	2.5
Mohs hardness(crude)	1-2
P^H (ISO 787-9)	7-8
% Loss at 105°C (expanded product)	<0.5
% Loss at 1000°C (expanded product)	<6
colour	Colourless, white, yellow, green, brown, black

Table 1:

B. Mix Proportions

An approach of choosing appropriate components of concrete and governing their moderate amounts with an objective of producing a concrete of the required strength, workability, durability and as economically as attainable, is termed as Mix Proportioning of Concrete. The proportioning of components of concrete is governed by necessitate performance of concrete in two states, i.e., plastic and the hardened states. If the concrete in plastic state is not workable, placement and compaction of concrete will not be proper. The effects of workability of concrete has vital importance.

The quantity and quality of cement; aggregates and water; mixing and batching; placing, compaction and curing are the important properties of concrete which plays an important role in the compressive strength of hardened concrete. The proportions of cement, aggregates and water will be taken in appropriate quantities so that the production of concrete will be more economical and the strength and durability will be maintained more effectively. From technical point of view, higher cement content and disorders in perfect proportions of ingredients in concrete leads to higher shrinkage and cracking in the structural concrete. The mix proportions of values of M35 and M40 are shown in table 2 and table 3.

S.No	Mix Identification	Cement (kg's)	Fine Aggregate		Coarse Aggregate (kg's)	Geo binder (lit)
			Sand (kg's)	Vermiculite (kg's)		
1	C.C	350	175	0	350	175
2	95% N.A + 5% VEREMICULITE	350	166.25	8.75	350	175
3	90% N.A + 10% VERMICULITE	350	157.5	17.5	350	175
4	85% N.A + 15% VERMICULITE	350	148.75	26.25	350	175
5	80% N.A + 20% VERMICULITE	350	140	35	350	175

Table 2:

S. No	Mix Identification	Cement (kg's)	Fine Aggregate		Coarse Aggregate (kg's)	Geo binder (lit)
			Sand (kg's)	Vermiculite(kg's)		
1	C.C	380	95	0	190	190
2	95% N.A + 5% VEREMICULITE	380	90.25	4.75	190	190
3	90% N.A + 10% VERMICULITE	380	85.5	9.5	190	190
4	85% N.A + 15% VERMICULITE	380	80.75	14.25	190	190
5	80% N.A + 20% VERMICULITE	380	76	19	190	190

Table 3:

III. EXPERIMENTAL INVESTIGATION

The experimental investigation is carried out to obtain the Compressive Strength, Split Tensile Strength, Flexural Strength and Water Absorption of M35 & M40 grade of concrete with replacement of Fine Aggregate by Vermiculite. In the present investigation, Concrete specimens were prepared with various percentages of Vermiculite (5%, 10%, 15%, 20%). After the completion of workability tests, the concrete has been placed in the standard metallic moulds in three layers and compacted each time by tamping rod. Before placing the concrete inner faces of the mould are coated with the machines oil for easy removal of test specimens and the surface of the specimens have been finished smoothly. After the casting of Cubes, The specimens are kept at room temperature for one day and the specimens are removed from the moulds after 24 hours of casting of concrete specimens. Marking has been done on the specimens to identify the casting items. To maintain the constant moisture on the surface of the specimens, they are placed in water tank for curing. All the specimens have been cured for the desired age. Concrete specimens are cured for 3, 7, 28 days.

Similarly ordinary M30 & M35 concrete Cubes, Cylinders & Standard Beams (size 100 mm × 100 mm × 500 mm) were casted as per the design mix proportion and cured under the above mentioned standard conditions for 28 days for testing

A. Compressive Strength Test:

Compressive strength is one of the important properties of concrete. Concrete cube of 150 x 150 x 150mm were cast. After 24 hours the specimen were de-moulded and subjected to water curing. After 7 and 28 days of curing of curing three cubes were taken and tested in compression testing machine. Compressive test is most common test conducted on hardened concrete, partly because it is an easy to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

The compressive test is carried out on specimens cubical or cylindrical in shape. Prism is also sometimes used, but it is not common in our country. Sometimes, the compressive strength of concrete is determined using parts of a beam is flexure and, because the beam is usually of square section, this part of the beam could be used to find out the compressive strength.

Fig. 1: Compressive Strength of Concrete

B. Split Tensile Test:

The split tensile strength tests of concrete can be broadly classified into direct and indirect methods. The first method suffers from a number of difficulties relating to placing or holding the specimen property in the testing machine without increasing the stress concentration and difficulties in applying axial load free of eccentricity on the specimen. Because of the difficulties involved in conducting the direct tension test, indirect test such as split tensile method has been used. Split tensile tests were conducted for various cylindrical specimens (150mm diameter * 300mm height) at the age of 7 and 28 days in the compression testing machine of capacity 200 tonnes. Cylindrical splitting tension test is also sometimes referred as "Brazilian test". This test was developed in Brazil in 1943. At about the same time this independently developed in Japan. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

Fig. 2: Split Tensile Strength Test

C. Ultimate Flexural Strength:

The deformations at this stage of loading are only a fraction of those occurring at the design service loads, but the results showed that the fibres are effective even when the extent of cracking is very slight. The visible first crack loads of the beams varied from the experimental failure loads.

The flexural rigidity at the point of maximum moment was calculated by dividing the bending moment by the curvature obtained from the concrete strain reading in the compression zone.

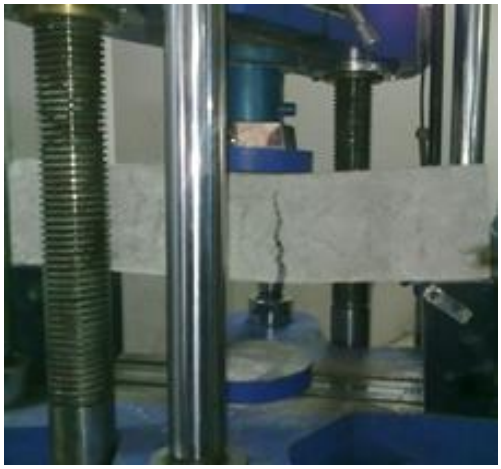

Fig. 3: Flexural Strength Test

IV. RESULTS AND DISCUSSION

Tests were conducted for workability on fresh concrete. Compressive Strength, Flexural Strength, Split Tensile Strength and Water Absorption were conducted on hardened specimens. Standard procedure was adopted for testing. The experimental program was designed to compare the Compressive Strength, Flexural Strength, Split Tensile Strength and Water Absorption of M35 and M40 grade of concrete and with different replacement levels of Fine Aggregate with Vermiculite. The program consists of casting and testing of specimens. The specimens of standard cubes (150mm X 150mm X 150mm), Prisms and standard cylinders of 150mm (dia) and 300mm (height) were cast with Vermiculite. Compression testing machine was used to test all the specimens.

A. Compressive Strength:

It can be observed that all proportions of Concrete with Vermiculite exhibits higher Compressive Strength compared to Controlled Concrete. But the Concrete with 10% Vermiculite exhibits higher compressive Strength. The percentage increase in Compressive Strengths of 5% Vermiculite, 10% Vermiculite, 15% Vermiculite & 20% Vermiculite are 7.09%,9.78%,2.57% &0.95% respectively shown in Table 4

Mix Designation	Vermiculite %	Compressive Strength (MPa) 28 Days
Control	0	42.13
5% Vermiculite	5	45.12
10% Vermiculite	10	46.25
15% Vermiculite	15	43.18
20% Vermiculite	20	42.53

Table 4: Experimental values of compressive strength of M35 Grade

B. Split Tensile Strength:

The split tensile strength of M35 grade of control concrete is 4.11 MPa. The split tensile strength of all the proportions of Vermiculite with Concrete exhibits improved strength compared to Control Concrete, The Concrete with 10% of Vermiculite possesses higher Split Tensile Strength when compared to all other proportions and with further increase in the content of Vermiculite, The percentage growth in split tensile strength decreases as shown in Table No. 6.2. The percentage increase in Split Tensile Strengths of 5% Vermiculite, 10% Vermiculite, 15% Vermiculite & 20% Vermiculite are 5.11%, 6.81%, 1.95% &0.73% respectively shown in Table 5.

Mix Designation	Vermiculite %	Split Tensile Strength (MPa)
Control	0	4.11
5% Vermiculite	5	4.32
10% Vermiculite	10	4.39
15% Vermiculite	15	4.19
20% Vermiculite	20	4.14

Table 5: Experimental values of Split Tensile strength of M35 Grade

C. Flexural Strength:

The Flexural strength of M35 grade of control concrete is 7.12 MPa. The Flexural strength of all the Proportions of Vermiculite exhibits improved strength compared to Control Concrete, The Concrete with 10% of Vermiculite possesses higher Flexural Strength when compared to all other proportions and with further increase in the content of Vermiculite , The Percentage in improvement of Flexural strength decreases as shown in Table No. 6.3. The percentage increase in Flexural Strengths of 5% Vermiculite, 10% Vermiculite, 15% Vermiculite & 20% Vermiculite are 5.01%, 6.6%, 1.72% &0.63% respectively as shown in Table 6

Mix Designation	Vermiculite %	Flexural Strength (MPa)
Control	0	6.38
5% Vermiculite	5	6.7
10% Vermiculite	10	6.81
15% Vermiculite	15	6.49
20% Vermiculite	20	6.42

Table 6: Flexural Strength

D. Water Absorption:

Water absorption characteristics of the concrete plays an important role for the durability of the structure. Ingress of water deteriorates concrete and in reinforced concrete structure, corrosion of the bars took place which results it no cracking and spalling of the concrete and ultimately reduce the life span of the structure. Test results of water absorption test are shown in Table 6.4. The result indicates that the water absorption of Concrete with Vermiculite is less compared to control concrete. Although the difference in % of gain in weight is very less.

Dry Weight (W_1)	Wet Weight (W_2)	% Gain in Weight $((W_2-W_1)/W_1) \times 100$
8.02	8.33	3.87
8.78	9.11	3.75
8.77	9.08	3.46
8.34	8.64	3.59
8.19	8.49	3.67

Table 7: Water Absorption

V. CONCLUSIONS

Using the results of the experimental investigation, it can be concluded that with the increase in the percentage of Vermiculite the various strength characteristics of concrete are increased up to 10%, with further increase in the Vermiculite the percentage increase in Compressive strength of concrete is decreased. The split tensile strength and flexural strength of concrete also indicated the similar trend

Compressive Strength:

1) Concrete containing 10% Vermiculite exhibits higher Compressive Strength compared to the rest. The Percentage increase in Compressive Strength goes up to 9.78 % for Concrete with 10% Vermiculite Specimens for M35 Grade of Concrete.
2) Similarly for M40 Grade of Concrete – The Concrete with 10% Vermiculite exhibits 11.20 % more Strength

than the control concrete and other Vermiculite proportions.

3) With further increase in content of Vermiculite – The Compressive Strength decreased further.

A. Flexural Strength:

1) 1.The percentage increase in Flexural Strengths of 5% Vermiculite, 10% Vermiculite, 15% Vermiculite & 20% Vermiculite compared to Control Concrete are 5.01%, 6.6%, 1.72% & 0.63% respectively for M35 Grade of Concrete.
2) 2.The percentage increase in Flexural Strengths of 5% Vermiculite, 10% Vermiculite, 15% Vermiculite & 20% Vermiculite compared to Control Concrete are 3.56%, 7.42%, 4.10% & 2.28% respectively for M40 Grade of Concrete.
3) 3.With further increase in content of Vermiculite (15% & 20%) – The Flexural Strength decreased compared to the Control Concrete for both M35 & M40 Grade of Concrete.

Similar trend is observed in Split Tensile Strength. The Percentage increase in Split Tensile Strength goes up to 6.81 % and 7.31% for 10% Vermiculite Specimens for M35 and M40 Grade of Concrete respectively.

B. Water Absorption:

Test results of water absorption test shows that the porosity of concrete with Vermiculite has less water absorption than the control concrete. It can be observed that Water Absorption for Control Concrete is 3.87% for M35 Grade of Concrete. The Water Absorption for the Concrete with Vermiculite is minimum when compared to Control Concrete. Least percentage in Gain of Weight is 3.46% for Concrete with 10% Vermiculite. It can be observed that Water Absorption for Control Concrete is 4.26% for M40 Grade of Concrete. The Water Absorption for the Concrete with Vermiculite is minimum when compared to Control Concrete. Least percentage in Gain of Weight is 3.98% for Concrete with 10% Vermiculite

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