Experimental Study on Concrete with Replacement of Fine Aggregate Using Vermiculite

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Abstract **- Concrete is one of the most extensively used construction material in the world. Aggregates are the major ingredients which occupy 60 to 80 percent of the total volume of concrete and greatly influence its properties, mix proportions and economy. Lack of fine aggregate can be solved by using vermiculite. Use of Vermiculite in concrete enhances the shrinkage and crack resistance, fire resistance, reduces environmental impact and also reduces the construction cost. The concrete mix design is done for M25 grade concrete. The main aim of this research is to study the strength parameters such as compressive strength and flexural strength of concrete using vermiculite as replacement with 0, 25, 50, 75 and 100% by weight.**

Index Terms **- Compressive strength, Fine aggregate, Flexural strength, Replacement, Vermiculite.**

I.INTRODUCTION

Vermiculite is a mica, a group of hydrated, magnesium – iron - aluminium silicate. Vermiculite is formed by weathering or hydrothermal alteration of biotite or phlogopite. Vermiculite is a rich mineral which is well known for its ability of exfoliation which expands rapidly when it is heated. Generally, vermiculite can resist the temperature up to 1200^{o} C. It is a low-density non-structural construction product system. It has specific property such as it is lighter in weight, odourless, improved workability, improved fire resistance, improved resistance to cracking and shrinkage. Use of thermally insulating materials impart comfort inside the room on one end and reduce the energy requirement for cooling in summer. It is mainly inert chemical nature. It is normally made simply by mixing exfoliated vermiculite as the aggregate with cement and water. The vermiculite used is shown in fig.1.1.

Fig.1.1 Vermiculite

II. OBJECTIVES

The objectives of this study are:

- To determine the behaviour of concrete using vermiculite as fine aggregate.
- Trial mixes by replacing 0, 25, 50, 75 and 100 percent of the weight of fine aggregate by vermiculite minerals.
- To study the strength properties with increasing the percentage values of vermiculite.
- To study the properties of vermiculite concrete with conventional concrete.
- To compare the variation of compressive strength and flexural strength at 7 and 28 days curing strength with conventional cubes and beams.

III. MATERIALS USED

3.1 Cement

The cement used was Portland Pozzolana Cement of PPC 53 grade confirming the Indian Standard code of 1489 (part 1) – 1991. Portland Pozzolana cement produces less heat of hydration and offers great resistant to the attack of aggressive water than normal Portland cement. Moreover, it reduces the leaching of calcium hydroxide liberated during the setting and hydration of cement.

3.2 Coarse aggregate

Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. The aggregate which passes through 20mm sieve and retained above 12.5mm sieve was used.

3.3 Fine aggregate

The sand particles should also pack to give minimum void ratio; as higher voids lead to requirement of more mixing of water. Fine aggregates passing through 2.36mm sieve was used to prepare the mortar confirming IS 383-1970.

3.4 Vermiculite

Vermiculite is a hydrous phyllosilicate mineral. It undergoes significant expansion when heated. It is chosen to replace fine aggregates in concrete because of its specific properties such as it is lighter in weight, improved workability, improved fire resistance, improved resistance to cracking and shrinkage. Vermiculite is the name used in commerce for a group of micaceous minerals that expand or exfoliate many times. It can be expanded up to 20 times its original volume.

IV. MATERIAL PROPERTIES

Table 4.1 Physical properties of cement

SI. No	Physical Test	Result
1	Fineness of cement	4.3%
2	Specific gravity	3.3
3	Consistency	31%
4	Initial setting time	40 mins
5	Final setting time	320 mins
6	Soundness	10 mm

Table 4.2 Physical properties of Coarse Aggregate

SI. No	Physical test	Result
1	Fineness modulus	6.9%
2	Specific gravity	2.79
3	Water absorption	0.56%
4	Impact value	16.6%

Table 4.3 Physical properties of Fine Aggregate

SI. No	Physical test	Result
1.	Fineness modulus	2.9% (Zone II)
2.	Specific gravity	2.66
3.	Bulk density	1627 kg/m^3
4.	Dry density	1534 kg/m^3

Table 4.4 Physical properties of Vermiculite

SI. No	Physical test	Result
1.	Fineness modulus	2.8%
2.	Specific gravity	2.5
3.	Bulk density	375 kg/m^3
4.	Dry density	600 kg/m^3

V. MIX RATIO FOR CONCRETE

Table 5.1 Mix ratio for FA and Vermiculite

SI. No	Percentage of FA and VM
1	100% FA and 0% VM
2	75% FA and 25% VM
3	50% FA and 50% VM
4	25% FA and 75% VM
5	0% FA and 100% VM

The vermiculite concrete was casted in the grade M25 with mix ratio of 1:1.8:2.3 and the fine aggregate was replaced in the fashion of 0, 25, 50, 75 and 100%.

VI. TEST ON CONCRETE

6.1 Compressive Strength Test

The specimens of size 150x150150mm for the various mix proportions for 0, 25, 50, 75 & 100% addition of Vermiculite. The casted cubes are kept for curing for 7 days and 28 days. Then the cubes are tested in Compression Testing Machine of capacity 2000 kN

for both 7 & 28 days. The Universal Testing machine setup is shown in fig 6.1

Compressive strength = Ultimate load (N) / Sectional area (mm^2)

Fig.6.1 Experimental setup for compressive strength of cube

Table 6.1 Compressive strength of cube

SI. No	Percentage of Vermiculite added	7 Days strength in N/mm^2	28 Days strength in N/mm^2
1.	0	22.10	30.06
2.	25	23.12	34.05
3.	50	14.52	21.67
4.	75	10.37	17.12
5.	100	8.80	15.02

Variation of 7 Days Compressive Strength:

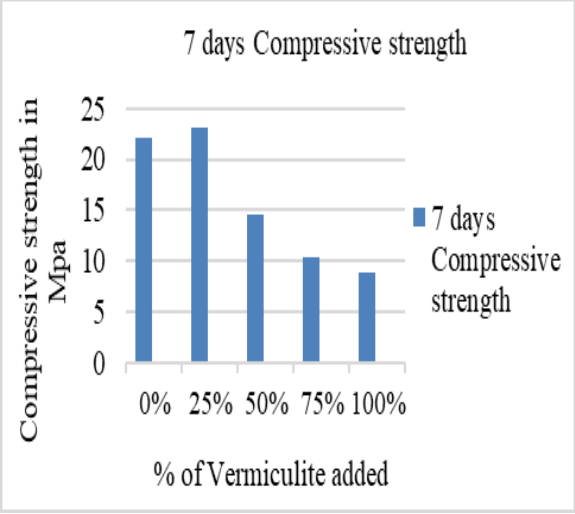

Fig 6.2 Variation of 7 days compressive strength

Variation of 28 Days Compressive Strength:

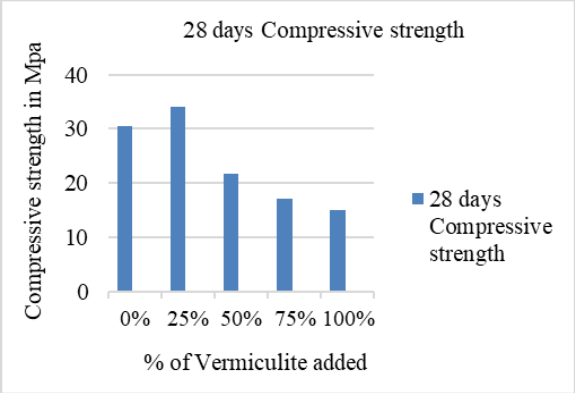

Fig 6.3 Variation of 28 days compressive strength

6.2 Flexural Strength Test

During the testing, the beam specimens of size 100x100x500mm were used. Specimens were dried in open air after 28 days of curing and subjected to flexural strength test under flexural testing assembly. The fracture indicates in the tension surface within the middle third of the span length. The flexural testing machine is shown in fig 6.2. The flexural strength was obtained by using the formula (R).

$R = Pl/bd^2$

Where,

- R = Modulus of rupture (N/mm^2)
- P = Maximum applied load (N/mm^2)
- l = Length of specimen (mm)
- b = Width of specimen (mm)
- d = Depth of specimen (mm)

Fig 6.4 Experimental setup for flexural strength test

Table 6.2 Flexural strength of beam

Variation of Flexural Strength for 28 Days:

SI. No	Percentage of vermiculite added	28 Days Strength in N/mm^2
1	0	3.05
2	25	4.08
3	50	2.88
4	75	2.17
5	100	2.02

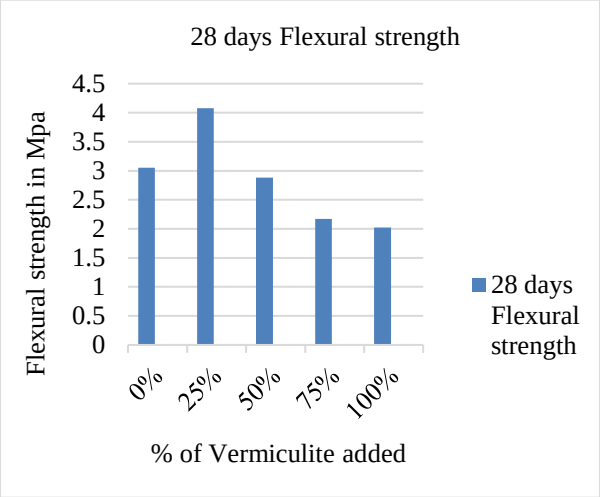

Fig 6.5 Variation of flexural strength for 28 days

VII. CONCLUSION

- The compression strength of cube for the Conventional concrete of M25 grade for 7 and 28 days are 22.10 N/mm^2 and 30.06 N/mm^2 respectively.
- The compression strength of concrete containing of Vermiculite of 25%, 50%, 75% and 100% for 7 days for M25 grade of concrete are 23.12 N/mm^2, 14.06 N/mm^2, 10.37 N/mm^2 and 8.80 N/mm^2 for 7 days for M25 grade of concrete are 34.05 N/mm^2, 21.67 N/mm^2, 17.12 N/mm^2 and 15.02 N/mm^2.
- The optimum compressive strength of concrete reaches at 25% for M25 grade of concrete.
- The flexural strength of beam for the conventional concrete of M25 grade for 28 days is 3.05 N/mm^2.
- The flexural strength of concrete containing of Vermiculite of 25%, 50%, 75% and 100% for 28 days for M25 grade of concrete are 4.08 N/mm^2, 2.88 N/mm^2, 2.17 N/mm^2 and 2.02 N/mm^2.
- The optimum flexural strength of concrete reaches at 25% for M25 grade of concrete.
- Based on the results, it was found that Vermiculite could be used upto 25% in concrete as a replacement of fine aggregate.

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