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AN EXPERIMENTAL INVESTIGATION OF CONCRETE USING VERMICULITE AS PARTIAL REPLACEMENT OF FINE AGGREGATE

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Abstract - *Concrete is the single most widely used building material in the world. Concrete is used in such large amounts because it is simply and extremely good building material. In many places of the world temperature is raising day by day. These days due to constant sand mining the natural sand depleting at an alarming rate. In this case fine aggregate is partially replacement of vermiculite. Uses of vermiculite it will enhance the shrinkage and crack resistance, fire resistance and reduces environment impact also reduce the cost. Important characteristics of a good quality aggregate include resistance to abrasion, resistance to freeze/thaw action, resistance to sulfates, correct shape and surface texture, proper gradation, density, and compressive and flexural strength. The concrete mix design is done for M30 grade concrete. The mix is prepared 10%, 15% and 20% for partial replacement of fine aggregate by vermiculite. The main aim of this study is to make economical and eco- friendly.*

Key Words: **Vermiculite, Compressive strength, Split Tensile Strength, Flexural test.**

1. INTRODUCTION

Vermiculite is a hydrated laminar mineral, which are aluminum – iron – magnesium silicates, resembling mica in an appearance. It undergoes significant expansion when heated. Vermiculite is chosen to replace fine aggregate 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 and mainly inert chemical nature.

Vermiculite is the name used in commerce for a group of micaceous minerals that expand or exfoliated many times (Commercial varieties exfoliate 8 to 20 times or more) the original thickness when heated.

Vermiculite, a mineral of natural occurrence of the group of hydromicas, when heated to above 300ºC, expands to become a highly efficient vermiculite, owing to its unique properties – low bulk density, low heat conductivity, relatively high melting point, chemical inertness, endurance, and environmental safety – can be used as a filler for heat-insulating materials. Heat insulators based on expanded vermiculite can be used in thermal power units with the hot-wall temperature not exceeding 1150ºC as replacement for lightweight chamotte components and fibrous heat insulators

Fig -1: Vermiculite

1.1 OBJECTIVES

The objectives of this study are:

- ✓ To study the properties of the vermiculite concrete with conventional concrete.
- ✓ To determine the behavior of concrete using vermiculite as fine aggregate.

- ✓ To reduce the cost of construction work and also maintain the same quality as like fine aggregate in cement concrete.
- ✓ To meet the scarcity of natural fine aggregate in future, the vermiculite can be alternatively used to determine the optimum level natural fine aggregate by vermiculite in concrete.

2. LITERATURE REVIEW

A. V. V. Sairam (2017) In this case fine aggregate is partially replacement of vermiculite. Use of vermiculite in concrete it will enhance the shrinkage and crack resistance, fire resistance and reduces environmental impact and also reduce the cost. In this present study, an attempt has been made to study the mechanical properties of M35 grade concrete with different percentages at a range of 5% ,10%, 15%,20%,25% and 30% as partially replacement with vermiculite to the total weight of fine aggregate along with mineral admixtures like Fly ash (FA) is replace cement by various percentages i.e., 10% , 15%, and 20% and silica fume (SF) as adding of 5% ,7.5%, 10% and 12.5% by weight of cement. Water cement ratio is 0.42, Optimum percentages of compressive strength is obtained.

S Syed Abdul Rahman and Gijo K Babu (2016),In this study, structural light weight aggregate concrete was designed with the use of natural vermiculite aggregate that will provide an advantage of reducing dead weight of structure and to obtain a more economical structural light weight concrete by the use of vermiculite power as a partial replacement of sand. Three mixes were produced with the cement content of 479 kg/m^3 in M_{30} grade and water cement ratio is 0.40. More over the group had proportion of 0%, 5%, 10%, as vermiculite replacement. The main scope of our project is to learn and gather knowledge of strength, and density. It may help us to get clear idea about the light weight concrete, using vermiculite.

M.R.Divya et al.,(2016) Have the study on M30 grade concrete using vermiculite as partial replacement with 40%,50% and 60% to the total weight of fine aggregate. The aim of their project is to study the strength parameters such as compressive strength, split tensile & flexural strength of concret. They study result shows the optimum strength in compare the strengths for different vermiculite percentage was observed to be 50%.

L.Vijayan (2016) In this paper the exfoliated vermiculite is used as a replacement of fine aggregate. This project is mostly related in places where the ecological temperature is very high. The replacements were done in 5 ,10 and 15 % of fine aggregate. And finally conclude that the vermiculite replaced concrete shows insignificant decrease in density up to 15% when compared to normal concrete. In split tensile test no much variations in split tensile strength when compare to normal concrete.

3. MATERIALS USED

3.1 Cement

Cement is the most important constituent of concrete, it forms the binding medium for the discrete ingredients made out of naturally occurring raw materials. “Ordinary Portland cement” 53 Mega Pascal grade of cement is used for concrete. The properties of cement were determined as per the IS 4031:1968

3.2 Fine Aggregate

The material which is smaller than 4.75mm size is called fine aggregate. Natural sands are generally used as fine aggregate. Angular grained sand produces, good and strong concrete because it has good interlocking property, while round grained particle of sand do not afford such interlocking. The specific gravity and water absorption were found to be 2.63 and 2.5% respectively, with sieve analysis data and fineness modulus value of sand confirms to grading zone I as per IS:383-1970.

3.3 Coarse Aggregate

The material retained on 4.75mm sieve is termed as coarse Aggregate. Crushed stone and natural gravel are the common materials used as coarse aggregate for concrete. For coarse aggregate crushed 20mm, normal size graded aggregate was used. The grading of aggregate should be conformed to the requirement as per IS: 383-1970.

3.4 Water

The major factor controlling strength, everything else being equal, is the amount of water used per bag of cement.

3.5 Vermiculite

Vermiculite is a hydrous phyllosilicate mineral. It undergoes significant expansion when heated. Vermiculite is used as a filler material and it is obtainable in golden brown, can also be white colorless or yellow. The specific gravity of vermiculite is 2.06. Vermiculite is chosen to replace fine aggregates in concrete because of its specific properties such as it is lighter in weight, improved workability, fire resistance and improved resistance to cracking and shrinkage and mainly inert chemical nature.

Determining the relative amounts of materials is known as mix design. Thus it can be defined as the process of selecting suitable ingredients of concrete and determining their relative quantities for producing the concrete of desired properties strength, durability and consistency, as per IS 10262:2009 economically as possible. Mix design are done as per IS 10262:2009 for M30 and M40 Grade concrete and it is shown in table1

Table -1: Mix design for M30 Grade concrete

Mix design	Water (L)	Cement (kg)	Aggregates (Kg)	
			Fine	Coarse
M30	160	380	711	1283

Mix ratio for M30 is 1:1.87:3.37:0.45

4. TEST RESULTS AND DISCUSSION

Testing of concrete plays an important role in controlling and confirming the quality of cement concrete. Cube, Beam & Cylinder is tested for its strength characteristics. The following tests are conducted, Compression strength test, Split tensile strength test, Flexural strength test (Two point loading).

4.1 Compressive Strength Test

The following procedure is adopted to conduct the compressive strength test

- Size of the specimen is 150×150×150mm cubes determined by averaging perpendicular dimensions at least at two places.
- Place the specimen centrally on the compression testing machine and load is applied continuously and uniformly on the surface parallel to the direction of tamping.
- The load is increased until the specimen fails and record the maximum load carried by each specimen during the test.

Compressive strength was calculated as follows

Compressive strength = P/A×1000

where,

P= Load in KN

A=Area of cube surface=150×150 mm^2

Table -2: Compressive Strength of Vermiculite concrete

S.No	% of Replacement	Compressive Strength (N/mm^2)		
		7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
1	10%	8.35	10.43	11.19
2	15%	7.24	8.75	10.23
3	20%	6.98	8.62	9.45

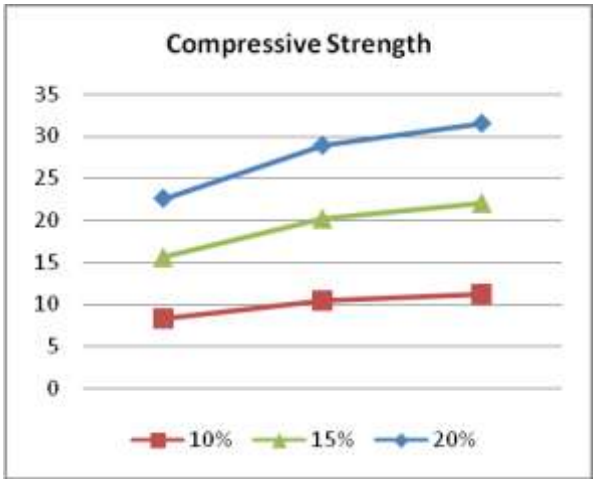

Chart -1: Compressive Strengths for various % Of Vermiculite

4.2 Split Tensile strength Test

The following procedure is adopted to conduct the tensile strength test.

- Draw diametrical lines on two ends of the specimen so that they are in the same axial plane. Diameter of specimen is 150mm and length 300mm.
- Determine the diameter of specimen to the nearest 0.2 mm by averaging the diameters of the specimen lying in the plane of pre marked lines measured near the ends and the middle of the specimen. The length of specimen also shall be taken be nearest 0.2 mm by averaging the two lengths measured in the plane containing pre marked lines.
- Centre one of the plywood strips along the centre of the lower pattern. Place the specimen on the plywood strip and align it so that the lines marked on the end of the specimen are vertical and cantered over the plywood strip. The second plywood strip is placed length wise on the cylinder cantered on the lines marked on the ends of the cylinder.

Apply the load without shock and increase it continuously at the rate to produce a split tensile stress of approximately1.4 to 2.1 N/mm2/min, until no greater load can be sustained. Record the maximum load applied to specimen .Computation of the split tensile strength was as follows.

Split tensile strength = $2P/\pi dL \times 1000$

where,

P = Load in KN and π = 3.142

d = Diameter of cylinder = 150 mm

L = Length of cylinder = 300 mm

Table -3: Spilt Tensile Strength of Vermiculite concrete

S.No	% of Replacement	Spilt Tensile Strength (N/mm²)		
		7 Days (N/mm²)	14 Days (N/mm²)	28 Days (N/mm²)
1	10%	2.48	2.95	3.37
2	15%	2.36	2.52	2.82
3	20%	2.12	1.84	1.90

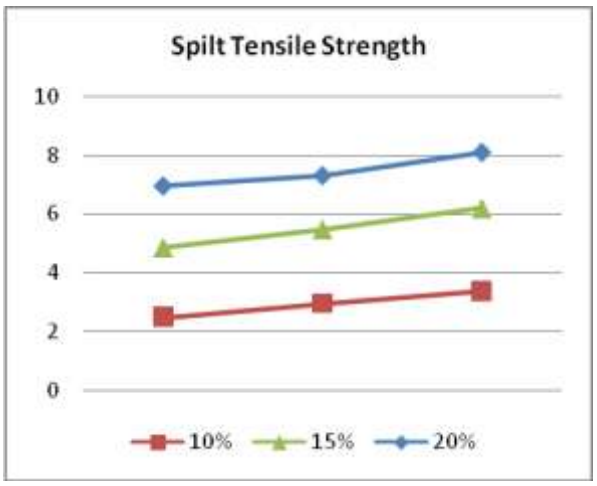

Chart -2: Spilt Tensile Strengths for various % Of Vermiculite

4.3 Flexural strength Test

The following procedure is adopted to conduct the flexural strength test.

- Brush the beam clean. Turn the beam on it side, with respect to its position as moulded, and place it in the breaking machine.

- Set the bearing plates with the beam and adjust for distance by means of the guide plates furnished with the machine.
- Place a strip if leather or similar material under the upper bearing plate to assist in distributing the load.
- Bring the plunger of the jack into contact with the ball on the bearing bar by turning the screw in the end of the plunger.
- After contact is made and when only firm finger pressure has been applied, adjust the needle on the dial gauge to "0".
- Here we are applying two point loading on the beam specimen, apply load till it breaks and note that as failure load.

Flexural Strength =PL/BD2×1000

Where,

P=Load in KN

L= Effective length of beam=250 mm

b=Width of the beam= 200 mm

d=Depth of beam =2000 mm

Table -3: Flexural Strength of Vermiculite concrete

S.No	Load (KN)	Flexural Strength		
		10%	15%	20%
1	0	0	0	0
2	5	2.1	1.95	1.75
3	10	2.20	2.00	1.90
4	15	2.50	2.40	2.25
5	20	2.85	2.65	2.32
6	25	3.10	2.80	2.46
7	30	3.12	3.00	2.94

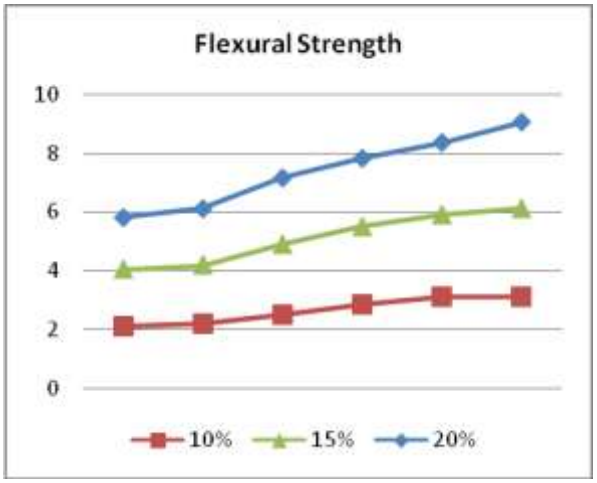

Chart -3: Flexural Strengths for various % Of Vermiculite

5. CONCLUSIONS

1. The strength parameters such as compressive strength, split tensile strength of vermiculite concretes of various percentages are found.The optimum strength in comparing the strengths for different vermiculite was observed to be 50%.Addition of vermiculites in concrete makes it heat resisting & resists shrinkage and cracks in concrete. Because of inert chemical nature of vermiculite when it is used in concrete it will not undergo any chemical reaction and also it is an eco-friendly material.
2. Vermiculite is a filler material used in the construction industry mainly for its low bulk density and inertness. Vermiculite is used for insulation property. We conclude here by comparing the various compression test of the sample (10% replacement of vermiculite to the total weight of sand) gives better results. Hence finally, it is economical and giving good compressive strength.
3. The following conclusions can be drawn from the above investigation. After 14 days curing, Vermiculite replaced concrete shows marginal

decrease in density up to 15% when compared to control concrete.

4. In spit tensile test no much variance in split tensile strength when compared to control concrete. Environment heat test comparing with control concrete 15% replacement shows better insulation.
5. There was a notable change in difference in room temperature and environmental temperature Thermal insulent concrete is thus achieved. Replacement of fine aggregate with vermiculite results in light weight concrete.

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