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Experimental Investigation on the Usage of Vermiculite Waste in Concrete

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Abstract –*Concrete is one of the most extensively used construction material in the world with two billion tons placed worldwide each year. It is used because of its easy workability and strength. 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. In order to reduce the cost of construction and to protect the natural resources, there is a need to use alternative and sustainable construction materials. Vermiculite, which is a waste mineral from the wire lining industry, can be used as partial replacement for fine aggregates in concrete. Use of Vermiculite in concrete enhances the shrinkage and crack resistance, fire resistance, reduces environmental impact and also reduces the construction cost. Important characteristics of a good quality aggregate include resistance to abrasion, resistance to freeze/thaw action, resistance to sulphates, correct shape and surface texture, proper gradation, density, and compressive and flexural strength. The main objective of this research is to study the strength parameters such as compressive strength, split tensile and flexural strength of concrete using vermiculite as partial replacement with 5%, 10% and 20% by weight. Several tests such as compressive strength, tensile strength and flexural strength test on concrete cubes and beam casted with vermiculite were conducted. The results showed that 10% of fine aggregates replaced by Vermiculite gave the best results. Vermiculite can be used as one of the best replacement for sand and moreover the weight of the concrete is greatly reduced in large extent.*

***Key Words*: Compressive strength, density, flexural strength, freeze/thaw action, sustainable materials, tensile strength, Vermiculite.**

1. INTRODUCTION

Concrete is a widely used construction material because of its good workability. It is mostly consists of aggregates, namely fine and coarse aggregates. Nowadays, sand is heavily depleted and it leads to an alarming state. Natural sand cannot be replaced by any other materials due to its significant properties. Due to the sudden decrease of sand, manufacturing sand came into existence for the replacement of river sand. Several alternatives for natural sand are being tested and reports are being published. Among the alternatives, Vermiculite, a mineral which is to be used as the replacement of fine aggregates partially up to some extent.

Vermiculite is a hydrous phyllosilicate mineral. It undergoes significant expansion when heated. Due to sufficient heating, Exfoliation occurs in Vermiculite and the effect is routinely produced in furnaces. It is a light weight material, hence if it is added as an ingredient of concrete, greatly reduces the self-weight of the structure.

Vermiculite is used in many commercial sectors namely,

1. Brake lining industries
2. Calcium Silicate boards
3. Soil conditioner
4. Waste treatment
5. Cementitious fire proofing products etc.

Table -1: Properties of Vermiculite

Chemical Analysis	
Silicon (SiO_2)	39.40%
Magnesium (MgO)	25.20%
Aluminium ($Al2O_3$)	8.80%
Potassium (K_2O)	4.50%
Calcium (CaO)	1.80%
Carbonate (CO_2)	1.40%
Titanium (TiO_2)	0.80%
Fluorine (F)	0.50%
Physical Properties	
Melting Point (°C)	1330
Specific Heat	1.08
Specific Gravity	2.5
Mohs Hardness (Crude)	1-2
pH (ISO 787-9)	7-8
% Loss at 105°C	< 0.5
% Loss at 1000°C	< 6

Many researchers have worked on Vermiculite concrete, replacing by weight of cement up to some percentage. Reference [1] observed that an increase in 13% of compressive strength while Vermiculite is replaced 5% by the weight of cement. Reference [2] showed that Concrete gives more compressive strength while cement is replaced by

Vermiculite. Usage of Vermiculite gives a good impact on the strength parameters as well as great reduction in self-weight. From references [3], [5], [6] & [7], it was observed that the vermiculite act as a high heat resisting material. References [4] & [8] showed that the lightweight material can be prepared from vermiculite with good heat insulating property.

Fig -1: Vermiculite

2. TEST ON MATERIALS USED

Ordinary Portland cement of 43 grade confirming to IS: 8112-1989, is used in this study. Aggregate is an essentially used construction material and inert material which contains 70 to 80 % volume of the concrete. Hence, if you want to study about the concrete, it is essential to know about the properties of aggregates because of its major volume.

Therefore, it should be completely tested before using for construction. Not only the aggregates should be strong and durable but should also have proper shape and size to act as monolithically in the structural components. Hence, it's essential to conduct several tests on aggregates in order to ensure the quality of aggregates and check their. The following are the test results conducted for the ingredients of concrete:

Table -2: Test results of Cement

S.No.	Property	Value
1	Normal Consistency	33%
2	Initial Setting Time	35
3	Final Setting Time	483
4	Specific Gravity	3.13
5	Fineness Of Cement	1.1

Table -3: Test results of Fine and Coarse Aggregate

S.No.	Property	Fine Aggregate	Coarse Aggregate
1.	Specific Gravity	2.65	2.85
2.	Fineness Modulus	2.80	6.19
3.	Water Absorption	1 %	0.6 %

Table -4: Test results of Vermiculite

S. No.	Property	Value
1.	Specific Gravity	2.34
2.	Fineness Modulus	2.43

3. METHODOLOGY

Based on the guidelines for mix proportions provided in IS: 10262-2009, mix proportion for M25 grade of concrete was arrived as 1:1.41:2.81 with water/cement ratio of 0.45.

Table -5: Mix proportions of concrete for 1 m^3

Cement	Fine aggregate	Coarse aggregate	Water
438 kg	614.93 kg	1228.21 kg	197.16
1	1.41	2.81	0.45

Workability is a main factor which directly connects the strength of concrete. The standard value has to be checked out for the functional strength of the concrete. The fresh concrete is prepared based on the ratio above said and slump cone test is conducted to determine the workability of concrete.

Table -6: Slump Cone test result

Workability	Replacement of Vermiculite in			
	0	5	10	20
Slump	52	52	55	58

4. RESULTS AND DISCUSSIONS

4.1 Compressive Strength

The compressive strength test was conducted on 3 specimens for each % replacement as per the recommendations of IS: 516-1959. The specimens were tested on the compression testing machine and the values are tabulated below.

Table -7: Compressive Strength Test Results

S. No.	Curing days	% of Vermiculite	Compressive Strength (N/mm²)
1	7 days	0	23.56
		5	24.44
		10	24.89
		20	24.00
2	14 days	0	27.11
		5	27.56
		10	28.89
		20	27.78
3	28 days	0	31.11
		5	31.78
		10	33.11
		20	32.22

The above table clearly shows that the compressive strength of 10% replaced vermiculite produced good result. Based on the above results, a graph was shown below.

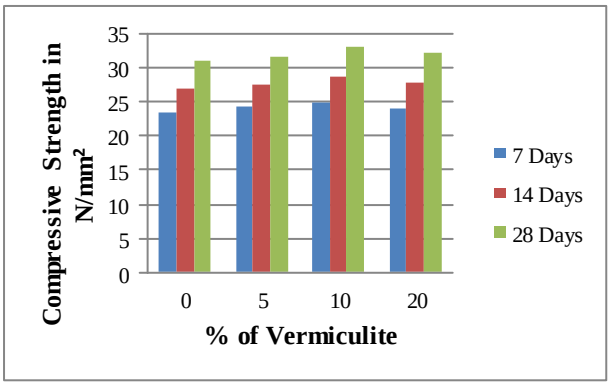

Chart -1: Compressive Strength graph

4.2 Split Tensile Strength

The split tensile strength test was conducted on 3 cylinder specimens for each % replacement as per the recommendations of IS: 5816-1999. The specimens were tested on the compression testing machine and the values are tabulated below.

Table 8: Split Tensile Strength Test Results

S. No.	Curing days	% of Vermiculite	Tensile Strength (N/mm²)
1	7 days	0	2.33
		5	2.44
		10	2.89
		20	2.78
2	14 days	0	2.78
		5	2.89
		10	3.33
		20	3.11
3	28 days	0	3.56
		5	3.89
		10	4.33
		20	4.00

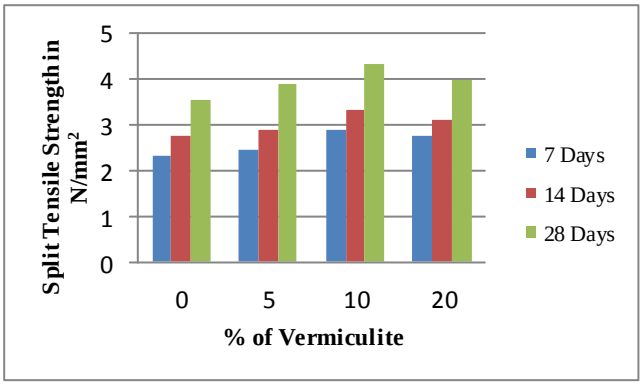

Chart -2: Split Tensile Strength graph

The above table and graph clearly showed that the tensile strength of 10% replaced vermiculite produced maximum strength.

4.3 Flexural Strength Test

The beams are designed and the reinforcement bars are placed accordingly. The flexural strength test was conducted on the beam specimens which was casted using reinforcement bars for each % replacement as per the recommendations of IS: 516-1959. The specimens were tested on the loading frames as shown below and the values are tabulated.

Fig -2: Flexural Strength Test

Table -9: Flexural Strength Test Results

S. No.	Curing days	% of Vermiculite	Flexural Strength (N/mm²)
1	28 days	0	63.58
		5	63.25
		10	68.36
		20	65.89

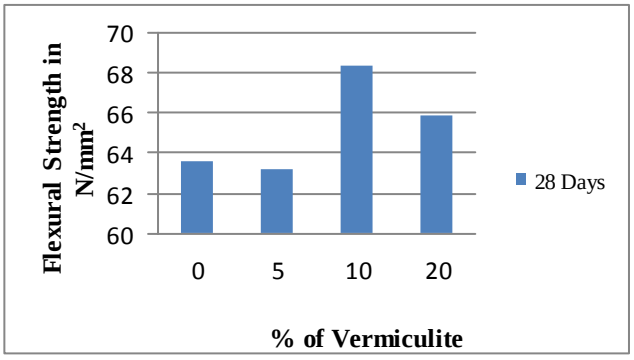

Chart -3: Flexural Strength graph

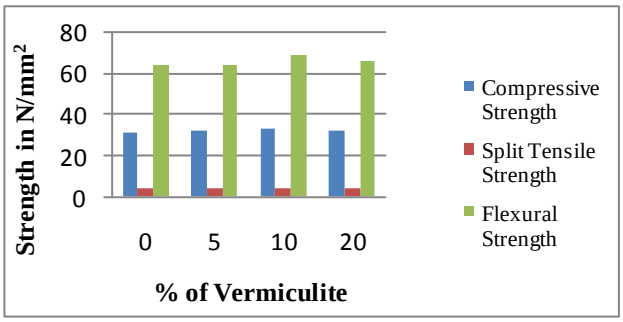

Chart -4: Cumulative Strength Test graph

From the above table and graph, the result obtained as 10% replaced vermiculite produced maximum strength.

5. CONCLUSION

This study was conducted to evaluate the effect of using Vermiculite as the partial replacement of fine aggregate in concrete composites and also gave an idea by using these materials within specific range. Several tests were conducted on the materials of the concrete composites and the reports were observed. With the results obtained, we conclude that 10% of fine aggregates replaced by Vermiculite will give best result. It was also suggested that in order to reduce the weight of concrete and improvement in the alternation of sand, Vermiculite is used as one of the best replacement and moreover the weight of the concrete is greatly reduce in large usage.

REFERENCES

1. James S. Webber, "Study the effect of vermiculite on concrete", Wadsworth Centre, NYS Department of Health, New York, 2011.
2. Faut Koksal, O.Genecel, W. Brostow and H.E. Hagg lobland " Effect of high temperature on mechanical and physical properties of light weight cement based refractory including expanded vermiculite", Materials Research Innovations, W.S.Maney &Son Ltd. 2012, Received 11 July 2011; accepted 9 September 2011, pages 7-13.
3. A.M. Papadopoulos, "State of art in thermal insulation materials and aims for future developments", Energy and Buildings, 2005, Pages 3777-86.
4. M. Akao, A. Yamazaki, Y. Fukuda, "Vermiculite board for novel building material", Journal of Material Science Letters, Volume 22, 2003, Pages 1483-1485.
5. Norman M.P. Low, "The Thermal insulating properties of Vermiculite", Journal of Building Physics, Volume 8, Issue 2, 1984, Pages 107-115.
6. Norman M.P. Low, "Vermiculite- A promising material for high-temperature", Refractories & Industrial Ceramics, Volume 44- No.3, 2003.
7. S.A. Suvorov, V.V. Skurikhin, "High-Temperature heat insulating materials-based on Vermiculite", Refractories & Industrial Ceramics, 2002, Pages 43383-389.
8. P.M. Carkner, "Lightweight insulating concrete and methods for using same", U.S.Patent no.6290769.
9. IS: 10262-2009, Bureau of Indian standard- Concrete Mix Proportioning – Guidelines (first revision) and IS: 456-2000.
10. IS: 516-1959, Methods of Tests for Strength of Concrete (Eighteenth Revision JUNE 2006).