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Study on Mechanical Properties of Low Density Concrete with Partial Replacement of Coarse Aggregate

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Abstract: Structural low density aggregate Concrete has an ability to reduce the self-weight of the structure as well as reduces the risk of earthquake damages to a structure because earthquake forces are proportional to mass of the structure. In Design of concrete structures, low density concrete plays a prominent role in reducing the density and to increase the thermal insulation. These may relate to both structural integrity & serviceability. For structural application of low density concrete, the density is often more important than the strength. A decreased density for the same strength level reduces the self-weight, foundation size and construction costs. Low density aggregates have high porosity, their resistance to chloride penetration is better than normal weight concrete because pores are not interconnected. Exfoliated vermiculite is studied; it is used as a filler material because of its low bulk density, high refractoriness, low thermal conductivity and adequate chemical inertness. All along vermiculite has high amount of silica content. Thus effective utilization of silica based materials as a building material. Structural low density aggregate concrete is a versatile material, which offers a range of technical, economic and environmental-enhancing. Structural low density aggregate concrete was designed with the use of expanded perlite aggregate, expanded vermiculite aggregate,that will provide an advantage of reducing dead weight of structure and to obtain a more economical structural low density concrete by the use of these materials as a replacement of the coarse aggregate.

Keywords: *Low Density Concrete, Exfoliated Vermiculite, Exfoliated Perlite, Mechanical Properties*

1. Introduction

Structural Low Density Aggregate Concrete has an ability to reduce the self-weight of the structure as well as reduces the risk of earthquake damages to a structure because earthquake forces are proportional to mass of the structure. In Design of concrete structures, light weight concrete plays a prominent role in reducing the density and to increase the thermal insulation. These may relate to both structural integrity & serviceability. For structural application of lightweight concrete, the density is often more important than the strength. A decreased density for the same strength level reduces the self-weight, foundation size and construction costs. The resistance of structural lightweight aggregate concrete to chloride penetration seems to be moderate and low. Although lightweight aggregates have high porosity, their resistance to chloride penetration is better than normal weight concrete because pores are not interconnected. The use of structural grade light weight concrete reduces the self-weight and helps to construct larger precast units. Exfoliated vermiculite is studied; it is used as a filler material because of its low bulk density, high refractoriness, low thermal conductivity and adequate chemical inertness. All along vermiculite has high amount of silica content. Thus effective utilization of silica based materials as a building material. Presently, vermiculite is used for its light weight in the construction industry as a filler material above the deck slab. Structural lightweight aggregate concrete is a versatile material, which offers a range of technical, economic and environmental-enhancing. Structural lightweight aggregate concrete was designed with the use of perlite aggregate, vermiculite aggregate, expanded clay aggregate that will provide an advantage of reducing dead weight of structure and to obtain a more economical structural lightweight concrete by the use of these materials as a replacement of the coarse aggregate.

2. Material Properties

The properties of materials used in the concrete are discussed below:

2.1 Cement

Ordinary Portland cement of 53 grades available in local market was used. The specific gravity of cement that was taken was 3.14

2.2 Fine Aggregate

The sand sieved through 4.75 mm sieve is used having specific gravity of 2.6. The fine aggregates belonged to grading zone III.

2.3 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 20 mm is used. The specific gravity of coarse aggregate that was taken was 2.67.

2.4 Vermiculite Aggregate

Expanded vermiculite of size 12mm heated in rotary kiln is used. The specific gravity of expanded vermiculite that was taken as 0.12.

2.5 Perlite Aggregate

Expanded Perlite of size 10mm heated in furnace is used. The specific gravity of Perlite that was taken as 0.15.

2.6 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water available in the laboratory was used.

3. Experimental Investigation

In this investigation the hardened properties of LDC for various partial replacement percentages of exfoliated vermiculite, exfoliated perlite are determined.

3.1 Mix proportions

Based on the Indian Standard Code (IS:10262-2009) guidelines the mix proportions of concrete were prepared for M30 grade.

3.1.1 Hardened properties of LDC

In order to find the mechanical properties Compressive strength tests were conducted at 28 days of cube (150 X 150 X 150 mm) specimens. For each combination, three specimens were tested.

In order to find the split tensile strength of concrete 28 days of cylinder (150 X 300 mm) specimen are cast. For each combination, three specimens were tested.

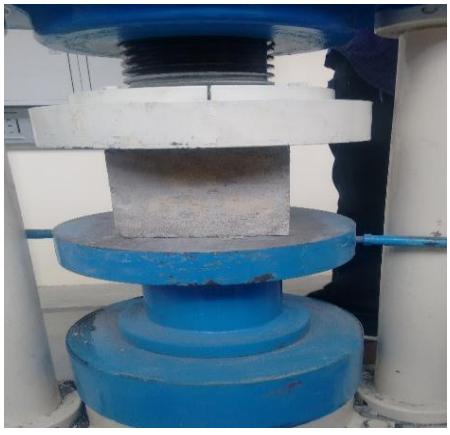

Figure 1*.Compressive strength test*

The following table shows the Compressive strength of LDC:

Table I: *Compressive strength of LDC with vermiculite*

S. no	Percentage Replacement of Vermiculite (%)	Compressive Strength 7days (N/mm^2)	28days (N/mm^2)
1	0	24.00	33.76
2	40	18.22	28.37
3	50	15.36	26.23
4	60	11.74	23.82

The following graph shows the variation in the Compressive strength of LDC with vermiculite:

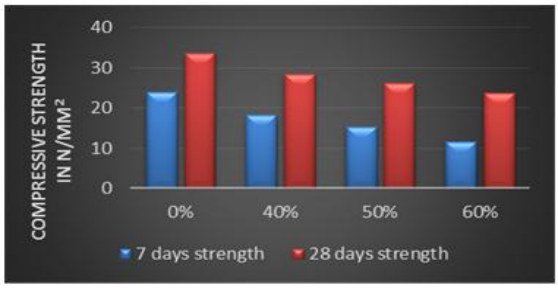

Figure 2*.Chart for compressive strength of low density concrete with vermiculite*

The following tables show the compressive strength of LDC with Perlite:

Table II: *Compressive strength of LDC with perlite*

S. No	Percentage Replacement of Perlite (%)	Compressive Strength 7days(N/mm^2)	28days(N/mm^2)
1	0	24.00	33.76
2	40	16.13	27.20
3	50	14.95	25.43
4	60	10.99	23.12

The following graph shows the variation in the Compressive strength of LWC with Perlite:

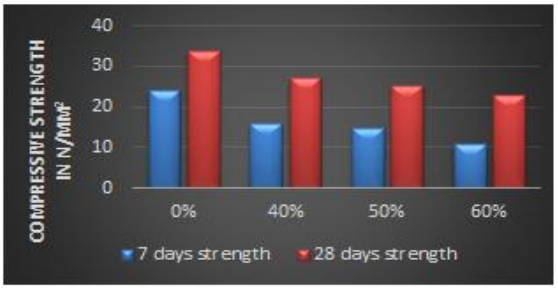

Figure 3*.Chart for compressive strength of low density concrete with perlite*

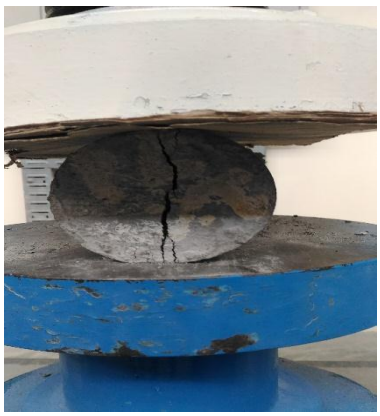

Figure 4*.Split tensile strength*

The following table shows the split tensile strength of LDC with vermiculite:

Table III: *Split tensile strength of LDC with vermiculite*

S. No	Percentage Replacement of Vermiculite (%)	Split Tensile Strength 7days (N/mm^2)	28days (N/mm^2)
1	0	2.40	3.22
2	40	1.82	2.7
3	50	1.41	2.4
4	60	1.00	2.1

The following graph shows the variation in the split tensile strength of LDC with vermiculite:

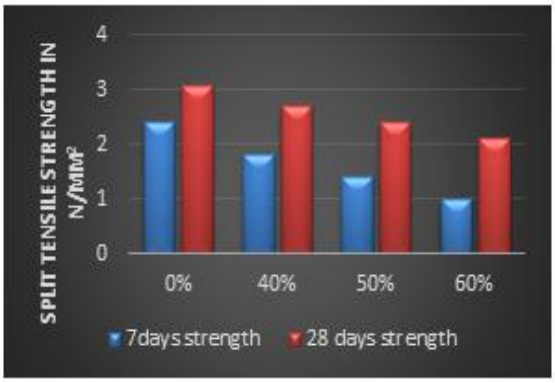

Figure 5.*Chart for split tensile strength of LDC with vermiculite*

The following table shows the split tensile strength of LDC with perlite:

Table IV: *Split tensile strength of LDC with Perlite*

S. No	Percentage Replacement of Perlite (%)	Split Tensile Strength 7days (N/mm^2)	28days (N/mm^2)
1	0	2.40	3.22
2	40	1.5	2.4
3	50	1.16	2.1
4	60	0.89	1.9

The following graph shows the variation in the split tensile strength of LDC with perlite:

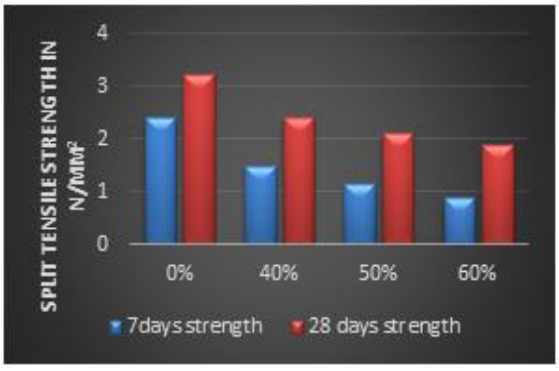

Figure 6.*Chart for split tensile strength of LDC with perlite*

4. Experimental Test Result of 1m Height Column

Figure 7.*Testing of column in load frame*

The following table shows the deflection of nominal concrete:

Table V: *Deflection of nominal concrete*

S.no	Load (KN)	Deflection (mm)
0	0	0
1	25	0.18
2	50	0.29
3	75	0.54
4	100	0.73
5	125	1.18
6	150	1.27
7	175	1.53
8	200	1.72

The following graph shows the variation in the deflection of nominal concrete:

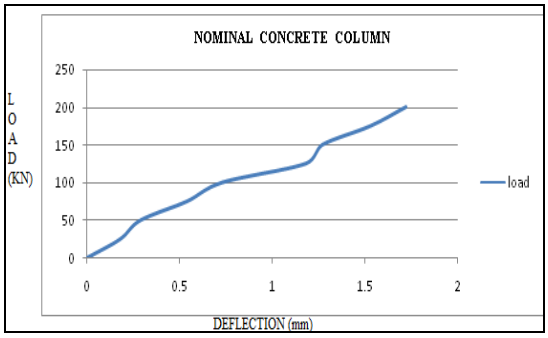

Figure 8.*Chart for deflection of nominal concrete*

Table VI: *Deflection of nominal concrete with vermiculite*

S.no	Load (KN)	Deflection (mm)
0	0	0
1	25	0.28

2	50	0.386
3	75	0.63
4	100	0.819
5	125	1.261
6	150	1.295
7	175	1.552
8	200	1.83

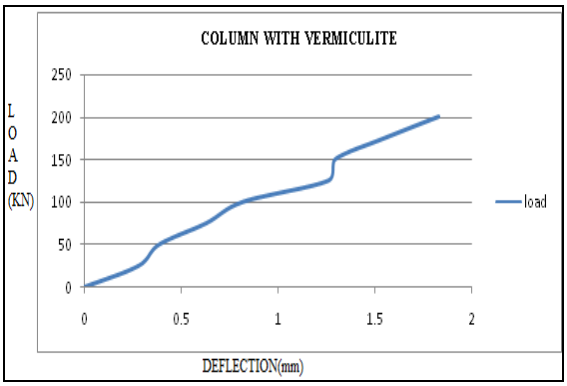

Figure 9.*Chart for deflection of nominal concrete with vermiculite*

Table VII: *Deflection of nominal concrete with perlite*

S.no	Load (KN)	Deflection (mm)
0	0	0
1	25	0.26
2	50	0.371
3	75	0.612
4	100	0.801
5	125	1.253
6	150	1.282
7	175	1.545
8	200	1.812

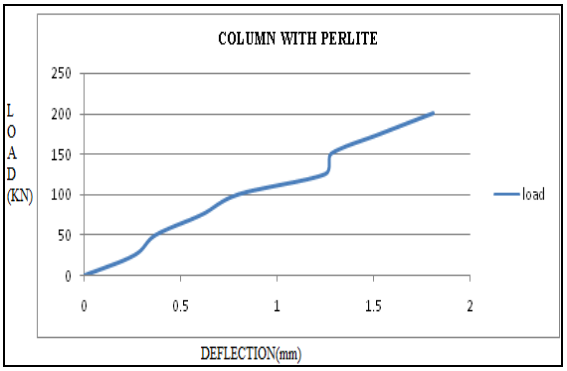

Figure 10.*Chart for deflection of nominal concrete with perlite*

5. Conclusion

- Expanded Perlite and expanded vermiculite provides an advantage by reducing dead weight of structure and to obtain a more economical structural low density concrete by the use of these materials.
- From the results of Compressive strength and Split tensile strength, we can concluded that the replacement of vermiculite and perlite aggregate by 50% of weight of aggregate increases strength with increases in age of concrete and obtain high early strength.
- The incorporation of lightweight aggregates such as perlite or vermiculite decreases the mechanical characteristics of the hardened product.
- The most important aspect followed in the project is to reduce the environmental hazards.

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