An Experimental Investigation of Light Weight Concrete Using Pumice Aggregate for Short Wall Panel Under the Application of Axial Load

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ABSTRACT

The project study with the special concrete such as light weight concrete by using pumice aggregate (Natural aggregate). One of the disadvantages of conventional concrete is having high self weight. This heavy self-weight will make it to some extent an uneconomical structural material. Light weight concrete having low density reduces dead load and increase the thermal insulation. The reduction in density is produced by using it as a replacement of coarse aggregate partially in concrete. In this Study an attempt has been made to find the compressive strength of light weight aggregate concrete using mix M25 with poly carboxyl ether admixture under the application of axial load on short wall panel. Light weight concrete is made by replacement of Coarse Aggregate of Pumice aggregates.

INTRODUCTION

Lightweight concrete is a specialized concrete mixture made with lightweight coarse aggregates, and sometimes lightweight fine aggregates, instead of traditional aggregates. Light weight concrete is the word to explain to increase the expanding agent that increases the volume of the mixture while giving additional qualities such as lessened the dead weight. Concrete is very variable material having a wide range of strength and the constituent materials are cement, fine aggregate, coarse aggregate and water. Replacing pumice stone with coarse aggregate is said to be structural lightweight concrete solves to reduce the self weight of building. One of the most advantages of pumice aggregate concrete has low density of concrete.

PUMICE AGGREGATES

A pumice stone is a type of volcanic rock that forms when lava suddenly cools during an eruption. It's porous and light and has a sponge like appearance. Many industries use pumice as an abrasive, including health and beauty. Pumice aggregate is utilized in the construction industry to produce economical, durable, fireproof lightweight building materials and bricks with excellent isolation. Shipments are made in bulk.

PROPERTIES OF PUMICE AGGREGATES

- **Low thermal conductivity concrete**

The lower thermal conductivity of pumice concrete means less heat loss. Hess pumice concrete has 4X the R-value of typical sand-and-gravel aggregate concrete. This significant R-value increase both slows heat transfer and eliminates or reduces moisture condensation on walls and ceilings. For those seeking the super-insulating benefits provided by insulated concrete forms (ICF), pumice concrete is the ideal concrete for ICF block walls and decks. Pumice concrete delivers a higher fire rating that standard concrete and will not spall under contact with direct flame.

- **Workability, appearance, acoustics**

Another key factor is workability, particularly in nailing, sawing, and drilling. As for appearance, pumice concrete has a uniform color and texture. Acoustical ratings are higher for pumice concrete as well.

- **Durability of pumice concrete**

Pumice concrete has superior resistance to harsh weather conditions like freezing and thawing. This, plus its inherent high R-value, makes pumice concrete desirable for colder climates and dramatic changes in weather.

LIGHTWEIGHT CONCRETE WALL PANELS

Light-weight concrete walls can be used universally. They are used as load-bearing or non load-bearing elements in residential, commercial construction or as noise barriers on streets and railway lines. Light-weight concrete slabs are available both with a raw and with a ground surface. Classifications of lightweight concrete wall panels can be based on several criteria, including composition, production method, intended use, structural properties and specific characteristics.

LIGHTWEIGHT CONCRETE WALL PANELS SUBJECTED TO AXIAL LOADS

When lightweight concrete wall panels are subjected to axial loads (loads applied along the axis of the panel), depends on various factors

including the panel's design, composition, reinforcement, and the magnitude of the load. Here's an overview of how lightweight concrete wall panels may behave under axial loads. Behaviour Under Axial Load

- **Compression Strength:** Lightweight concrete wall panels are typically designed to withstand compressive forces. Axial loads primarily induce compressive stresses within the panel.
- **Buckling Resistance:** Depending on the panel's slenderness ratio (ratio of height to thickness) and support conditions, it may be susceptible to buckling under high axial loads.
- **Cracking and Deformation:** Excessive axial loads can lead to cracking or deformation in the panels, particularly if the load exceeds their capacity or if there are design flaws.
- **Failure Modes:** Failure under axial loads can occur due to material crushing, excessive deflection, or buckling, depending on the design, material properties, and support conditions.

DESIGN CONSIDERATIONS

- **Load Capacity Calculation**: Engineers use structural analysis methods to calculate the maximum axial load a lightweight concrete panel can withstand, considering factors such as material properties, dimensions, and intended use.
- **Safety Factors:** Designers apply safety factors to ensure that the panel can safely withstand anticipated loads without failure or excessive deformation.
- **Code Compliance:** Adherence to building codes and standards ensures that the design and construction of lightweight concrete wall panels meet safety and performance requirements.

LITERATURE STUDY

1. Basic Properties of Pumice Aggregate R. S. Muralitharan and V. Ramasamy investigated the mechanical properties of pumice light weight aggregate concrete. In this investigation, pumice stone are proposed to be utilized as the coarse aggregate. It is possible to develop lightweight concrete using pumice with a dry density of 1200 kg/m3 up to 1450 kg/m3.At present, the amount of works has been undertaken to investigate the mechanical properties of lightweight aggregate concrete, (i.e.) Compressive strength, splitting tensile strength, acid resistance, and thermal resistance were investigated for pumice lightweight aggregate concrete and at various ages of curing. The objective is to develop lightweight concrete using Indian pumice coarse aggregate and to study the behavior of pumice lightweight concrete under cyclic loading. At the end of the investigation, the following conclusions were made: Structural compressive strength of pumice almost reached normal coarse aggregate compressive strength. Reduction in density confirms that lightweight concrete can be used for lightweight structures.
2. Experimental Investigation on Lightweight Concrete using Pumice Aggregate A. Suba Lakshmi, S. Karthick, Gasper Helden, M. Dinesh Boopathi and V. Balaji Pandian carried out the study on lightweight concrete by using pumice aggregate. Replacing pumice stone with coarse aggregate is said to be structural lightweight concrete solves to reduce the self-weight of building. The main objective is to determine whether pumice stone lightweight concrete can be used as structural concrete, to determine the compressive strength and split tensile strength of lightweight concrete having density below 1800kg/m3 and to study the effect of various types replacements of natural aggregate by light weight aggregate (pumice) and conventional concrete on 28 days. From the study, it is found that 50% replacement of pumice lightweight aggregate with conventional coarse aggregate is the optimum replacement level and the increasing percentage of pumice aggregate decreases the strength of concrete.
3. The Study on Strength Properties of Lightweight Concrete using Lightweight Aggregate B. Devi Pravallika and K. Venkateswara Rao carried out an experimental study on strength and durability properties of M40 concrete by partial replacement of coarse aggregate with a natural lightweight aggregate pumice stone. Pumice stone which is of natural lightweight aggregate is being chosen as the best material for the partial replacement to coarse aggregate. It gives good strength when compared to the other materials. The method of the study will be conducted on by replacing the usual aggregate by natural lightweight aggregate by 0%,10%, 20%, 30%, 40% and 50%. The physical and mechanical properties of natural aggregate are evaluated and found that

20% replacement of pumice lightweight aggregate gives optimum value and beyond 20% the strength of concrete decreases.

4. Yasar et.al. have performed a study on the design of structural lightweight concrete (SLWC) made with basaltic pumice (scoria) as aggregate and fly ash as mineral admixtures that will provide an advantage of reduction in dead weight of a structure. The compressive and flexural tensile strengths of hardened concrete, the properties of fresh concrete including density and slump workability were measured. Laboratory compressive and tensile strength tests results showed that SLWC can be produced by the use of scoria. SLWC has an advantage of the reduction of the dead weight of the structure at the average of 20% since the dry weight unit of NWC is about 2300 kg/m^3.
5. Rajeshwari S,Dr.Sunilaa George –In this study attempt have been made to compare conventional concrete and light weight concrete using mix M25.partial replacement of coarse aggregate by pumice aggregate by 60% the compressive strength is comparable with normal concrete M25.
6. Eric Jacques and Jon Makar-Behaviour of Structural Insulated Panels Subjected to Short-Term Axial Loads (2019) Structural insulated panels, commonly known as SIPs, constitute a panelized building system composed of external facer panels, such as oriented strand board (OSB) sheets, bonded to a lightweight foam core. As the demand for SIPs increases as an alternative to light frame construction in residential and light- commercial buildings, so too does the need for proper design requirements to satisfy regulatory agencies and building officials. This paper describes a combined experimental and analytical study whose objective was to investigate the structural behaviour of OSB-faced SIPs subject to short-term axial loading. Reliability-based design expressions were developed for the ultimate limit state of SIPs subjected to short-duration concentric and eccentric axial loading. The results were also compared to current allowable stress design practices. In addition to presenting important test data for researchers, this paper presents a number of practical design recommendations to improve the performance of SIPs.

MATERIAL COLLECTION

Factors considered for material selection:

The following factors are to be considered while selecting the materials for lightweight wall panels:

- Weight and Density
- Strength and Structural Integrity
- Insulation Properties
- Fire Resistance and Safety
- Moisture Resistance and Durability
- Sound Insulation and Acoustic Performance
- Environmental Impact and Sustainability
- Cost - Effectiveness
- Ease of Installation and Handling
- Appearance and Aesthetic Considerations
- Compatibility with other Building Components
- Regulatory Compliance and Standards
- Maintenance Requirements

Material Composition of Pumice Aggregate:

Ingredient	Percentage
SiO_2	70.97 %
TiO_2	00.14 %
Al_2O_3	4.24 %
MnO	0.140 %
Fe_2O_3	1.880 %
CaO	1.370 %

Properties of Coarse and Pumice Aggregate:

Determination	Coarse Aggregate	Pumice Aggregate
Weight of saturated surface-dried sample	107 g	50g
Weight of oven-dried sample	102 g	45 g
Water absorption	4.4 %	11.1 %

PREPARATION OF TEST SPECIMEN

A full set of machine which correct the dimension and the aspect of the specimen before the test in order to obtain reliable results. By mechanical action (grinding or cutting) or secondary materials (neoprene) the tested surfaces are rectified, making them flat and uniform.

TESTING OF SPECIMEN

After 28 days curing, we have to test the concrete Wall Panel. First take out the concrete specimens from the tank and let dry the surface of cubes. Note down the date of casting and the specimen number for a proper data management. Place the concrete wall panel in the Loading Frame testing Machine. Connecting five LVDT equipment used to measure the load variations in the machine. The specimen should be placed in such a way that the direction of casting should be perpendicular to the direction of load application. Start applying the load, from the Loading Frame testing machine till the specimen fails. Record the maximum load from the Loading Frame Testing machine. Finally to calculate the maximum compressive strength of wall Panel.

Fig:1 Test Specimen

Fig:2 Concrete Specimen in Loading Frame

Fig:3 Application of Axial Load on Test Specimen

Fig:4 Formation of in Test Specimen

Fig:5 Failure of Test Specimen

TEST RESULTS

Compressive strength is the most common and well-accepted measurement of concrete strength. It is the main criteria used to determine if a given concrete mixture can withstand the structural forces being applied. It is the most common attribute cited in construction specifications. Compressive strength is the maximum stress a material can sustain under pushing,crushing force. It is determined by the shattering fracture of the material under these forces. For this test the specimens of size 914 mm x 380 mm x 120 mm is used. Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength=Load/Cross-sectional Area

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during the production of concrete, etc. The specimen is tested for mix ratio is taken as the compressive strength it was tested by compression testing machine of capacity 1000 kN. The max. load at failure was taken 459.8 kN.

The Compressive strength of Light weight concrete wall panel specimen at 28 days is 10.08 N/mm2 for mix proportion of M25 grade of concrete.

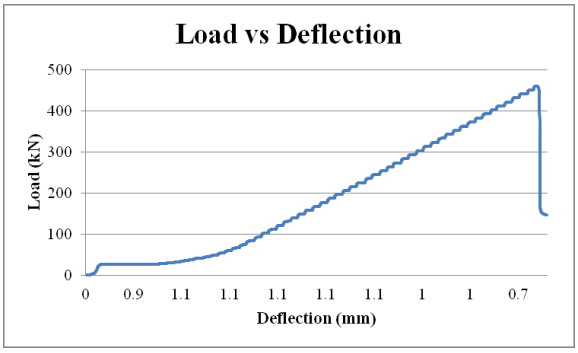

Fig:6 Load vs Deflection Curve

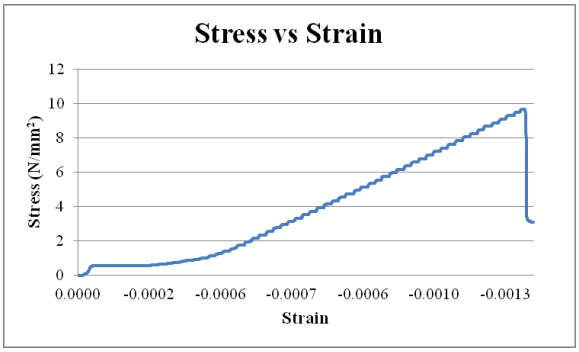

Fig:7 Stress-Strain Curve

CONCLUSION

Based on the experimental investigations concerning the compressive strength of Light weight concrete using pumice aggregates, the following conclusions are drawn from the study:

- To study the maximum axial load which is applied on short wall panel specimen which is prepared using light weight concrete using pumice aggregates.
- Compression strength value of light weight concrete in replacement of pumice stone the strength is comparable with normal concrete.
- Result has to be noted that, light weight concrete having density 1500kg/m3 and conventional concrete 2400kg/m3 .
- The increasing percentage of pumice stones will show negative impact on strength of concrete (strength decreases).
- Generally Pumice stone absorbs more water compared to the nominal coarse aggregate, to overcome this problem additional usage of super plasticizes is added.

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