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Concrete Technology and Standard Practice for Block Masonry

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ABSTRACT
Due to their low specific gravity, concrete created with naturally occurring light weight aggregate derived from hard rock has a small range of density (300kg/m3-1840kg/m3) as opposed to regular concrete, which has a density between (2200kg/m3-2600kg/m3).Over 2,000 years have passed since the invention of lightweight concrete (ACI 213R; American Concrete Institute [ACI], 2003). The Coliseum, Pantheon Dome, and Port of Cosa are examples of early LWC constructions. Compared to conventional weight concrete, structural LWC structures are employed significantly less frequently today. The high porosity of light weight aggregates, which results in a low apparent specific gravity, is one of its key properties. While some low weight aggregates are produced artificially or from industrial waste, others are produced naturally.

Keywords: *concrete, technology, masonry*

I. INTRODUCTION

1.1 General

Lightweight concrete (LWC) has been used for more than 2,000 years (ACI 213R) (American Concrete Institute [ACI], 2003). Early notable LWC structures include the Port of Cosa, the Pantheon Dome, and the Coliseum. In modern times, structural LWC structures are widely used but to a much lesser extent than normal weight concrete.

1.2 Light Weight Concrete

Concrete made with natural light weight aggregate originating from hard rock has a density within a narrow range (300kg/m^3-1840kg/m^3) because of their low specific gravity while that of normal concrete lies between (2200kg/m^3-2600kg/m^3).

The light weight concrete having low density helps in the reduction of dead load, increases the progress buildings,and lowers haulage and handling cost. The weight of a building on the foundation is an important factor in design, articularlyin the case of weak soil and tall structures. If the floors and walls are made up of light weight concrete it will result on considerable economy. Another most important characteristic of light weight concrete is the relatively low thermal conductivity, a property which improves with decreasing density.

1.3 Classification of Light Weight Concrete

It is convenient to classify the various types of lightweight concrete by their method of production. These are:
1. By using porous lightweight aggregate of low apparent specific gravity, i.e. lower than 2.6. This type of concrete is known as lightweight aggregate concrete.
2. By introducing large voids within the concrete or mortar mass; these voids should be clearly distinguished from the extremely fine voids produced by air entrainment. This types of concrete is variously knows as aerated, cellular, foamed or gas concrete.
3. By omitting the fine aggregate from the mix so that a large number of interstitial voids are present; normal weight coarse aggregate is generally used. This concrete as no-fines concrete.

1.4 Light Weight Wggregates

The essential characteristics of light weight aggregates are its high porosity, which results in a low apparent specific gravity. Some light weight aggregates occurs naturally; others are manufactured from natural materials or from industrial by-products.

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1.4.1 Natural Aggregate

These types of aggregates are naturally available. They are classified into two types.

➢ **Inorganic Natural Aggregates**

Diatomite, pumice, scoria and volcanic cinders are natural, porous volcanic rocks with a bulk density of 500 - 800 kg/m^3 which make a good insulating concrete

➢ **Organic Natural Aggregates**

Wood chips and straw can be mixed with a binder to provide a lightweight natural aggregate. These are cellular materials which have air trapped within their structures once they have low moisture content.

1.4.2 Manufactured Aggregate

They are made by heating the appropriate raw materials to the point of incipient fusion in a rotating kiln, at which point the materials expand due to the production of gases and become trapped in a viscous pyroplastic mass. Some examples of manufactured aggregate are vermiculite, perlite, and clinker aggregate. Pumice stone has been chosen as the project's coarse aggregate.

1.5 Pumice

A naturally occurring lightweight aggregate known as pumice stone is created when molten volcanic material suddenly cools. Viscous magma that is primarily siliceous and rich in dissolved volatile components, particularly water vapor, erupts from volcanoes during eruptions to produce pumice.

Pumice can be utilized as a lightweight aggregate since it is both light and robust. When molten lava erupted from a deep location beneath the earth's crust, gas was able to escape, which is why they were so light. Due of its small weight and porous texture, pumice can float for a long time—sometimes years—before it ultimately gets wet.

The bulk density of pumice, a light-colored, froth-like volcanic glass, ranges from 500 to 900 kg/m3. There is no volcanic dust or clay present. A acceptable concrete made of pumice has a density of 800 to 1800 kg/m3, is good at insulating, but has high absorption and significant shrinkage. It offers excellent thermal insulation. It has a 15 to 40 kg/cm2 strength range.

The many vesicles and the delicate walls separating them give pumice a relatively low specific gravity. The rock can often float on water since it has a specific gravity of less than one. Pumice stone typically has a specific gravity of 0.67.

1.5.1 Uses

- Pumice is widely used to makjhue lightweight concrete or insulated low density cinder blocks.
- It is also used as an abrasive, especially in polishes, pencil erasers, cosmetic exfoliants and the production of stone-washed jeans.
- When used as an additive for cement, a fine grained version of pumice called pozzolan is mixed with lime to form a light weight, smooth, plaster-like concrete.
- It is used as aggregate in light weight concrete, as landscaping aggregate, and as an abrasive in a variety of industrial and consumer products.
- The pumice is used as a decorative ground cover in landscaping and planters.
- It is used as drainage rock and soil conditioner in plantings.
- It is used as a traction material on snow covered roads.
- It is used as a traction enhancer in tire rubber and absorbent in cat litter.
- It is used as a light weight filter for pottery clay and also used as a fine grained filter media.

1.5.2 Advantages of Pumice Stone

- Excellent mechanical strength to weight ratio; Although approximately 30% lighter than traditional concrete, pumice stone features high strength values with significant benefits for the structure's cost efficiency and behavior (reduced dead loads and transportation cost)
- All types of light weight concretes can be manufactured by altering the pumice stone's granularity and the concrete composition;

➢ Structural: compressive strength greater than 15 Mpa, density less than 2000kg/m^3.
➢ Structural and thermal insulating: compressive strength greater than 3.5Mpa density less than 1400kg/m^3.

➢ Thermal insulating: compressive strength greater than 0.5Mpa density less than 1000kg/m^3

- Lightweight concrete using pumice stone has good sound dampening properties. This is due to the pumice stone's porous structure that traps air and high sound proofing to weight ratio.
- Pumice stone products are non-combustible and thus enhance the structures fire resistance
- Pumice stone products feature good seismic behavior. Pumice stone light weight concrete is ideal for
- Filling interior floors and shaping final elevations and inclinations before lying marble, tiles or asphalt membrane.
- Insulations as either the final layer to form insulations or thermal insulation for roofs or thermal sound insulation of interior flooring.
- Construction and repairs, where reduced permanent loads and improved seismic behavior are required.

1.6 Characteristics of Light Weight Concrete

➢ **Density**

The density of light weight concrete varies from 300- 1200kg /m^3

➢ **Workability**

Due to low density and the characteristics texture of porous aggregates especially in the crushed state, the workability of concrete needs special attention. In general, placing compacting and finishing light weight aggregate requires relatively loss effort; even 50 or 75mm slump may be sufficient to obtain workability of the type that is shown by 100 to 125mm slump of normal-weight concrete.

➢ **Unit Weight**

Unit weight and strength are two properties generally sought from light weight concrete. With given materials, it is generally desired to have the highest possible strength/ unit weight ratio with the lowest cost of concrete. The air -dried unit weight of concrete is limited to a maximum of 18.40 KN/m^3. The use normal sand to control the proportions of hardened concrete tends to increase the unit weight, although this tendency is partially offset from the balancing effect of entrained air, which is invariably prescribed for improving the workability. Most structural light weight concrete weigh between 16.00 to17.60 KN/m^3; however job specifications in special cases may allow higher than18.40 KN/m^3.

➢ **Strength**

Design strength of 20 to 35Mpa, 28 day compressive strengths are common although by using a high cement content and good quality light weight aggregate of small size (9 to 13 mm maximum) has made it possible, in some precast and pre stressing plants, to produce 40 to 48 Mpa concrete. Lightweight aggregates with controlled micro porosity have been developed to produce 70 to75 Mpa lightweight aggregate which generally weight 18.40 to 20.00KN/m^3. The ratio between the splitting tensile strength and compressive strength decreases significantly with increasing strength of light weight concrete.

➢ **Thermal Insulation**

It is about 3-4 times more than that of bricks and about 10 times than that of concrete.
●Fir resistance is excellent.
● Sound insulation is poor.

➢ **Durability**

Aerated concrete is slightly alkaline. Due to this porosity and low alkalinity the reinforcement may be subjected to corrosion and as such, require special treatments.

➢ **Repairability**

Lightweight cellular element can be easily sawn, drilled or nailed which makes for each construction and repairs

➢ **Economy**

Due to light weight and high strength to mass ratio, the cellular products are quite economical.

1.7 Advantages of Using Light Weight Concrete

- Decreased dead load: less mass is required to support additional weight. Structural reinforcement can be less demanding

- Higher seismic resistance: in lower densities concrete can actually absorb shock. Light weight concrete is often used in ballistic tests ability. because of this Hammer blows can be absorbed without fracturing the concrete
- Lower water permeability: greatly reduced due to the diffusion of closed cells which prevent sponging. Also reduces problems caused by rusting rebar by eliminating the problem at its sources.
- Greater insulation: Enhanced R-values, especially in the lower density Range. Again, this is more sound absorption: The transmission of sound is inversely related to the number of air/solid interfaces. Light weight concrete has a high number of these interfaces, thus more due to the increased number of air/solid interfaces.
- Increased fire resistance: Greatly improved due to low thermal conductivity. Spalling is reduced or eliminated. Adaptability: Lighter weight increases options for on-site casting. Forming can be swifter and easier due to less supported weight Simplicity: ordinary tools can be used for alterations. It can be easily sawn and sculpted, and nailed or screwed without pre-drilling.
- Handling capabilities are vastly improved. Concrete does not need to be cold, damp, dense and hard to work with.

1.8 Disadvantages of Lightweight Concrete

- Very sensitive with water content in the mixtures.
- Difficult to place and finish because of the porosity and angularity of the aggregate.
- In some mixes the cement mortar may separate the aggregate and float towards the surface.
- Mixing time is longer than conventional concrete to assure proper mixing.

1.9 Applications of Lightweight Concrete

- Low density cellular concrete is used for precast floor and roofing units.
- Load bearing walls using cellular concrete blocks.
- As insulation cladding to exterior walls of structures.

1.10 Methodology

- Study on basic characteristic
- Testing of material
- Mix design
- Casting of cubes
- Testing of cubes
- Analysis of results

II. LITRATURE REVIEW

I. Application of Pumice Aggregate in Structural Lightweight Concrete

T. Parhizkar, M. Najimi and A.R. Pourkhorshidi

This study, presents experimental investigation on the two groups of light weight concrete are built and the physical/mechanical and durability aspects of them are studied. The results of compressive strength, tensile strength and drying shrinkage show that these lightweight concretes meet the requirements of the structural lightweight concrete. Also, the cement content is recognized as a paramount parameter in the performance of Light weight aggregate concretes.

II. Pumice Aggregates for Structural Lightweight and Internally Cured Concretes

Samuel Green, Nicholas Brooke and Len McSaveney

This paper presents research on the utilization of New Zealand’s abundant resources of pumice aggregates for producing structural lightweight and internally cured concretes. Mixture designs were developed for lightweight concrete containing both partially saturated and fully saturated pumice aggregates. A vacuum saturation system was developed to completely saturate the normally partially saturated aggregates and consequently avoid a loss of workability attributed to the high absorption capacity of pumice. Shear strength and bond strength of pumice concrete was investigated, as well as the application of saturated fine pumice aggregates as an internal curing

Media for both high performance concrete and ready-mixed full scale thin concrete slabs with a low water cementations materials ratio. The research presented demonstrates the potential to commercially produce structural lightweight concrete containing naturally occurring pumice aggregates, while meeting the requirements of New Zealand Concrete Design Standards

III. The Effects of Different Fine and Coarse Pumice Aggregate/Cement Ratios on the Structural Light Concrete Properties Without Using Any Admixtures.

L. Gunduz, I.Ugur

In buildings and structures, structural lightweight concrete provides weight and durability solutions. Lightweight concrete mixtures containing fine pumice aggregate (FPA) from the Nevehir region in Turkey and coarse pumice aggregate (CPA) from Yali Island in the Eastern Mediterranean were tested to produce high strength concrete for civil engineering applications, and the research results were discussed in this paper. Pumice aggregate lightweight concrete (PALC) mixture testing samples with a slump of between 35 and 45 mm were made in order to analyze the effects of FPA and CPA/cement ratios on the structural concrete engineering properties. The different pumice aggregate/cement (A/C) ratios of 2:1, 2 1/2:1, 3:1, 3. 1/2:1, and 4:1 by weight and cement contents of 440, 375, 320, 280, and 245 kg/m3, respectively, were used. The results of the experimental investigation demonstrated that PALC is typically 30–40% lighter than regular weight concrete, however has strengths comparable to that material. Due to its lower density values, PALC demonstrated design flexibility and significant cost savings by supplying reduced dead load. Compressive strength, elastic modulus, and density are the qualities that grow in value and signify rising quality with lower A/C ratios (high cement concentrations). Water absorption and carbonation depth are properties that decline in value and show an increase in quality with decreasing A/C ratios. Reduced A/C ratios (greater cement content) always result in higher quality. The study demonstrated that fine and coarse pumice aggregate mixes can be used to create structural lightweight concrete without the need for admixtures or other additives.

IV. Effect of Prewetting Methods on Fresh and Hardened Properties of Concrete with Coarse Aggregate

Nihat Kabay, Fevziye Akoz

The high water absorption capacity of the aggregates as a result of their porous structure is one of the main issues with the manufacture of lightweight aggregate concrete. Rewetting the lightweight aggregates or adding more mixing water are typical solutions for this issue. It is critical to consider aggregate rewetting techniques prior to the fabrication of lightweight concrete since they have a major impact on the properties of both fresh and hardened concrete.

The effects of three presetting techniques on several newly formed and hardened characteristics of lightweight pumice concrete are the main subject of this study. Prior to mixing, pre-soaking, water-soaking, and vacuum-soaking techniques were used on pumice lightweight aggregate. According to test results, lightweight aggregate that had been vacuum- and water-soaked in concrete had much better fresh and hardened properties than lightweight aggregate that had been pre-soaked in concrete. Pumice lightweight concrete's workability, compressive strength, and drying shrinkage were all improved by vacuum- and water-soaking the aggregate.

V. Effect of Coarse Aggregate Type and Loading Level on the High Temperature Properties of Concrete

Minho Yoon, Gyuyong Kim, Gyeong Choel Choe, Youngwook Lee, Taegyu Lee

When concrete is exposed to temperature changes, its durability is reduced because of the decomposition of cement metrics generation of cracks within its structure as its component materials undergo different volumetric changes. Coarse aggregates play an important role in such behavior of concrete.

Thus, using two different types of concrete—one with a coarse aggregate made of granite (NWC: normal weight concrete) and the other with a lightweight aggregate made of clay and ash (LWC: lightweight concrete)—we conducted a fire experiment under loading in order to assess the impact of coarse aggregates on the fire resistance performance of a concrete structure. Under thermal load conditions, LWC showed more residual compressive strength than NWC. High temperatures caused a lot of cracks to appear inside the NWC, whereas the LWC's interior showed fewer cracks due to the voids that helped to reduce the stress caused by thermal expansion. Both NWC and LWC showed quasi-equilibrium between the thermal expansion strain and the loading-induced shrinkage strain when a load equal to 20% of its room temperature compressive strength was applied. The specimen showed shrinkage strain under the 40% loading condition, and it was shown that its compressive strength significantly dropped below 500 °C.

VI. Laboratory Investigation of Lightweight Concrete Properties

H. Celik Ozyildirim, Ph.D., P.E.

The purpose of this study was to evaluate the density (unit weight), splitting tensile strength, and elastic modulus of LWC mixtures under different curing conditions to achieve a better understanding of the LWC properties that are essential for long-lasting and cost-effective structures. Further, the study examined the correlation between the results of the rapid chloride permeability test and the surface resistance test using the Wenner probe to investigate whether the latter could be used to predict the permeability of LWC mixtures, as it is faster and more convenient. The scope of the study was limited to LWC mixtures having different lightweight aggregates prepared and tested in the laboratory.

The results indicated that measured densities are different than those calculated from batch weights; curing conditions affect the splitting tensile strength and elastic modulus values; and the correlation between the results of the rapid chloride permeability test and the surface resistivity test for a given lightweight aggregate was good. The study recommends that fresh concrete densities be used in designing for dead load computations of LWC structures; that the curing condition be stated for the hardened concrete properties; and that the surface resistivity test be permitted for screening or acceptance of LWC specimens for permeability after the test is standardized by the American Association of State Highway and Transportation Officials.

VII. Some Mechanical Properties of Pumice Llightweight Aggregate Concrete Incorporating Rise Husk Ash

Kawkab H. Al-Rawi, Mazin T. Al-Kuttan, Rawa'a A. Al-Niemey

This study looks into the viability of producing structural lightweight aggregate concrete with locally-sourced pumice rocks (found in the northern part of Iraq).

The effect of incorporating high range water reducing admixture (HRWRA) synergistically with 8% rice husk ash (RHA), as a partial replacement by weight of cement, on the mechanical properties of LWAC was investigated in this study. Two types of lightweight concrete (LWC) were produced using pumice stone as a coarse aggregate with natural sand and also with fine pumice aggregate.

All varieties of lightweight aggregate concrete were examined at various curing ages for hardened unit weight, compressive strength, and splitting tensile strength. In comparison to the reference concrete, the addition of 8% RHA as a partial replacement by weight of cement and the recommended dosage of HRWRA (6% by weight of cement) resulted in a significant improvement in mechanical qualities at all curing ages.

The air-dry density of LWAC containing fine pumice aggregate is lower than that of sanded-LWAC. In comparison to sand-LWAC, LWA concretes containing fine pumice aggregate exhibit lower compressive strength and splitting tensile strength at all curing ages.

VIII. Experimental Study on Light Weight Aggregate Concrete with Pumice Stone, Silica fume and Fly Ssh as a Partial Replacement of Coarse Aggregate

Lakshmi Kumar Minapu, M K M V Ratnam, Dr. U Rangaraju

Using light weight aggregate pumice stone as a partial replacement for coarse aggregate and mineral admixture components such fly ash and silica fume, an attempt has been made in this study to examine the mechanical properties of a structural grade light weight concrete M30. In order to evaluate the compressive strength, tensile strength, and flexural strength, 12 sets were created along with a Control Mix. There are 4 cubes, 2 cylinders, and 2 prisms in each set. For each blend, a slump test was performed in its fresh state. 28-days In the hardened state, tests for compression, tensile strength, and flexural strength were conducted. The investigation is also expanded to include the mixing of several admixtures made of minerals with concrete. The test findings revealed a general increase in strength and a loss of weight on different trails.

By using 20% of light weight aggregate as a partial replacement to natural course aggregates the compressive strength is promising. The density of concrete is found to decrease with the increase in percentage replacement of natural aggregate by pumice aggregate. The compressive strength of concrete is found to decrease with the increase in pumice content. With the addition of mineral admixtures, the compressive, split-tensile and flexural strengths of concrete are increased. Light weight aggregate is no way inferior to natural coarse aggregate and it can be used for construction purpose.

IX. High Strength Natural Light Weight Aggregate Concrete with Silica Fume

A.Yenigobali,, K.G.Sobolev, S.V.Soboleva, M.Tokyay

In Turkish standards highest strength classes for light weight aggregate and pumice concretes are 30 and 16MPa. In this research selected samples of these light weight rocks were used to produce high strength light weight aggregate concretes. The binding medium was made of ordinary Portland cement, silica fume and super plasticizing admixture. For each concrete mixture properties such as unit weight, workability, compressive strength at various ages, as well as splitting tensile strength, modulus of elasticity and thermal conductivity values were determined to find the optimum quantities of materials to be used.

Tests show that it is possible to produce a natural lightweight aggregate concrete with a 28 day compressive strength of 55MPa, a dry unit weight in the range of 1700-2100kg/m^3 and coefficient of thermal conductivity value of about0.55W/m^{2}K. Results showed that the bleeding and shrinkage of the light weight aggregate concrete was very much less when compared to that of the conventional concrete. The usage of silica fume improved the compressive strength, split tensile strength and modulus of elasticity.

X. Fibre Reinforced Light Weight Aggregate (Natural Pumice Stone) Concrete

N. Sivalinga Rao, Y.Radha Ratna Kumari, V. Bhaskar Desai, B.L.P. Swami

A composite material called steel fiber reinforced concrete (S F R C) was created to significantly increase the ductility of concrete while reducing its brittleness. To line tunnels and other underground structures, thicken pavements, repair and reinforce various constructions, steel fiber reinforced concrete (S F R C) is frequently employed. Pumice stone is a very common raw material since structural applications are using lightweight materials more and more. More than the target meaning M 20 concrete's strength is obtained with a 20% substitution of pumice for natural coarse aggregate and a 1.5% addition of fiber. Additionally, the average target mean strength of M20 concrete is attained with 40% pumice and 0.5% of fibers. The compressive strength of pumice concrete is observed to rise with the fiber content and reaches an optimal value at 1.5% of fiber content, after which it falls for varied pumice contents.

According to the experiment, the ideal replacement proportion for natural aggregate is 20% pumice and 1.5% fiber, since this combination results in a higher number of blows. Additionally, a 20% pumice content without fiber is thought to be the ideal range for achieving the best impact value.

III. MATERIAL PROPERTIES

Cement

- Fineness : 6.5
- Specific gravity : 3
- Standard consistency : 30%
- Setting time test : Initial setting time : 35min and final setting time should not exceed 10 hrs.

Sand

- Specific gravity is 2.67

Pumice Stone

- Specific gravity of bottom-ash is 0.64

Coarse-Aggregate

- Specific gravity of coarse aggregate is 2.74
- Bulk density : 1673.13 kg/m^3

IV. METHODOLOGY

4.1 Mix Design

Table1: Mix Proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
206(L)	412 Kg	600.92 Kg	1045.43 Kg
0.5	1	1.50	2.50

Table2: Materials Required for One Cube of Size 150mm×150mm×150mm (w/c = 0.5)

SI No	Cement in Kg	Fine Aggregate in kg	Coarse Aggregate in kg	Water cement ratio	Pumice stone in%	Pumice stone in kg
1	1.0	1.50	2.50	0.5	0	0
2	1.0	1.50	2.0	0.5	20	0.138
3	1.0	1.50	1.50	0.5	40	0.277
4	1.0	1.50	1.0	0.5	60	0.416
5	1.0	1.50	0.50	0.5	80	0.554
6	1.0	1.50	0	0.5	100	0.693

V. TEST FOR CONCRETE

Table3: Test results for Hardened Concrete

S.NO	% of pumice stone added	Compressive strength		Durability test 1% HCl acid immersion		Tensile strength	
		7 days	28 days	7 days	28 days	7 days	28 days
1	0	23.43	32.80	18.77	27.80	0.74	1.90
2	20	17.21	28.27	15.19	23.22	0.60	1.86
3	40	16.32	26.70	12.11	21.90	0.50	1.71
4	60	13.11	22.19	11.01	18.02	0.47	1.66
5	80	10.09	20.36	7.22	16.85	0.43	1.58
6	100	9.36	17.84	5	12	0.35	1.50

VI. RESULT AND DISCUSSION

Replacement of pumice stone in coarse aggregate by 0, 20, 40, 60, 80, or 100%. Maximum compressive, tensile, and durability compared to other compositions are achieved with zero replacement of pumice stone. Following that, replacing 20 and 40 percent of the coarse aggregate with pumice stone increases the concrete's strength and durability by 20 m. After this, substituting pumice stone for coarse aggregate by 60, 80, or 100 percent failed to increase the strength and durability of the concrete.

VII. CONCLUSION

Pumice stone works well as a substitute for coarse aggregate. Although it performed less well than coarse aggregate, M20 concrete was nevertheless achieved. This can be used to stop the need for coarse aggregate. Lightweight aggregate can be utilized in construction and is in no way inferior to natural coarse aggregate.

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