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Investigate the Possibility of Utilizing Cellular Lightweight Concrete and Autoclave Aerated Concrete Block Dust as Partial Replacement of Cement: A Review

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ABSTRACT:

In the present scenario where the constructions are increasing, the need to find a supplementary Cementing material for the improvement of strength and which has less environmental effects is of great significance.The main objective of the research work is to investigate the possibility of utilizing cellular lightweight concrete and autoclave aerated concrete block dust as partial replacement of cement. The basic properties like consistency, specific gravity was determined and compare with ordinary Portland cement. SEM, EDX and XRD analysis is also performed for chemical composition and crystallography of utilizing cellular lightweight concrete and autoclave aerated concrete block dust. The result of the study shows that up to 20% replacement of cellular lightweight concrete block dust gives more strength that normal mortar cube. However, large levels of replacement lead to delayed hydration of the mix and porous microstructure and consequently lower compressive strength of cube. From the XRD analysis of cube sample shows that 20% replacement of cellular lightweight concrete block dust has more calcite component than 0% replacement of mortar cube.

Keywords: chemical composition, compressive strength, consistency, crystallography, specific gravity

INTODUCTION:

Engineering projects that are environmentally beneficial are uncommon. Portland cement is used in the construction industry, which significantly raises CO2 emissions and damages the environment. In the last 20 years, construction has significantly increased in India. It is a well-known fact that CO2 emissions contribute 65% of the rise in global temperatures, and by 2020, they are projected to have climbed by 100%. The cement industry contributes to the atmosphere annually with over 2.8 billion tonnes of greenhouse gas emissions, or about 7% of all man-made emissions. Numerous additional environmentally hazardous pollutants produced by the cement industry, Additionally, gases that contribute to global warming, like sulphur dioxide (SO3) and nitrogen oxides (NOx), are created. Due to the contamination brought on by the making of cement, the concrete industry was compelled to find numerous ways to lower CO2 emissions. Cellular Lightweight Concrete (CLC) block dust and Autoclave Aerated Concrete (AAC) are two alternatives to cement.

CELLULAR LIGHTWEIGHT CONCRETE

Cellular light weight concrete (CLC) is sometimes known as foam concrete. Extremely lightweight Cellular Light Weight Concrete (CLC) is created in a natural setting using the same processes as conventional concrete. A cement-bonded product called CLC Blocks is made by combining cement slurry. To create foam concrete, stable, pre-formed foam that is produced locally is injected into this slurry. The amount of slurry in fresh foam concrete, which has a milkshake-like appearance, determines the foam concrete's cast density

Fig: - Cellular Lightweight Concrete (CLC) block

APPLICATIONS OF CELLULAR LIGHTWEIGHT CONCRETE

With dry densities of 400–1600 kg/m3 and 7-day strengths of roughly 1–10 MPa, foamed concrete can be created. Foam concrete is ideal for filling voids and insulating floors and roofs because it is fire resistant and provides good thermal and acoustical insulation. Additionally, trench reinstatement benefits greatly from it. Several uses for foam concrete include:

- Precast concrete blocks
- Precast wall panels / elements
- cast-in-place walls / Cast-in-situ
- Insulating compensation laying
- Insulation floor screeds
- Insulation roof screeds
- Sunken portion filling
- Trench reinstatement
- Sub-base in highways
- Filling of hollow blocks
- Prefabricated insulation boards

PROPERTIES OF CELLULAR LIGHTWEIGHT CONCRETE

- **Light in Weight:** It is extremely light, with a density of 300 to 1800 kg/m3. This was three times lighter than clay brocks or fly ash.
- **Eco friendly:** It honours the natural world. Blocks are made in part from fly ash and other industrial waste, thus foam concrete is created using eco-friendly ingredients. Neither during production of foam concrete nor during use do harmful effluents leak into the environment. It is ideal for use in the construction of partitions due to its low weight. In this case, foam concrete will replace the need for plywood dividers. Less deforestation will occur as a result, which is excellent for the environment.
- **Sound Insulation:** The house is kept warm in the winter and cool in the summer thanks to the excellent sound insulation provided by foam concrete, which also results in energy and electricity savings for heating and cooling. Even higher numbers can be possible depending on the block thickness.
- **Thermal Insulation:** To produce the same level of thermal insulation as a 100mm thick CLC wall, a dense concrete wall would need to be more than ten times heavier and five times thicker.
- **Lower Water Absorption:** Cellular lightweight concrete blocks have a relatively lower water absorption rate than other types of concrete blocks. This is significantly superior than concrete's 50% water absorption rate and standard brick's 50% to 80% water absorption rate. The decreased water absorption capacity of these materials will aid in reducing wall cracks.
- **Fire Protection:** When a fire hazard is present, cellular lightweight concrete blocks provide better fire protection. It can sustain a fire for 4 hours with a wall that is only 100mm thick and has a density of 1000kg/m3 while still transporting heat and not emitting any harmful gases. Compared to dense concrete or brickwork, cellular concrete has a significantly greater fire rating.

- **Easy to Handling:** Building costs are decreased since foam concrete blocks are easy and quick to assemble. They require very little maintenance, which lowers overall expenditures. Foam concrete blocks save money by reducing the need for cement, sand, water, labour, and energy.

AUTOCLAVED AERATED CONCRETE

A high-quality building material called autoclaved aerated concrete is created from quartz sand, cement, aluminium compound, lime, and water. The high strengthening, light wt., and thermal qualities of AAC are the result of a number of natural chemical reactions that occur during the manufacturing process. For partition walls, interior walls, and external walls, lightweight AAC (Autoclaved Aerated Concrete) blocks (bricks) can successfully replace conventional bricks and precast concrete. A wide range of structures, including public buildings, industrial buildings, civil houses, hospitals, hotels, schools, retail businesses and supermarkets, have used the new building materia

Fig: - Autoclaved Aerated Concrete (AAC) block

APPLICATIONS OF AUTOCLAVED AERATED CONCRETE

AAC works best in urban areas with tall structures and large temperature variations. Due of its lower density, AAC requires less steel and concrete for structural members in high rise buildings. Less mortar is needed to install AAC blocks since there are fewer joints. Similarly, less material is required for portrayal due to the dimensional accuracy of AAC. Since AAC eliminates the need for separate building and insulation materials, it is suitable for use in hot regions and speeds up construction while lowering construction costs.

PROPERTIES OF AUTOCLAVED AERATED CONCRETE

- Compared to other cement construction materials, it has a number of essential benefits, the most noteworthy of which is that it has a smaller environmental impact.
- Better thermal efficiency lowers the heating and cooling load on buildings; Porous structure provides improved fire resistance.
- Workability enables precise cutting, which reduces the amount of solid waste produced while in operation.
- Lightweight items are more likely to survive seismic action and use less fuel and money for delivery.
- **Environmentally friendly:** When compared to using conventional concrete, It contributes to at least a 30% reduction in environmental waste. The amount of greenhouse gas emissions has dropped by 50%. Utilising autoclaved aerated concrete has a greater positive impact on the environment.
- **Fire resistant:** ACC is similarly fire resistant to regular concrete. It is completely inorganic and nonflammable.
- **Great ventilation:** Due to its high airiness, this substance enables for water dispersionAs a result, the building's humidity will decrease. ACC will take in moisture and expel humidity to prevent condensation and other mildew-related problems.
- **Non-toxic:** Aerated concrete that has been autoclaved is free of hazardous substances and toxic gases. Rodents and other pests cannot harm it since they are not drawn to it.
- **Lightweight:** Concrete blocks produced by ACC weigh around one-fifth as much as normal concrete. They are additionally provided in manageable sizes for quick manufacture.
- **Quick assembly:** The assembly is significantly quicker and easier because the material is lightweight and simple to work with.

LITERATURE REVIEW:

Studies in RCA Concrete

Today, there is a lot of crushed concrete produced as a result of tearing down ancient buildings. Worldwide, 145 million tonnes of construction trash are produced each year [Revathi et al. 2013]. This much rubbish needs a tremendous amount of space to be landfilled. Therefore, recycling of building debris is essential to protect the environment through resource conservation as well as to lessen the quantity of open area needed for land-filling [Revathi et al. 2013, Pacheco-Torgal et al. 2013]. According to numerous studies [Khalaf and Venny 2004; Pacheco-Torgal and Said 2011; Ameri and Behnood 2012; Vázquez 2013; Behnood et al. 2015; Pepe 2015 and Behnood et al. 2015], recycling lowers energy use, pollution, global warming, greenhouse gas emissions, as well as cost.

Several academics have looked into the mechanical and physical characteristics of RCA and how they affect concrete when RCA is used to partially or entirely replace natural aggregate. It has been discovered that the RCA concrete's mechanical strength is lower than that of regular concrete. This is because the RCA is significantly more porous than natural aggregates and contains more [Rahal 2007, Brito and Saikia 2013] Replacement material for natural aggregate.

Barbudo et al. (2013) looked into the impact of the water-reducing additive on the mechanical characteristics of recycled concrete. The results of this investigation show that recycled concrete has certain properties may be enhanced by the application of plasticizers. Rahal (2007) compared the mechanical characteristics of concrete using recycled material to concrete with natural aggregate.

In 2009, Tabsh and Abdelfatah investigated the mechanical characteristics and behaviour of recycled aggregate. Recycled concrete is said to have a 10–25% lower strength than concrete with natural aggregate. According to reports, even if recycled aggregate performs worse than natural aggregate, its qualities are still within acceptable bounds.

From the known conventional approaches, Bairagi et al. (1990) suggested a method of mix design for recycled aggregate concrete. According to some estimates, the additional cement needed was around 10% higher due to the weaker aggregate.

According to reports, with the same water to cement ratio (w/c) and cement type, concrete constructed entirely of recycled aggregates is weaker than concrete made entirely of natural aggregates. According to a large body of published evidence, RCA concrete without NCA reduces compressive strength by up to 25% less than NCA concrete (Amnon, 2003; Tabsh and Abdelfatah, 2009; Elhakam et al., 2012; McNeil and Kang, 2013). Flexural strength and tensile splitting.

Studies on Mechanical Properties of CLC and AAC Block

Autoclaved aerated concrete is very light weight and has a highly porous structure, with air pores and micropores making up around 80% of the volume of the hardened material. In addition, it is simpler and quicker to utilise in construction and building operations than traditional concrete and has lower thermal conductivity, stronger heat resistance, and lower shrinkage than that material [Alduaij et al. 1999; Kearsley et al. 2001]

Using the waste sugar sediment in the concrete composite, Thongtha et al. (2014) were able to pinpoint the advantages of AAC. Significant and crucial findings with regard to the physical, mechanical, and thermal properties of the enhanced Autoclaved Aerated Concrete (AAC-SL-30-7.5) include increased compressive strength, slower heat transfers, and lower thermal conductivity.

According to research by Cai et al. (2016), increasing the substitution mass ratio of iron tailing has a detrimental impact on the compressive strength of AAC, whereas iron tailing that is more finely ground can significantly increase the strength of AAC products.

Tests on cellular concrete were conducted by Rudolph and Valour (1954), who proposed that the flexure strength of CLC was 1/3 to 1/5 of compressive strength. In his recent study on the impact of synthetic and protein foaming agents on the properties of cellular concrete, Panesar (2013) found that the material has good potential for use in lightweight structural applications because of the development of its mechanical properties, transport properties, and thermal resistanc

Studies on Mortar Cube using Different Cementitious Materials

Numerous additional environmentally hazardous pollutants produced by the cement industry, such as sulphur dioxide (SO3) and nitrogen oxides (NOx), which are factors in global warming, are also produced. The concrete industry was forced to discover numerous solutions to reduce CO2 emissions due to the contamination caused by cement manufacture.

Shehab et al. (2016) conducted research on fly ash-based geo-polymer concrete and found that the 50% cement replacement ratio produced mixtures with the highest compressive strength, bond strength, splitting tensile strength, and flexural strength at 28 days.

Vardhan et al. (2015) conducted research on marble dust. According to the study's findings, marble powder can substitute cement up to 10% of the time without affecting the final mixture's technical properties. In fact, replacing up to 10% of the cement with marble powder improves the mix's workability while leaving the mix's compressive strength unaffected.

Research on using rice husk ash instead of cement in the manufacturing of concrete was conducted by Alex et al. in 2016. They found that RHA fractions with higher fineness exhibit improved Chapelle activity. In the event of the development of compressive strength, the partial replacement of RHA ground samples at 20 wt% and for unground RHA at 15 wt% may be regarded as acceptable. in the tensile

Singh et al.'s (2017) study on the results of cement replacement with waste marble slurry. This is advantageous for appropriate concrete setting since the initial setting period needs to be lengthy enough to allow for the transportation and placement of cement. Because marble slurry has a higher magnesium concentration than cement, the soundness rating

Bentz et al.'s (2017) research looked at limestone and silica powder as cement substitutes. Both limestone and silica powders have been shown to speed up early-age hydration and shorten or maintain initial setting times.

A. Costa [1] Inventive materials and technical solutions often make this constructive system more economically favorable with respect to the other structural options in terms of cheaper construction, maintenance, and operation. Therefore, studying the comparison between the application and utilization of two materials in seismic prone areas still requires further verification of the anticipated structural performance of RC in filled frames.

Abdel-Mooty et al [2] An experimental program is designed to evaluate the performance of lightweight autoclaved aerated concrete masonry wall strengthened using fibrocement layers, in a sandwich structure, under in-plane compression and outof-plane bending. The 25 mm thick ferrocement mortar is reinforced with steel welded wire mesh of 1 mm diameters at 15 mm spacing. Different types of shear connectors are used to evaluate their effect on failure loads.

Alexandre A et al [3] The need to assess the seismic performance of autoclaved aerated concrete (AAC) masonry arose in different countries in the last years. The use of AAC for load-bearing walls is quite common in low seismicity areas in Central and Northern Europe, where its thermal insulation properties, together with lightness and workability, are particularly appreciated.

Er. Deepak Khanal, [4] The increasing demand of construction is a challenge to be fulfilled in this regard different new construction materials are found to be utilized differently. The compressive strength of the AAC block was found to be 4.324 N/mm2 even with a low density of 617.6 kg/m3when compared to a 3.402 N/mm2 average compressive strength of brick of 1685.8 kg/m3 density. However, the water absorption of the AAC blocks was found higher than that of the Clay brick.

MIX PROPORTIONING OF CONCRETE INGREDIENTS

The mortar cubes used in this research were manufactured in accordance with ASTM C-109/C-109M. The specimen moulds measure 50mm by 50mm by 50mm (2 inches by 2 inches by 2 inches). The proportion of components for the common mortar is one part cement to 2.75 parts graded standard sand by weight. For all types of Portland cement, use a 0.485 water to cement ratio. The following materials must be mixed in the batch of mortar at one time to create the six test specimens:

Then several % of CLC and AAC block dust (in wt.) were used to replace the regular Portland cement, including 0%, 5%, 10%, 15%, 20%, 25%, and 30%. In Tables 1 and 2, respectively, the mix ratio for specific samples of mortar cubes made of CLC and AAC block dust is displayed.

Table: 3.5- Cement replacement with CLC block dust

Specimen No.	OPC (gm)	CLC block dust (gm)	Sand (gm)	Water(mL)
C-0	500	0	1375	242
C-1	475	25	1375	242
C-2	450	50	1375	242
C-3	425	75	1375	242
C-4	400	100	1375	242
C-5	375	125	1375	242
C-6	350	150	1375	242

Table: 2- Cement replacement with AAC block dust

Specimen No.	OPC (gm)	AAC block dust (gm)	Sand (gm)	Water (ml)
A-0	500	0	1375	242
A-1	475	25	1375	242
A-2	450	50	1375	242
A-3	425	75	1375	242
A-4	400	100	1375	242
A-5	375	125	1375	242
A-6	350	150	1375	242

MIXING OF INGREDIENTS AND CASTING OF SAMPLES

Sand and the necessary amount of Ordinary Portland Cement should be mixed completely and dried. To the dry mixture of cement and sand, add the specified volume of water (0.485P), and thoroughly combine for no longer than 4 minutes. (Potable water ought to have been used to prepare the control specimen)

Place the cement mortar in the moulds, install it in the vibrating machine's holder, and securely fasten it

To achieve the necessary compaction, fill the moulds with the necessary quantity of cement mortar while vibrating, and vibrating should be done at the specified speed (12000 cycles per minute).

Remove the moulds from the holder once the necessary compaction has been achieved, and place them somewhere for 24 hours so they can set.

To get the required cure, take the cube out of the moulds after 24 hours and immediately submerge it in water.

TEST PROCEDURES

Dry density

The desired density for this project is 1500 kg/m3, and since the density of the cubes completely depends on the amount of foam in the mixture, as foam content rises, dry density falls. For this investigation, 1.5% of the foam is blended. The dry density results are shown in table 1 and graphs 1-2. Additionally, it has been found that adding quarry dust to CLWC increases its density.

It is the mass of unit volume of homogenous material. Density of a material greatly influences its physical material. Density = mass / volume

Water Absorption: The results of the cellular light weight concrete's absorption test are shown below in table 2 and graphs 3–4. The water absorption test results demonstrate that adding quarry dust to CLWC lowers CLWC's water absorption. Cement: Fly ash (65:35) While T6 mix, which contains 30% quarry dust, has a water absorption of 10.34%, CC mix has a water absorption of 14.78%.

it is the capacity of a material to absorb and retain water and the dry material is fully immersed in water and then water absorption is workout either as % of weight or % of volume of dry material. % of water absorption = ((W2 – W1) / W1) X 100

Compressive Strength: According to the technique stated in the applicable Indian Standard, all of the cement mortar cubes are tested in a load-controlled universal testing machine to determine their unidirectional compressive strength at 7 and 28 days. Figures show the hardened mortar cubes prior to the compressive strengthening test and the strain-controlled UTM, respectively. display the compressive strength of CLC and AAC mortar cubes after 7 and 28 days of curing. The results for CLC mortar cubes are plotted at 7 and 28 days, respectively, Similar results are shown for the compressive strength of AAC block dust at 7 and 28 days, respectively,

The compressive strength was calculated according to the following formula:

$\sigma = P/A$

where,

σ = Compressive Strength (N/mm^2)

P = Maximum load sustained by the cube (N)

A = Area of cross section of cube (mm^2)

The average compressive strength of three specimens at 7 days, 28 days, and 90 days for each concrete mix was used to calculate the results of the compressive strength tests.

Figure: Compressive Strength Test on Compression Testing Machine

SUMMARY:

Following a thorough analysis of the literature, many earlier researchers investigated the use of different cementitious materials in place of cement to strengthen concrete's compressive strength. Numerous previous research have concentrated on recycled aggregate to prevent the needless disposal of demolished concrete in productive land. There aren't many studies on CLC and AAC blocks that could be used in place of cement.

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