Experimental Studies on Cellular Light Weight Concrete Based On Foam, Fly Ash, and Silica Fume: A Review

Abbas Joun[1], Mr Rajneesh Kumar[2]

[1]*Master of Technology in Civil Engineering, Lucknow Institute of Technology, Lucknow, India*
[2]*Assistant Professor, Civil Engineering, Lucknow Institute of Technology, Lucknow, India*

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Abstract - *After the mixture that contains Portland cement, fly ash, and finely crushed siliceous filler has been subjected to expansion and hardening, lightweight cement-stone dust blocks can be manufactured by adding air or gas to the mixture. The mixture's ingredients include Portland cement, fly ash and finely crushed siliceous filler. The expansion and hardening procedures need to be performed on the mixture before anything further can be done with it. In the end, this results in the development of a structure that is permeable throughout its whole in its entirety. The inclusion of aluminium metal powder into the mixture may be directly ascribed to the production of porous structures. [Case in point:] [Case in point:] The formation of pores in the structure is the result of a reaction that takes place between the calcium hydroxide that is produced during the hydration of cement and the aluminium metal powder. This reaction results in the release of hydrogen gas, which causes the structure to be porous. In this study, the properties of lightweight cement stone dust blocks are investigated and contrasted with those of regular blocks with the same features as well as traditional bricks made from burned clay. Additionally, regular blocks with the same features are compared to bricks traditionally made from burned clay. In addition, regular blocks with the same qualities as bricks typically formed from burnt clay are contrasted with one another in this study. Typically burned clay bricks might be replaced in structures with blocks constructed of lightweight cement-stone dust to lessen the amount of strain that is placed on the structure as a direct consequence of the weight of the structure itself.*

Key Words: Foam, Fly ash, Silica, Cellular Lightweight Concrete, Cement.

1. INTRODUCTION

It is feasible to define lightweight concrete as a kind of concrete that includes an expansion agent. This is one way to explain lightweight concrete. This agent acts to raise the volume of the mixture while also providing other aspects to the concrete, such as the capacity to be nailed and a reduction in the amount of weight that is contributed to the finished product. It is much lighter than the normal kind of concrete. The United States of America, the United Kingdom, and Sweden are just some of the countries that have seen an increase in the prevalence of the use of lightweight concrete in recent years. The most notable advantages that come along with using lightweight concrete are that it has a lower density and a higher heat conductivity than other types of concrete. By using this strategy, one may be able to receive several advantages, some of which include the removal of dead load, an increase in construction rates, and a reduction in the costs connected with shipping and handling. The major emphasis of this research was on analysing how well aerated lightweight concrete performed. Specific tests, including those assessing compressive strength, water absorption, and density, in addition to supplementary testing and comparisons with different types of lightweight concrete, were carried out. Because of the reaction that takes place when pozzolanic admixtures and CaOH come into contact with one another, more CSH phases are generated. This results in concrete that is denser and more long-lasting. Because of their very delayed hydration properties, some extra cementitious materials, such as fly ash, contribute relatively little to the early age strength of the cement. On the other hand, vermiculite is capable of accelerating the hydration process of cement due to its high level of reactivity with calcium hydroxide. Vermiculite contains several properties. The use of pozzolanic admixtures not only lowers emissions of carbon dioxide but also makes it possible for structures to have longer service lives. This, in turn, lowers the negative impact that these structures have on the environment. Pozzolanic admixtures are used in concrete, mortar, and other building materials. This is due to the increased permeability levels of contemporary concrete buildings, which allow for more aggressive materials to enter and create corrosion difficulties.

1.1. Light Weight Concrete

Despite this, there have only been a few recent studies and a relatively small number of studies done overall on the durability performance of concrete that includes pozzolanic by-products. The objective of this study is to compile empirical evidence about the performance of concrete containing vermiculite and fly ash from the standpoints of both its tensile strength and its abrasion resistance. The use of supplementary cementitious materials (SCM) as a partial substitute for cement is an effective strategy that may be utilised to decrease the negative impact that is exerted on the environment in which it is located. This method has the potential to result in financial savings, savings in terms of energy consumption, and a decrease in the quantity of waste that is created. There have been a large number of studies that have been published on the subject of improving the performance of concrete through the partial or complete replacement of Portland cement with other types of mineral admixtures. These studies have been conducted both in the United States and in other countries. Fly ash, silica fume, blast-furnace slag, and other materials that are quite similar to them are some examples of these admixtures. The advantages provided by mineral admixtures may be summed up as follows: an improvement in workability; increased resistance to thermal cracking; increased resistance to chemical assaults; and the production of high-performance concrete. Concrete's workability, mechanical properties, and durability may all benefit from the use of sustainable building materials (SCMs), in addition to the fact that these materials have a positive impact on the surrounding ecosystem. The reactivity of SCMs might be classified as pozzolanic, latent, or hydraulic; alternatively, it could be a combination of these three types of reactivity. Pozzolan is a type of siliceous substance that, when combined with calcium hydroxide in the presence of water and the form of finely split particles, will undergo a chemical reaction that will result in the formation of cementitious compounds. This chemical reaction will take place in the form of finely split particles. When the pozzolan is already in the form of particles that have been finely divided, this reaction may take place. The word "pozzolan," which is used to describe the substance, is the origin of the name "pozzolan," which was given to the substance. Pozzolans can originate from either naturally occurring sources or from sources that are manufactured intentionally. Pozzolans are naturally occurring chemicals that may be found in the environment in a variety of forms, such as diatomaceous earth and volcanic ash. Pozzolans are used in a variety of applications. On the other hand, pozzolans, which are created from the byproducts of industrial operations, are the materials that are used in contemporary building construction the most often. Recently, there has been a growth in interest in the use of high-reactivity vermiculite in the concrete industry as supplementary cementitious material. This interest has been spurred on by the fact that this usage of vermiculite is becoming more commonplace. The most recent events that have taken place in the industry have helped to pique this curiosity. Recent occurrences have been acting as a primary motivating factor behind this rekindled interest. The most recent events and discoveries in this area have served as the fuel for this reinvigorated interest in the subject matter. This interest was reignited as a result.

1.2. Foam

The study of physical chemistry is where the word "colloidal system" was first developed. This phrase is used to describe a foam or foam spray. It is a dispersion of particles in a medium that is continuous, and in this case, the particles take the form of gas bubbles while the medium is a liquid. In other words, the particles are suspended in a liquid. This kind of occurrence is referred to as bubble dispersion in the scientific community. When people talk about foam, they are often referring to a lightweight substance that may be either stiff or sponge-like depending on the cellular constitution of the foam.

Figure-1: Foam

1.3. Fly Ash

The production of fly ash occurs anytime coal is burnt in boilers, regardless of whether or not such boilers are used in the production of goods or the generation of energy by utilities. The four most common kinds of boilers that burn coal are known as pulverised coal (PC), stoker-fired or moving grate, cyclone, and fluidized-bed combustion (FBC) boilers. The most prevalent kind is known as pulverised coal, or PC, boilers.

The use of pulverised coal is required for the most typical kind of boiler that burns coal to be capable of producing heat. Since it is the boiler with the highest efficiency, the PC boiler is the one that is used the most often, especially in significant power-producing plants. In an industrial or cogeneration scenario, you may have a larger possibility of spotting boilers of one of the many different varieties. This is something that you should keep in mind. Fly ashes are a byproduct of FBC boilers; but, for some reason, those ashes are not taken into consideration on this page. Fly ashes are a byproduct of FBC boilers.

Electrostatic precipitators, also known as ESPs, or filter fabric collectors, more often referred to as baghouses, are used in power plants to collect fly ash from flue gases. Both of these types of collectors have a variety of other names. These two categories of collectors are known by a wide number of other names. The physical and chemical properties of fly ash are impacted in various ways by a variety of factors, including the type of burning, the provenance of the coal, and the form of the particles.

Figure-2: Fly Ash

1.4. Cellular Light Weight Concrete

The phrase "cellular lightweight concrete" is what "CLC" stands for when it's abbreviated. To put it another way, CLC may also be referred to as foamed concrete in some contexts. The CLC has quickly become an incredibly popular material for use in the construction sector as a substitute for traditional concrete bricks. This is because it provides users with a wider range of advantages and potential uses. The foamed concrete is made by first combining Portland cement, fly ash, sand, water, and performed foam in variable proportions, and then mixing the material that is generated as a consequence of this combination. This cellular lightweight concrete, also known as CLC, may be created on building sites using the same sorts of machines and molds as are used for conventional concrete. Another name for this material is a cellular lightweight aggregate (CLA).

Figure-3: Cellular Light Weight Concrete

2. LITERATURE SURVEY

In the literature survey section, we studied the research work related to the research topic which some research work has been completed, the summary of all research work is given below:

[1] Nandhini, Vallabhy: The purpose of this research was to establish the viability of using Vermiculite as a fine aggregate replacement in concrete composites and to outline the parameters for doing so. The components of concrete composites were tested extensively, and the findings are recorded. Research like this may provide information on the exact percentage of increase in Compressive and Flexural strength of the Concrete, as well as statistics on Durability. As a result, vermiculite may be considered a very efficient substitute.

[2] Dhanalakshmi , Hameed: Alternative materials such as quarry dust and Marble Sludge power (MSP) were investigated, with the results lending strong support to the feasibility of using MSP as a filler in SCC manufacture. Additions of up to 30% quarry dust, 14% clinkers, and 8% limestone powder with silica fume as a mineral admixture did not affect the self-compacting property. While further research is needed, there have been some conclusive discoveries about HSSCC behavior.

[3] Shahul. al: In keeping with the findings of a Because of ecological and environmental concerns, experimental study into the availability of natural sand for concrete has been put on hold in recent years. The goal of this study is to examine the effects of chloride penetration on self-compacting green concrete (SCGC) made from marble sludge powder (MSP) and quarry rock dust (CRD) obtained from different types of industrial waste. To reduce the number of pores in concrete, MSP may be used as a filler. Therefore, this aids in increasing concrete's longevity. Several experiments have been carried out to ascertain the effects of MSP and CRD on SCGC's chloride resistance when used in combination. According to the results, CRD with 15% MSP is preferable to river sand while making SCGC.

[4] Maheshkumar, Tharkrele: developed two foam concrete mixes to achieve the desired plastic density of 1900 kg/m3, one with sand and the other without. The increases in strength of foamed concrete are compared to those of conventional concrete using force and percentage results. Eighteen cube specimens are created and analyzed for combinations using physical (Density) and specialized structural (Compressive Strength) testing.

[5] Raman Kumar et.al: The common sand is used for concrete's fine aggregate, an essential material in building all over the globe. To complete building projects, sand must be mined extensively. Outstanding mining operations are reducing biodiversity, which in turn heightens scour depth and sometimes boosts the risk of a surge. Because of this, it's becoming more important to use non-conventional components in concrete.

Marble is an essential material used throughout the building process. During the cleaning and cutting of marble squares at a handling facility, around 20-25 percent of the raw marble is turned into powder form. Using powdered marble is a major issue for the environment, and the marble business is to blame. Findings from this study indicate that recycled marble powder might be used as a viable alternative to sand in the building sector. We analyzed the qualities of the cement by replacing 10, 15, and 20% of it.

[6]Aswathy: revealed When it comes to construction, charred brick is a must for the country. Eco-friendly, non-detrimental solutions to national problems are now the top priority. The fact that foam may be utilized at temperatures below freezing improves its insulating and soundproofing properties. Foamed cement is by far the most popular thin cement used in underdeveloped nations. Lightweight Concrete squares provide an answer that may satisfy both the requirements of the building industry and the goals of the green movement. First, a slurry of cement, fly ash, and water is thrown into a typical solid blender, where it is blended with the expansion of pre-frothed stable froth. To that purpose, we attempt here to combine set-ups for pieces of 4, 6, and 8 inches in thickness. This study demonstrates how this phenomenon has affected the progress of concrete.

[7] Shibi Varghese et.al: about which talk took place Concrete that has been "foamed" consists mostly of cement, water, fine aggregate, and air. The absence of a coarse aggregate phase and the uniformity of the other textures are glaring. foamed concrete takes on the characteristics of the binder and the foaming agent. Chemical and natural foaming agents are used here. Binding component silica fume makes foam concrete stronger than it would be without. Understanding the effects of silica fume on the characteristics and production of foamed concrete is the focus of this study, which provides a summary of the current state of knowledge in this area.

[8]Ali J. Hamad: Because of the air pockets inside the material, aerated lightweight concrete has a lower thermal expansion coefficient than conventional concrete and greater noise-deadening ability. Specifically, we identify foamed concrete and autoclaved concrete as the primary constituents of aerated lightweight concrete and systematically dissect each to understand their individual properties. Some examples of the many possible components, additives, and applications of aerated concrete are shown below. Foamed concrete and autoclaved concrete are two types of concrete made using different methods. This review of the literature focuses on aerated lightweight materials and covers topics including porosity, permeability, compressive strength, and splitting strength.

[9] Rameshwar Kalra et.al: showed that there were economic and environmental benefits to using fly ash concrete. It's also possible that concrete production might contribute to environmental sustainability. Currently, India only uses around half of its fly ash output. New infrastructure construction is at an all-time high throughout the globe, which is a good sign for the global economy as a whole. Cement is utilized more than any other building material, and its manufacture is responsible for 7 percent of all human-caused carbon dioxide emissions. Carbon dioxide is the most dangerous greenhouse gas because it can raise global temperatures. Too far, no practical alternative to $CO2$ has been found for use in cement, despite widespread interest in doing so as part of the fight to lower carbon dioxide ($CO2$) emissions. Charcoal dust in the air There has been a recent shift toward utilizing building materials with a reduced cement content, and concrete is a prime example of this tendency. The purpose of this paper is to discuss the use of fly ash concrete in construction as a solution to (a) the massive disposal of fly ash, by the production of thermal power plants, resulting in environmental degradation through large areas of landfills, and (b) the high percentage of carbon dioxide emissions into the atmosphere from the cement industry.

[10] Hanizam Awang et.al: foamed concrete experiments using AR-glass, polypropylene, steel, kenaf, and oil palm fiber. Foamed concrete mixtures with a target density of 1000kg/m3 were produced using a mix ratio of (1:1.5:0.45). The fibers were used as filler. Between 0.25 and 0.40 percent, fiber by volume was maintained throughout. To examine the effect of the fiber on the durability of foamed concrete, its permeability to water, thermal expansion, and shrinkage were measured. The results of a study into drying shrinkage showed that AR-glass fiber had the lowest value.

[11] M.Shahul Hameed: The effect of MSP and CRD on the toughness and tensile strength of SCC was investigated. Some examples of durability tests include compression, split tensile strength, water absorption, permeability to chloride ions, electrical resistance, and half-cell potential. The results demonstrate that compressive strength may be improved by using MSP as a replacement for up to 15% of the CRD. The compressive strength and the split tensile strength are directly proportional to one another. Electrical resistivity was highest in 100% CRD normal concrete, whereas SCC exhibited a significant increase.

[12] A. S. Kanagalakshm: Results from studies analyzing the effects of utilizing quarry dust instead of sand in foam concrete were provided. The purpose of this research was to determine the compressive strength of foam concrete that was formulated using quarry dust as a partial sand replacement. The feasibility of using 10%, 20%, 30%, 40%, and 50% quarry dust instead of sand in foam concrete is investigated. Different quarry dust-to-foam concrete ratios were developed. Concrete made from quarry dust has its compressive strength measured using cube tests, with results compared to those from tests conducted using a control foam concrete. It has been shown that quarry dust foam concrete has a compressive strength that is around 43% more than that of control foam concrete.

Based on the results of the experiment, foam concrete blocks may be a suitable alternative to traditional burnt clay bricks. An assessment of the cost-effectiveness of manufacturing and deploying foam concrete bricks is complete.

[13] Qin Xin: An analysis of the qualities and production techniques of foam concrete is provided. presents the challenge of creating and using foam concrete, explains the current level of understanding of the effect of blending materials, admixtures, and fibers on the performance of foamed concrete, and argues that sustainable development should form the basis of any future work in this field.

[14] Dr.G. Balamurugan: illustrated how blending cement with river sand, sea sand, and quarry dust affected the longevity of foam concrete. Cement-to-aggregate ratios of 0:1, 1:3, 1:2, and 1:3 by weight are all possible. Thereafter, it was mixed with water and the foaming agent. After waiting the appropriate amount of time, the gel is poured into a mold of 19 centimetres in length, 9 centimetres in width, and 9 centimetres in height, producing a brick sample. Twenty-eight days were spent curing these samples in water. We measured the compressive strength of these foam concrete bricks at room temperature after they had cured for 28 days. After curing at room temperature for 28 days, samples were heated to 100 degrees Celsius for 24 hours before analysis. The compressive strength of the samples was also evaluated after they were heated to 100 degrees Celsius for 24 hours and then submerged in water. The control and experimental concrete were subjected to heat and cold shock resistance tests, respectively (River sand as filler). The results indicate that sea sand and quarry dust might be used in place of natural river sand in foam concrete without affecting the performance of the latter.

[15] Zhifeng Xu: Strawboard-lined cold-formed steel high-strength lightweight foamed concrete (CSHLFC) shear walls are suggested based on the seismic behavior of CFS shear walls. The failure mode, load capacity, ductility, stiffness characteristic, and energy dissipation of six full-scale shear wall specimens were determined by testing. The experiments were conducted using a range of HLFC densities, stud section areas, wall thicknesses, and vertical loads. Seismic performance and failure mechanism of shear walls were shown to be more influenced by HLFC than was previously believed. The wall's ductility and energy absorption characteristics were proved by its several modes of failure, which included the cracking and crushing of HLFC, the cracking of straw boards, the local buckling of studs, and the relative sliding between HLFC and studs. Shear strength and stiffness were improved by the HLFC's compressive bearing capacity and its restricting impact on the steel frame. When the vertical load was increased, the seismic performance suffered, but it improved with increased wall thickness, HLFC density grade, and stud section size.

[16] M.Shahul Hameed and S. S. Sekar: experimental results suggest that both quarry rock dust and marble muck powder may be utilized as drop-in substitutes for sand in concrete. The durability of green concrete against that of natural sand concrete has been the subject of certain studies. Concrete made with quarry rock dust is over 14% stronger than conventional concrete, according to studies of its compressive strength, split tensile strength, and durability. The damaging effects of sulfates on concrete were greatly mitigated. Give green concrete a try if you want to reduce your environmental footprint while increasing the durability of your concrete under extreme conditions.

3. CONCLUSION

The review of the relevant literature makes it clear that the performance of cellular lightweight concrete is highly dependent on the kind of foaming agent and fillers that are used. This is evident. The density of foamed concrete has a connection that is inverse to the quantity of foam that is present in the foamed concrete. Protein-based foaming agents are what is required to complete the task at hand if the stable foam is to be produced. Within the scope of this research are the topics of compressive strength as well as an air-void ratio. Recycled materials such as glass and plastic might be put to use as filler if they are in good enough condition. The compressive strength of concrete made using glass filler foam was found to be much higher when compared to that of concrete made with plastic filler foam. It has been shown that using fly ash in cellular lightweight concrete might potentially result in considerable improvements to the concrete's properties.

REFERENCES

1. Dhanalakshmi A, Shahul Hameed M, "Review Study on High Strength Self Compacting Concrete", International Journal of Science Technology & Engineering, Volume 4, Issue 12, June 2018.

2. Shahul Hameed, M., Saraswathy, V., and Sekar, "Chloride Penetration Study on Self-Compacting Green Concrete Using Crusher Rock Dust and Marble Sludge Powder as Fine Aggregate", e-journal of Non-Destructive Testing• , (NDT), ISSN. No.1435-4934, Vol.15, No.2, 2010.

3. Maheshkumar H. Thakrele "Experimental study on foam concrete "International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development Vol. 4, No. 1, 2014.

4. Raman Kumar, Ankit "An experimental study of marble powder on the performance of concrete" International Journal of Civil Engineering and Technology Volume 7 No.4, 2016.

5. Aswathy .M "Experimental study on lightweight foam concrete" International Journal of Civil Engineering and Technology volume-8, No.8, 2017

6. Shibi Varghese, Ashik M Ashok, Atheena K Joseph, Shaniyo Emmanuel, Swathylekshmi " A study on properties of foamed concrete with natural and synthetic foaming agent" International Research Journal of Engineering and Technology Volume: 04, No.3,2017.

7. Ali J. Hamad " Materials, Production, Properties, and Application of Aerated Lightweight Concrete" International Journal of Materials Science and Engineering Vol. 2, No. 2 December 2014.

8. Rameshwar Kalra&Ravi Rana "A review on fly ash concrete" International Journal of Latest Research In Engineering and Computing vol.3, No.2, 2015.

9. Hanizam Awang, Muhammad Hafiz Ahmad "Durability Properties of Foamed Concrete with Fiber Inclusion". World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering Vol:8, No:3, 2014.

10. Shahul Hameed M. A. Sekar A.S.S. L. Balamurugan L.and V. Saraswathy V. "Self-Compacting Concrete Using Marble Sludge Powder and Crushed Rock Dust " KSCE Journal of Civil Engineering Volume:16, No.6,2012.

11. Dr. A. S. Kanagalakshmi, k. Sasikumar, e. Britto Pravin. "An Investigation On Foam Concrete With Quarry Dust Replacement For Filler In Mix Design " International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE) ISSN: 0976-1353 Volume 13 Issue 1 –MARCH 2015.

12. Qin Xin "Research Status of Foamed Concrete International Journal of Multidisciplinary Research and Development Volume 3; Issue 4; April 2016;

13. Dr.G.Balamurugan, K.Chockalingam, M.Chidambaram, M.Aravindha Kumar, M.Balasundaram, "Experimental study on lightweight foam concrete bricks " International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 04,2017.

14. Zhifeng Xu, Zhongfan Chen, Bashir H. Osmanc, Suhang Yang "Seismic performance of high-strength lightweight foamed concrete-filled cold-formed steel shear walls" Journal of Constructional Steel Research Volume: 143,2018.

15. M. Shahul Hameed and A. S. S. Sekar, "Properties Of Green Concrete Containing Quarry Rock Dust And Marble Sludge Powder As Fine Aggregate " ARPN Journal of Engineering and Applied Sciences VOL. 4, NO. 4, JUNE 2009.

16. M.Iqbalmalik, Muzafar Bashir Sajad Ahmad, Tabish Tariq, Umar Chowdhary(2013)," Study of concrete involving the use of waste glass as partial replacement of fine aggregate", Volume-3, PP:08-13.

17. Juan He, Qie Gao, Xuefeng Song, Xiaolin Bu, Junhong He(2019) "Effect of foaming agent on physical and mechanical properties of Alkali Activated Slag foamed concrete" College of Materials science and Engineering, Xian University of Architecture and technology xian 71005.China, Mathematics Department, Baoji University of Arts and Science, Baoji 721013, China Volume -226 PP:280-287

18. Kennouche Salim, Abdeli Houssam, Amrane Belaid, Hami Brahim (2019) "Reinforcement of building plaster by waste plastic and glass" ICSI 2019 The 3rdInternational conference in structural Integrity, Volume-17, PP:170-176

19. B.Karthikeyan, R.Selvaraj, S.Saravanan (2015) , "Mechanical properties of foam concrete "Volume 08,No.02,PP:115-119.