MULTISCIA
JOURNALS PUBLISHERS

FRONTIERS IN CIVIL ENGINEERING AND CONSTRUCTION MATERIALS

ISSN: (3065- 4181)

editor.fcecm@gmail.com

https://multisciajournals.com/journals/index.php/fcecm

Frontiers in Civil Engineering and Construction Materials

Volume 1 Issue 1 2025

Lightweight aggregate concrete made on pelletized fly ash: a potential material

L. Srivani* and A. Goumathi
Department of Civil

Article Info

Received: 30-01-2025 **Revised:07-03-2025** **Accepted:18-03-2025** **Published:28-03-2025**

Aggregate is a necessary inert filler in concrete manufacturing because it adds bulk volume and rigidity to the material. The widespread use of crushed aggregates in concrete has the potential to deplete natural resources, calling for the development of substitute construction materials. As a result, there was a flurry of activity researching potential aggregates made from recyclable materials. Fly ash is an intriguing substance with potential use as a lightweight aggregate and a complement to cementitious materials. Industrial waste materials including fly ash, bottom ash, silica fume, slag from blast furnaces, rice husks, slag, palm oil shells, slate, clay, and slag may be transformed into artificial, manufactured lightweight aggregates. The growing need for lightweight concrete in large-scale projects has spurred the use of more economical building materials. In order to control the rising costs of construction, it is necessary to replace some or all of the concrete components. The use of synthetic aggregates has recently attracted a lot of interest owing to their comparable quality to natural aggregates and their ability to significantly reduce building costs.

Key words: Fly ash, aggregate, pelletizer, lightweight concrete.

INTRODUCTION

At present, thermal power plants in India that burn coal generate an estimated 110 million tonnes of fly ash per year, which is a significant quantity for the country's power industry. About 30% of the world's fly ash comes from fills and embankments, backfills, pavement bases, and subbase courses; the remaining 70% goes into making blended cement, concrete pipes, precast/prestressed product materials, lightweight concrete bricks/blocks, autoclaved aerated concrete, and lightweight aggregate, among other intermediate technical uses (Baykal and Doven, 2000). Aerated cellular concrete, lightweight aggregate concrete, and no-fines concrete are the three main types of lightweight concrete. An alternative to the over-depletion of natural aggregates is synthetic lightweight aggregate made from recycled materials. aggregate used for structural purposes. The self-load of a structure may be significantly reduced and bigger precast units can be handled with the help of structural grade lightweight concrete. A lightweight concrete composition that may be made utilizing 60 to 75% fly ash by weight is autoclaved cellular concrete (ACC) (Ahmaruzzaman, 2010). The agglomeration process is one of the most prevalent ways that lightweight aggregate is produced. Pellets may be created using the agglomeration process in two ways: compaction or agitation granulation. The agitation technique relies on rotational forces instead of external ones. The cohesive force of the particles increases when the dose of water in the binder is increased. According to Bijen (1986), there are three distinct methods for making the green pellet hard: sintering, autoclaving, and cold bonding. Lightweight aggregate may partially replace conventional weight aggregate by 20 to 40% by volume, with a compressive strength difference of just 1% (Behera et al., 2004). The purpose of this article is to provide a cost-benefit analysis of fly ash lightweight aggregate and to recommend a specific manufacturing process for its use

F

Route 3

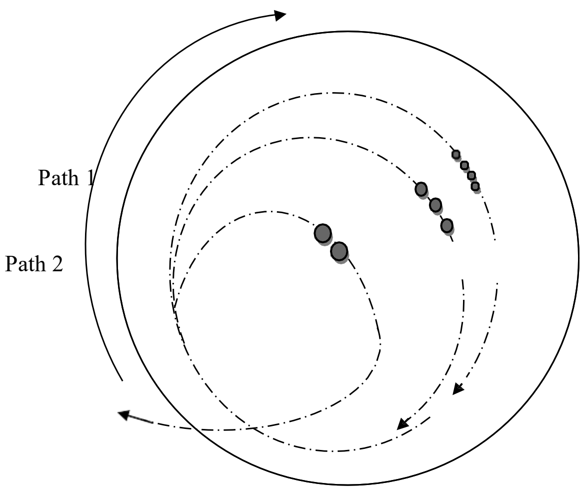

Figure 2. Disc pelletizer machine.

Figure 1. Growing path of pellets (Bijen, 1986).

LWA, mix proportions, strength improving physical and mechanical properties of lightweight aggregate concrete. Lightweight aggregate concrete is used for structurally lightweight structure, it reducing the density of concrete also over all weight of the structure.

PELLETIZING PROCESS

The desired grain size distribution of an artificial lightweight aggregate is either crushed or by means of agglomeration process. The pelletization process is used to manufacture lightweight coarse aggregate; some of the parameters need to be considered for the efficiency of the production of pellet such as speed of revolution of pelletizer disc, moisture content, angle of pelletizer disc and duration of pelletization (Harikrishnan and Ramamurthy, 2006). The different types of pelletizer machine were used to make the pellet such as disc or pan type, drum type, cone type and mixer type. With disc type pelletizer the pellet size distribution is easier to control than drum type pelletizer. With mixer type pelletizer, the small grains are formed initially and are subsequently increased in particle size by disc type pelletization (shown in Figure 1, Bijen, 1986). The disc pelletizer size is 570 mm diameter and side depth of the disc as 250 mm, it is fixed in a flexible frame with adjusting the angle of the disc as 35 to 55° and to control for the rotate disc in vertically manner should varying speed as 35 to 55 rpm shown in Figure 2 (Manikandan and Ramamurthy, 2007). In a cold bonded method is to made the increase the strength of the pellet as to increase the fly ash/cement ratio as 0.2 and above (by weight) (Yang, 1997). Moisture content and angle of the disc parameter influence the size growth of pellets (Harikrishnan and Ramamurthy, 2006). The dosage of binding agent is more important for making flyash balls

and the optimum range was found to be around 20% to 25% by the total weight of binders (Bijen, 1986). Initially some percentage of water is added in the binder and then poured in a disc; remaining water is sprayed during the rotating period because while rotating without water in the disc the fly ash powder tends to form lumps and does not increase the distribution of particle size. The pellets are formed approximately in duration of 20 min.

HARDENING PROCESS IN LWA

According to ASTM C 618, there are two main categories of fly ash, class-C and class-F, which are distinguished by the chemical composition that is a consequence of the various coal burning processes. The combustion of sub-bituminous coal, lignite, and class-C fly ash often results in class-C fly ash. With the addition of binder materials such as cement, lime, bentonite, metakaolin, kaolinite, glass powder, and ceramic powder, the pellet's strength is increased, despite the flyash particles' porosity. According to Geetha and Ramamurthy (2011), clay binders such as kaolinite and metakaolin increase the fines value. Multiplying the fly ash weight by 100 gives you the binder content %. Several processes, including autoclaving, sintering, and cold bonding, are used to harden the pellets. There are a few alternative ways to harden cold-bonded fly ash aggregates: autoclaving, steam curing, and regular water curing. Compared to the conventional water curing procedure, autoclaving and steam curing are not as successful in improving the aggregate's characteristics. Because of the dense microstructure development, autoclaved aggregates of accelerated cured class c fly ash have characteristics that are more similar to those of regular water cured aggregate. To improve the aggregate strength, the curing process is very crucial. Therefore, autoclaving is an option and a standard water curing process may be used. selected because of its great early strength (Manikandan and Ramamurthy, 2008). After 8 to 10 hours of autoclave curing, the aggregate will be stronger (Bekir and Tayfun, 2007).The cold-bonded pellet is burned in a muffle furnace at temperatures ranging from 800 to 1200°C during the sintering process. The crystalline structure (CSH) is formed when the mineral particles in the binder fuse together, which increases the aggregate's strength. As a result, making lightweight aggregate from sintered fly ash is more practical than making regular aggregate (Verma et al., 1998).

MIX DESIGN OF LWAC

The mix design of lightweight aggregate concrete is not same as the conventional concrete mix design. Since the aggregates are porous and results in compensation of extra water for obtaining more workability. The mix design concepts are usually based on the production of higher strength matrix to low water cement ratio for the weaker aggregate. Therefore in ordinary concrete, the number of batches that are necessary to determine the best composition can be reduced to a minimum. But in a Lightweight aggregate concrete mix design more complicated for adding of water, LWA is a porous aggregate so we need extra water in the concrete (Grubl, 1979). The gradation of aggregate with different aggre- gate grading size distributions are required to improve the engineering properties in the concrete mix (Sari and Pasamehmetoglu, 2005).

The self-consolidating properties of lightweight aggregate concrete can be obtained by means of densified mixture design algorithm (DMDA) which gives higher strength, flow-ability and excellent durability as compared to the ACI 211.11 method (Chao-Lung and Meng-Feng, 2005). The design of lightweight aggregate are followed in two methods; loose volume calculation and absolute solid volume calculation (Wang et al., 2005). In mix proportion the LWA are mixed in different status while fully saturated condition, partially saturation condition and dry condition. The lightweight aggregate is pre-wetting before addition of concrete mix. The Polyurethane (PUR) foam waste as a lightweight aggregate were prepare before mixing in a concrete mix while LWA were immersed in water of 24 h to improve the workability of concrete (Amor et al., 2010). The selection of sand-aggregate ratio is 28 to 42% in the mix proportion, which can influence the compressive strength and regulate the workability of concreter (Wang et al., 2005).

The strength of concrete is equal to the effective water to binder ratio which is chosen as 0.26. The quantity of the ingredients can be selected the volume of coarse aggregate to total volume of aggregate ratio as 0.6; based on the cold-bonded fly ash aggregate the quantity of cement content as 551 kg/m^3 greater than sintered fly

PHYSICAL PROPERTIES OF LWAC

The physical characteristics of the lightweight aggregate produced by pelletization are given in Table 2 (Bijen, 1986). The moisture content and amount of binder can affect the size of fly ash aggregates thus formed. The fineness of the fly ash (414 m^2/kg) givash aggregate as around 548 kg/m^3. Both type of lightweight aggregate concrete had shown the higher compressive strength (Niyazi and Turan, 2011). Lightweight concrete incorporating the bottom ash and the sintered fly ash in the concrete should increase the permeability; by replacing 30% of OPC with fly ash, to improve the permeability of LWC (Yun Bai et al., 2004). Addition of admixture in the lightweight concrete is to increase the strength and elastic modulus. The addition of silica fume at 5 to 15% in the LWC can improve the strength properties while, replacements of 10% fly ash instead of cement in concrete can decrease strength as compared to without fly ash (Shannag, 2011). A detailed mix proportion of light weight aggregate concrete adopted in different studies are given in Table 1.

es the better pelletization efficiency compared to the coarser fly ash (257 m^2/kg). Therefore finer fly ash needs the addition of the binder material and the addition of clay binder in the coarser fly ash will increase the pelletizing efficiency (Manikandan and Ramamurthy, 2007). The specific gravity of fly ash lightweight aggregate is increase without adding binder and it’s a denser structure. The addition of bentonite and glass powder in fly ash is to reducing the specific gravity as compare to lime and cement binder in fly ash (Ramamurthy and Harikrishnan, 2006).

Density of LWAC

The properties of lightweight aggregate can be improved with the addition of different binder at various percentage. Therefore, the percentage of binder increased vice versa density increase. Density of sintered fly ash aggregate with binder is decreased while increased the temperature range between 1150 to 1200°C. The bentonite and glass powder binder is melted and bloating firmly for rising temperature and the glassy particle filled the voids in a crystal form to improve the strength (Niyazi and Turan, 2011). The difference between the density of the pre- wetting and without pre-wetting PUR lightweight aggre- gate concrete is lower than 12 Kg/m^3 (Amor et al., 2010). The density of shell aggregate is 28% lower than the normal aggregate (Okafor, 1988)

CONCLUSION

In terms of novel building material uses, lightweight aggre-gate has even more astounding potential. When looking for ways to drastically reduce building costs, the most desirable approach is to use cost-effective procedures and alternative construction materials. Rather of being thrown away, fly ash has several practical uses in concrete, such as filler aggregate, fine aggregate replacement, or even as a material for fly ash bricks. In sum, research from a variety of sources has shown that pelletized fly ash aggregate may be a useful ingredient in concrete. Pelletizer speed, pelletizer angle, and binder type all affect pelletization efficiency in addition to fly ash. Mass production of fly ash aggregate, made possible by streamlined and cost-effective production methods, might be an appropriate replacement for the material used in a wide variety of infrastructure projects. The use of fly ash aggregate will soon be able to adequately offset the loss of natural aggregate supplies.

REFERENCES

(Ahmaruzzaman M.) (2010). The use of fly ash reviewed. Journal of Energy and Combustion Science, 36, 327–363. Working with Jan Olek and Menashi D. Cohen, Amir Elsharief (2005). Modifications to Mortar's Microstructure and Stability Induced by Lightweight Aggregate. Journal of Cement and Concrete Research, 35, 1368–1376, 2017.I love it Pierre Mounanga, Ben Fraj, and Mohamed Kismi (2010). Enhancement of Lightweight Aggregate Concrete with Coarse Rigid Polyurethane Foam Waste. Materials for Construction, 24: 1069-1077. In 2004, Behera, Nayak, Ray, and Sarangi published a study. Investigation on the Use of Sintered Fly Ash as a Partial Substitute for Regular Granite in Lightweight Concrete. No. 85, pages 84–87, IE (I) Journal–CV. Uygunoglu Tayfun and Bekir Ilker Topcu (2007). Characteristics of Autoclaved Lightweight Cementitious Material. Structure and Environment, 42: 4108-4116.According to Bijen JMJM (1986). Manufacturing procedures of artificial lightweight aggregates from fly ash. International Journal of Cement Composites, Volume 8, Issue 3, Pages 191–199. The work of Byung-Wan Jo, Seung-Kook Park, and Jong-bin Park was completed in 2007. The characteristics of concrete blended with alkali-activated fly ash lightweight aggregate (AFLA). Section 29: 128–135 of Cement Concrete Composites. Meng-Feng Hung and Chao-Lung Hwang (2005). Lightweight self-consolidating concrete: performance and design for durability. Proceedings of the Institution of Building Materials, 19(3), 619-626. In 2003, Chi, Huang, Yang, and Chang published a paper. Modifications to Lightweight Concrete's Strength and Stiffness Induced by Different Aggregate Characteristics. Concrete and Cement Composites, 25: 197–205. Yang Chung-Chia and Huang Ran (1998). Estimating the Micromechanics-Based Strength of

Constructed Lightweight Aggregate. Advances in Cement-Based Materials, 7, 133–138. Ramamurthy K. Geetha (2011). Characteristics of Clay-Binded Sintered Low-Calcium Bottom Ash Aggregate. Computers in Buildings, 25: 2002-2013. In 1979, Grubl published a paper. Mix Design of Lightweight Aggregate Concrete for Structural Purposes. Int. J. Lightweight Concrete, 1(2): 63-69. Harikrishnan KI, Ramamurthy (2006). Influence of Pelletization Process on the Properties of Fly Ash Aggregates. Waste Manag., 26: 846- 852.Kayali O (2008). Fly ash lightweight aggregates in high performance concrete. Constr. Building Mater., 22: 2393-2399. Kayali O, Haque MN, Zhu B (1999). Drying shrinkage of Fibre reinforced lightweight aggregate concrete containing fl ash. Cement Concrete Res., 29: 1835-1840. Kayali O, Haque MN, Zhu B (2003). Some characteristics of high strength fiber reinforced lightweight aggregate concrete. Cement Concrete Composit., 25: 207-213. Lo Tommy Y, Cui HZ, Tang WC, Leung WM (2006). The effect of aggregate absorption on pore area at interfacial zone of lightweight concrete. Constr. Build. Mater., 22: 623-628. Lo Y, Gao XF, Jeary AP (1999). Microstructure of pre-wetted aggregate on lightweight concrete. Build. Environ., 34: 759-764. Manikandan R, Ramamurthy K (2007). Influence of fineness of fly ash on the aggregate pelletization process. Cement Concrete Composites, 29: 456-64. Manikandan R, Ramamurthy K (2008). Effect of Curing Method on Characteristics of Cold Bonded Fly Ash Aggregate. Cement Concrete Composites, 30: 848-853. Mehmet Gesoglu, Turan Ozturan, Erhan Huneyisi (2004). Shinkage Cracking of Lightweight Concrete made with Cold-bonded Fly ash Aggregates. Cement Concrete Res., 34: 1121-1130. Min-Hong Zhang, Gjorv Odd E (1990). Microstructure of the interfacial zone between lightweight aggregate and cement paste. Cement Concrete Res., 20: 610-618. Nambu Masateru, Kato Masahiro, Anosaki Takao, Nozaki Kenji, Ishikawa Yoshitaka (2007). Pozzolanic Reactions between natural and Artificial Aggregate and the Concrete matrix. World of Coal ash. Niyazi Ugur Kockal, Turan Ozturan (2010). Effects of lightweight fly ash aggregate properties on the behavior of lightweight concretes. J. Hazard. Mater., 179: 954-965. Niyazi Ugur Kockal, Turan Ozturan (2011). Charecteristics of lightweight fly ash aggregates produced with different binders and heat treatments. Cement Concrete Composites, 33: 61-67. Niyazi Ugur Kockal, Turan Ozturan (2011). Durability of lightweight concretes with lightweight fly ash aggregates. Constr. Build. Mater., 25: 1430-1438. Niyazi Ugur Kockal, Turan Ozturan (2011). Optimization of Properties of Fly ash Aggregates for High-strength Lightweight Concrete Production. Mater. Des., 32: 3586 - 3593. Niyazi Ugur Kockal, Turan Ozturan (2011). Strength and Elastic Properties of Structural Lightweight Concretes. Mater. Des., 32: 2396-2403. Okafor OF (1988). Palm Kernel Shell as a Lightweight Aggregate for Concrete. Cement Concrete Res., 18: 901-910. Ramamurthy K, Harikrishnan KI (2006). Influence of binders on properties of sintered fly ash aggregate. Cement Concrete Composit., 28: 33-38. Santish Chandra, Leif Berntsson (1983). Technical notes: Influence of polymer microparticles on acid resistance of structural lightweight aggregate concrete. Inter. J. Cement Composit. Lightweight Concrete, 5(2): 127-131. Sari D, Pasamehmetoglu AG (2005). The effects of gradation and admixture on the pumice lightweight aggregate concrete. Cement Concrete Res., 35: 936-942. Shannag MJ (2011). Characteristics of Lightweight Concrete Containing Mineral Admixtures. Constr. Build. Mater., 25: 658-662. Shondeep L Sakar, Satish Chandra, Leif Berntsson (1992). Interdepence of Microstructure and strength of Structural Lightweight Aggregate Concrete. Cement Concrete Composites, 14: 239-248.

Swamy RN, Lambert GH (1981). The microstructure of Lytag aggregate. Int. J. Cement Composit. Lightweight Concrete, 3(4): 273- 282.Verma CL, Handa SK, Jain SK, Yadaw RK (1998). Techno-commercial perspective study for sintered fly ash light-weight aggregates in india. Constr. Build. Mater., 12: 341-346. Wang Lijiu, Zhang Shuzhong, Zhao Guofan (2005). Investigation of the Mix Ratio Design of Lightweight Aggregate Concrete. Cement Concrete Res., 35: 931-935. Wasserman

R, Bentur A (1997). Effect of Lightweight Fly ash Aggregate Microstructure on the Strength of Concretes. Cement Concrete Res., 27(4): 525-537. Yun Bai, Ratiyah Ibrahim, Muhammed Basheer PA(2004). Properties of Lightweight Concrete Manufactured with Fly ash, Furnace Bottom ash and Lytag. International Workshop on Sustainable Development and Concrete Technology. pp. 77-87.