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Reviews on the Properties of Aggregates made with or without Geopolymerisation Method

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Abstract. Aggregates are popular for use in concrete and lightweight concrete applications. Recent research shows that the by-product materials such as fly ash can be used as raw material in producing aggregates and lightweight aggregates. The usage of this material can improve the quality of the aggregates produced compared to conventional in term of structurally strong, physically stable, durable, and environmentally inert. This paper summarized the process and mechanical testing on the fly ash aggregates and lightweight aggregates to be used in concrete.

Introduction

Previous research shows the approaches to convert fly ash into aggregates as replacements for natural aggregates. The reason of this approach is due to the demand for aggregates are large and increasing continuously while the natural aggregate resource is depleting. Many countries like USA, UK, Poland, Russia and Germany are producing aggregates commercially under different trade names. [1] Research institute from India have used the technological of pilot plant on producing lightweight aggregates of fly ash and found out that this material will reduce the dead weight and material handling cost for multi-storeyed constructions. [1]

Aggregate may count for 70-80% by mass of concrete. Aggregates can also be used as soil conditioners, water savers, and soil and sand stabilizers. [2] The use of lightweight aggregates also can reduce the dead load that may result in reduction of footings sizes and reduction in reinforcement. Furthermore, lightweight aggregates are lighter and smaller precast elements needing smaller and less expensive handling and transporting equipment. The use of this material also classified as high thermal insulation and enhanced fire resistance. [3]

The use of cost effective construction materials has accelerated in recent times due to the increase in demand of lightweight concrete for mass applications. [4] This can be solved by replacing the concrete constituents with other industrial by-products to bring down the construction costs. Furthermore, the use of artificial aggregates has shown reasonable costs and produce better quality compared to conventional aggregates. [4] This paper reports the result of the investigation to produce lightweight aggregate using fly ash and other potential materials to be used as lightweight aggregate.

Materials and experiment

Raw Materials. Past research are very limited to the material used in producing the aggregate and only focused on utilization of aggregates made from fly ash. Niyazi and Turan [5] have choose fly ash mixed with bentonite and glass powder as raw material in aggregate production. Ramamurthy and Harikrishnan [6] used fly ash mixed with ordinary Portland cement (OPC), Na-bentonite and powdered limestone as binders for palletization. Study carried out by Byung-wan et al. [7] used the fly ash mixed with sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) as an oxidizing agent. MnO_2 was also used to improve strength and the small amount of OPC was added to increase strength. However, Hamzah F. et al. [2] used geopolymer material of fly ash mixed with Na_2SiO_3 and NaOH solutions as binder to form aggregates. The solid-to-liquid ratio of 1:5 was used in this study. [2]

Experimental Method. All materials were mixed together in the mixture and certain amount of water was added to the mixture to produce a workable paste. The combined materials were mixed in the mixer for 10 min until homogeneous paste was achieved. Then, this paste was moulded in a cylindrical mould with 2:1 height to diameter ratio. [2] After moulded in the mould, the samples were left in an oven at 60°C for 4 days to cure the geopolymer into aggregate pellets. [2] Study carried out by Byung-wan et al. [7] stated that the hardened paste of fly ash was granulated to produce the specified nominal maximum aggregate size as shown in Fig.1. The grain size distribution must met the ASTM C 33 requirement for the use of artificial lightweight aggregate.

Niyazi et al. [5] used the pelletization disk to form the pellets of aggregates. Water was added by spraying onto the powder mixtures with a quantity of 22-25% of the total material to form the spherical pellets which took about 20 min to rotate in the pelletizer pan. After that, the pellets were dried at 110°C, and then sintered for 1h at 1100°C, 1150°C and 1200°C.

Some research [8] stated that the incorporation of a gas former waste to the fresh mixture that conformed in spherical form and heat treated at high temperatures around 1100-1200°C (Fig. 2) may form the lightweight aggregates. The voids are generated by combustion or gasification of the waste included in the mass of aggregate. The other way to produce the lightweight aggregate is by using waste glass that milled until fine particle size and mixed with foaming additives such as silicon carbide or calcium carbonate. [9]

Fig. 6. Grain shape of AFLA.

Fig.1. Grain shape of artificial fly ash lightweight aggregate [7]

Fig.2. Particles of lightweight aggregate at different stages of heating. [10]

Results and Discussion

Specific gravity. The specific gravity of sintered fly ash aggregate is increases when a binder of lime is used. Aggregate with bentonite has a low specific gravity of 1.75. [6] Byung-wan et al. [7] stated that the specific gravity of fly ash lightweight aggregate was 1.66. Theses two values are higher than clay artificial lightweight aggregate which is in the range of 1.10-1.32. [7] This is due to larger internal void produced in clay artificial lightweight aggregate compared to fly ash lightweight aggregate.

Water absorption. The water absorption of sintered fly ash aggregate without binders is in the range of 21-22%. With the addition of 20% bentonite as binder, water absorption reduced significantly to 15-16%. [6] However, the water absorption found by Byung-wan et al. [7]was much lower which is 11.8%. Monica et al. [10] found lower water absorption of the fly ash lightweight aggregate when sintered at 975-1050°C. This shows that the water absorption can be modulated by controlling the expansion temperature.

Compressive strength. The strength of geopolymer aggregates increases with decreasing liquid-to-solid. [2] This shows that, the amounts of sodium silicate and sodium hydroxide affects the strength of geopolymer aggregates. Other research shows that the strength of the specimen that used natural aggregate was 33.0 MPa, while the specimen used fly ash lightweight aggregate was 26.7 MPa due to internal voids that affect the strength of fly ash lightweight aggregate. However, this strength of fly ash lightweight aggregate is satisfied to use in lightweight concrete.

Potential of LUSI mud as aggregates material

Large quantities of mud volcano known as LUSI (LU-lumpur, SI-Sidoarjo) has become a big issues since May 29th 2006 when this mud volcano started to erupt caused by drilling of the gas exploration well in the Porong area, Sidoarjo, East Java [11-13] or due to the Yogyakarta earthquake that occurred at 05:54 am on the 27th May 2006. [12 , 14] From this problem, the new solutions need to be found to manage the quantity of LUSI mud which increasing day by day. The chemical compositions show that LUSI mud volcano has a potential environmental friendly binder for artificial aggregate materials due to their Si and Al contents as an effort to explore the potential benefits of the unstoppable flow of LUSI mud volcano. On the same time, the natural aggregate resource now is depleting day by day. However, the demand for aggregates in the market is large and increasing continuously. So, the alternative of producing the aggregate with LUSI mud volcano will reduce the natural resource used with better properties and strength and may help the Indonesian government to reduce the cost of the damages.

Conclusions

The overall studies conducted by various researchers shown that the use of fly ash aggregates is more phenomenal in terms of the usage which is more efficiencies and more cost effective as new construction materials with more simplified production techniques for manufacturing fly ash aggregates. In the near future, the production of aggregates can be various by other by-product materials of natural resources materials such as LUSI mud.

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