Fabrication of Light Aggregates Using the Fly Ash-Clay Slurry

Seunggu Kang, Kigang Lee and Junghwan Kim
Department of Materials Engineering, Kyonggi University, Suwon, Kyonggi-Do 442-760, Korea

Abstracts

The light aggregates were fabricated by sintering green bodies made from the fly ash-clay slip. The content of fly ashes in the slip could be increased up to 70wt.% due to controlled rheological behavior of the slip, and the green body of uniform microstructure could be obtained by DCC(Direct Coagulation Casting) method. The apparent density, microstructure and compressive strength for sintered bodies fired at 1100～1200℃ were evaluated. The properties of light aggregates fabricated depend on slip density, particle behavior in the slip and sintering conditions. The sintered body prepared by firing a green body made from slip of density 1.60 at 1150℃/2hr satisfied conditions of a light aggregate as apparent density of 1.49±0.02 and compressive strength of 584±62kg/cm^2.

I. Introduction

In recent years, recycling of wastes are very important matter in the view point of environmental protection. The amount of fly ash from coal fired power plant was about 3 million tons in 1996 and expected to 7 million tons in 2000. The cycling rate of fly ash, which is classified as a general waste, in the nation is more or less 20%. Hence advanced nations consider fly ash as the third resource and their recycling rate reached up to 60%. It is very urgent to prepare recycling policy when we consider problems in short of and in selection of reclamation area. The demand of gravel in the nation was 200 million m^3 in 1996; however the supply was only 120 million m^3. About the half of demand was satisfied with illegal method which could destroy our environment.

In this study, the process for making the porous slips and cakes by controlling the flocculation-dispersion behavior of the fly ash slip will be studied through experiments on the interfacial characteristics of the ashes and rheological behaviors of the slips. Finally, the optimum sintering conditions for the light aggregates which have a density below 1.6 and a compressive strength above 200kg/cm^2 will be examined by controlling the sintering time, temperature and heating rate.

II. Experimental Procedures

The fly ash 70% - clay 30% slip were produced using fly ash obtained from power plant at Boryong in Chungchungnam-Do and clay with good plasticity produced at Ichon in Kyonggi-Do, Korea. Three kind of slips of different densities as of 1.55, 1.60 and 1.65 were prepared, and green bodies and sintered bodies were fabricated from the slips formed previously. The water-glass (Na_2O-$2SiO_2$) and $CaSO_4$ were used as a deflucculant and flocculant, respectively. The green body produced was naturally dried and sintered at 1100～1200℃. The specimens were cut to the rectangular shape, 6×6×12mm (aspect ratio=1:2), for the compressive strength test.

III. Results and Discussions

For controlling the pore size and pore distribution of the green body, the water glass was used to deflocculate the slip, and the $CaSO_4$ to re-flocculate the slip. The $CaSO_4$ has a plus 2 charge ion in it so the maximum effect could be expected for re-flocculating particles in the slip. Two nomenclatures were introduced as slip F and slip C; slip F means the viscosity of the slip is in 1000～1200cP, and the slip D in 200～300cP. The particle size distribution did not depend on the density of slips; average particle size in three different slips are very similar as 15㎛. Increasing the $CaSO_4$ content, the viscosity of the slip D increases because the interparticle coagulation occurred by decreasing the electrical double layer.

The gel curves for the slip D and C were measured to examine the time-dependence for the slip rheology (Fig. 1). All slip Ds are stable and the viscosity showed no changes with time, before and after the no-appled force duration. For the slip C, the viscosity increases after the no-appled force duration which is so called gelling. The gelling of slip is used in this study to cast slips to green body, and this method are known as DCC (direct coagulation casting).

The pore size measurement was done for the 3 different slips as average pore size of 2.5㎛ indicating a very homogeneous microstructure of green body. This is because of formation of relatively week flocs due to the plus 2 charges from $CaSO_4$ and the flocs are gelling to green body with uniform pore distribution. The pore distribution for the green body and sintered body fabricated from slip of density 1.60 are shown in Fig. 2. The uniform pore distribution was not destroyed after the sintering process.

The specimens prepared from various slips using DCC method were sintered and evaluated. The bulk density of sintered bodies increases with increasing slip density. The bulk density as a function of sintering temperature are shown in Fig. 3. Increasing the sintering temperature, the bulk density of the sintered body increases. The horizontal line at Fig. 3 indicates the density of the green body showing similar value as in specimen sintered at 1100℃. Above the sintering temperature 1100℃, the bulk density for the sintered body is higher than that of green body. The bulk density of the body sintered at 1150℃/2hr with heating rate 10℃/min was 1.49±0.02 which satisfy the condition for the light aggregates. The F-body shown in Fig. 3 is prepared from the coagulated slip, not from the flocculated slip. The density of F-body is smaller than that of body prepared by the DCC method because the non-uniformly flocculated particles is not easy to sinter.

The compressive strength for the sintered bodies were measured and shown in Fig. 4. The compressive strength for the sintered bodies increases with increasing sintering time and decreasing firing rate. As the sintering temperature increases, the compressive strength of the specimen increases. The compressive strength for the body sintered at 1100℃ is relatively low 137kg/㎠. When the sintering temperature, however, is raised up to 1120℃, the compressive strength reaches to 676kg/㎠ which is 5 time higher than that of sintered at 1150℃. The compressive strength for the F-boy is 455kg/㎠ which is lower than that of body prepared by DCC method. The compressive strength of the body sintered at 1150℃/2hr with heating rate 10℃/min was 584±62kg/㎠ which is satisfying the condition for the light aggregates.

IV. Conclusion

By this study, it is proven that the rheological control is crucial for obtaining uniform microstructure, desirable strength and density from the fly ash - clay body. The light aggregates of bulk density <1.50 and compressive strength >500kg/㎠, satisfying the condition for the light aggregates, using the fly ash 70% - clay 30% slip by DCC method, were fabricated.

Acknowledgements

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References

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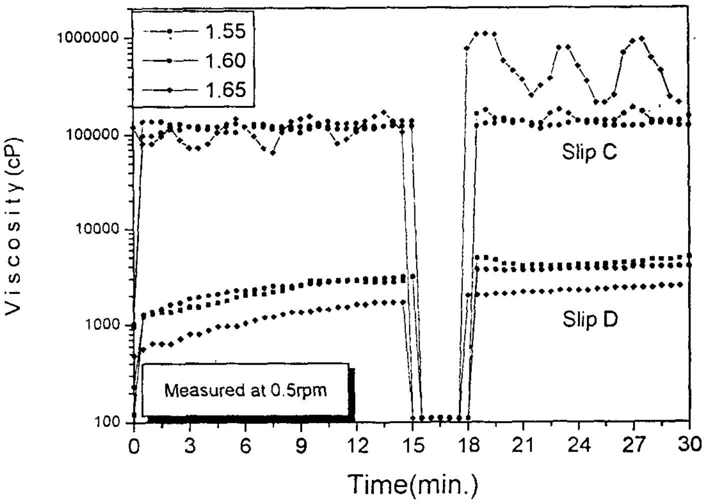

Fig. 1 Gel curves for the slips with various density.

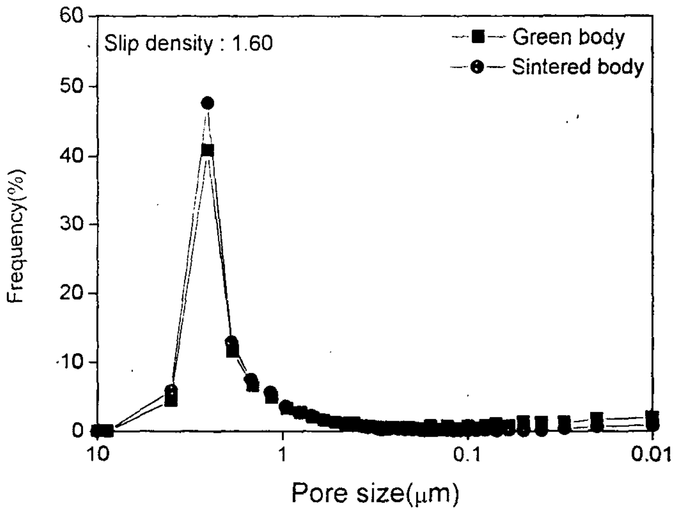

Fig. 2 Pore size distribution for green and sintered bodies.

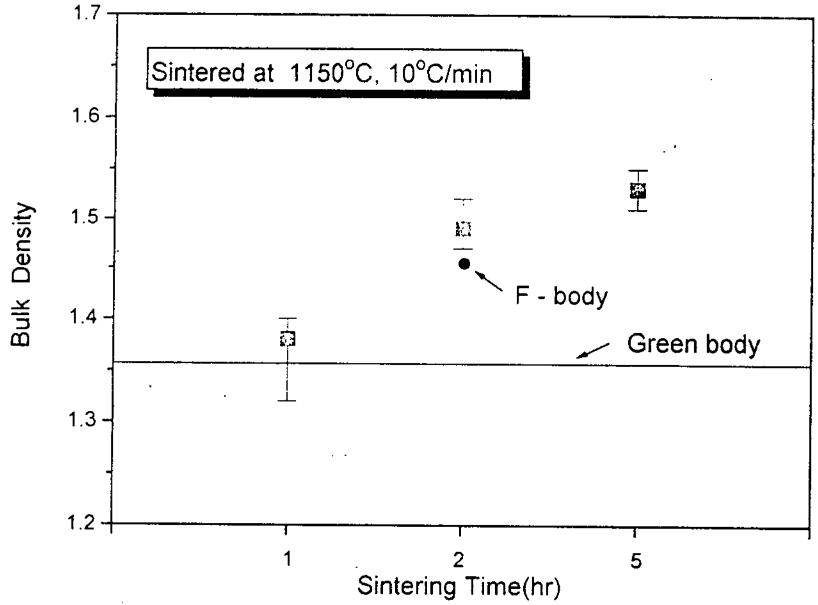

Fig.3 Bulk density for the sintered bodies fabricated at various conditions as a function of sintering time

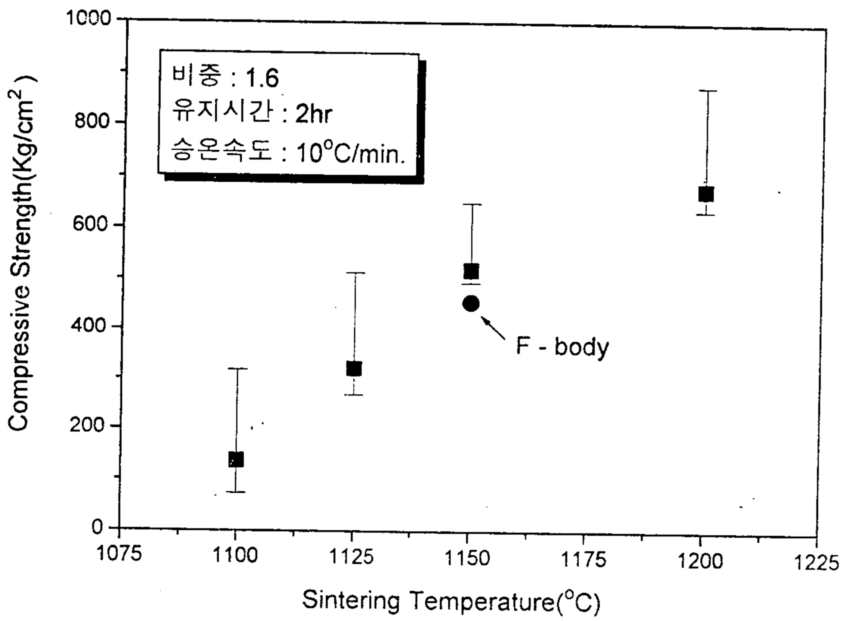

Fig.4 Compressive strength for the sintered bodies as a function of sintering time