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Fundamental Properties and Durability of Concrete with Gasification Molten Slag as Fine Aggregate

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1 Introduction

With environmental concerns restricting the extraction of natural aggregate, Japan's concrete industry is finding it difficult to secure supplies and is pursuing research to develop substitute aggregates. Currently coal-fired power generation accounts for approximately 32.3% of all electricity generated in Japan. Conventional coal-fired power stations emit tremendous quantities of CO_2, so technology to reduce CO_2 emissions is needed. For this reason, the use of the highly efficient Integrated Gasification Combined Cycle (IGCC) has been promoted. With IGCC technology, impurities from coal that has been heated in a gasification furnace are melted and discharged as coal gasification molten slag (CGMS). Establishing a method for effective use of this CGMS is essential to expansion of IGCC utilization. It is thought that using CGMS as concrete aggregate could make a major contribution to society. However, no standards have yet been established for such use of CGMS. This study investigates the potential for use of CGMS as a concrete aggregate. The fundamental properties of concrete incorporating CGMS are estimated and problems that must be resolved are isolated in order to provide data for the establishment of standards for the use of CGMS aggregate.

2 Fundamental Properties of Concrete Using CGMS as Fine Aggregate

The water-cement ratio was fixed at 50%. Sand fine aggregate was replaced by CGMS at volume ratios of 0%, 50% and 100%; the replacement ratio is expressed as Sg/S. The target values of fresh properties were 12.0±1.5 (cm) for slump and 4.5% ± 1.5% for air content.

In the results of the freeze-thaw tests. Concrete including CGMS fine aggregate showed very poor frost resistance. It is thought that this is because of the weaker interface bonding between paste and coarse aggregate particles, resulting from the high bleed rate. The expansion pressure of freezing water in the voids causes this reduced resistance. There is a need for studies aimed at improving the freeze-thaw resistance of concretes containing CGMS fine aggregate.

3 Experiment to Improve the Frost Resistance of Concrete Including CGMS Fine Aggregate

The results of the freeze-thaw test show that the resistance of concrete made with CGMS fine aggregate is significantly reduced. A possible method of improving freeze-thaw resistance by increasing the air content was examined.

The water-cement ratio was fixed at 50%. Sand fine aggregate was replaced by CGMS at a volume ratio (Sg/S) of 100%. The target values of fresh properties were 12.0 ± 1.5 (cm) for slump and the three values of air content: 4.5±1.5%, 6.0±0.5% and 7.5 ± 0.5%.
Figure 1 shows the results of the freeze-thaw test. As can be seen in these results, freeze-thaw resistance was greatly improved by increasing the air content.

In order to obtain the target air content, it was necessary to add a large amount of AE admixture. These results indicate that CGMS contains a large amount of non-combustion carbon and this will require further study. These results demonstrate that the freeze-thaw resistance of concrete containing CGMS fine aggregate can be improved, but further study is needed.

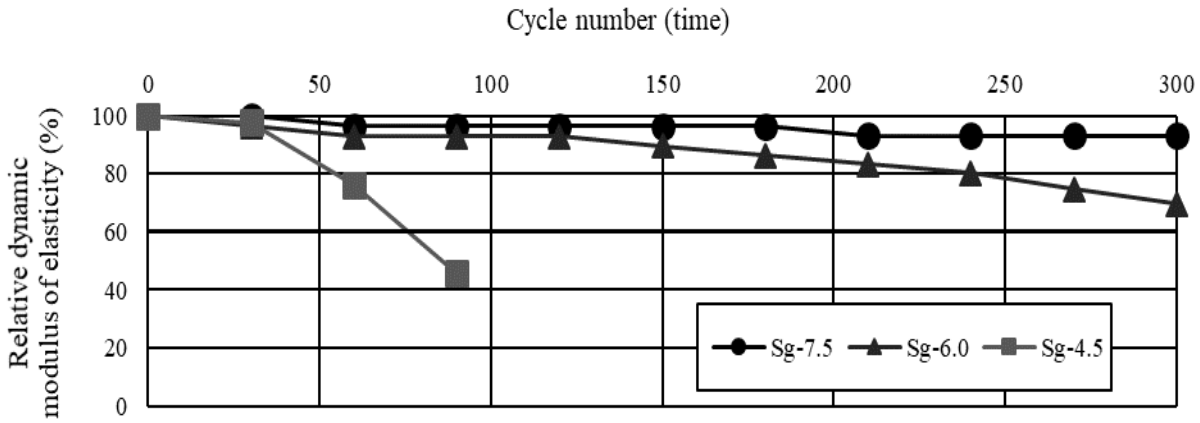

Figure 1. Results of freeze-thaw test.

4 Conclusions

Experiments to determine the basic properties of concrete containing CGMS as fine aggregate showed that fluidity improved while compressive strength decreased slightly. In other results, drying shrinkage strain was reduced while carbonation resistance decreased.

In terms of durability, tests of freeze-thaw resistance were not very good. However, freeze-thaw resistance was shown to be improved by increasing the air content of the fresh concrete.

References

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