Flexural Strength and Drying Shrinkage Cracking of Concrete Mixed with Hwang-toh

Jang Ho Jay Kim
Professor
Yonsei University
Seoul, Korea
jjhkim@yonsei.ac.kr

Sung Bae Kim
Doctoral student
Yonsei University
Seoul, Korea
sztk77@yonsei.ac.kr

Hyun Young Kim
Master student
Yonsei University
Seoul, Korea
wittyman@yonsei.ac.kr

Keun Sung Lee
Master student
Yonsei University
Seoul, Korea
karma0108@paran.com

Yun Mook Lim
Professor
Yonsei University
Seoul, Korea
yunmook@yonsei.ac.kr

Kwang Hoe Jung
Doctoral student
Yonsei University
Seoul, Korea
jkh@hdec.co.kr

Summary

Recently, public interest in eco-friendly structure has been increasing and many Hwang-toh researches are being actively performed. Hwang-toh is one of traditional environment friendly construction materials used as a construction and plastering material. Also, Ondol, traditional Korean under floor heating system, used in Korean style house uses Hwang-toh as its main construction material for duct and floor system due to its favorable heat absorbing capacity. Hwang-toh has many advantages as construction material due to its high heat storage capacity, auto-purification, antibiotic ability, and infrared ray emission characteristic. But, currently it is not been developed and used in modern construction due of its low strength and dry shrinkage cracking prone characteristics. According to the recent researches and study results, Hwang-toh can be used as a natural pozzolanic material such as fly-ash or pozzolan. The possibility of using Hwang-toh as a construction material became favorable after the research findings showed that its chemical and mineralogical proportions are like Metakaolin and Kaolinite. In this study, drying shrinkage and structural flexure behavior experiments of slag and Hwang-toh added concrete are carried out. The variables in this study were the replacement ratios of Hwang-toh and slag. The test results showed that drying shrinkage of concrete mixed with Hwang-toh has relatively higher drying shrinkage than OPC concrete, but has similar RC flexural strength.

Keywords: eco-friendly structure, Hwang-toh, pozzolan, drying shrinkage, flexural strength.

Recently, global environmental problems have been a matter of grave concerns around the world due to acceleration of global warming. Since the construction related industries produce 42% of the total CO_2 generated by the Korean industries, the construction engineers' attempt to use eco-friendly materials for construction has been continuously increasing. Especially, in construction industries, which consume significant amount of energy and generate superfluous amount of waste, reduction of cement and steel usages became a central issue in an attempt to reduce greenhouse effect. Therefore, in order to improve eco-friendly construction practices by decreasing usage of environmentally hazardous materials and emission of industrial pollutions, it has been forced to change from the existing development concept of "the development for the sake of development" to a new paradigm centered on sustainable development using eco-friendly construction technologies including natural resource usage reduction, energy saving, service life extension, and waste recycling. This study evaluates applicability of Hwang-toh concrete as a part of efforts to reduce the consumption of cement.

According to the compressive strength test results, OPC (Ordinary potland cement concrete) specimen showed the highest compressive strength of 30MPa. On the contrary, SC (Slag concrete) specimen mixed with a slag, AH(A-type hwang-toh concrete) and NH(N-type hwang-toh concrete) specimens mixed with Hwang-toh, AHS and NHS specimens mixed with Hwang-toh and slag showed relatively lower compressive strengths than the OPC specimen. This result reveals that hydration of Hwang-toh and slag is less than that of cement.

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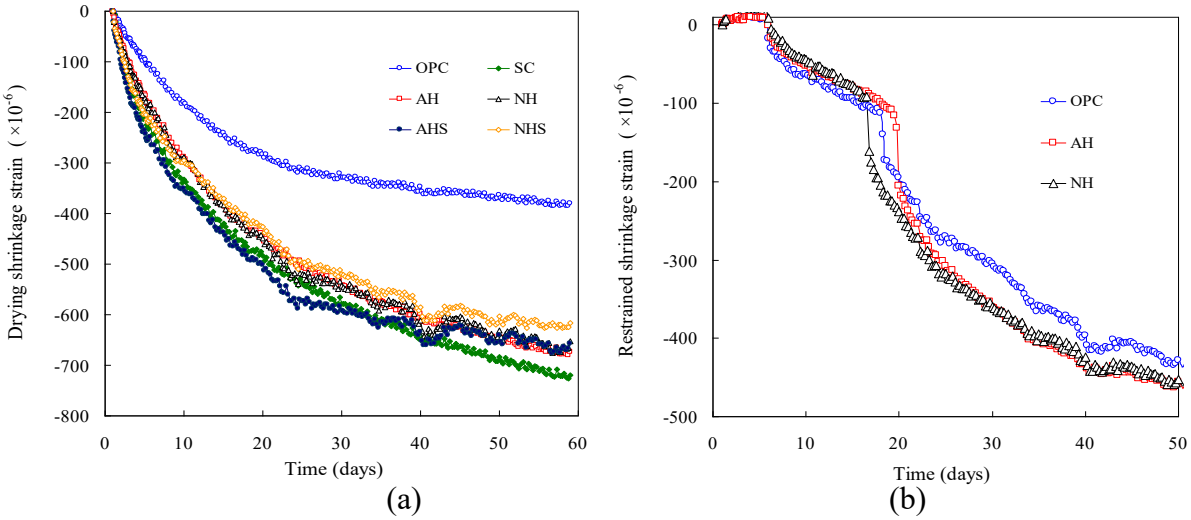

Fig. 1: Free and restrained drying shrinkage strain

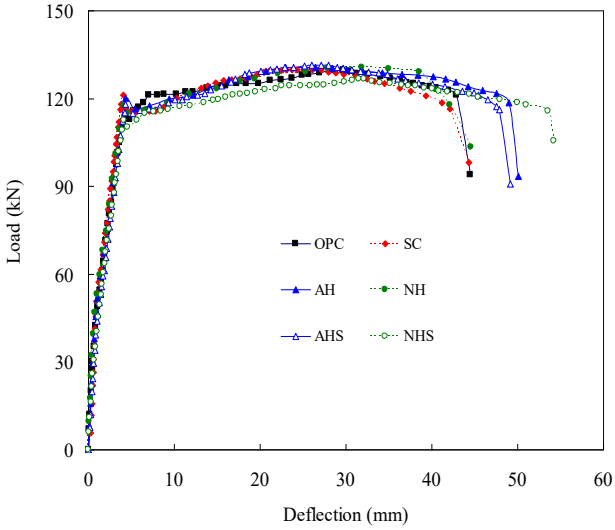

Fig. 2: Comparison of the load-deflection curves for beam specimens at the age of 28 days

The measured free drying shrinkage strain is shown in Fig. 1(a). OPC specimen showed the least free drying shrinkage strain, while Hwang-toh and Slag added concrete specimen showed 200%~250% more shrinkage strain than OPC specimen. The measured restrained drying shrinkage strain verses curing time is shown in Fig. 1(b). Full-through cracks occurred on 17 and 20 days in NH and AH specimens, respectively, whom are the min. and max. cracking time observed among all specimens.

The measured load-deflection relation from RC flexural tests is shown in Fig. 2. The results showed that elastic behavior of all of the specimens before cracking were similar, even though the admixture added concrete specimens were different. The ultimate strength of the specimens casted with Hwang-toh and slag concrete were similar to that of OPC concrete. The failure behaviors of all specimens showed similar behavior to that of OPC specimen. However, flexural capacity of AH and AHS specimens, which contain A-type Hwang-toh, were slightly higher than that of OPC specimen. General flexural behavior was similar to that of OPC specimen, where flexural tensile failure occurred rapidly as it reached ultimate load.

Conclusion

1) Compressive strength of the concrete mixed with Hwang-toh was similar to those of OPC showing its possibility as a structural material.

2) The free drying shrinkage strain of concrete mixed with Hwang-toh and slag was approximately 2~2.5 times greater than that of OPC specimen. But, in the restrained drying shrinkage strain test, it shows similar behavior to OPC where the cracking time of concrete mixed with Hwang-toh was similar to the OPC specimen, once again showing its possibility as a structural material.

3) In the flexural capacity test, the ultimate load capacity of the RC specimen was approximately 130kN regardless of casted concrete type. Also, the overall failure behavior was very similar for all of the specimens, which proved the validity of using concrete mixed with Hwang-toh as a structural material.