매립형 FBG 센서를 이용한 고성능콘크리트 기둥의 초기재령시 자기수축

Early-Age Autogenous Shrinkage of HPC Columns by FBG Sensors

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Abstract

This paper carried out the early age autogenous shrinkage research of large scaled HPC column specimens by embedded Fiber Bragg-Grating (FBG) strain sensor. Temperature compensation for FBG strain sensor by thermocouple was also attempted.

요약

이 논문은 매립형 FBG 스트레인 센서를 이용하여 고성능콘크리트 시험체의 초기재령시 자기수축에 관하여 연구하였다. Thermocouple 에 의한 FBG 스트레인 센서의 온도보정도 이 논문에서 수행했다. HPC 자기수축량에 대한 배근영향, 크기효과, 온도효과 역시 분석했다.

1. Introduction

HPC may develop pretty high autogenous shrinkage (AS) due to the addition of admixture and its low water to cement ratio comparing with ordinary concrete. This paper carries out the early age AS study of HPC by monitoring HPC columns with actual dimension with embedded FBG strain sensor.

2. Sensing Mechanism of FBG and temperature compensation technique

If fiber Bragg grating is subject to strain and temperature simultaneously, the wavelength shift is:

$$d\lambda_B = \alpha_\varepsilon \varepsilon + \alpha_T dT \tag{1}$$

where λ_B is Bragg wavelength, α_ε is strain sensitivity coefficient of fiber Bragg gratings, and α_T is temperature sensitivity coefficient of fiber Bragg gratings [1]. By the embedded thermocouple inside concrete specimen, the temperature variation dT can be obtained directly, which can be used to compensate the temperature effect of FBG strain sensor. Total deformation ε_{total} of concrete, which includes following two parts without loading:

$$\varepsilon_{total} = \varepsilon_{shrinkage} + \varepsilon_{thermal} \quad \text{in which} \quad \varepsilon_{thermal} = \alpha_c dT \tag{2}$$

where α_c is the concrete coefficient of thermal expansion. Total deformation and shrinkage of concrete specimens can be got by Eq.(3) below:

$$\varepsilon_{total} = \frac{d\lambda_B - \alpha_T dT}{\alpha_\varepsilon} = \frac{d\lambda_B}{\alpha_\varepsilon} - \left(\frac{\alpha_T}{\alpha_\varepsilon}\right) dT \quad \text{and} \quad \varepsilon_{shrinkage} = \varepsilon_{total} - \varepsilon_{thermal} = \frac{d\lambda_B}{\alpha_\varepsilon} - \left(\frac{\alpha_T}{\alpha_\varepsilon} + \alpha_c\right) dT \tag{3}$$

3. Experiment programs

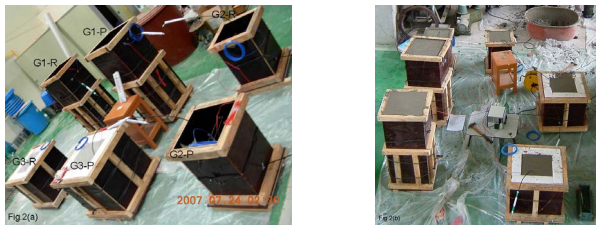

Fig.1 Templates of all specimens (a) before concrete casting (b) after concrete casting

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Table1. Concrete mixture proportion (Unit weight: kg/m^3)

28-day strength	w/c	S/F	w	c	S	G	F/A	PC
60MPa	0.30	60	152	495	738	986	68	8.4

Table2. The specification for experiment specimens

Specimen Number	Specimen Size	Reinforcing or not	Supplement	
G1	40x40x100	Reinforced	G1-R	
		Plain	G1-P	
G2	32x32x50	Reinforced	G2-R	
		Plain	G2-P	
G3	32x32x50	Reinforced	G3-R	Sponge enclosed
		Plain	G3-P	

4. Results and discussions

Initial setting is about 5.3 hrs after concrete pouring. Concrete shrinkage and thermal deformation were measured just after casting by the embedded FBG strain sensors inside the specimens and the temperature can be measured simultaneously. As there is no loading on the concrete specimens at their early age, the measured shrinkage equals autogenous shrinkage. Hydration temperature varying and autogenous shrinkages within the first 33hrs from initial setting time are shown as below graphs.

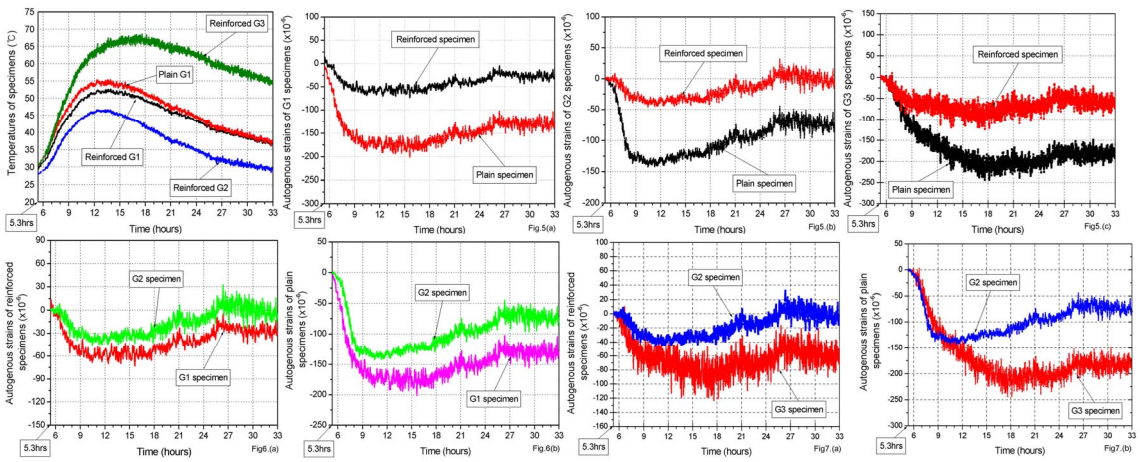

Fig.2 (a). Temperature varying of HPC specimens; (b)-(d). AS comparison of plain and reinforced specimens for different groups separately; (e)-(h). AS comparison of different group specimens for reinforced and plain ones separately.

5. Conclusions

The results showed that temperature compensation for FBG strain sensor is feasible, although it is not as precise as FBG temperature sensor; the cost of thermocouple is much attractive. Reinforced specimen has much less autogenous shrinkage than plain one, and autogenous shrinkage value of reinforced specimen has related with the reinforcing ratio. The size effect on autogenous shrinkage is that bigger specimen has higher autogenous shrinkage than small one. And temperature effect on autogenous shrinkage is that higher temperature may lead to larger AS.

6. Acknowledgements

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References

[1].Ying-wei YUN and Il-Young JANG, Application of FBG Sensor to Monitor Early-Age Deformation of HPC. Proceedings of 8th International Symposium on Utilization of HSC and HPC, Vol.2, P757-762, 2008, Tokyo, Japan.