PROPERTIES OF NON-SHRINKAGE CHEMICAL GROUT USING SILANOL/Si-OH FOR REPAIRING AND STRENGTHENING OF CONCRETE STRUCTURES

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Introduction

In repairing and strengthening of concrete structures, epoxy has been generally applied to members after the target parts got wet by primer. [1] In other words, epoxy resin diluted by a solvent is penetrated to the damaged area to decrease the surface energy and contact angle at crack. However, the use of primer tends to cause the strength and hardness of epoxy to be weakened, and concrete surface is often delaminated from substrate by induced stresses during epoxy hardening process. Any water on the working surface also reduces the bond strength of epoxy resin. In case of the water soluble epoxy resins with an emulsifying agent, their applications for repairing and strengthening of structural members are not suitable due to their low elasticity and strength.

To overcome these limits of existing epoxy for repairing and strengthening of degraded structures, the non-shrinkage chemical grout (NCG) is developed in this research. The NCG makes a strong chemical welding by ionic bonding characteristics of Silanol/Si-OH. In this study, material performances of NCG are experimentally investigated, and its practical applicability are presented.

Material Properties

Bonding Mechanism

The Silanol (Si-OH) in NCG resin is reacted with mineral ion in substrate releasing the water molecules, which lead to a strong chemical welding by ionic bonding of Si-O and concrete as shown in Fig. 1. In this chemical reaction, water and ions interacted relatively freely in pores between substrate and NCG, which does not cause any interface pressure in strengthened (or repaired) region and leads to maintain stable state. Thus, the NCG developed in this study provides a strong bond strength and excellent durability, which makes differences from existing epoxy materials.

Experimental

Material tests, according to KS F 4042[2], were conducted to investigate the properties and performances of the developed NCG, which were also certified in Korea Institute of Construction Materials (KICM) and Korea Institute of Industrial Technology (KITECH). Table 1 shows the material test results of the NCG, compared to an existing epoxy product commonly used in market. The compressive strength and the modulus of rupture of NCG were significantly greater than the existing epoxy product as well as the basic concrete material. All other material properties and performances were also excellent compared to the existing epoxy product. [3] Especially, as presented in Fig. 2, the specimen coated with NCG showed great acid and alkali resistances superior to the specimen without NCG.

Fig. 3(a) shows the specimens exposed to external environment on laboratory yard for 1 year, which reveals that specimen coated with NCG has the good resistance against neutralization compared to specimen without NCG. Fig. 3(b) and Fig. 4 show the appearance of the specimens after freezing-thawing test and relative resilient modulus against the number of freezing-thawing cycle, in which the specimen coated with NCG provided greater freezing-thawing resistance than the non-coated specimen. Fig. 5 shows that coating with NCG significantly reduces the drying shrinkage of conventional concrete, which is because the NCG is basically a non-shrinkage material.

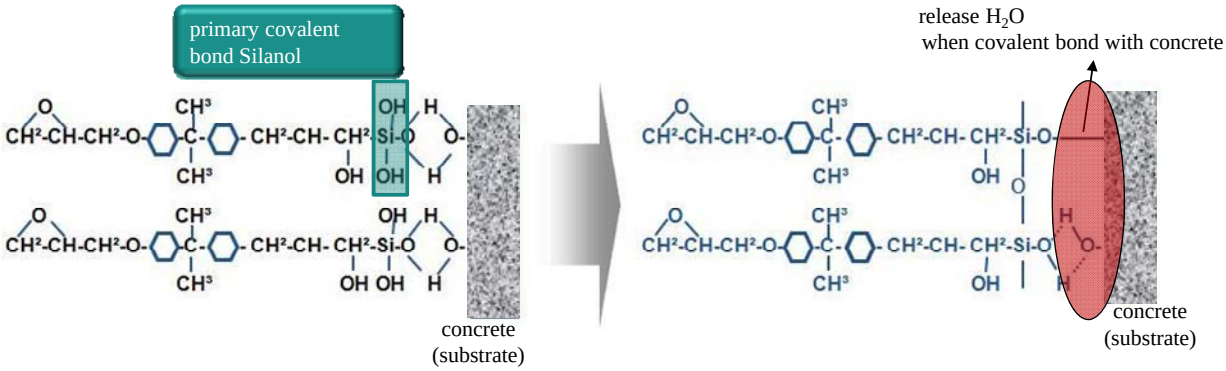
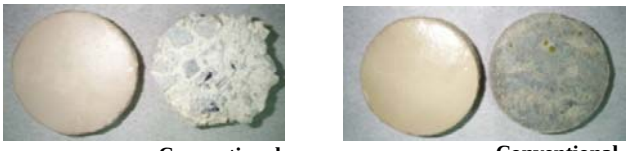


Fig. 1 Chemical bonding mechanism of non-shrinkage chemical grout (NCG)

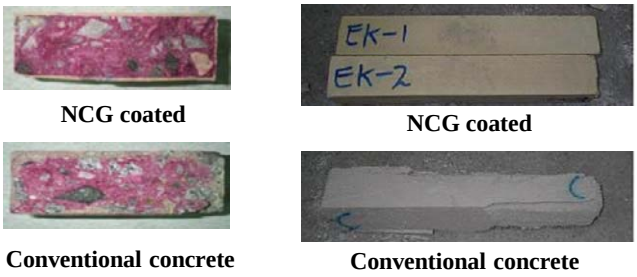
Table 1 – Results of material tests

Tests		Testing Lab.	NCG	Epoxy
Compressive strength (MPa)		KICM	59.1	51.3
Modulus of rupture (MPa)		KICM	20.1	8.2
Bond strength	Standard (MPa)	KICM	2.1	1.9
	Cyclic heat temperature (MPa)	KICM	1.9	1.5
Alkali resistance (Compressive Strength) (MPa)		KICM	57.4	50.4
Water permeability (g)		KICM	1	2
Coefficient of water absorbing ($kg/m^2 \cdot h^{0.5}$)		KICM	0.06	0.11
Moisture permeability, S_d (m)		KICM	1.2	1.7
Chloride ion permeation resistance (Coulombs)		KICM	427	3926
Changing rate of length (%)		KICM	-0.06	-0.10
Neutralization depth (mm)		KICM	1.9	3.2



(a) Acid resistance (b) Alkali resistance

Fig. 2 Test results on acid and alkali resistances



(a) Neutralization resistance (b) Freezing-thawing test

Fig. 3 Tests results on durability

Applications

Since the NCG developed in this research as an ion resin causes almost no surface tension force, the process of primer work is not required before its application. The NCG also has sufficient hardness and strength competitive to conventional concrete, which can enhance the weak tensile and flexural strength of concrete as well as the resistance against temperature change. Thus, it is suitable for repairing cracks and prevents recurrence of cracking along the repaired spots. Moreover, its packing ability is remarkable and its volume loss is merely occurred. Thus, the NCG has outstanding constructability when placing or injecting to concrete cracks. On occasional demands, curing time can be also reduced by mixing ultra-rapid hardening cement to NCG. Based on these superior material properties and performances, it is considered that the application of NCG for repairing and strengthening of concrete structures is very useful and promising.

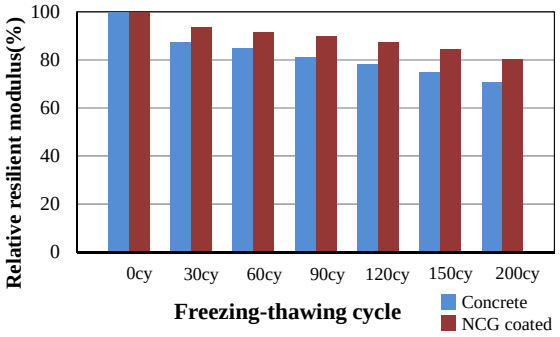


Fig. 4 Detailed results of freezing –thawing test

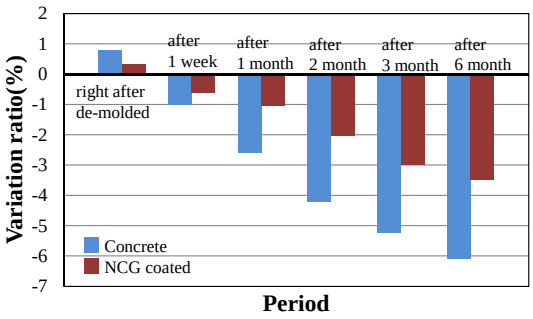


Fig. 5 Measured drying shrinkage of the specimen coated with NCG compared to conventional concrete

Conclusion

In this study, a non-shrinkage chemical grout (NCG) is developed, which provides a strong chemical welding utilizing Silanol/Si-OH. The investigation on the material characteristics of the NCG revealed its excellent performances in repairing and strengthening of structural/non structural members. It is expected that the NCG can be widely used for repairing work and can possibly replace existing epoxy products.

Acknowledgement

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