Shrinkage and Creep of Self-compacting Concrete using Limestone Powder

Kochi University of Technology Graduate student JSCE student member ○Vong Seng
Kochi University of Technology Professor JSCE member Hiroshi Shima

1. Introduction

Since it was developed in mid 1980 in Japan, Self-compacting concrete (SCC) has been used for various structural applications in the world, especially for precast concrete product. In order to use SCC in prestressed concrete technology successfully, creep and shrinkage are important factors to be investigated. Many types of SCC have been developed among three main types: powder type, viscosity type and combination type. Usually powder beside cement named additive is used to produce SCC for the reason of cost saving and the improvement of concrete quality. Some additives are chemically reactive and some are chemically virtually inert. As powder content and powder type used for producing SCC are principle parameters effecting on creep and shrinkage, the investigation was made on SCC powder type with different limestone powder contents incorporating with ordinary Portland cement in this experiment. The mix proportions were prepared as follows: firstly the mix was designed for the conventional concrete for strength of 55MPa. Based on this mix proportion SCC was designed by increasing the powder content in term of reducing coarse aggregate content and using the superplasticizer. Three types of SCC were produced with the same powder volume but different contents of limestone powder as shown in Fig1.

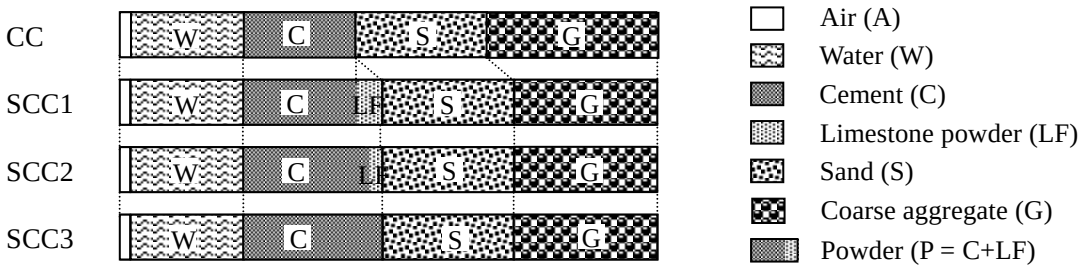

Fig1. Four types of mix proportions

2. Experiment outline

Materials used for mix proportions: type of cement was ordinary Portland cement (specific gravity: 3.15), sand was mixed sand of 50% sea sand (specific gravity: 2.59, water absorption: 2.07, F.M.: 2.92) and 50% crushed sand (specific gravity: 2.59, water absorption: 1.67, F.M.: 3.27), coarse aggregate was crushed stone with maximum size of 20mm (specific gravity: 2.69, water absorption: 0.39, F.M.: 6.46), additive was limestone powder (specific gravity: 2.70), and chemical admixture was superplasticizer (type: SP8SB). Details of mix proportions and some of concrete properties are shown in Table1. Self-compactability was evaluated by a slump flow test, a V-funnel test and a Box container test.

Table1. Details of mix proportions

Descriptions		CC	SCC1	SCC2	SCC3
Unit weight (kg/m^3)	W	175	175	175	175
	C	437.5	437.5	500.8	567
	LF	0	113.4	56.7	0
	S	777	777	777	777
	G	987	807	807	807
	SP	2.174	6.303	6.969	7.645
Fresh properties	flow(mm)	Slump = 10.5cm	675	625	605
	V-funnel(s)		10.15	11.45	12.48
	Box(mm)		325	315	305
Strength (MPa)	4days	38.19	42.75	52.58	61.70
	28days	56.34	65.36	72.55	80.67

The strength of concrete was tested at the age of 4 days and at the age of 28 days (specimens: cylinder 100x200mm).

Keywords: shrinkage, creep, self-compacting concrete, limestone powder
Contact address: Department of Infrastructure Systems Engineering, Kochi University of Technology
185 Miyanokuchi, Tosayamada-cho, Kami-gun, Kochi 782-8502

The shape and dimensions of specimen are shown in Fig2. A plastic duct for prestressing bar was arranged at the center of specimen. Sixteen point gages for the contact gage meter of 300mm basic length and two wire strain gages were put on two symmetry surfaces. The experiment was performed under the same test conditions for these four types of concrete. The formwork was removed at 24 hours after casting and all specimens were air-cured in a constant temperature and constant humidity room at 20±2°C, 60±5%. The measurement of shrinkage was started after just removing formwork. For creep test, stress of 40% of strength was introduced at the age of 4 days by tensioning a 21mm prestressing bar with apparatus as shown in Fig3. Because of the prestress loss due to shrinkage, creep and relaxation of prestressing steel which occurs with time, each specimen was reloaded to maintain the error of applied stress 2%.

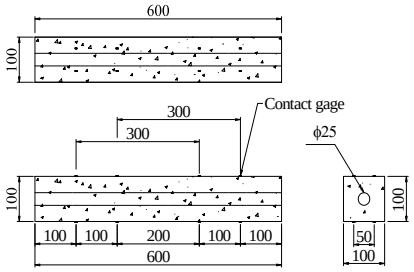

Fig2. Dimensions of specimen

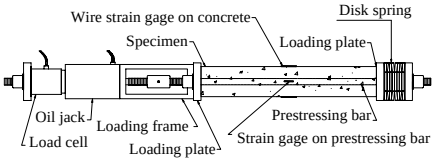

Fig3. Testing apparatus

3. Results and discussion

JSCE2002 design code was used to calculate shrinkage and specific creep for the case of volume to surface ratio is 22mm even its limitation value given in the code is 100mm. The test results of shrinkage compared with JSCE2002 are shown in Fig4 and the test results of specific creep compared with JSCE2002 are shown in Fig5. As can be seen, the shrinkages show almost the same value for these four types of concrete. Specific creep of SCC with higher powder content shows higher specific creep, but for the case of SCC which was made by adding limestone powder content to conventional concrete, it shows almost the same specific creep of the conventional. Test results give the same characteristics to JSCE design code.

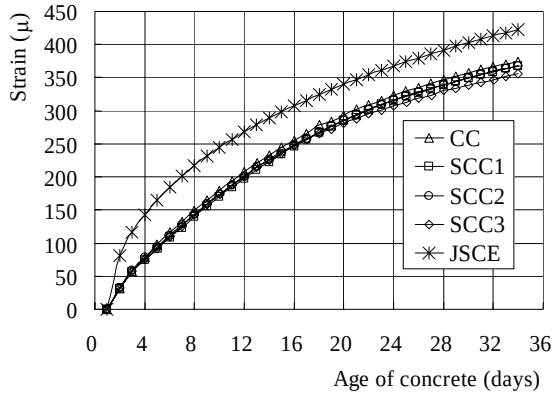

Fig4. Shrinkage compared with JSCE2002

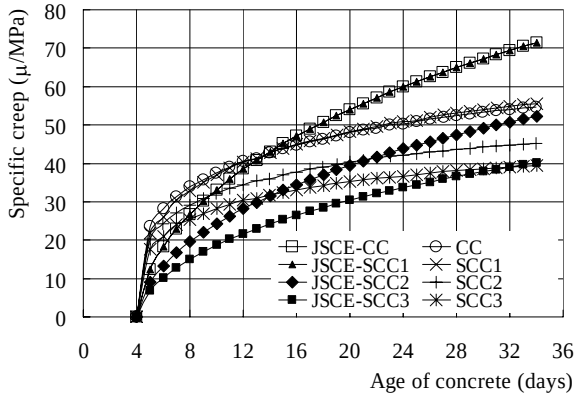

Fig5. Specific creep compared with JSCE2002

4. Conclusions

1) Limestone powder does not significantly effect on shrinkage. JSCE2002 shrinkage model which considers absolute water content as main parameter can be applied to Self-compacting concrete using limestone powder.

2) Self-compacting concrete with high content of limestone powder content shows higher specific creep and self-compacting concrete which was made by adding limestone powder content to conventional concrete shows almost the same specific creep of the conventional.

References

1).Shima H., Noritake K., ‘Strain increase of concrete subjected to sustain compressive stress at early age’, ICCM/IBST2001.

2). Sakata Kenji, Ayano Toshiki, ‘A non linear creep prediction equation for concrete’, CLI of JSCE No. 21, June 1993

3). JSCE, ‘Standard specifications for concrete structure-2002’- March, 2002

4). JSCE, ‘Recommendation for Self-Compacting Concrete’, August 1999