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KCI Database of Test Data for Creep and Shrinkage of Concrete

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ABSTRACT

The creep and shrinkage of concrete causes a long-term behavior of concrete structures such as the increase of deflection over time, the tensile cracking due to shrinkage, the long-term loss of pre-stressing force in pre-stressed concrete structures, the differential column shortening in high-rise buildings, the redistribution of stress and strain over time, etc. In order to predict the long-term behavior, it needs a material model for creep and shrinkage which is generally developed based on the curve fit for the test data of creep and shrinkage. A database for the test results is essential in developing a model and analyzing the long-term behavior of concrete structures.

The Korea Concrete Institute committee 211 (KCI 211-creep and long-term behavior of concrete structures) recently established a database for the creep and shrinkage tests. The laboratory test data were extracted from the research papers published in the KCI Journal for twenty years from 1992 to 2012 and were collected according to the test condition and the test methods. The database consists of 101 and 62 data sets for the creep and the shrinkage tests, respectively. The collected test data were compared with the creep and shrinkage strains calculated from the existing models, KCI model, ACI model, CEB MC 90 model, B3 model, and GL 2000 model. The database will be continuously updated and will be used in developing a new model appropriate to concrete produced in Korea.

1. INTRODUCTION

In a service state of concrete structure, the stress acting on the concrete is generally less than 40% of the actual compressive strength of the concrete, and the elastic strain corresponding to the stress ranges from 300 to 400×10^{-6}. The shrinkage strain of concrete due to drying is usually about 200 to 600×10^{-6}. The creep coefficient,

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which is defined as a ration of the creep strain to the elastic strain, is about 2.0 to 4.0. It definitely indicates that the time-dependent strain caused by the drying shrinkage and creep is generally more than the elastic strain. Many problems in concrete structures such as long-term deflection, the tensile cracking, the long-term loss of pre-stressing force in pre-stressed concrete members, and the differential column shortening in high-rise buildings are cause by the creep and shrinkage. Therefore, the long-term behavior of concrete structures should be considered in the process of design and construction.

In order to predict the long-term behavior, it needs a material model for creep and shrinkage which is generally developed based on the curve fit for the test data of creep and shrinkage. The existing models, ACI, CEB MC 90, B3, and GL2000, were also developed based on the databases. The concrete property depends on the regionality because the concrete consists of local constituents, cement, sand and gravel. The properties of creep and shrinkage may have the regionality. For this reason, to develop an appropriate model for concrete manufactured in Korea, it needs a database for the creep and shrinkage tests performed in Korea.

Recently, the Korea Concrete Institute committee 211 (KCI 211-creep and long-term behavior of concrete structures) built a database for the creep and shrinkage tests. The laboratory test data were extracted from the research papers published in Koreal for twenty years from 1992 to 2012 and were collected according to the test condition and the test methods. The database consists of 101 and 62 data sets for the creep and the shrinkage tests, respectively.

In this paper, what the new database is made up of will be first explained, and the collected test data will be compared with the creep and shrinkage strains calculated from the existing models, ACI model, CEB MC 90 model, B3 model, and GL 2000 model. Finally, the future plan for maintaining and updating the database will be given.

2. KCI Database of Test Data for Creep and Shrinkage

The KCI database consists of three parts: basic information for the tests, creep test data, and shrinkage test data as shown in Fig.1. The test data were extracted from all the literatures published in Korean domestic journal until October 2012. 101 data sets for creep tests and 62 sets for shrinkage tests were collected and included in the database.

The first part, the basic information, include the information for the representative researcher name, the publishing year, water to cement ratio, cement content, compressive strength at 28 days, specimen size, curing condition, temperature and relative humidity, as shown in Fig.1 (a). The measured creep strain was transformed into the value of the creep compliance function at the measuring time. The values of creep compliance function at the measuring times were first included in the second part of the database. The calculated values of the compliance function based on the existing models were also included for the comparison between the measured and the calculated compliances as listed in Fig. 1(b). As for the shrinkage test data, the measured shrinkage strains at the measuring times were first entered. For the same testing condition, the shrinkage strains were predicted based on the existing models. The predicted strains were listed together as shown in Fig. 1(c).

ID	Author	Year	file name	TestNo	experiment info.										
					wc	ac	c	fc28	E28	Geometry	2VS	H0	t'	T	H
1	안성수	2006	Ahn06	1	0.48	4.044	412	24.5	27125.64	c150x300	200	65	6	22	65
2	김병윤	2005	Kim05_재생골재1_0	1		5.514285714	315	27.8	24900	p100x400	200	60	7	20	60
3	김병윤	2005	Kim05_재생골재1_30	2		4.79047619	315	28.9	24700	p100x400	200	60	7	20	60
4	김성후	1997	Kim97_고강도1_7	1	0.36	3.364197531	486	47.2	27200	c150x300	300	100	7	23	50
5	김성후	1997	Kim97_고강도1_28	2	0.36	3.364197531	486	47.2	27200	c150x300	300	100	28	23	50
6	김성후	1997	Kim97_고강도1_90	3	0.36	3.364197531	486	47.2	27200	c150x300	300	100	90	23	50
7	김광종	2002	Kim_PSC1	1	0.42	4.096296296	405	40.2	27042	c150x300		100	7	23	100
8	김광종	2002	Kim_PSC2	2	0.42	4.096296296	405	40.2	27042	c150x300		100	28	23	100

(a) Basic information (Researcher, Material, Temperature, and Humidity)

ID	Author	Year	file name	fc28	t'	Cement type	Cured Method	V/S	Humidity	Jcreep(Measuredx10^-6)		Jcreep(B3)	Jcreep(ACI)	Jcreep(ceb)	Jcreep(Gl2000)
										tt'	Compliance	Compliance	Compliance	Compliance	Compliance
1	안성수	2006	Ahn06	24.5	7	1	Cured in water	37.5	0.65	0.07	51.60	75.87	53	53.06	55.21
										8.33	71.27	104.11	78.07	97.31	99.03
										10.59	75.95	106.38	81.04	101.56	102.62
										13.28	79.70	108.62	84.01	105.82	106.03
										20.15	83.47	112.97	89.86	114.34	112.37
										21.80	86.09	113.82	91.01	116.05	113.57
										40.16	91.96	120.72	100.27	130.39	122.99
										53.22	106.04	124.06	104.62	137.59	127.38
										58.22	108.11	125.15	106	139.96	128.79
										84.16	108.58	129.72	111.61	149.94	134.54
2	정원섭	2010	Joung10_고강도1	33	28	1	Cured in water	37.5	0.5	32.93	51.96	63.60	62.33	78.75	79.74
										37.80	56.65	64.57	63.55	80.58	81.48
										69.40	67.78	69.30	68.98	89.13	89.51
										96.73	76.01	72.21	71.87	94.05	94.02
										129.08	80.20	74.92	74.28	98.36	97.90

(b) Creep data

ID	Author	Year	file name	TestNo	shrinkage		shrinkage(ACI)		shrinkage(B3)		shrinkage(CEB)		shrinkage(GL)	
					days	strain(*10^-6)	days	strain(*10^-6)	days	strain(*10^-6)	days	strain(*10^-6)	days	strain(*10^-6)
1	안성수	2006	Ahn06	1	0.61	68.14	0.61	8.08	0.61	33.88	0.61	42.61	0.61	47.05
					1.43	107.40	1.43	18.67	1.43	51.90	1.43	59.53	1.43	72.00
					1.63	144.56	1.63	21.18	1.63	55.38	1.63	62.81	1.63	76.81
					2.66	171.44	2.66	33.85	2.66	70.66	2.66	77.29	2.66	97.89
					6.58	247.98	6.58	77.37	6.58	110.44	6.58	115.11	6.58	152.31
					14.24	318.48	14.24	145.50	14.24	160.34	14.24	162.15	14.24	219.31
					20.67	347.64	20.67	190.26	20.67	191.06	20.67	190.64	20.67	259.67
					28.95	426.42	28.95	236.35	28.95	223.03	28.95	219.81	28.95	300.82
					43.46	480.69	43.46	296.15	43.46	266.92	43.46	258.98	43.46	355.75
					51.73	594.57	51.73	322.15	51.73	287.45	51.73	276.94	51.73	380.79
					59.40	625.85	59.40	342.55	59.40	304.38	59.40	291.57	59.40	401.12
					83.25	676.37	83.25	390.30	83.25	347.71	83.25	328.33	83.25	451.84
2	김재기	2003	Kim03_2_강동	5	0.25	45.97	0.25	4.57	0.25	19.37	0.25	56.36	0.25	25.16
					4.38	220.78	4.38	72.84	4.38	80.85	4.38	119.48	4.38	103.77
					18.06	342.40	18.06	234.35	18.06	163.79	18.06	204.16	18.06	202.80
					38.26	419.28	38.26	375.00	38.26	236.58	38.26	271.16	38.26	280.43

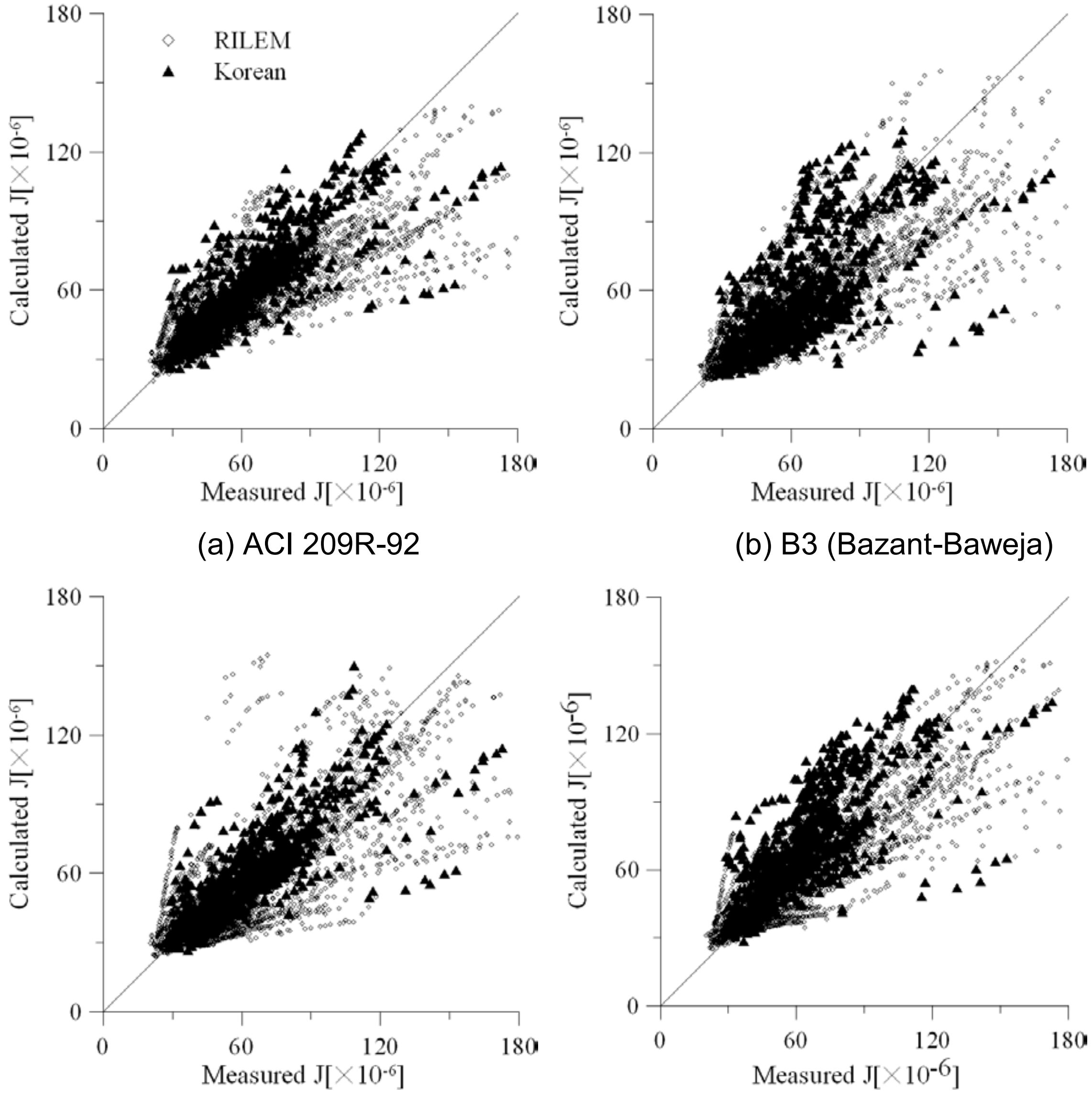
(c) Shrinkage data

Fig. 1 Database for Creep and Shrinkage Tests

3. Analysis for creep and shrinkage test data

3.1 Creep test data

The measured creep compliance was compared with the compliance calculated from the existing models in Fig. 2. In the Fig. 2, the solid dots are the test data came from KCI database, and the hollow dots from Rilem database. As the increase of the creep strain, the difference between the measured and the calculated creep is becoming larger, and the measured was generally getting larger than the calculated.



(a) ACI 209R-92

(b) B3 (Bazant-Baweja)

(c) CEB MC90-99

(d) GL 2000

Fig. 2 Comparison between the measured and the calculated creep strains

From the comparisons of Fig. 2, the coefficient of variation was calculated to estimate the discrepancy between the measured and the calculated compliances as listed in Table 1. In the case of Rilem data base, the coefficient of variation for the GL2000 model was the lowest value as 24.0%, which indicates that the GL200 model is the most accurate in predicting the creep data. On the other hand, the ACI model turned out to be the most accurate for the creep data of KCI database.

Table 1. Coefficient of Variation for Creep Data

Model	ACI 209R-92		B3		CEB MC90-99		GL2000	
Database	KCI	RILEM	KCI	RILEM	KCI	RILEM	KCI	RILEM
Coefficient of Variation (%)	25.7	33.0	37.8	32.0	26.0	34.0	30.5	24.0
Order of ccuracy	1	3	4	2	2	4	3	1

3.2 Shrinkage test data

Figure 3 shows the comparison between the measured shrinkage strains and the shrinkage strains calculated from the existing models. In the Fig. 3, the solid dots are the test data came from KCI database, and the hollow dots from Rilem database. As the increase of the shrinkage strain, the difference between the measured and the calculated shrinkage strains is becoming larger, and the measured was generally getting larger than the calculated.

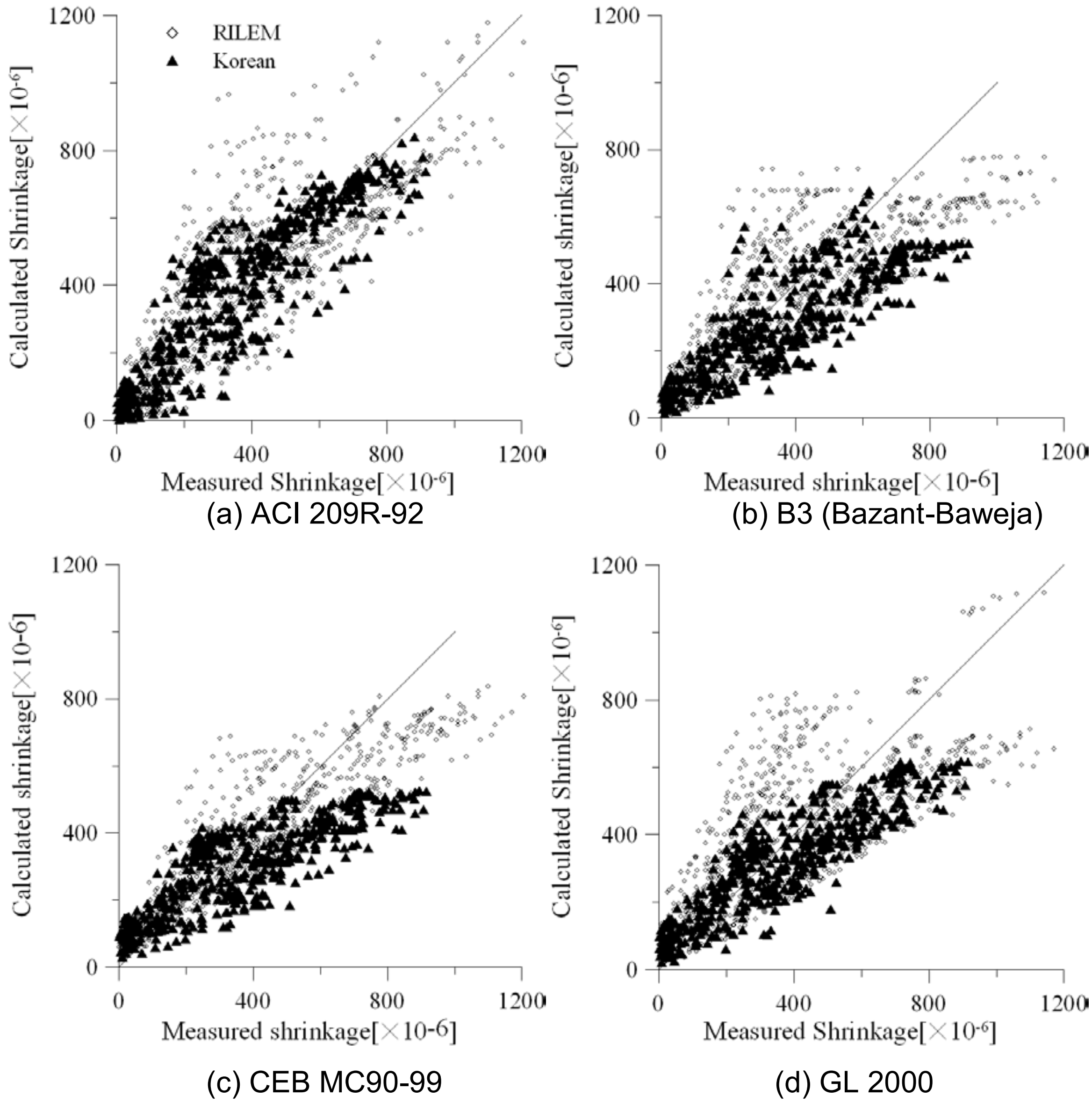
From the comparisons of Fig. 3, the coefficient of variation was calculated to estimate the discrepancy between the measured and the calculated shrinkage strains as listed in Table 2. The coefficient of variation for the shrinkage test data was larger than that for the creep test data in most cases.

In the case of Rilem database, the CEB MC 90 model has the lowest coefficient of variation. On the other hand, similarly to the creep test data, the ACI model was the most accurate in predicting the shrinkage data of KCI database.

4. Concluding Remarks

A new database for the creep and shrinkage test data extracted from the literature published in the Korean domestic journals was recently established by KCI committee 211. Among the existing models, the ACI model gives the most accurate prediction for the measured creep and shrinkage data. In the near future, the KCI database will be used in developing a new prediction model that is appropriate to the concrete manufactured in Korea.

The KCI committee will keep updating the database by including new types of cementitious materials which have been recently developed.



(a) ACI 209R-92

(b) B3 (Bazant-Baweja)

(c) CEB MC90-99

(d) GL 2000

Fig. 3 Comparison between the measured and the calculated shrinkage strains

Table 2. Coefficient of Variation for Shrinkage Data

Model	ACI 209R-92		B3		CEB MC90-99		GL2000	
Database	KCI	RILEM	KCI	RILEM	KCI	RILEM	KCI	RILEM
Coefficient of Variation (%)	51.9	46.1	59.1	43.3	61.8	36.0	52.8	57.9
Order of Accuracy	1	3	3	2	4	1	2	4

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RILEM Data Bank, provided by Dr. Harold S. Muller, Universitat Karlsruhe (TH), Institute fur Massivbau und Baustofftechnologie, Abteilung Bautstofftechnologie, Postfach, D-76128 Karlsruhe, Germany