論文 A Study on the Evaluation and Analysis on the Correlation of High Fluidity for High Flowing Concrete

Kim Moo Han[*1] · Koh Yoshiro[*2] · Kamada Eiji[*3] · Kim Gyu Yong[*4]

ABSTRACT : This paper presents the result of comparison and analysis on relationships between flowability and spatial passability through the evaluation method of the high flowing concrete such as slump flow test, V-funnel test, L-flow test and L-spatial test. The result of this study indicate that the flowing time and velocity of high flowing concrete depends on their flowing shape and direction, and it is to analyze the correlationship of high fluidity and propose the adequate range of each fluidity for evaluation of high flowing concrete.

KEYWORDS : high fluidity, spatial passability, V-funnel, L-spatial,

1. INTRODUCTION

High flowing concrete has to meet some requirement performances in a fresh state, i.e. flowability, compactability, spatial passability, resistance of segregation and so on.[1),2)]

Therefore, many testing methods for evaluating these requirement performances such as slump-flow test, L-flow test, V-funnel test,s L-spatial passability test have been proposed so far[3)], which should be accompanied with the purpose of accurate evaluation of the performances. And, it is difficult to exactly evaluate and analyze the relationship among fluidity of high flowing concrete in abbreviating test method. However, it is necessary to estimate the relationship of high fluidity, and establish an investigation method of fluidity in the fresh state of high flowing concrete. Here upon, we organized and carried out some experiments for synthetical evaluating the relationship between flowability and passability of high flowing concrete. The results of this study would be of useful reference value to estimate the high fluidity of high flowing concrete.

Table 1. Experimental Factors and level

Items	Factor	Level
Mixing Factors	W/B	0.35
	Replacement of Fly-ash(°/wt)	15, 30. 45, 60
	water (kg/m³)	175
	S/A (%)	48, 50, 52
Material Factors	Kinds of Cement	OPC : Ordinary Portland Cement HBC : High Belite Cement
	Admixture	Fly-ash
	Kinds of High range water reducing AE agent	Polycarbon acid based : 1 type Naphthalene based : 3 types
	Kinds of Fine Aggregate	River-sand : SG 2.57 FM 2.64 Crushed-sand : SG 2.58 FM 2.87 Sea-sand : SG 2.58 FM 3.38
	Kinds of Coarse Aggregate	Crushed stone 20mm : SG 2.58 FM 6.54 25mm : SG 2.62 FM 6.61

2. EXPERIMENTAL PROGRAM AND METHODOLOGY OF THE STUDY

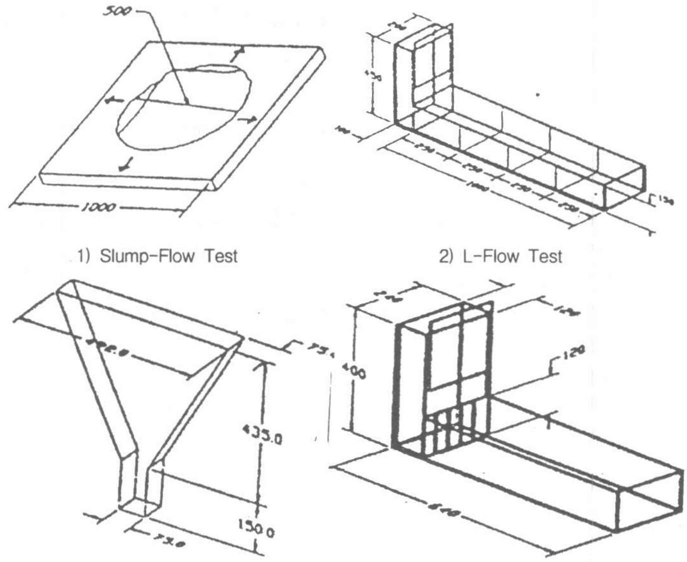
2.1 EXPERIMENTAL PROGRAM

As a part of series of an experimental study about evaluating and analyzing fluidity of high flowing concrete, this study aims to synthetically

* 1 Prof., Dr. Eng., Dept. of Architectural Engineering, Chungnam National Univ. in Korea, Member of JCI
* 2 Emeritus Prof., Dr. Eng., Dept. of Architectural Engineering, Hokkaido Univ. Member of JCI
* 3 Prof., Dr. Eng., Dept. of Architectural Engineering, Hokkaido Univ. Member of JCI
* 4 Researcher, Dr. Eng., Dept. of Architectural Engineering, Chungnam National Univ. in Korea

evaluate fluidity of high flowing concrete on the basis of the measured values from slump-flow test, L-flow test, V-funnel test and L-spatial passability test.

The study is planned to analyze and compare properties of each testing apparatus by speculating bibliographic documents, and then to consider the correlationship of high fluidity, after comparing and analyzing the high flowing concrete by testing L-spatial passability test, slump-flow test and L-flow test.



1) Slump-Flow Test 2) L-Flow Test 3) V-Funnel Test 4) L-Spatial Passability Test

Fig 1. Testing Apparatus

2.2 EXPERIMENTAL FACTORS AND LEVEL

The concrete used in this experimental study is powder type and composed with a large quantity of binder as shown in Table 1. As shown in Table 2 we carried out slump-flow test and L-flow test for evaluating the flowability. Also we execute V-funnel test, L-spatial passability test for evaluating spatial passability. It is used the testing apparatus proposed by JCI for measuring the various fluidity as shown in Fig 1.

Table 2. The Tesitng items and Method of Fresh Concrete

Evaluating items		Measurment and Method
Flowability	Slump-Flow	Slump-flow (cm) Slump-flow velocity of 50 cm
	L-Flow	L-Flow(cm) L-Flow velocity of 50 cm
Spatial passability	V-Funnel	V-Funnel time (sec) Relative Velocity of V-Funnel (5/Tv)(Tv=Passing time)
	L-Spatial Passability Test	L-Spatial Slump (cm) L-Spatial Flow (cm) L-Spatial Flow Velocity of 50 cm

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 SLUMP-FLOW AND L-FLOW

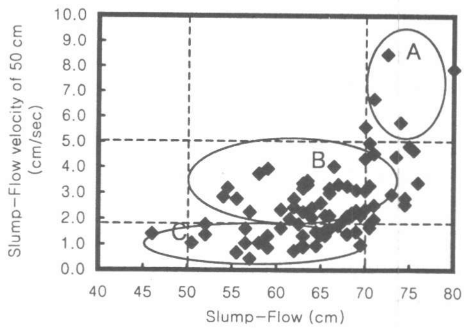


Fig. 2 Relationship between Slump-Flow and Slump-Flow Velocity of 50cm

Relationship between slump-flow and slump-flow velocity of 50 cm is shown in the Fig 2. As a high flowable area of high flowing concrete presented in JASS 5, B area is formed around the data in the range of slump-flow 50~70 cm and slump-flow time of 50 cm of 3~8 sec(slump-flow velocity of 50 cm : 1.875~5.000 cm/sec)[4]. But in this study, experimental data are formed a little lower area than suggested area. As in the C area, slump-flow velocity of 50 cm is below 1.875 cm/sec in slump-flow 50~70 cm, it can be regarded as high viscosity area. In the A area, it is over the slump-flow 70 cm and 5.0 cm/sec of slump-flow velocity of 50 cm, it can be regarded as an area that possibility of segregation could be high.

The relationship between slump-flow and L-flow is shown in the Fig 3. In slump-flow testing apparatus, concrete flows on two dimensional radial direction, but in L-flow testing apparatus, concrete flows in the form of one dimensional side direction. In this experimental study, L-flow value is about 1.76 times higher than slump-flow's in range from 35 cm to 80 cm. And it is difficult to measure L-flow values below 35 cm of slump-flow.

That is nearly consistent with the existing research report[5]. This relationship is presented the following equation, as showm in Fig 3.

$Lf = 1.762Sf - 24.067$ (R^2=0.8987)

where, Lf is L-flow,

Sf is Slump-flow

Relationship between slump-flow velocity of 50 cm and L-flow velocity of 50 cm is shown in the Fig 4. L-flow velocity of 50 cm is about 3.5 times faster than slump-flow velocity of 50 cm in each flowing velocity. The maximum value of L-flow velocity of 50 cm is approximately 25 cm/sec and slump-flow velocity of 50 cm is about 8 cm/sec.

Presenting this correlationship, it is as the following equation

$Lv_{50} = 3.557 \times Sv_{50} + 1.858$ (R^2=0.7635)

where,

Lv_{50} : L-flow velocity of 50 cm

Sv_{50} : Slump-flow velocity of 50 cm

The flowing behaviour of high flowing concrete is influenced by the flowing direction and shape as the above mentioned.

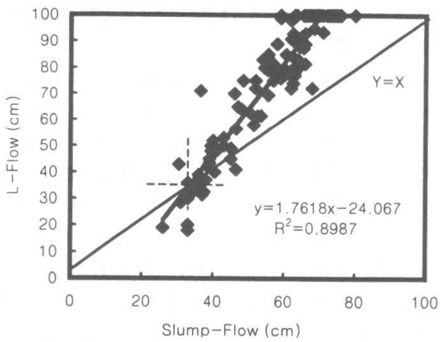


Fig 3. Relationship between Slump-Flow and L-flow

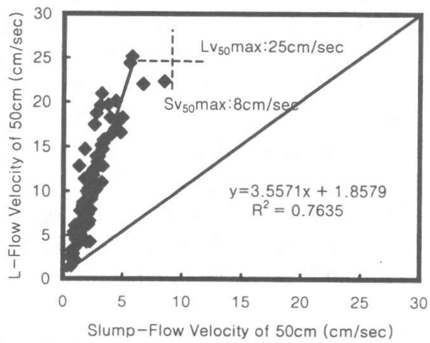


Fig 4. Relationship between Slump-flow Velocity of 50 cm and L-flow Velocity of 50 cm

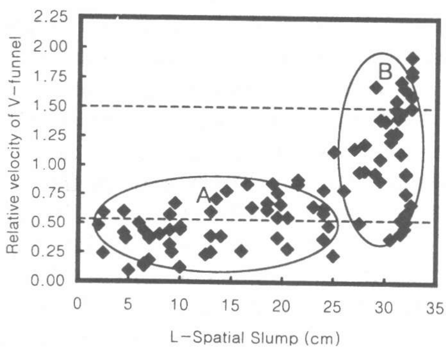


Fig 5. Relationship between Relative velocity of V-Funnel and L-spatial slump

3.2 V-FUNNEL AND L-SPATIAL PASSABILITY

As the Fig 5 showing the relationship between L-spatial slump and relative velocity of V-funnel, B area, which L-spatial slump is in range of 25~33 cm and relative velocity of V-funnel is in range of 1.0±0.5, is regarded as superiority in the spatial passability. Even though data are formed in range of 1.0±0.5, there are some data which is below 25 cm of L-spatial slump. Therefore, there is relatively more difficult to pass the L-spatial than V-funnel.

3.3 FLOWABILITY AND SPATIAL PASSABILITY

As the Fig 6 showing the relationship between slump-flow and relative velocity of V-funnel in the case of L-flow values of 80~100 cm, which is distributed in A area, it is regarded as appropriate flowability and spatial passability. L-flow values below 80 cm is forming B area is out of an appropriate fluidity. Therefore, appropriate L-flow value for high fluidity is regarded over 80 cm.

The Fig 7 shows relationship between L-flow and relative velocity of V-funnel according to L-spatial slump. As the above mentioned, in case of over 25 cm of L-spatial slump, the most appropriate fluidity area is distributed over 80 cm of L-flow and in relative velocity of V-funnel 1.0±0.5. But in the case of L-spatial slump 25 cm below, it is divided by B area which is lower passability.

3.4 SLUMP-FLOW AND RELATIVE VELOCITY OF V-FUNNEL ACCORDING TO L-SPATIAL SLUMP

As the Fig 8 showing relationship between slump-flow and relative velocity of V-funnel according to L-spatial slump, High fluidity area which is over 25 cm of L-spatial slump is formed in the range of slump-flow 50~70 cm and relative velocity of V-funnel 1.0±0.5. However in the case of slump-flow value of 50~70 cm, there are some case of below 25 cm of L-spatial slump and relative velocity of V-funnel 0.5. Therefore, it is necessary to investigate not only the high fluidity but also the spatial passability of high flowing concrete.

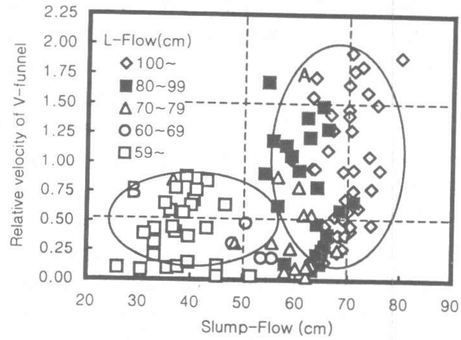


Fig 6 Relationship between Slump-flow and Relative velocity of V-funnel

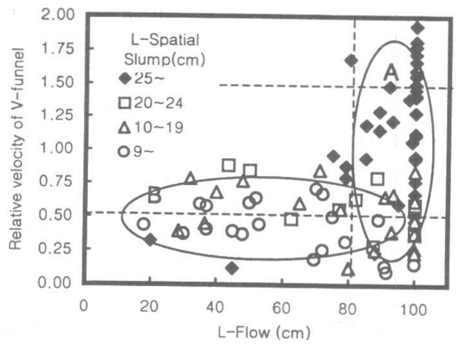


Fig 7 Relationship between L-flow and Relative velocity of V-funnel in each L-spatial slump

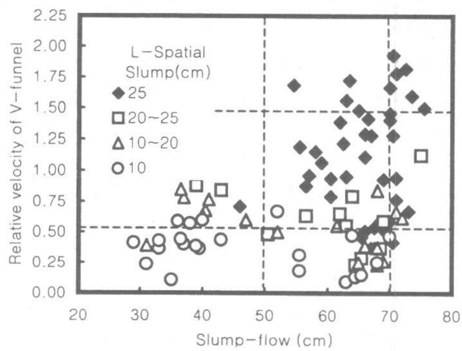


Fig 8. Relationship between Slump-flow and relative velocity of V-funnel according to L-spatial slump

3.5 V-FUNNEL AND L-SPATIAL FLOW VELOCITY OF 50 CM

As the Fig 9 showing relationship between relative velocity of V-funnel and L-spatial flow velocity of 50 cm according to L-spatial slump and slump-flow, it was analyzed synthetically concerning each level of slump-flow and L-spatial slump. Especially, there is some cases that don't satisfy an appropriate spatial passability, even though it is in slump-flow 50~70 cm. Therefore we can say that it is necessary to take careful attention for investigating the fluidity of high flowing concrete with slump-flow values only. On the other hand, considering the relationship between flowability and passability, in the case over 25 cm of L-spatial slump, an appropriate spatial passability area is distributed mostly in relative velocity of V-funnel 1.0±0.5. But, in that case which L-spatial slump is below 25 cm, there are some unappropriated spatial passability. On the other hand, in the area which is over 70 cm of slump-flow, 1.5 of relative velocity of V-funnel, and 25 cm of L-spatial slump, it could be classified as the segregative tendency area. As shown in the relationship between relative velocity of V-funnel and L-spatial slump value, an appropriate L-spatial flow velocity of 50 cm is ranged in 4~14 cm/sec.

3.6 SLUMP-FLOW VELOCITY OF 50 CM AND L-SPATIAL FLOW VELOCITY OF 50 CM

Fig 10 shows the relationship between slump flow velocity of 50 cm and L-spatial flow velocity of 50 cm according to slump-flow and L-spatial slump. The relationship between slump-flow velocity of 50 cm and L-spatial flow velocity of 50 cm can be presented as the following form of secondary equation.

$Lv = -0.25Sv^2+4.55Sv_{50}-3.75$, ($R^2=0.7305$)

here,

Lv_{50} : L-spatial flow velocity of 50 cm

Sv_{50} : slump-flow velocity of 50 cm

In the relationship between slump-flow velocity of 50 cm and L-spatial flow velocity of 50 cm according to L-spatial slump, the level of L-spatial slump over 25 cm is distributed in B area which is regarded as the adequate spatial passing level. Therefore, in the case of L-spatial slump over 25 cm and slump flow velocity of 50 cm ranging in 1.8~5.0 cm/sec, it is considered to be satisfied the flowability and spatial passing properties at the same time.

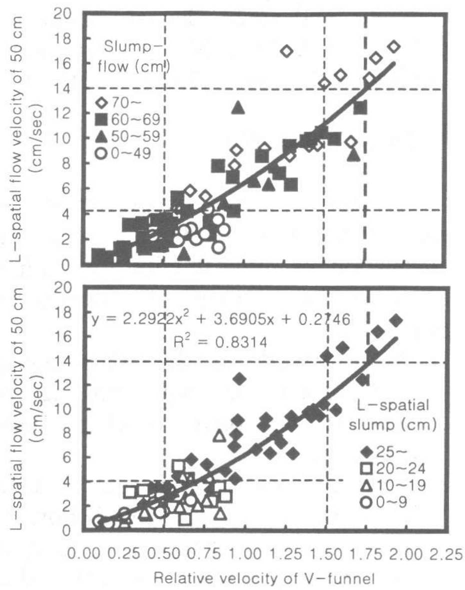


Fig 9. Relationship between relative velocity of V-funnel and L-spatial flow velocity of 50 cm

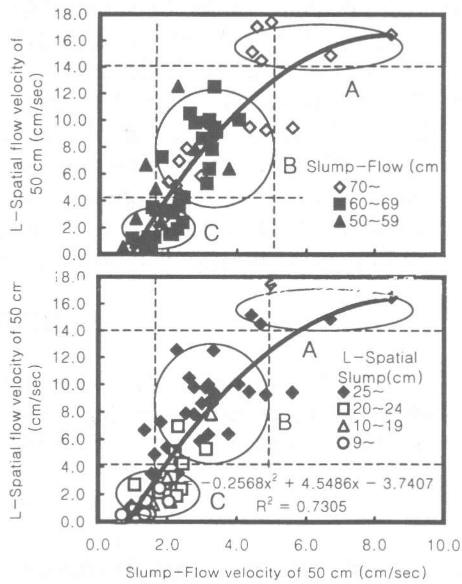


Fig 10. Relationship between Slump-flow velocity of 50 cm and L-spatial flow velocity of 50 cm

3.7 L-FLOW VELOCITY OF 50 CM AND L-SPATIAL FLOW OF 50 CM

Fig 11 shows relationship between L-flow velocity of 50 cm and L-spatial flow of 50 cm according to L-flow and L-spatial slump. In the range of L-spatial flow velocity of 50 cm, the appropriate area to satisfy the range of over 25 cm of L-spatial slump is 4~14 cm/sec. Therefore, it is comformed that we can use the L-flow velocity of 50 cm to evaluate the appropriate abilities of high flowing concrete, and such adequate range is turned out to be L-flow 80~100 cm and 10~21 cm/sec as L-flow velocity of 50 cm.

4. CONCLUSIONS

Basing on this experimental study on the evaluation and analysis on the correlation of high fluidity for high flowing concrete, the following conclusions could be drawn.

1) It is considered that the flowing time and velocity of high flowing concrete depends on their flowing shape and direction.
2) According to the synthetic evaluation of L-spatial slump, L-spatial flow velocity of 50 cm and slump-flow, it is inferred that the range of relative velocity of V-funnel can be magnified from the range of 0.50~1.50 to 0.50~1.75.
3) The adequate range to satisfy the range of slump-flow 50~70 cm and 0.50~1.75 of relative velocity of V-funnel is over 25 cm in L-spatial slump and 4~14 cm/sec of L-spatial velocity of 50 cm.
4) As the result of analyzing the correlation of slump-flow, L-spatial slump and L-spatial flow velocity of 50 cm, the slump flow velocity of 50 cm is inferred to be 1.8~5.0 cm/sec as adequate level.
5) As the result of investigating the correlation of the L-flow, L-spatial slump and L-spatial flow velocity of 50 cm, the value of L-flow velocity of 50 cm is conformed to be useful evaluation index of high flowing concrete.

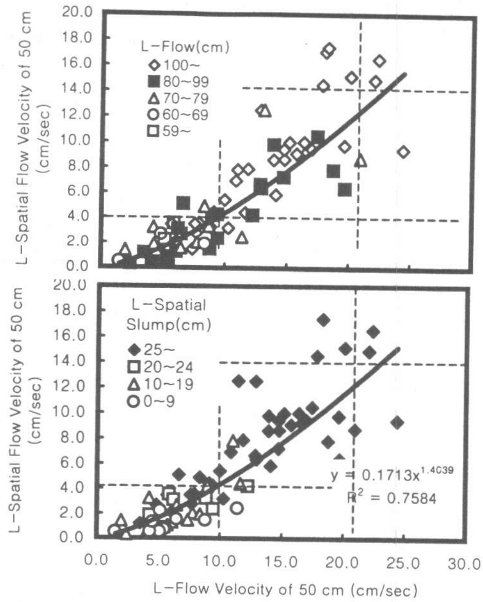


Fig 11. Relationship between L-flow velocity of 50 cm and L-spatial slump

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