V－58　高流動コンクリートのワーカビリティーを評価指標としてのSlump/V-time比の提案

Introducing the Slump/V-time Ratio to Describe the Workability of High Fluidity Concrete

東北大学　学生会員　○Safawi Mohammad Ibrahim
東北大学　野村　浩
東北大学　フェロー　三浦　尚

1.0 Introduction

High fluidity concrete is characterized by its ability to flow under its own weight. As fresh concrete behaves like a plastic fluid, its flow is close to a Bingham model having both yield stress and viscosity. In a standard slump cone test, high fluidity concrete spreads into a round circle rather than takes up the shape of the cone. Thus, measuring the diameter of slump (termed as slump flow) is more relevant than the slump height. The slump flow is dependent on the yield stress of the concrete. Slump flow alone is not sufficient to describe the workability of high fluidity concrete. For example, in the case of Self-Compacting concrete (SCC), other than being flowable, the viscosity of the concrete must also be at an optimum (V-funnel time =10s). Hence, a V-funnel test was introduced as a measure of different concrete viscosity. The time taken for the concrete to flow out from the V-funnel (Fig.1) is known as V-funnel time or V-time. Unfortunately, the slump flow and V-time are not strictly correlated to one another. In this study a Slump/V-time ratio is introduced as a single parameter to describe fresh high fluidity concrete.

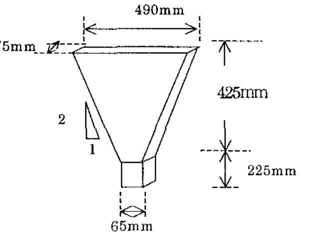

Fig.1 Dimension of V-funnel

2.0 Derivation of Slump/V-time ratio

A standard slump cone, having a base(B) of 200mm, is taken as a length parameter [L] as in [1]. The time parameter is taken from the flow of concrete in the V-funnel test. As concrete flows out due to gravity, g, over the height of the V-funnel (H = 425mm) the time parameter is then computed as in [2]. With respect to plastic fluids its flow is normally characterized by a Bingham number. The Bingham number is a dimensionless number that is a measure of the ratio of the yield stress to the viscous stress. Based on this, by taking the ratio of slump flow to V-funnel time, a non-dimensional Slump/V-time ratio is formulated as in [3].

$$length\ \ parameter\ \ ,[L] = B \qquad [1]$$

$$time\ \ parameter\ \ ,[T] = \left(\frac{H}{g}\right)^{1/2} \qquad [2]$$

$$Slump/V-time\ ratio = \frac{slump\ flow/[L]}{V-funnel\ time/[T]}$$

$$= \frac{Slump\ flow}{V-funnel\ time} \times \left(\frac{H^{1/2}}{B \times g^{1/2}}\right)$$

$$= 0.001 \times \frac{Slump\ flow}{V-funnel\ time} \qquad [3]$$

3.0 Experimental applications

Two experimental cases are presented here to verify the significance of the Slump/V-time ratio. Case 1 involved testing the self-compactability of SCC. A U-box test was used according to JSCE-F 511-1999 Concrete that reached a U-box height above 300mm is accepted as SCC. Three mixes were made in the laboratory and their fresh properties are shown in Table 1. In addition, a

Table 1 Mix proportion (kg/m^3) and slump flow and V-time

W	C	S	G	Sp (%xC)	Slump (mm)	V-time (s)
175	600	750	850	1.5	485	9.9
175	600	750	850	2.5	645	9.2
175	640	650	750	2.1	575	24.0

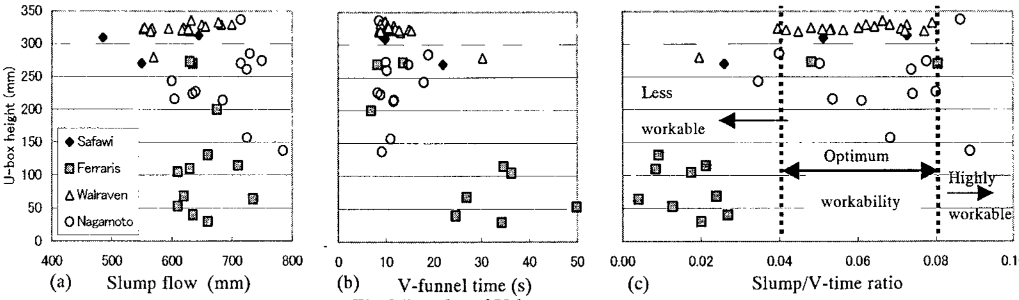

Fig.2 Results of U-box test

compilation of published results from three other researchers, namely Ferraris[1], Walraven[2] and Nagamoto[3] were also shown. Fig.2a shows the slump flow with respect to U-box height. Despite the high flowability, fresh concrete could have varying viscosity as seen in Fig.2b. It is evident that either the V-time be constant yet slump flow varies widely (Walraven's) or slump flow ranged between 600-700mm yet V-time differs broadly (Ferraris') or else a scattering of slump flow and V-time data (Nagamoto's) could be possibly achieved. Concrete with slump flow less than 500mm could have a V-time of 9.9s and a U-box height above 300mm (Safawi's). When all the data are plotted against Slump/V-time ratio (Fig.2c) the effects of both slump flow and viscosity are all encompassing. The data position will show whether the fresh concrete is workable or not. For Slump/V-time ratio less than 0.04 fresh concrete is physically hard while more than 0.08 it is liquid-like while optimum workability lies in between the two.

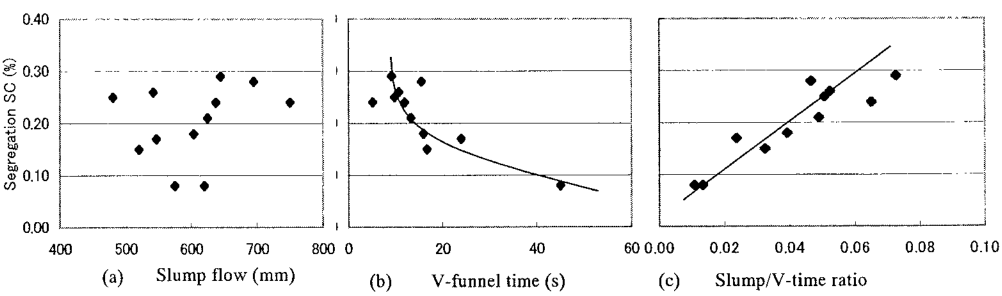

Fig.3 Vibration of high fluidity concrete

Case 2 involved an ongoing research in Tohoku University on vibration of high fluidity concrete. Using a poker vibrator, concrete of different slump flow and V-funnel time were vibrated. The degree of segregation is quantified by the segregation coefficient, SC[4]. Fig.3a shows little correlation between slump flow and SC, yet a steady pattern emerged from the graph of V-funnel time (Fig.3b). However, Fig.3c shows a collapsed data with respect to SC.

4. Conclusion

Discussion of high fluidity concrete often requires the consideration of viscosity as well as flowability. The Slump/V-time ratio covers both parameters and better represents the workability of high fluidity concrete.

【References】

1) Ferraris, C.F. et al "Workability of SCC", Int'l Symposium on HPC, Sept. 25-27, 2000

2) Walraven, J.C, "Development of SCC in Netherlands", 1st Int'l Workshop on SCC, 23-26, August, 1998

3) Nagamoto, N. et al, "Mixture Properties of SCHPC", ACI International, SP-172, 1997

4) Safawi, M.I., et al, "The Effects of Flowability & Plastic Viscosity onVibrated High Fluidity Conc." 57th JSCE Conf., 2002