The Effects of Flowability and Plastic Viscosity on Vibrated High Fluidity Concrete

東北大学　学生員　Safawi, Mohammad Ibrahim
東北大学　正会員　岩城一郎
東北大学　フェロー 三浦　尚

1. Introduction

The importance of vibration as a means of compacting concrete has been recognized for a very long time. Over-vibrated concrete would produce a very wet surface and a layer of mortar without coarse aggregates. Particularly the present concrete that uses High Range Water Reducing agent, making it more flowable and viscous. Vibration of such concrete would inevitably produce segregation of coarse aggregates to the bottom. Khayat[1], et al worked on vibrating fluid concrete to study the effects of using viscosity enhancing agent against segregation of aggregates. This paper extended the work to describe the macroscopic changes in the concrete environment due to vibration. For this purpose, coarse aggregate measurements throughout the concrete were done and different profiles of vibrated concrete compared.

2. Experimental Steps

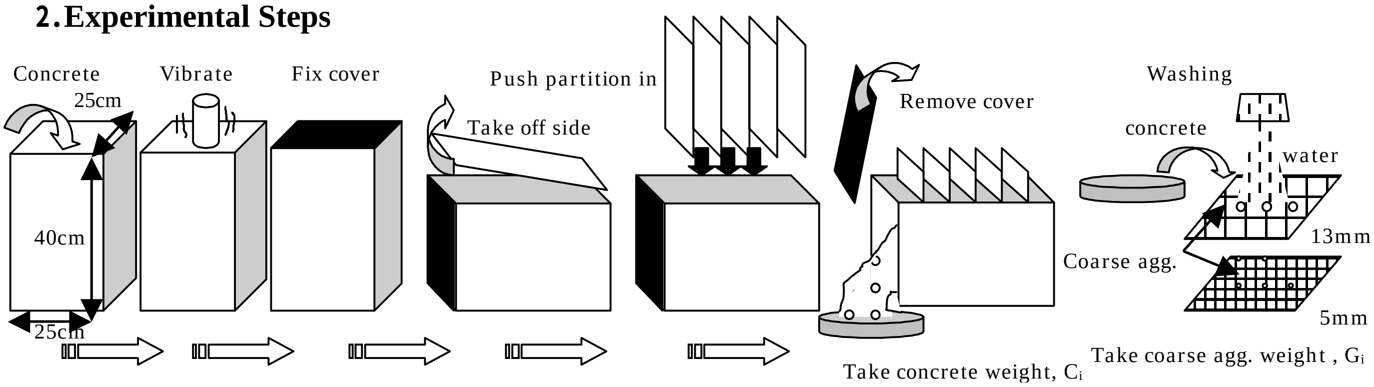

Fig. 1 Experimental steps for getting weight of concrete and coarse aggregates

The experimental steps are schematically shown in Fig. 1. Table 1 shows the mix proportion for the high fluidity concrete. The mix is close to a self-compacting concrete (SCC) mix in that it contained 30% unit volume coarse aggregates. The dimension of the formwork is 25 x 25 x 40 cm. To obtain the coarse aggregate profile, the concrete was divided into equal parts by means of metal slides. The sides of the formwork have guides to ensure vertical insertion. This approach relied on the knowledge that aggregate settlement stops immediately after vibration is terminated [2]. At the end of mixing, slump flow and V-funnel time were taken. The slump and V-funnel tests are representative of the yield stress and plastic viscosity of concrete respectively. After filling in the moulds, the concrete were vibrated using a poker vibrator for 10 and 20 seconds. One sample was left without vibrated as a control. The weight ratio of coarse aggregates to concrete was calculated and the segregation coefficient is given as [1].

Table 1 High fluidity concrete mix (Kg/m^3)

Label	W	C	S	G	Sp (%) (C x %)
C-1	175	600	750	850	0.015
C-2	183	671	681	786	0.02
C-3	185	635	688	794	0.02

$$SC = \sqrt{\frac{s\sum(1-x_i)^2}{H}} \qquad [1]$$

$$x_i = \frac{(G/C)_i}{(G/C)_{average}}$$

$$\left(\frac{G}{C}\right)_i = \frac{\text{weight of coarse agg. in each tray}}{\text{weight of concrete in each tray}}$$

$$\left(\frac{G}{C}\right)_{ave.} = \frac{\text{total weight of coarse agg.}}{\text{total weight of concrete}}$$

Height of formwork, H = 40cm
Distance between partitions , s = 8 cm

キーワード：Vibration, Segregation profile, flowability, plastic viscosity

〒980-8579 宮城県仙台市青葉区荒巻字青葉 06 東北大学大学院工学研究科土木工学専攻　TEL 022-217-7431

3. Experimental results

Table 2 Data of slump flow and V-funnel time

Label	Slump flow (mm)	V-funnel time (s)
C-1	486	9.9
C-2	547	24.0
C-3	607	16.0

The results of slump flow and V-funnel time for the mixed concrete are shown in Table 2. Concrete C-1 was the least viscous yet having the lowest flow of all. The mix with the highest flow was C-3 but with average plastic viscosity. Figure 2 shows the different segregation profiles obtained from the experiments. Fig.(a) shows the segregation profiles for cases of no vibration. All profiles are close to 1.0, which is equal to the average ratio of G/C. This implies homogeneity of the mix. Fig.(b) is the profile of concrete applied with 20s vibration. The degree of segregation in ascending order is C-1, C-3 & C-2. This sequence is similar to the V-funnel time that in turn, indicates the different plastic viscosity. This could imply a direct relationship between segregation and viscosity but not with flowability. The profile of C-3, which is of highest flow, lied in between the two other cases. Fig.(c) shows a typical profile of C-3 for cases with 0, 10 & 20 seconds vibration times. The longer the vibration time the greater the degree of segregation. However, further research using this technique could possibly reveal the allowable limit of vibration time before any detrimental effects can be expected. With respect to different sizes, 5-13mm(s) and 13-20 mm(b) as shown in Fig.(d), segregation of the smaller size aggregates was not obvious. Most of the segregation profiles were contributed from that of 13-20mm aggregates. It further supports the earlier conclusion that viscosity is an important factor in considering the vibration of high fluidity concrete. Values of segregation coefficients (SC) are shown in Fig.3. A higher SC value indicates greater segregation condition. Note that 10s vibration showed the lowest value in C-2 than the remaining mixes which could be due to the fact that C-2 is the most viscous of all.

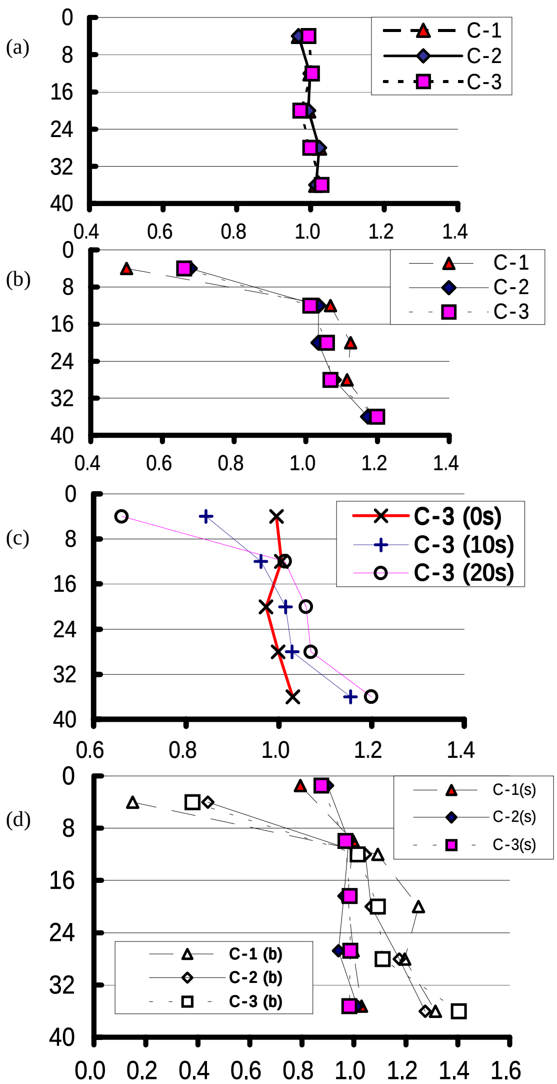

Fig. 2 Graphs of segregation profile

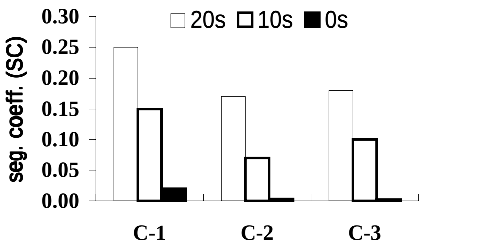

Fig. 3 Segregation coefficient of all mixes

4. Conclusion

The experiments concluded that plastic viscosity of concrete is the more important criteria than flowability when considering the vibration of high fluidity concrete. Optimum vibration can be achieved by considering the plastic viscosity of such concrete. The proceeding experiments aimed to achieve the above goal.

References

1) Khayat, H.K & Guizani, Z, "Use of Viscosity-Modifying Admixture to Enhance Stability of Fluid Concrete", ACI Mat. Journal, July/Aug. 1997

2) Petrou, M.F., et al, "Influence of Mortar Rheology on Aggregate Settlement", ACI Mat. Journal, July/Aug. 2000