V－551 INFLUENCE OF THE PRESENCE OF PASTE LAYER ON REBOUND OF SHOT MORTAR

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1. INTRODUCTION

In shotcrete, the particle rebound is highly affected by the paste (cement paste in case of mortar shotcrete and mortar paste in case of concrete shotcrete) either surrounding fine aggregates (or coarse aggregates) or appearing freely in the interstice of them, respectively. This kind of theoretical hypothesis is intended to give realization by pneumatically shot mortar against a target wall. In mortar shotcrete, the W/C ratio plays an important role in the existence of paste layer. An investigation was made by changing W/C ratio assuming that it is an important parameter in the existence of paste layer and its effect on particle rebound was measured in term of particle rebound with respect to shooting time and increment of shooting thickness.

2. SHOTCRETE IDEALIZATION

The dynamics of shotcrete can be idealized by separating the process into two stages. The first stage is defined as the time during which a thin cushion-like layer of shotcrete is being established. The rate of rebound during stage 1 is extremely high (from 50 to 100 %) [1]. The stage 2 is defined as the period when the incoming shotcrete impacts on a relatively soft cushion of fresh concrete. The very high rebound rate in the first stage is primarily because of the aggregate bounces energetically off the bare and hard wall with little energy dissipation. Some fines begin to stick to the wall, however, and a layer of fines or paste is gradually built up. The paste acts both as a cushion to absorb some of the impact energy of particles and as a restraining layer tending to hold particles in it. If the fresh shotcrete on the surface becomes harder, conditions for and the rate of rebound begins to increase. This transition back to higher rebound could be caused by increased accelerator dosage, shooting drier, or by a brief period of setting before nozzle is pointed at that spot again. The transition from stage 2 back to stage 1 is the result of subtle changes in consistency and the increases in rebound are gradual. The hypothetical example of how rebound decreases with time as shotcrete on the wall gets thicker can be shown as in Fig. 1.

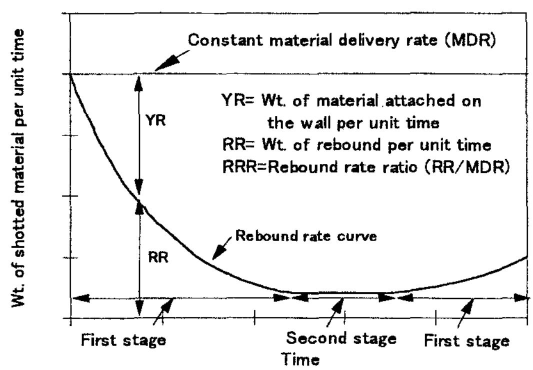

Fig. 1 Hypothetical variation of rebound rate with time

3. MORTAR SHOTCRETE EXPERIMENT

The shotcrete experiments were performed using mortar with W/C ratios 50 % and 55%, the cement by sand ratio by 1:3 in all mix and with 4 % coagulant as an accelerating agent. The shooting distance and the pressure were fixed 30 cm and 0.5 MPa in all shooting experiments. The mix proportion used is shown in Table 1. It is realized that rebound of particles during shooting is time as well as increment of shooting thickness dependent. In order to measure particle rebound to shooting time and thickness increment, the total mix in one batch was separated into three parts (approximately 20, 10, 10 kg) and shot separately. The rebound was measured separately in each parts of shooting by using multiple-trap method and also the shooting time and thickness were recorded at the end of shooting of each parts. The result obtained from the experiments (as for W/C =50%) is shown in Table 2 and pictorially shown in Fig. 2 to compare for different W/C ratios.

Keywords: Rebound rate ratio (RRR), First stage of shooting, Second stage of shooting
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Table 1 Mix proportions (with 4% Coagulant)

Mix. no.	W/C by wt.,%	C/S by vol.	Amount in kg per m^3		
			Cement	Water	Sand
1	50	1:3	565	283	1431
2	55	1:3	549	302	1390

It was confirmed from the experiment that during shooting, the instantaneous particle rebound (denoted by RRR) went on changing with the progress of shooting time and thickness. In the beginning, RRR was very high and gradually decreased after a layer of paste cushion was formed to entrap the incoming aggregates into it in the second 10 kg shooting. At final shooting, the particle rebound slightly increased due to the fact that in this experiment, the separation of amount of shooting was done manually and a significant time lost in the subsequent shooting of the mortar. So, the after shooting the 2nd 10 kg due to the hardening of shooting wall as well as shooting mortar, the shotcrete stage reversed back to the first stage showing a little higher rebound while 3rd 10 kg was shot as mentioned in Sec. 2. It was also clear that in the usual way of reporting rebound, R_{ave} measured could have any values from 45.44% to 41.45% depending upon when the shooting is stopped. It is essential to report the shooting thickness while reporting particle rebound, otherwise it does not carry any significant meanings.

Table 2 Mortar shotcrete experimental result (W/C=50%)

Shooting time, sec	Rebound in each stage,kg	Total shot in each stage, kg	RRR	Total rebound, kg	Accu. total shot, kg	R_{ave} %	T, cm
50.75	11.04	24.30	0.45	11.04	24.30	45.44	1.1
21.51	3.24	9.64	0.33	14.28	33.94	42.09	1.75
26.4	2.84	7.37	0.38	17.12	41.32	41.45	2.38

RRR= rebound rate ratio at any instant, R_{ave}= average rebound, T= shooting thickness

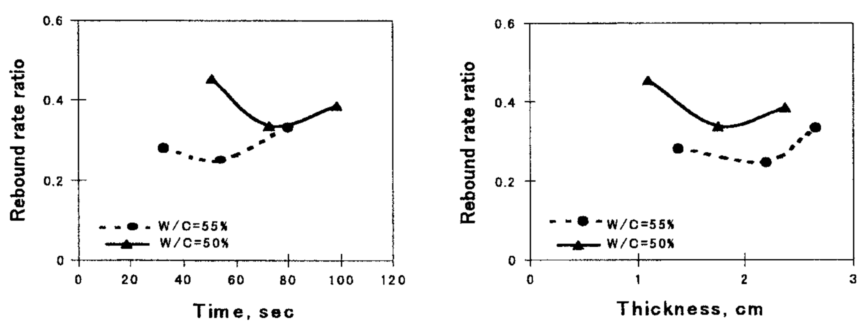

Fig. 2 Rebound rate ratio versus shooting time and thickness

4. CONCLUSIONS

1. The particle rebound is highly dependent on the amount of shooting time and thickness built up on the shooting wall, i.e., rebound decreases with increasing shooting time and thickness. It is essential to mention the amount of shooting thickness while reporting rebound to make it worthful.
2. The amount of the particle rebound is highly affected by the cement paste layer in case of mortar shotcrete which is ultimately controlled by W/C ratio, i.e, higher W/C ratio less rebound.

5. ACKNOWLEGEMENT

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6. REFERENCE

1. ACI Committee 506, "Proposed ACI Standard Recommended Practice for Shotcreting", Journal of American Concrete Institute, Feb. 1966, pp 219-243.