V-159 FLOW AND SEGREGATION OF FRESH CONCRETE IN BIFURCATING PIPE LINES

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1.INTRODUCTION

The bifurcation point in pipe system may be one of the most severe conditions to segregation of flowing concrete. In the case of non-symmetric arrangement of pipes, the concrete coming from bifurcations was segregated or blocked[1]. We selected this research target on which we focus our efforts for understanding the segregation process around bifurcations and creating the concept of high performance concrete with high deformability and segregation resistance.

2. VISUALIZED TEST AND IMAGE ANALYSIS

Visualized test with model concrete was carried out by applying HASHIMOTO's method[2] so as to get information on aggregate movement around bifurcation point. The apparatus used consists of a rectangular pipe, pistons with rods and a video camera which records movements of plastic balls. Width of both outlet pipes was the same as that of inlet, 180mm, and angle of bifurcating pipe was decided to be 48.6 degree. The piston head in inlet pipe was controlled by an electric motor at a constant speed, 4.0cm/s.

Model concrete used consisted of water absorbent polymer as mortar (liquid) phase and plastic balls as aggregate (solid) phase which is considered to trigger segregation of flowing concrete and the movement of balls around bifurcation was recorded with a digital video camera. Using the video data recorded, image analysis was conducted, based on the A/D converter and micro processor[3].

In this study, the authors intentionally changed liquid viscosity to observe the segregation process virtually. Test B1 represents low viscosity and test B2 high viscosity with adding cellulose agent. Low viscosity means that flowing time in P funnel test is 4mts 15sec and high viscosity means that 12mts. Other conditions such as particle arrangement and boundary condition are common to both tests.

3. SEGREGATION PROCESS AND MECHANISM ON VISUALIZED TEST

The volume content distribution represents segregation as shown in Fig.1(a). Lower content of aggregate volume in a branched pipe can be seen than that in the inlet pipe, while volume density in a straight outlet pipe seems to be the same as that in an inlet pipe. This is because particles are restrained by surrounding particles to relative movement. Compared with test B1, the volume content distribution of particles in test B2 shows very little segregation in Fig.1(b), where the volume content is stable condition in a inlet pipe, a straight outlet pipe and a branched outlet pipe.

Stream lines of test B1, as shown in Fig.2(a), indicate that more than one-half of the particles flow into a straight pipe, which means large segregation between particles and liquid phase. Stream lines in test B2 show that particles from a inlet pipe are divided into two pipes almost in proportional to the speed ratio of piston head in two outlet pipes, 1 to 1.5. The smoother stream line and smooth turn from inlet side to the branched outlet pipe are observed in Fig.2(b) though test B1 shows fluctuation of stream line and sudden turn of particles in the bifurcation, as shown in Fig.2(a). In spite of unbalanced speed condition of both outlet pipes and close contact arrangement of particles, high viscous liquid phase resists segregation between solid particles and liquid phase. This is because that highly viscous liquid phase can carry particles to a branched pipe against their inertia forces and mutual interaction between particles.

From a view point of the deformation rate of particles as solid phase, let us consider the behavior of particle movements. In test B1, deviatoric deformation ratio shows two distinct sliding zones as shown in Fig.3(a). The deformation direction in the left side of two sliding zones gives negative rotation and that in the right side positive rotation as shown in Fig.4(a), which represents rotation rate ω_{xy}. These behaviors lead to the deformation around the bifurcation, as shown in Fig.5, that

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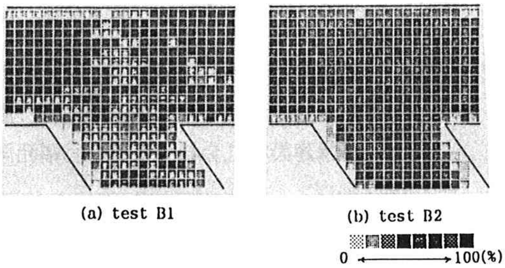

Fig.1 Volume content distribution of particles

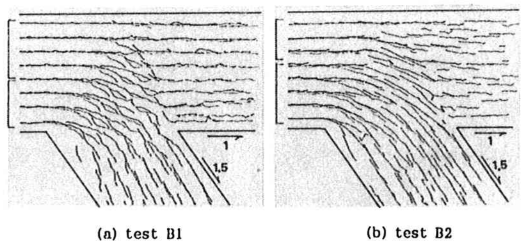

Fig.2 Stream lines of particles

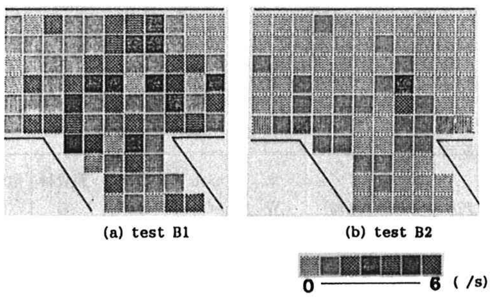

Fig.3 Deviatoric deformation rate "J"

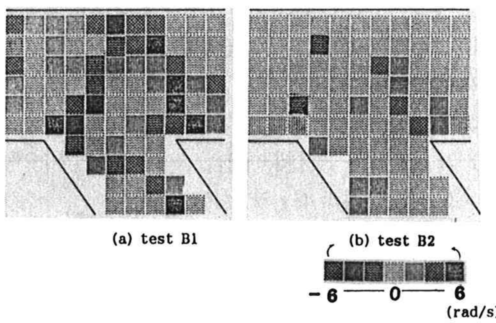

Fig.4 Rotation rate ω_{xy}

particles in the triangle zone of the bifurcation is induced to move down to a branched outlet pipe by the following particles of inlet pipe. In comparison with data of test B1, the shear deformation rate and rotation rate of particles shows no distinct shear sliding band but uniform distribution in Fig.3(b) and Fig.4(b), which implies the smoother flow of particles with the few mutual collision between particles.

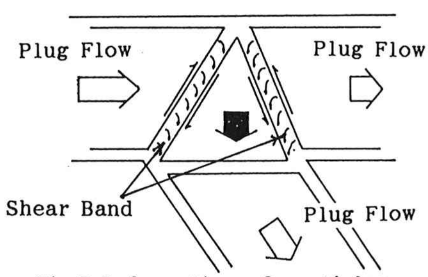

Fig.5 Deformation of particles around bifurcation in test B1

4. CONCLUSION

From these results it is concluded that high viscous liquid phase relaxes the mutual interaction between particles and flows smoothly associated with particles into a branched pipe, which results in unifying the localization of shear deformation of particles. Accordingly, it is considered that deformation of aggregate phase induced by the mutual collision is restrained considerably, which will reduce the interparticle contact stress. This is why the high viscous liquid phase prevents segregation and blocking of particles even though it increases the total pressure.

ACKNOWLEDGMENT

The authors express their gratitude to the financial support by the Grant-in-Aid No.61850090 from the Ministry of Education of Japan.

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