Application of High Pressure Water Jet to Grouting for Soil Improvement
- Analyses of Two-Phase Flow Structure of Water Jet -

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The water jet is utilized in various industrial application such as cutting carious materials and soil. In particular, the jet grouting for the soil improvement is one of the most important application of water jet under high pressure and high liquid flow rate. Such technology is already in practical use in the civil engineering. In order to improve the efficiency and the performance of the jet grouting, it is quite important to clarify the hydrodynamic structure of water jet under high pressure and high flow rate. However, basic researches on this subject are quite insufficient both experimentally and analytically. The water jet utilized in jet grouting is usually two-phase dispersed flow, where liquid droplets flow in continuous air with interacting each other. Almost no analyses have been made on hydrodynamic structure of water jet based on such two-phase flow modeling. Therefore, detailed analyses of water jet based on two-fluid model of two-phase dispersed flow have been carried out.

Mass and momentum conservation equations for liquid phase (droplet) and gas phase (air) were formulated separately (two-fluid model formulation). For the physical modeling for water jet, the water jet disintegration into droplet, the droplet stability, the cavitation in jet, the diffusion of droplets, the drag coefficient of droplet in dispersed flow, the turbulence in gas phase, the shear stress and entrainment of water jet interface, etc. has been taken into account in detail and the constitutive equations for these physical phenomena have been developed. Based on the two-fluid model basic equations and the constitutive equations, the two-dimensional and three dimensional analyses have been carried out considering simplified turbulence model. The velocity distributions for both phase, the pressure distribution, and the distribution of volumetric fraction of liquid phase and the jet diameter have been calculated as a function of axial distance form the jet nozzle. It is clarified that droplet diameter, drag coefficient of droplet and diffusion coefficient of droplet have great effects on the structure of water jet. The analytical prediction of the jet diameter, the pressure distribution of water jet showed reasonable agreement with the experimental data and the observation by high speed camera.

In the practical application of present analyses, some preliminary analyses on cross jet where two water jets collide with certain collision angles have been carried out, and the predicted results reasonably explain the experimental results.
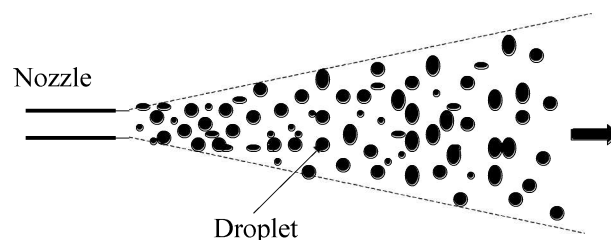

Fig.1 Schematic Representation of Water Jet with Droplet Flow