Simulation analysis on cast-in place pile pouring

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Abstract. Simulation of concrete pouring progress has been done for cast-in place pile. ICEM was used to geometric model establishing and grid generation. Fluent was used to fluid model establishing and calculating. Results show that pressure appears when concrete arrives and reach the largest when concrete is tanked up. Eddies appear at the beginning of pouring but will not be obvious by pouring going on. The shapes of concrete flow line at the bottom of pipe will change along with pouring depth. Order of appearance is overlaying to expanding to pushing up.

1. Introduction
Cast-in place pile is a kind of underground construction. During construction, a pile hole will be drilled and a pipe will be used to pour concrete into hole. All of these will be go on underground and can’t be seen. There is an interface between concrete and slurry in pile hole. During pouring, the pipe can’t to be pull out of concrete. The bottom of pipe can’t to be across this interface. In order to control pulling distance of pipe, the pressure can be detected along pipe because the density is different between concrete and slurry. Transducers can be fixed on the pipe to detect pressure. By detecting the pressure on pipe, the interface can be found. The flow regime is not clear. But it is very important to know that how the concrete flow underground. In reality, it is very difficult to simulate pouring progress. Therefore, simulation with computer and proper software selecting are feasible.

Fluent software is used to simulate concrete pouring. From pouring until finished, flow regime of concrete in any moment can be seen easily. Pressure on pipe can be calculated by fluent easily. Flow velocity can be seen for any moment.

2. Extraction Model
In reality, the concrete mixer truck pours out concrete continuously one by one. Concrete is poured into pipe and jet out from bottom of pipe. Every pouring 6 meters depth, the pipe will be pulled until its bottom is buried under concrete at least 2 meters. This is a cyclic progress. So the model can be extracted as follow. In the model, sizes of pipe and pile are all alterable.

It can be extracted as a 2D problem. Pile hole is 6 meters depth. Diameter of pile is 1.2 meter. Diameter of pipe is 30centimeters. Thickness of pipe is 8millimeters. The distance between bottom of pipe and bottom of pile hole is 50centimeters. Figure 1 is the 2D model of cast-in place pile.
3. Simulation Steps
ICEM CFD 16.0 has been used for establish the geometric model and made mesh generation. Fluent 16.0 has been used to establish fluid model and calculate. Tecplot has been used to analyse simulation results.
The 2D dimension was selected. Gravity was need to be checked. VOF multiphase was selected. The primary phase is slurry and the secondary phase is concrete. Volume Fraction is 1 to keep concrete push all of the slurry out of pipe hole. 600 steps calculation are designed. Time steps are 30. Keep flowing 10 minutes.

4. Simulation Results Analysis
Concrete phase figure and its velocity figure can be output by Tecplot software. From concrete phase figure, flow state of concrete can be seen clearly. From velocity figure, flow route of concrete can be seen clearly.

4.1. Pressure on Pipe
Figure 2 is pressure at the bottom of pipe at different moments. There is pressure on the 60th second. At this moment, concrete arrive at below pipe orifice. Pressure is the highest on the 280th second. At this moment, concrete reaches up pipe orifice. After 280 seconds pouring, pile hole which is 6 meters depth has been tanked up.

4.2. Flow State
From figure 3 to figure 6, flow state in different moment can be seen. From figure 3, concrete has been pour into pipe. After 1 minute pouring, concrete arrives at the bottom of pile hole. There are symmetrical eddies. The range of eddies is about 20centimeters depth. From figure 5, concrete reach
up to 1.8 meters high. Eddies at the bottom of pile is already not obvious on account of concrete weight above. Eddies just stay below 30 centimeters away from bottom of pile.

![Figure 3. concrete phase after 30s pouring](image1)

![Figure 4. concrete phase after 60s pouring](image2)

![Figure 5. concrete phase after 90s pouring](image3)

![Figure 6. concrete phase after 240s pouring](image4)

4.3. Flow Velocity

Figure 7, figure 9 and figure 11 are concrete flow velocity in different moment. At the beginning, new concrete jet into existed concrete. There is a ‘W’ shape at the bottom of pile hole as shown in figure 7. By pouring continued, ‘W’ shape is not obvious and instead of ‘U’ shape as shown in figure 9. After ‘U’ shape, there is ‘I’ shape when concrete is poured high enough from bottom as shown in figure 11.
Therefore, during concrete pouring, the shapes of concrete at the bottom of pipe will change along with pouring depth. At the beginning, it is overlay type as shown in figure 8. And then it is expanding type as shown in figure 10. At last, it is pushing up type as shown in figure 12.
5. Conclusion
Simulation of concrete pouring progress has been done for cast-in place pile. ICEM was used to geometric model establishing and grid generation. Fluent was used to fluid model establishing and calculating. There are a few conclusions as follows.

Concrete flow state on any moment can be seen from phase figures. The interface of concrete and slurry is clear. There are eddies at the bottom of pile at the beginning of pouring but will not be obvious by pouring going on.

The shapes of concrete at the bottom of pipe will change along with pouring depth. At beginning, it is overlay type like the letter ‘W’. After a few moments, it is expanding type like the letter ‘U’. At last, it is pushing up type like the letter ‘I’.

On out wall of pipe, pressure appears when concrete arrives. Pressure will be the largest when concrete is tanked up.

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