Application of Self-feed-back System in Dewatering-Recharge Engineering of Foundation Pit

Song Xiangdong\(^1\)*, Miao Guojian\(^1\), Qu Chengsong\(^1\)

\(^1\) Shanghai Changkai Geotechnical Engineering Co., Ltd., 200093, China

*Corresponding author’s e-mail: songxiangdongsd@163.com

Abstract. The self-feed-back system consisted of information acquisition system, information processing system and control system is applied in a complicit dewatering-recharge engineering of foundation pit. This self-feed-back system is made up of wireless monitoring devices and electronic control units. The application of self-feed-back system in Heyan-road-crossing-river-passage shows good serviceability in actual project.

1. Introduction

With the development of digitalization, informatization, intellectualization and the maturity of the Internet of Things technology, it is possible to monitor and control every link of dewatering-recharge engineering in real time. For example, the groundwater level can be real-time monitored by automatic-monitoring-water-level-meter wirelessly and remotely, the pumping quantity of each pumping well can be recorded real-time by electromagnetic liquid flowmeter or ultrasonic flowmeter, and the subsidence of surrounding buildings and soil can be recorded by soil subsidence meter during the dewatering [1]. The application of these monitoring and measurement techniques and visualization techniques can visually display the data of dewatering in the field on the computer or mobile terminal, and timely alarm the personnel of relevant units by pushing alarm message by mail, SMS, or APP software when the monitoring value exceeds the threshold value. In this way, the operation risk of dewatering in the foundation pit could be effectively controlled and foundation pit excavation safety could be ensured.

At present, many dewatering companies have studied the automatic control of foundation pit dewatering and achieved some results. For example, Zeng Hua [2] (2007) uses the automatic control system of power supply to ensure that the pump can start up immediately after power failure in the unattended state. Li Tailing [3] et al. (2010) use the clamp level switch to control the submersible pump automatically and then to control the level in the well.

However, by now the integration of dewatering monitoring and control is insufficient. Most of them just use one single monitoring quantity to control dewatering automatically. There are few cases of intelligent precipitation control based on comprehensive analysis of multiple monitoring quantities. In fact, dewatering engineering is a systematic and integral project, which is restricted by the combined influence of many factors. The automatic control of one part or one factor alone can not achieve the goal of coordinated and orderly operation of dewatering. Therefore, it is necessary to establish a set of self-feed-back control system, which can automatically adjust the power of dewatering equipment or the flow rate of recharge by analysing the water volume, water level data and surrounding subsidence data collected by the automatic monitoring system with the factors such as excavation conditions and weather conditions.
This kind of system is badly needed in the complicit dewatering-recharge engineering in large foundation pit. In the Heyan-road-crossing-river-passage pit, a self-feed-back system is built in order to operate the dewatering-recharge engineering successfully.

2. Design of Dewatering-Recharge Engineering
The elevated section of the southern part of the Heyan-road-crossing-river-passage is was constructed with open-cut and buried method. The depth of pit in this site varies from 0.39m to 25.7m as shown in Tab.1.

Table 1. Details of foundation pit

| Mileage (m) | Length (m) | Depth of pit(m) | Width of pit(m) | Foundation pit form (Depth: m) |
|------------|------------|-----------------|-----------------|-------------------------------|
| ZK4+691~ZK4+712 | 21 | 25.7 | 46 | 1000mm continuous concrete wall 48 |
| ZK4+715.5~ZK4+760 | 48 | 19.894~22.136 | 35.14~36.147 | 800mm continuous concrete wall 31 |
| ZK4+760~ZK4+804 | 44 | 14.099~15.84 | 34.43~35.14 | | |
| ZK4+804~ZK4+834 | 30 | 12.814~14.099 | 33.907~34.43 | | |
| ZK4+834~ZK4+891 | 57 | 10.443~12.814 | 32.911~33.907 | 43.5 |
| ZK4+891~ZK4+945 | 60 | 7.961~10.443 | 33.907~35.23 | 6000mm continuous concrete wall 16 |
| ZK4+951~ZK4+981 | 30 | 6.67~7.961 | 47.942~54.463 | 11 |
| ZK4+981~ZK4+501 | 30 | 5.479~6.67 | 47.068~47.942 | 14 |
| ZK5+041~ZK5+071 | 60 | 3.77~5.479 | 45.838~47.068 | | |
| ZK5+071~ZK5+131 | 60 | 0.386~2.975 | 44.523~45.838 | | |

In this site, confined aquifers are thick, consisted of silt, fine sand, medium-coarse sand, gravel and round gravel. Hence, in order to excavate the pit without the affect of groundwater, dewatering wells are arranged in the pit where the excavating depth exceeds 3 meters as shown in Tab.2.

Table 2. Details of wells

| Mileage (m) | Type of wells | Number of wells | Depth of wells(m) | Diameter of wells (mm) | Diameter of holes (mm) |
|------------|---------------|-----------------|-------------------|------------------------|-----------------------|
| ZK4+691~ZK4+712 | Dewatering well | 6 | 36 | 273 | 650 |
| ZK4+715.5~ZK4+760 | Dewatering well | 10 | 48 | 325 | 700 |
| ZK4+760~ZK4+804 | Dewatering well | 2 | 55 | 325 | 700 |
| ZK4+981~ZK5+501 | Observation well outside the pit | 8 | 55 | 325 | 700 |
| ZK5+041~ZK5+071 | Dewatering well | 3 | 55 | 325 | 700 |
| ZK5+071~ZK5+131 | Observation well outside the pit | 8 | 46 | 325 | 700 |
| ZK4+834~ZK4+891 | Dewatering well | 12 | 23 | 273 | 650 |
| ZK4+891~ZK4+951 | Observation well outside the pit | 2 | 21 | 273 | 650 |
For the aim to protect the surrounding building, the recharge wells are arranged outside the site. The depth of the recharge wells is 25 meters and the length of the filter part of the well is 15 meters. The diameter of the recharge wells is 0.273 meter. Totally 217 recharge wells were arranged around the pit. It is quite difficult to control 378 operating wells manually during the excavation of the pit, for example, the water level in different section of pit should be controlled differently because that excavation depth is different Therefore it is very necessary to apply the self-feed-back system in this dewatering-recharge engineering to control the water level and subsidence according to the field situation

3. Self-feed-back system and its application
This self-feed-back system consists of three parts: information acquisition system, information processing system and control system. The information acquisition system collects, classifies and stores the data of water quantity, water level and surrounding subsidence data in real time, and transmits them to the information processing system. The information processing system will analyse the data and give instructions to the control system according to the pre-set control variables (such as the drawdown of water level, subsidence rate, water level drawdown rate, etc.). According to the instructions of the information processing system, the control system controls the water output, water level and subsidence by adjusting the power of the pump and the size of the valve, and the data after control is fed back to the information processing system by the information acquisition system. The information processing system automatically adjusts the control instructions according to the control results, thus playing the function of feedback regulation.

The information acquisition system of this work site consists of automatic-monitoring-water-level-meter, ultrasonic flowmeter and soil-subsidence-meter. In order to reply the field situation in time while avoiding being inundated by too much data flood, the sampling frequency is set as once/ per minute. The acquired data could be displayed at the website and on mobile APP in real time as shown in Fig.2. If the data exceeds the pre-set alert value, the alarm message is sent in the form of SMS or email.

| ZK4+951~ZK4+981 | Dewatering well | 8 | 20 | 273 | 650 |
| ZK4+981~ZK5+011 | Observation well outside the pit | 1 | 20 | 273 | 650 |
| ZK5+011~ZK5+041 | Dewatering well | 6 | 15 | 273 | 650 |
| ZK5+041~ZK5+071 | Observation well outside the pit | 1 | 15 | 273 | 650 |
| ZK5+071~ZK5+131 | Dewatering well | 9 | 6 | 273 | 650 |
| **Totally** | **114 dewatering wells inside the pit, 47 observation wells outside the pit** |
Information processing system compares the real-time value with the pre-set aimed value and sends the order to the control system according to the drawdown of water level, subsidence rate, water level drawdown rate, etc. According to the feed-back values, the information processing system automatically adjusts the control system, thus playing the function of feedback regulation.

The control system controls the power of pump to adjust the outflow of dewatering wells and dominate the water level inside the pit. At the same time, the control system controls the valve of the recharge wells and inhibits the subsidence of surrounding soil. The control system also ensure power supply by switching loads to the standby power immediately after power failure in the unattended state.
4. Result and conclusion
The excavation of pit begins in November 2018 and finishes in July 2019, lasting about eight months. During this time, the self-feed-back system works well and saves a lot of human resources. The information acquisition system displays real-time information to the participating parties and sends hundreds of alarms to the related persons. The information process system maintains the water level of pit at the proper value and avoids too much subsidence of surrounding buildings. In short, the self-feed-back system fits well in the complicit dewatering-recharge engineering.

In the future, it can be combined with the pit monitoring system such as the concrete girder stress monitoring and enclosing structure displacement structure. In this case, the self-feed-back system can play a more important role in the construction of pit.

References
[1] Qu Chengsong. Foundation pit dewatering system and its application [J]. Land and Resources of Shanghai, 2010, 31 (4): 48-52.
[2] Zeng Hua, Zhang Guoqiang. Research and application of automatic control of deep foundation pit dewatering [J]. Geological equipment, 2007 (06): 28-31.
[3] Li Tailing, Li Wulun, Guo Peihe. Discussion on automatic control system of foundation pit dewatering [J]. China Coal Geology, 2010, 22 (02): 46-48.
[4] Song Xiangdong, Qu Chengsong. Subsidence inhibiting effect of recharge in floodplain area near Yangtze River[C], IOP Conference Series: Earth and Environmental Science (EES), ICACHE 2019, July, 2019.
[5] Song Xiangdong, Qu Chengsong, Xu Dan. Analysis of recharge test in floodplain area near Yangtze River in Nanjing[C], IOP Conference Series: Earth and Environmental Science (EES), HCEA 2019, May, 2019.
[6] Miyake N, Kohsaka N, Ishikawa A. Multi-aquifer pumping test to determine cut off wall length for groundwater flow control during site excavation in Tokyo, Japan[J]. Hydrogeology Journal, 2008, 16(5):995-1001.