Dewatering Design of a Foundation Pit

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Abstract. Foundation pit dewatering project is one of the important guarantee measures for the smooth construction of building foundation under the groundwater level. Through hydrogeological investigation and precipitation test, to find out the hydrogeological conditions of the site and obtain accurate hydrogeological parameters is the basis of determining the best precipitation scheme which is safe, reliable, economic and reasonable. Taking the dewatering design of a foundation pit as an example, the analysis and summary are made.

1. Introduction
Foundation pit dewatering is to create dry working conditions for the construction of the building foundation below the groundwater level. Selecting the safe, reliable, economic and reasonable best dewatering scheme is one of the important measures to ensure the smooth construction of the building[1-4]. The excavation depth of the foundation pit of a project is 6.0m, and the foundation is 4M below the groundwater level, and the construction period is long.

2. Hydrogeological engineering geological conditions of the site
The construction site of the project is located in the front of the first terrace on the South Bank of the Yellow River, with flat and open terrain and no other important buildings around. The construction site is square with an area of 50×50m².

2.1. Formation lithology
The main formation lithology of the site area is from top to bottom:
(1) loess like silt (Q₄al): Grayish yellow, relatively uniform soil, loose, semi dry hard plastic, wet saturated. The thickness is about 2.0m.
(2) pebble (Q₄al): It is greenish gray, mainly composed of hard metasandstone and granite, with particle size of 30-80m m, good roundness, sandy filling, medium dense and saturated. It is formed by the alluvial of the Yellow River. The thickness is 7.0-7.4m.
(3) sandy mudstone(E): Orange-maroon, the upper part is strongly weathered, with a thickness of more than 100m. It is an aquiclude.

2.2. Hydrogeology
The pebble layer in the site area contains pore phreatic water with small hydraulic gradient, and the groundwater flows slowly from southwest to northeast. Due to the long-term large-scale leakage of production and domestic wastewater, the groundwater level in this area has been rising for many years.
The part of the groundwater level has entered the upper loess like silt layer, with the buried depth of the static water level of 3.0m, the average buried depth of the pebble layer bottom of 1.0m, and the thickness (H) of 8m. The site area is more than 1000m away from the Yellow River.

3. Precipitation test and calculation of hydrogeological parameters

3.1. Precipitation test

In order to provide reliable hydrogeological parameters for the design of dewatering engineering, three steady flow porous dewatering tests have been carried out by using the existing well js1 and well JS2 in the southwest of the site. The distance between the two wells is (x) 25m, and the hydrogeological conditions revealed are basically similar. Well js1 in the first and second precipitation tests is a pumping well, and well JS2 is an observation well; well JS2 in the third precipitation test is a pumping well, and well js1 is an observation well. The data of the three precipitation tests are summarized in Table 1.

| Serial number | 1   | 2   | 3   |
|---------------|-----|-----|-----|
| Flow Q (m³/d) | 740 | 630 | 630 |
| Stable drawdown of pumping Well S (m) | 2.8 | 2.3 | 2.1 |
| Stable drawdown of observation well S1 (m) | 0.6 | 0.4 | 0.45 |
| Well spacing X (m) | 25  | 25  | 25  |
| Permeability coefficient K (m/d) | 55.2 | 44.1 | 54.3 |
| Radius of influence R (m) | 96  | 81  | 80  |

3.2. Calculation of hydrogeological parameters

According to the hydrogeological conditions of the site, it can be generalized as a horizontal and infinite extended phreatic aquifer model. According to the calculation formula of complete well:

\[ K = \frac{0.732Q}{(2H-S-S_1)(S-S_1)^{0.5}} \cdot \frac{X}{r_{ew}} \]  \hspace{1cm} (1)

In style \( r_{ew} \)- Radius of tube well (0.15 m)

\( H \)- Aquifer thickness (7.0m)

By substituting the three precipitation test data into formula (1), the permeability coefficient K of aquifer is calculated, which is 54.1m, 43.5m and 55.2m respectively, with an average of 51m.

According to Kusagin’s empirical formula:

\[ R = 2S\sqrt{KH} \]  \hspace{1cm} (2)

The influence radii of three precipitation experiments is 93 m, 78 m and 79 m respectively.

The values of permeability coefficient K and influence radius R obtained from each precipitation test data and calculation are respectively substituted into the calculation formula of complete well flow of phreatic water.

\[ Q = 1.366K(2H-S) \cdot \frac{X}{S_{ew}} \]  \hspace{1cm} (3)
The calculated single well flows are 736, 568 and 665 m³/D respectively, which are close to the actual pumping capacity. It is shown that the permeability coefficient obtained by precipitation test is in accordance with the actual situation.

4. Precipitation Scheme Design

4.1. Total water inflow of foundation pit and number of dewatering wells

According to the requirements of engineering excavation and the buried depth of groundwater level, it is necessary to reduce the overall groundwater level by 3m. The dewatering well shall be arranged along the periphery of the foundation pit so as not to affect the integrity and waterproof of the foundation. Considering the requirements of foundation pit sloping, the dewatering area of foundation pit is 50 × 50 m².

Calculation of total water inflow of foundation pit based on equivalent well method.

Equivalent well radius

\[ r_e = \frac{R}{\pi} = \frac{65}{\pi} = 20.67 \text{(m)} \]

Radius of influence

\[ R_a = 25\sqrt{KH} = 2 \times 3 \times 51 \times 7 = 114 \text{(m)} \]

Then the total water inflow of the foundation pit is:

\[ Q_T = \frac{R}{r_a} = \frac{114}{20.67} = 5.51 \text{(m}^3/\text{d}) \]

If the average water level in the field is reduced by 3M, the water level in the dewatering well pipe will be reduced by about 5m. Therefore, the thickness of the aquifer at the dewatering well will be changed to about 2m, and the length (L) of the filter pipe in the water outlet section will be 2m, so the water output capacity of a single well will be:

\[ q = 120\pi \cdot r_e \cdot L \cdot \frac{1}{\sqrt{K}} = 420 \text{(m}^3/\text{d}) \]

The number of wells required for the dewatering project of the site is

\[ n = Q_T/q + 1 = 3764/420 + 1 \approx 9 + 1 = 10 \]

This dewatering project is very important, and the guarantee coefficient C is 1.2, and the actual number of wells required is:

\[ n = C \times m = 1.2 \times 10 = 12 \]

4.2. Plane layout and structure design of dewatering well

Twelve dewatering wells are evenly distributed around the foundation pit, i.e. 3 dewatering wells at each side of the foundation pit, with a spacing of 20–22m.

The dewatering depth of any point in the foundation pit is predicted by using the formula (4) of dewatering depth of complete interference well of phreatic water.

\[ S = H - \sqrt{\frac{H^2}{1.366K} - \frac{Q_T}{\log R - \frac{1}{ln}[g(r_1 \cdot r_2 \cdots r_{12})]}} \]

ri- Distance between No.I dewatering well and calculation point.

Taking the center point of the foundation pit as an example, the drawdown is 3.38 m according to formula (4), which meets the requirement of dewatering. The calculation and prediction of other points are similar, which proves that the plane layout of dewatering well is reasonable.

According to the requirements of hydrogeological conditions, groundwater level and excavation depth of foundation pit in the site area, and considering the submergence depth of pump body and sediment deposition at the bottom of the well, the design well depth of dewatering well is 12.5m. The opening diameter is 500 mm, and the cement pipe with an outer diameter of 300 mm is put in, among which 5-10 m is the filter pipe. Gravel is filled outside the pipe and the well is washed with piston.
The extracted groundwater is discharged into the sedimentation tank through the collection pipeline arranged around the foundation pit, and then discharged into the nearby urban water system after sedimentation. As there is no important building around the site, no settlement monitoring has been carried out.

5. conclusion
Through hydrogeological investigation and precipitation test, the hydrogeological conditions of the site are found out, and more accurate hydrogeological parameters are obtained. After analysis and calculation, a safe, reliable, economic and reasonable precipitation engineering scheme is determined. After 76 days of precipitation, it provides a dry operation site for foundation pit excavation and foundation construction, ensures the smooth progress of the project, and achieves good engineering results and economic benefits.

References
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