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Hancheng Xiyuan Village 1# Water Supply Well Technology Design

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Abstract

No.1 water supply well in xiyuan village of hancheng city, as a new water supply project to solve the problem of water supply for residents, the quality of the well will directly affect the normal water consumption of urban residents in hancheng city. According to the geological data obtained in the early stage of geological exploration, this paper analyzes the characteristics of geological structure, formation lithology and hydrogeology in the design area, and designs the whole process of well completion by field investigation method, comprehensive analysis method and optimization selection comparison method. By comparing different formation lithology characteristics, design a reasonable hole structure, and then selects the TSJ-1000 water drill, rock bit drilling method, and determine the appropriate corresponding to the formation of flushing fluid and drilling into the water supply tube well drilling parameters, finally uses the cementing cement water stop, piston flushing method makes water supply tube well to meet the use requirements. This design is of great significance for safe, efficient and economical drilling, as well as improving well quality and extending the normal service life of the well.

Keywords

Water supply well; Well structure; Suppling process; Design.

1. INTRODUCTION

In recent years, with the rapid development of society and economy and the rapid increase of population, people's demand for water resources has been increasing[1]. The existing water supply facilities in Hancheng City can no longer meet people's water demand; they have built a plate in Xiyuan Village, Longmen Town. Due to the limited water supply capacity, the river water supply project has led to the growing problem of domestic and drinking water in 11 administrative villages in Longmen Town. The design of the 1# water supply pipe well in Xiyuan Village is designed to solve the problem of people's water difficulties. The author believes that a good well-forming process design will meet safe, efficient and economical drilling, which not only guarantees the smooth completion of the well, but also contributes to the increase of the water output of the water supply pipe well and the extension of the service life, and is designed to be suitable for the water supply pipe well[2]. The well-forming process will change the long-term water shortage of residents.

2. GEOLOGICAL OVERVIEW

The area of the 1# water supply pipe well is located on the slope terrace of the F1 mountain front large fault, about 250m east of the Hancheng big fault. The Hancheng large fault is the first-order structure of the Yanqi basin, and the north-south direction is northeast 20°~50°,

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tends to the southeast, and the inclination angle is about 50°. It is a large regional fracture formed by stretching and stretching, and the fault zone is widely developed. The maximum distance is up to 1000m, and there are more faults near the fault[3]. Breccia, gravel composition is relatively simple, mostly limestone fragments.

The stratum and lithology are from 0 to 270m in order from the top to the bottom of the Quaternary Upper Pleistocene loess layer (Q2+3). The distribution area is large, the upper part is a homogeneous structure with soft texture, and the sparsely developed yellow powder. Sandy clay, 270~320m is the coal-bearing Taiyuan Formation (C3t). The lithology is mainly gray-black argillaceous sandstone, thin layer-medium-thick layered, with flat bedding, wavy cross-layered layer, carbonized layer Plant stems and leaves fossils, rock is relatively broken; 320~395m is the Ordovician Zhongtong Fengfeng Formation (O2f), lithology is mainly limestone, dolomitic limestone, argillaceous dolomite; 395~600m is Ordovician The Majiagou Formation (O2m2) is mainly composed of dolomite and is the main water-rich layer.

The source of water supply in the area is mainly carbonate karst water. The water level of the aquifer is relatively stable. The total thickness of the stratum is about 280m. It mainly exists and migrates in the fractured karst. The water content is not uniform, and the water conservancy is complicated. The large fault plays a controlling role in the formation and migration of karst groundwater, and a strong run off zone along the fault zone is formed in this area. The fracture near the fault zone develops better and constitutes the karst runoff area in Hancheng area. Therefore, the groundwater recharge of Ordovician limestone in this area is good, the runoff conditions are good, the hydrogeological conditions are relatively simple, and it belongs to the medium-strong and rich water-rich section, which can create good water supply conditions for the normal water supply of the tube well.

3. 1#WATER SUPPLY PIPE WELL DRILLING PROCESS DESIGN

3.1. Borehole Structure

The well structure design from bottom to top can not only reduce the number and length of casing, but also reduce drilling cost and improve efficiency. The well structure is generally designed on the basis of the physical properties of the rock being drilled, the thickness of the overburden, the formation of the perforated formation, the hydrogeological conditions, the depth of the aquifer and the drilling method[4].

The strata in this area are quaternary loess and ordovician limestone, the upper part is loose loess, and the lower part is hard and stable bedrock aquifer.The design of large well diameter can achieve multi-layer isolation, and the gap between casing and well hole is large, which can reduce the risk of stuck drilling, etc. The primary drilling stratum is soft rock loess, and the design diameter is 500mm to prevent the collapse of the well wall. The secondary drilling stratum is mainly limestone, and the limestone layer is stable, and the design diameter is 215mm.In the strata in the design area, the ordovician limestone aquifer is the main aquifer, and the bottom strata of the ordovician limestone is up to 600m deep, so the design depth of water supply well no.1 is 600m (see figure 1).

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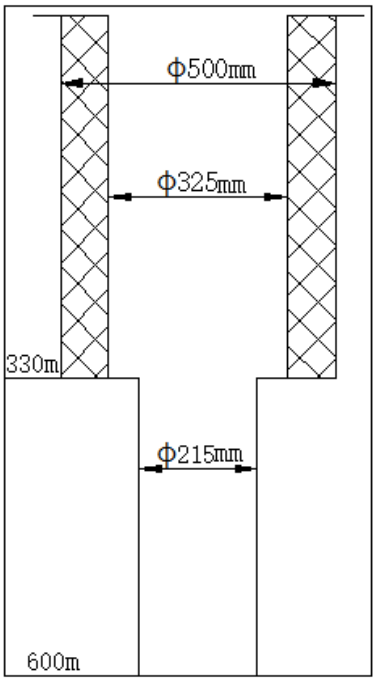

Figure 1. Schematic diagram of well shaft structure

3.2. Drilling Method

The strata encountered by the 1# water supply well are mainly quaternary loess, ordovician limestone, dolomite and limestone, etc. When drilling into limestone strata with larger grain size, its hardness and high abrasive property will cause slow drilling rate and less footage, which will reduce drilling efficiency and increase drilling cost. During the drilling process, the cone bit has the combined rock-breaking effect of pressing, crushing and shearing on the rock, which improves the efficiency of the broken rock and can be used for drilling from soft rock to very hard rock.At the same time, because the roller is mainly dependent on rolling and sliding rock fragments, the rotary torque is small and the power consumption is small, so it can be used for drilling Wells with large diameter[5].When drilling into the stratum encountered in this well, compared with similar drilling methods, cone drilling has a wide range of applications, low cost and high efficiency. Therefore, the cone bit selected for drilling can not only meet the requirements of loess drilling but also meet the requirements of limestone drilling. The specific drilling process is shown as follows:

First, drilling hole construction pilot hole, drilling into the depth of about 330m complete limestone formation, and then drilling hole expansion, in the process of hole expansion, must be equipped with 2~3 groups of the corresponding aperture centralizer, to ensure the drilling vertical, to prevent hole tilt;After the completion of hole reaming, the casing is inserted and cement is injected into the annular gap between the casing and the borehole wall for cementing and stopping water. After the casing is inserted, clean water is used as far as possible to ensure the unobstructed water flow and avoid the pollution of the well.

The second drilling to the well depth of 600m, and then carry out subsequent well washing, pumping test and other work.

3.3. Rig

The drillers used in our country are TSJ-1000 and TSJ-2000 drillers. The drilling rig must meet the requirements of drilling depth, lifting capacity and rotary torque, etc[6]. Tsj-1000 drilling rig is adopted in the design area (as shown in Fig.2). The drilling depth exceeds 1000m, which is a kind of drilling rig specially used for water source and shallow oil drilling.The drilling machine adopts mechanical transmission device, low rotating center of gravity, long service life,

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simple operation, good practicability, the drilling machine is easy to maintain and repair cost is low and widely used, from its various parameters (see table 1), it can be seen that it is more suitable for the design area rock and construction requirements[7]. Both from the technical level and the economic benefits, it is in line with the requirements of optimization selection of the drilling rig.

Table 1. Main parameters of TSJ-1000 water well drilling rig

Type:	TSJ - 1000.
Main uses:	Water source, shallow oil, coal bed methane and other drilling
Rotating speed:	49, 69, 110, 190
Overall size:	4320 * 2100 * 1290 (mm)
Quality:	58000 (N)
Maximum lifting capacity:	70 (kN)
Maximum drilling depth:	2000 (m)

Figure 2. Tsj-1000 water well drilling rig

Figure 3. Three cone bit

3.4. Bit

According to the data obtained from previous geological exploration, the strata revealed in the drilling process are mainly the middle and upper pleistocene loess layer of the quaternary system, taiyuan formation of coal measures, fengfeng formation of the middle ordovician system, majiagou formation of the middle ordovician system, etc.The silty clay with calcareous nodules in the loess layer is soft, while the limestone, dolomitic limestone, argillaceous limestone and argillaceous limestone with larger grain size in the middle ordovician strata are hard. In order to meet the requirements of drilling from soft to hard strata, a three-cone drill bit with wider drillability is selected in this drilling (as shown in figure 3 below).

According to the design of well bore structure and outer diameter of the casing, the first stage use Φ311.15mm cone bit, drilling and the deep about 330m complete limestone stratum, and expanding to Φ500mm; the second stage hole diameter is 215mm, so choose Φ215.9mm cone bit, drilling to 600m depth. According to the matching relation between drill size, the first stage matchs diameter drill collar Φ159mm+Φ89mm drill pipe; the second stage collocation Φ159mm diameter drill pipe+drill collar Φ89mm satisfies the requirement of safety drilling.

3.5. Drilling Parameters

Drilling parameters include: bit pressure, rotation speed, pumping capacity and other parameters. Generally, when drilling into soft strata (such as quaternary loess), the method of

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small bit pressure and high rotation speed should be adopted[8]. When drilling into harder strata (such as limestone and dolomite with larger grain size), the method of large bit pressure and low rotation speed is adopted. When drilling broken formation, should be appropriate to reduce the rotation speed and bit pressure.

According to the formation lithologic characteristics of the design area and the well body structure designed in this study, it can be determined that the rotation speed of ①0~330m is 45~65r/min, the bit pressure is 20~40kN, and the pump capacity is 850L/min.②The rotation speed of 330~600m is 45~65r/min, the bit pressure is 30~60kN, and the pump capacity is 750L/min.

3.6. Drilling Fluid

The particularity of drilling requires that drilling fluid must have good wall-building property to prevent collapse and protect the hole wall[9]. Good leak-blocking and water-resisting ability.The water supply well adopts two-stage drilling, and the hole diameter of the two stages is different. According to the characteristics of different formation lithology and pressure as well as drilling requirements, different flushing fluids should be used for flushing drilling:

0~270m well section: the quaternary formation is mainly composed of loess mixed with gravel, which has poor cementation, looseness and stability. Therefore, ordinary mud is used to protect the stability of the hole wall.

270~330m well section: drilling into the coal measure taiyuan formation adopts polymer mud as drilling circulation fluid, so as to balance the pressure in the hole, protect the well wall from collapse, effectively carry cuttings, and facilitate the cementing of the lower pipe.

330~600m well section: this section is the main effluent section. In order to avoid water pollution and dredge the pores of the aquifer, clean water is used for drilling.

The slurry materials include: sodium bentonite, caustic soda, high-viscosity cellulose, polyacrylamide PAM, potassium humate, etc. The mud performance requirements are shown in table 2 below:

Table 2. Properties of segmented rinse solution

Well section (m)	Drilling fluid type	Conventional performance			
		Density (g/cm3)	Viscosity (s)	Sand content (%)	PH
0 ~ 270	Ordinary mud	1.05 ~ 1.15	24 ~ 30	< 4	8 ~ 10
270 ~ 330	Polymer mud	1.05 ~ 1.10	20 ~ 30	< 4	7 ~ 9
330 ~ 600	Clear water	1.0	/	/	/

4. 1#WATER SUPPLY PIPE WELL COMPLETION PROCESS DESIGN

4.1. Lower Casing

In order to ensure the continuity of the casing down and the sealing between the pipes, the casing down of this 1# water supply pipe well is welded down in the opposite direction[10]. To facilitate welding, the nozzles must be grooved, with four pre-welded steel plates at the wellhead to facilitate piping and increase the tension of the welding rod. The upper end of each well pipe must be more than two meters higher than the square wood of the supporting pipe, so as to align with the theodolite when welding the next well pipe. During welding, uneven shrinkage caused by concentrated burning should be avoided, which may cause the well pipe skew.

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4.2. Cementing Water Stop

In order to prevent the upper soil lager and water mixed with the lower strata, and the upper 330m in 1# water Wells, the aperture is Φ325mm interval, a open casing water stop using cement to the permanent water closed upper contaminated water, outside the tube cement return up to 50m, 10m cement plug pipe, Φ215mm segments for the outlet section, there is no water.To prepare a fluid cement slurry, the amount of added water should reach about 50% of the weight of cement, water-cement ratio 0.5, cement slurry density should not be less than 1.80g/cm, when the liquid cement slurry solidified, the volume should be reduced by 7%~8%, the amount of stopped water cement is calculated with formula 3.1 below, and the actual amount is determined according to the actual depth[11].

$$V = (1.2\text{-}1.3)(D_1 - D_2)^2 \cdot L \cdot \frac{\pi}{4} \tag{1}$$

Where, V -- is volume of closed section (L); L water height (m); D is the diameter of the outer hole (mm); D is the casing diameter (mm);

$$Q = \frac{V}{V_1} \times 100\% \tag{2}$$

Where, Q - is the amount of cement (T); V - the volume of cement slurry (L) obtained from 100kg of cement; The calculated cement content is about 7.6t, as shown in table 3 below:

Table 3. Cement parameters and usage scale

Cement mud return height (m)	Water cement ratio	Height of cement plug (m)	Cement slurry density (g/cm3)	Cement content (t)	Cement mark	note
50	0.5	10	1.80	7.6	R42.5	Loss factor 1.2-1.3

4.3. Wash Well

This no.1 water supply well has a depth of 600m, and the aquifer section is ordovician limestone section with a large buried depth of water level. Therefore, it is required that the well cleaning process cannot pollute the well. The specific well cleaning process is as follows: add a piston at the lower part of the drill pipe and pull the piston through the drill pipe. At the beginning of the well cleaning, the piston should be cleaned layer by layer from shallow to deep. The piston should be lowered smoothly and the lifting speed should be controlled between 0.6m/s and 1.2m/s.

4.4. Pumping Test

This no.1 water supply well has a relatively large depth and is designed to be pumped by submersible pump, which can meet the conditions of continuous pumping and deep well pumping. The pumping method is steady flow pumping test.

(1) Before the test, the pumping equipment and test instruments, such as measuring barrel, air compressor and various water pumps, should be reasonably selected according to the structure of water supply pipe well, the depth of water level drop and other conditions;

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(2) After well washing and before pumping test, static water level and well hole depth should be measured; as far as possible, do a pumping test with maximum depth and decrease, and the pumping duration shall be no less than 36 hours, and the pumping shall be carried out continuously;

(3) The dynamic water level and flow rate of the pumping well must be observed at the same time. After the beginning, the observation should be conducted in a time sequence of 1, 2, 3, 4, 6, 8, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100 and 120 minutes;

(4) The stable pumping time shall be no less than 8 hours, and a full analysis sample of the quality of drinking water shall be taken before the end;

(5) After the completion of pumping, restore water level observation shall be conducted in a time sequence of 1, 2, 3, 4, 6, 8, 10, 15, 20, 25 and 30 minutes, and then monitored every half hour until the water flow reaches a stable state.

5. CONCLUSION

By optimizing the well completion process design of water supply well no.1 in xiyuan village of hancheng city, the following conclusions are finally drawn:

(1) Well body structure: according to the formation lithologic characteristics, drilling parameters and water inflow requirements, the structure of no.1 water supply well is designed. Its well depth is 600m and it belongs to the bedrock water supply well.

(2) Drilling method: according to the formation condition of the design area and the selection of drilling equipment, the cone bit drilling method is selected for drilling. The design area adopts the TSJ-1000 water-source drilling machine, with the maximum drilling depth of 2000m, which is easy to operate and low cost, and can make the drilling work go smoothly.

(3) Open bit with a diameter of Φ311.15mm roller bit drilling, reaming to Φ500mm diameter, combined with the selected equipment requirements such as drill, drill bit type, collocation of drill collar +Φ159mm+Φ89mm diameter pipe; Two open using Φ215.9mm cone bit drilling and the bottom of 600m, choose Φ159mm diameter drill pipe, drill collar +Φ89mm satisfies the requirement of safe drilling and reducing drilling cost.

(4) 1#water supply well design 0~330m section bit pressure is 20~40kN, 45~63r/min, pump capacity is 850L/min, with ordinary mud; the pore diameter of the section 330~600m is 215mm, the drilling pressure is 30~60kN, the pumping capacity is 750L/min, and water is used as drilling fluid.

(5) In the completion stage, cement cementing is adopted to stop water flow, and piston well washing method is adopted to wash the well. The steady flow pumping test is designed for the water supply well, and the water yield exceeds 50m/h, reaching the expected water yield. The well-completion process design scheme meets the social demand of no.1 water supply well.

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