

# Analysis on treatment of covered karst foundation of high-rise building in Shenzhen area

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**Abstract.** Foundation design of high-rise buildings in karst region is always the difficult point of ground treatment in a construction project. In order to ensure the stability of the foundation, the foundation and ground of high-rise building need to be strengthened in karst area. According to the characteristics of foundation deformation and failure in karst area and the requirement of foundation stability, this paper discusses the common ground treatment methods and their application range in Shenzhen karst area, China.

**Keywords:** karst, ground treatment, high-rise building, sinkhole, foundation.

## 1 Introduction

Karst is formed in the chemical and mechanical action by the dissolution of limestone, marl and other long-standing water soluble rocks [1]. The karst foundation has the properties that many soil caves and caverns are found; rock surface is greatly undulating; ground water there is unpredictable and so on. These complex conditions in karst area to some extent make the foundation design of high-rise buildings extremely challenged. The foundation treatment of high rise buildings in karst area is the difficulty of foundation treatment in the construction engineering. There are many ways to deal with the karst foundation, such as digging and filling, raft crossing, grouting and so on. The large diameter pile foundation is often used in the construction of high-rise buildings in karst areas [2].

Although pile foundation construction difficulties caused by karst development and high cost of penetration resulted in by greater burial depth of karst cave, pile foundation must be placed on the roof of the cave in some construction areas of China [3-8]. Based on the engineering geological conditions, site characteristics, engineering practice and so on, this paper discusses the different foundation treatment methods of the complex karst foundation.

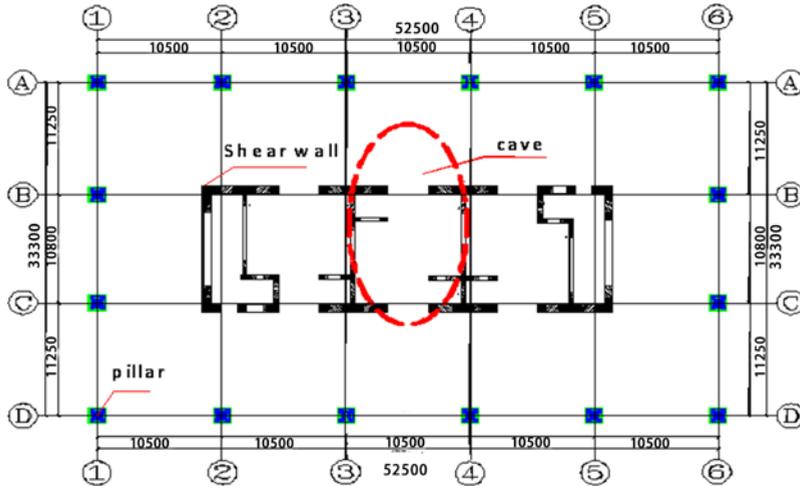
The total construction area of the project is 127262m<sup>2</sup>. The main building is the frame tube structure, which is about 191.15m. The foundation is the punching pile.

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## 2 Distribution of karst cave

The location of the cave is located in the middle of the building below 33m. And the thickness of the cave roof is about 0.2m. The shape of the cave is a three-dimensional elliptic sphere with the long axis of 20m and the short axis of 10m. The cave roughly planar position is shown in Figure 1.

The phenomena of Karst are mainly manifested as dissolution fissures, karst valleys and karst caves. Due to the active surface of the rock, the rock is more active, and the rock has significant erosion, which forms a channel and a groove. The depth of cave is from 0.30m to 16.60m. The cave that the depth of is more than 10m and no filled, accounted for 11% of the total; The cave which depth is 7 to 10m, accounted for 11% of the total; The cave which depth is 4 to 7m, accounted for 28% of total cave; The cave which depth is 0.30 to 4m, accounted for 50% of the total.



**Figure 1.** Schematic diagram of the plane position of karst cave.

## 3 Treatment of karst cave

### 3.1 Pile foundation through the hollow cavity

It need to prevent mud loss so that hole collapse while the pile hole wall mud pressure lost when the drill wear cave. After drilling through the cave, the bottom of cave was filled with low-grade plain concrete in a few meters at first, blocking the undercurrent, then filling with rubble and clay mixed in amount of cement. The function of added cement is to increase the mechanical properties of the filler. After a period for the weight deposition of filler, then the bored pile is constructed. In this way, the stability of the hole wall in the construction of the partial pile foundation of the karst cave is guaranteed.

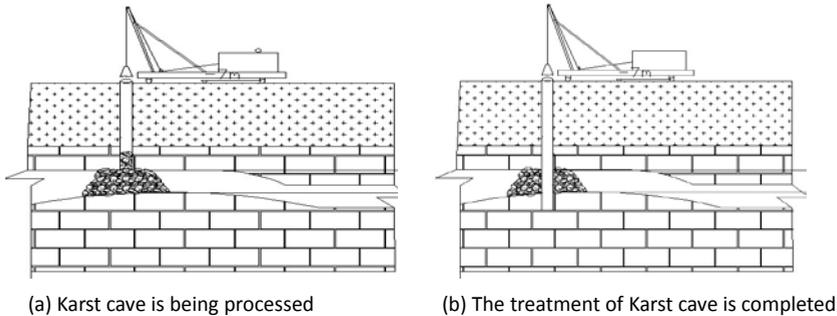
### 3.2 Treatment of karst fracture and small karst cave

The harm of small cave is relatively light, while the size of karst fissure is less than 0.5m. In this case, when the bored pile was drilled through the cracks, usually require a certain depth of drilling that must be filled with a certain amount of clay backfill. The backfill is squeezed into the cracks and clogging around hole fissures, which can keep the slurry concentration. The main harm of karst fissure is fractured leakage. To prevent leakage, the casing depth was taken to increase. If there is leakage of slurry, should pay as soon as possible, then clay and rubble were put a depth of 2 to 3m in proportion of 1:1 again from the new drilling. When once again the leakage of slurry, it is deal with according to the above method.

### 3.3 Treatment of common karst cave

Generally, the common cave is a cave with a height less than 4m and a poor connectivity. Before punching, a lot of clay and rubble and a certain number of bagged cement were prepared near the bored pile. In the process of drilling, with the requirements of the pump and abundant water, to ensure that in the event of leakage of slurry can immediately replenishment fills slurry.

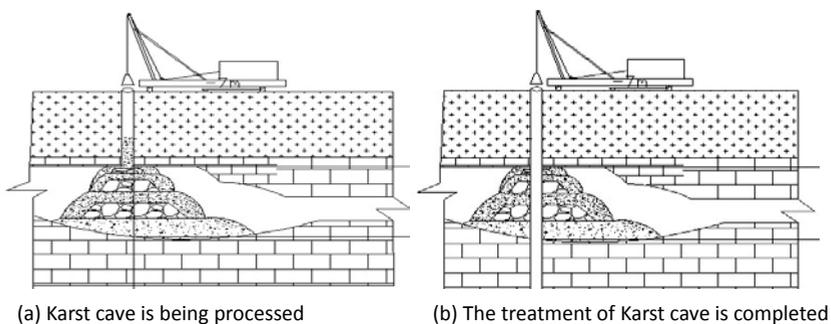
When drilling through the cave, the rubble and clay were filled. Then, the filling stones and clay were compacted using hammer. If there are a large number of leakages of slurry, it indicates that the cave may be connected with other karst caves. In the absence of the collapse of the case, immediately put down the pipe at the bottom of the hole, and with low grade concrete filled with layers. 24 hours later, punch again. The construction process is shown in Figure 2.



**Figure 2.** Treatment of common karst cave.

### 3.4 Treatment of large karst cave

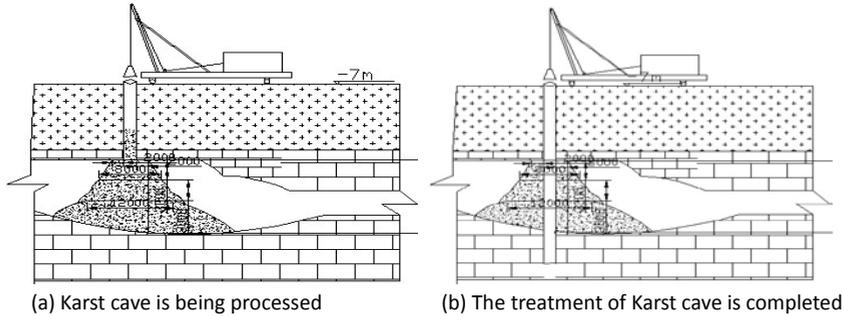
The large cave is defined as the general height of cave is from 4 to 8m. For the large cave, it needs to be tracked during the construction. Ready for backfilling rubble and cement bag, in order to facilitate the instant of large cave back filling. Without hole collapse, when drilling through the strata of upper cave, if hole appeared in a large number of mud loss, instant installation concrete pipe on the upper end of the cave strata to the timely filling concrete to prevent hole collapse phenomenon occurs. Low grade concrete can be filled with holes in the bottom of the hole, even if the collapse is produced. In order to reduce the loss of concrete, it is needed to fill the layer multiple times, until the upper end of the karst cave is blocked. 24 hours later, can pull out the catheter, and then punching. If the upper strata drilled through the cave, did not produce a lot of mud loss, the hole was filled with rubble clay. 6 hours later, then punch. If appear repeatedly in the slurry, filling rubble and clay at the same time, by filling cement bag, in order to enhance the strength of mud. The construction process is shown in Figure 3.



**Figure 3.** Treatment of large karst cave.

### 3.5 Treatment of super large karst cave

Super large karst cave is defined as a height greater than 8m. For the super large cave, it needs to be tracked during the whole construction. When drilling through the upper rock stratum, if a large number of running slurry, it is suggested that the large karst cave. The cave was filled so many times with rubble and clay and cement bag. If the drilled strata of upper cave, resulting in no case of hole collapse, the label of C15 of concrete and rubble layer are filled until a similar cone of filling is formed in the cave. Or the plain concrete is filled with layer up to the top of the cave. 24 hours later, the drill is carried out. The construction process is shown in Figure 4.



**Figure 4.** Treatment of super large karst cave.

### 3.6 Treatment of multilayer karst cave

When drilling through the holes that are composed of small and common karst caves, there are many diseases such as leakage and inclined holes. The treatment of this cave is using the solution of common cave in many times.

Grouting method and inner cylinder method can be used for the treatment of multi layer karst cave composed of large cavern. When drilling through the cave, the bottom of the steel tube is supported on the bottom plate or the top plate of the karst cave. And drill holes in the inner tube. If the leakage pulp is produced, the inner protection tube method is used to deal with the leakage.

### 3.7 Pile foundation construction with filling material of karst cave

According to the density of filling material, different methods can be adopted to carry out the construction of the pile foundation. When the fill in the cave is denser in real time, the conventional method of bored pile construction was used, but the size of the mud pool is 1 times larger than that of the conventional. When drilling through the cave, if water head down quickly, the rubble and clay and the amount of cement backfill in time, until the water head stabilization. Packing launch first is cement, then clay, finally the rubble.

## 4 Conclusions

Longgang District, Shenzhen City, belongs to the karst development area, easy to form karst ground collapse geological disasters. The relevant engineering geological experts have proved that Longgang district is not suitable for the construction of high-rise buildings. But after treatment of the karst foundation, the building (height of 191.15 meters) has successfully completed, which indicates the high-rise building can be built on the karst region with correct processing of foundation. Therefore, the foundation treatment method should consider the particularity of its safety, economy, site and geological condition.

## Acknowledgments

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