

# EFFECTIVE APPLICATION OF REVERSE CONSTRUCTION TECHNOLOGY IN CONSTRUCTION PROJECTS

Stephen Devos  
*Aarhus University, Aarhus, Denmark.*

**Abstract:** With the development of the economy and the continuous improvement of construction technology, many problems have emerged in the traditional underground engineering construction using the forward construction method. The reverse construction method has emerged as the times require and has developed rapidly. At the same time, it has also achieved good practical results, has become a widely used construction method for underground structural engineering at this stage. This article first introduces the advantages and disadvantages of reverse work in construction engineering construction, and finally focuses on the key points of reverse work construction technology and construction quality control methods to ensure the effective application of reverse work.

**Keywords:** Construction engineering; Reverse; Construction technology; Application

## 1 ADVANTAGES AND LIMITATIONS OF REVERSE CONSTRUCTION METHOD

Many problems have emerged in the traditional down-cut method of underground engineering construction. The reverse -cut method emerged as the times require and has developed rapidly. At the same time, it has achieved good practical results and has become a widely used construction method for underground structural engineering at this stage. This article mainly introduces the key to the reverse construction technology of construction projects and the methods of construction quality control to ensure the effective application of the reverse construction method.

The reverse construction method can be divided into three parts: the first part is to complete the underground support mechanism. Usually according to the actual situation of the building, a supporting structure is built in the basement and the key support piles are poured. The second part of the work is to build a connecting floor between the ground and the underground. On the one hand, it increases the rigidity of the underground structure; on the other hand, it provides a certain construction environment for the upper construction, thereby alleviating the lack of construction space faced by underground construction.

### 1.1 Advantages of Reverse Construction Method

After a lot of engineering practice, the reverse construction method has been widely used in urban subways, tunnels, high-rise buildings, basements and other construction projects. Compared with the traditional forward construction method, it has the following technical construction advantages.

#### 1.1.1 Short construction period

The sequential construction method is often carried out in the order of spatial structure. Once the construction progress of a certain process does not meet the requirements, it will affect the construction time of the subsequent process, resulting in the extension of the construction period. The reverse construction method can realize the parallel overlap between the upper space and the lower space structure of the foundation pit construction to achieve synchronous construction. At the same time, the structure built in the upper space will be used as a supporting structure for the building instead of a temporary support, which avoids the consequences of demolition. It also reduces the waste of materials and complicated processes, and also shortens the construction period.

#### 1.1.2 Low cost

In terms of construction design, the reverse construction method eliminates intermediate construction links and temporary structures by "replacing columns with piles", "replacing horizontal supports with floors" and "replacing structural exterior walls with retaining walls". The manpower needed to dismantle the structure also reduces the cost of waste management, reduces various costs in the construction process in many ways, and reduces the project cost to a certain extent. In addition, by using the inverse construction method, the composite structure of the underground diaphragm wall can bear the load of the underground structure and the above-ground structure at the same time, forming a "two walls in one", which reduces the workload of the basement exterior wall and allows the building materials to be fully utilized. The reverse method uses its own structure to form a support structure, and can also use the underground enclosure structure to save the amount and cost of earthwork and filling projects, reducing project costs.

#### 1.1.3 Optimizing the construction site

For some foundation pit construction sites with special geology, the traditional forward construction method for foundation pit support will often face the problems of narrow construction sites and difficult construction. However, the reverse construction method uses parallel construction of the upper and lower parts. The roof can be constructed with priority. Without affecting the construction progress of the project, the roof can not only optimize the construction site of the underground engineering volume and carry out orderly layout and planning, but also create a closed construction environment for the lower construction to avoid The impact of climatic factors on construction.

#### **1.1.4 Make full use of urban underground space**

Conventional foundation pit support construction often requires sufficient construction operation space outside the foundation pit. Therefore, the basement exterior wall often retreats within the planning line, making it impossible to fully utilize the underground space planned for the project. Adopting the reverse construction method can make fuller use of underground space, and can even lay out lines at the planning red line, and build an underground enclosure structure below the planning red line, and turn it into a permanent basement structure exterior wall.

#### **1.1.5 Better building structural performance**

Modern urban buildings tend to be more high-rise and super high-rise, and the utilization of underground space is also more extensive. Multi-layer underground structures are very common. It is difficult to ensure the compactness of the backfill using the smooth method, which will affect the stability of the building structure and other structural properties. Using the reverse construction method can naturally bond the underground enclosure structure to the original geological soil, ensuring the vertical load capacity of the building structure and improving the stability of the structure.

#### **1.2 Limitations of Reverse Construction Method**

At present, the reverse construction method has been generally recognized in the construction industry, but it has been found during domestic construction that the reverse construction method still has certain limitations.

First, the requirements for construction design are higher. Compared with the traditional construction design of the forward construction method, using the reverse construction method, at the beginning of the design, the designer must comprehensively consider the support and maintenance system of the structural system and the permanent structural relationship, the design of each node of the project also needs to consider the different requirements of the construction stage and trial stage from many aspects, which is relatively difficult in design. For most small and medium-sized construction units in my country, more resources need to be invested in preliminary design work.

Second, the technical requirements for construction units are extremely high. For construction units, due to the high technical requirements of reverse construction, they must master relevant core technologies, such as concrete pouring technology, verticality adjustment technology, and the space-time effect of reverse construction. Excavation technology, reverse method uneven settlement control technology, etc. The implementation of these technologies often requires on-site construction instructors to have rich reverse construction experience and be able to find timely solutions to related problems during the construction process. For some construction units with relatively junior qualifications and less practice, they are prone to quality control problems during construction due to the lack of such high-end talents.

Third, the reverse construction method adds more manual labor. The reverse construction method often creates a relatively closed underground construction environment. Although it effectively alleviates the disadvantages of narrow underground construction sites, the closure relief is often not conducive to large-scale construction. As for the operation of machinery, most of the work is completed by manpower, which increases labor costs. At the same time, construction accuracy and efficiency are also subject to certain limitations.

## **2 EFFECTIVE APPLICATION OF REVERSE CONSTRUCTION TECHNOLOGY IN CONSTRUCTION PROJECTS**

### **2.1 Key Technologies of Reverse Construction**

#### **2.1.1 Key technologies for construction of underground diaphragm walls**

The construction of underground diaphragm walls mainly includes four parts: node construction, guide walls, flatness control and verticality control.

Joint construction can generally be divided into two types: rigid joints and flexible joints, which are generally determined according to actual working conditions. Flexible joints mainly include wedge joints, corrugated pipe joints, rubber joints, etc. Due to their limitations in shear resistance and bending resistance, this type of joint has relatively few applications in underground diaphragm walls as the main structure. It is used when the structure or component does not bear the upper vertical load or the load is small. At the same time, some structural measures need to be taken, such as setting up top beams, setting up wall columns at the joints, setting up bottom ring beams in the bottom plate, etc. Relatively speaking, rigid joints are more widely used in actual projects. Common joint forms include perforated steel plates, steel bar overlaps, shaped steel streets, etc. The construction process of rigid joints is generally: horizontal concave and convex overlap - reinforcement cage derivation - reserved overlap space - construction of construction trough section - steel bar overlap - pouring of concrete in the construction trough section.

Guide wall construction: Open the outer wall in the trough section and build guide walls on both sides of the continuous wall. Make sure that the wall surface of the guide wall is vertical and the top surface is horizontal.

Vertical control: Normally, the verticality of this type of underground diaphragm wall needs to be controlled within 1/300. However, for underground diaphragm walls in ultra-deep foundation pits, the verticality of the grooves is more stringent and needs to be controlled within 1/300. Within 600. During the construction process, it is necessary to strengthen the precision adjustment of the machinery. During the groove forming process, it is necessary to strengthen the technical training and technical specifications of the operators to ensure the standardization of construction operations. At the same time, in terms of process design, it should be based on the actual working conditions. The situation determines the order of trench digging. Pay close attention to the verticality of the trench wall during the operation.

#### **2.1.2 Key technologies for pile construction**

In the reverse construction method, the piles are usually structurally processed to become structural columns of the building and bear part of the load. The construction methods are different depending on the piles.

The construction process of manually dug piles is: setting out - positioning piles - tying of steel bars - pouring concrete retaining walls with support formwork - installation of movable manhole covers, related lifting facilities and lighting facilities - Section 2 pile body - bearing layer inspection - bottom expansion - Clean the site - hoist the steel cage - and pour the pile body. During the construction of manually dug piles, construction safety must be taken into consideration. For the construction of the wall protection, reasonable wall protection measures need to be formulated based on the excavation soil conditions and the site environment.

The construction process of bored piles is: laying out the pile position - excavation - burying the casing - hole position correction - hole formation - hole cleaning and grouting - final hole acceptance - placing the steel cage - pouring underwater concrete - forming the pile. When the support column uses bored piles, pile holes are first formed in the ground, then the drill is lifted for grouting, then the drilling rig is lifted out, and finally the steel cage and steel columns are put in and concrete is poured. The strength of the concrete below the pile top elevation is required to meet the design strength requirements. Therefore, the concrete generally has a grouting height of more than 2 m, which can be gradually removed during the excavation process of the foundation pit. During the implementation process, the pile steel cage and steel columns are placed into the completed pile holes. Only after the position and verticality of the steel columns are adjusted to the design requirements, the pile concrete is poured. Under permitted conditions, the column piles can be specially driven bored piles, but engineering piles should be used as much as possible to reduce the workload and cost of the temporary support system.

### **2.1.3 Key technologies for excavation construction**

The reverse earthwork method is a critical factor that affects the progress of the entire project. During the earthwork excavation process for the basement structure, most of the earthwork excavation is performed under cover. On the one hand, the excavation construction environment is more complex; on the other hand, during the excavation It is also extremely easy to cause deformation of the retaining structure and foundation pit soil during the process, which will bring great difficulties to the excavation construction. Therefore, the first solution to the problem of reverse construction is to formulate a scientific and reasonable organization for earthwork construction, and to take safety measures and emergency plans during the earthwork construction process. Several key technical points in excavation construction are as follows.

(1) In the selection of excavation forms, different excavation forms often have different focuses. Before the reverse construction excavation, a comprehensive on-site survey of the foundation pit earthwork must be carried out to determine the foundation pit. The soil conditions, etc.; secondly, each layer segmentation must be reasonably planned according to the underground space planning of the building. Usually, before the ground floor slab is constructed, the open-cut method is used for construction.

(2) Different excavation methods will also have a greater impact on construction efficiency, which will have an impact on the economic benefits of the overall project construction. Economy and construction progress are usually two major considerations in the selection of excavation methods. For foundation pits with a large area, basin excavation can be used, that is, open excavation from the middle of the foundation pit, which can not only effectively improve the excavation The workload and excavation efficiency can also play a certain role in controlling the deformation of the foundation pit. For excavation of foundation pits with large clearance on the excavation surface, especially when the bottom of the pit immediately adjacent to the foundation pit is related to adjacent buildings, it is necessary to change the excavation method. Generally, the center island excavation method is used. A central island is constructed by pouring the bottom plate in the middle of the foundation pit. After reaching the strength requirements, the central island is excavated in strips and poured in strips.

## **2.2 Reverse Construction Control**

### **2.2.1 Technical control**

The control measures for the reverse method of planting reinforcement technology mainly include: inserting reinforcement into the column (wall) located in the pile, and no less than 3 positioning stirrups (horizontal bars) should be tied to the lower part and welded firmly to the vertical steel bars of the pile. Outside the hoisting range of the tower crane, all bottom column steel cages are tied in place on the ground, and concentrated time is used to lower them into the holes using a truck crane. In the reverse method, all extensions of pile steel bars are mechanically connected with straight threads.

Excavation technology control: When the earthwork is unstable during the excavation process and an earth wall cannot be formed, M5 cement mortar is used to lay shale bricks as brick retaining walls or bamboo wood retaining boards. The bottom form of the basement retaining wall should be determined based on the actual conditions on site. If the soil layer after excavation is used as the bottom plate, all the ground form will be removed after pouring the retaining wall at this level.

### **2.2.2 Management control**

First, it is necessary to ensure the safety of on-site construction, do a good job in safety protection of construction personnel, do a good job in safety production education before construction, do a good job in on-site safety supervision and management during construction, and make reasonable isolation of nearby buildings. Ensure the safety of nearby people.

Second, environmental protection issues during the construction process should be taken into consideration. Construction waste should be strictly managed and uniformly recycled and destroyed to avoid pollution to the environment near the construction site.

Third, it is necessary to strengthen construction inspection and control the deformation and settlement values of each working condition according to the design requirements, especially to control the uneven settlement of underground diaphragm walls and supporting columns to prevent floor slabs from cracking due to excessive differential settlement.

### **3 CONCLUSION**

As a new method in building construction that can effectively avoid the disadvantages of traditional underground construction, the reverse construction method is a new method to further improve construction efficiency and quality, and is of great significance for promoting building construction in the new era. Therefore, reverse work construction technology should be studied more actively and in-depth, and the limitations of reverse work construction technology should be found out by closely linking theory and practice, and should be further improved, improved, and actively promoted in order to obtain more social benefits and economic benefits. benefit.

### **COMPETING INTERESTS**

The authors have no relevant financial or non-financial interests to disclose.

### **REFERENCES**

- [1] Jia Jian. Methods and practices for controlling unloading deformation during reverse excavation of deep foundation pits. *Chinese Journal of Geotechnical Engineering*, 2015, 29(2): 304-308.
- [2] Jiang Shujie. Review of the application and development prospects of reverse construction in urban underground space development. *Building Construction*, 2004, 26(4): 280-283.
- [3] Jiang Lixue. Analysis on the impact of reverse construction of foundation pit on the settlement of surrounding buildings. If it is difficult to use scaffolding steel pipes for support, Party A may be advised to use bricks. *Building Structure*, 2005(7):20- 22.