

Review on the Research and Application Progress of TRD Construction Method in Foundation Pit

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Abstract. with the development of the times, the expansion of urban scale and the development and utilization of underground space, the building foundation pit is developing in the direction of "large and deep". The traditional deep foundation pit support construction technology can no longer meet people's needs for the construction of deep and large foundation pits, thus deriving a new construction technology TRD construction method, which has a wide range of application, guaranteed wall quality and depth, and high construction efficiency. This construction method has been born for more than 30 years and has been popularized and applied in China for more than 10 years. This paper will briefly introduce the trd method from the aspects of its development, characteristics and academic research process of related applications. It is not difficult to see from the relevant research that the trd method has broad application prospects in China.

Keywords: deep foundation pit excavation; TRD construction method; Underground works; Water stop curtain.

1. Introduction

With the development of the times and the continuous expansion of the city scale, especially the development and utilization of underground space, super large and super deep foundation pits are widely used in various construction projects [1,2]. In order to ensure the safety and stability of deep foundation pit engineering, the design and construction of support structure become very important, and often face problems such as controlling the seepage of groundwater, considering the geological soil conditions, controlling the impact on the surrounding environment, and controlling the displacement of foundation pit support structure [3,4].

Considering the above construction problems, in recent years, a relatively mature construction technology TRD method for deep foundation pit construction has been applied in more and more deep foundation pit projects in China and achieved good results [5,6]. As a new type of foundation pit support adopted in China in recent years, the trd method (trench cutting&re mixing deep wall method), that is, the construction method of continuous wall under cement soil, inserts the chain cutter into the soil, drives forward along the horizontal direction by the rotation of the chain cutter, forms a continuous groove, and at the same time sprays the curing liquid from the end of the cutter, and mixes it with the soil in situ. It is a widely used support type in recent years [7], and its construction diagram is shown in Figure 1 [8], and the site construction drawing of a TRD method is shown in Figure 2.

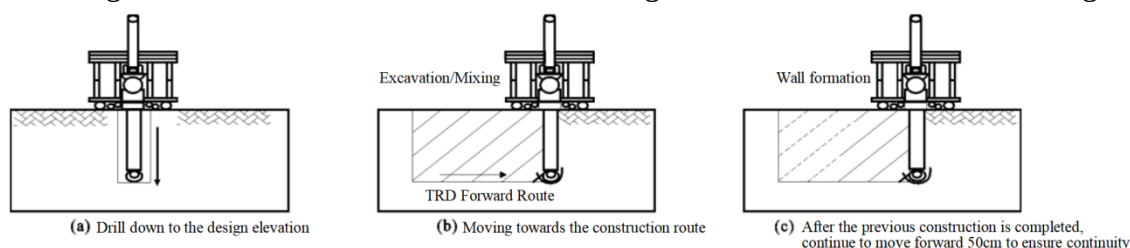


Figure 2 TRD construction diagram[8]



Figure 2 Site construction drawing of TRD method in a project

However, the development of TRD construction method can be traced back to Japan in the early 1990s. From 1992, the predecessor of the method successfully applied for a patent for the purpose of forming a temporary water stop wall by chain cutting, to 1997, the method was approved by the Japan Construction Machinery Association, and TRD construction method was formally applied in construction with a new technology ^[9]; This technology developed relatively late in China. Since 2007, Liaoning Fudao Heavy Industry Machinery Co., Ltd. has carried out technical cooperation with Japanese enterprises and started to research and develop TRD construction equipment. By 2009, the localization of relevant equipment has been realized, and then more and more Chinese enterprises have conducted research on relevant technologies ^[10]. Thanks to China's huge base of deep foundation pit construction, China has made good achievements in the innovative development and engineering application of TRD construction method. Figure 3 shows the quantities of TRD construction method in China ^[11]. By the end of 2021, the total number of TRD projects in China had exceeded 500, and the total amount of TRD construction was nearly 6million m³. At the same time, in the field of ultra deep foundation pit technology of TRD construction method, it has reached the leading level in the world, such as the domestic sx50 double wheel slot milling machine ^[12] in Figure 4, which uses high torque milling head, large diameter gas lift slag removal, and different Cutterheads are configured according to the formation, and the groove depth can reach 80 m~120 m ^[13]; In addition, relevant industry regulations and standards have been issued successively, such as JGJ/t303-2013 technical specification for canal type cutting cement soil continuous wall and jb/t 13969-2020 construction machinery and equipment chain knife type underground continuous wall forming machine ^[14].

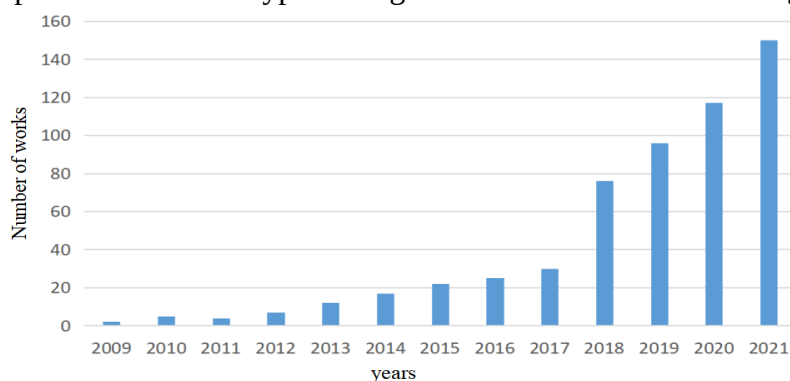


Figure 3 Quantities of TRD method in China[11]



Figure 4 SX50 double wheel slot milling machine made in China[12]

The widely used TRD construction method has obvious advantages in the construction of deep foundation pit ^[15,16]. For example, compared with the traditional foundation pit support, the underground continuous wall formed has high strength and stability to better support the underground building structure; In addition, the construction method can quickly construct, and the excavation of the channel, soil mixing and wall solidification can be carried out at the same time, which improves the construction efficiency; The construction method can also adapt to various soil conditions after process adjustment, including soft soil, silt, sand and clay; And the noise and vibration generated during the construction process are small, and the impact on the surrounding environment and nearby buildings is small. However, the trd construction method also has considerable difficulties and shortcomings in the current application ^[17]. For example, the construction cost is high. Compared with the traditional construction method, although the efficiency has been improved, the high equipment cost and complex excavation technology make its economic feasibility still need to be further evaluated; In addition, in the face of different construction geology, process adjustment is usually required, but the method of process adjustment has not been uniformly determined at present; In addition, the problem of quality control is also a big problem. How to ensure the uniformity, strength and compactness of the cement soil wall, as well as the correct laying and connection of pipelines, requires a strict quality monitoring and inspection system; At the same time, there are certain requirements for the space of the construction site. Because the size of the excavation and mixing equipment is larger than that of the traditional equipment, the trd method may be limited in some narrow or limited construction sites; And the construction difficulty of this method will rise sharply beyond a certain depth.

Based on the above shortcomings, the trd method is not yet able to completely replace the traditional foundation pit support construction method ^[18]. However, with the support of China's huge urban underground space construction project base and relevant policy guidance, the trd method will get more and more engineering applications, and there are also many academic studies on the trd method. I believe it will be developed in the future, The relevant shortcomings of TRD method will get more experience accumulation and technical innovation in the design and construction practice, so as to promote the development and application of TRD method. Because continuous research and practice will help to solve these problems and further improve the technology and methods of TRD method. In general, the trd construction method has broad development prospects in China ^[19]. It provides an efficient and stable underground engineering construction method, helps to meet the demand for underground space in the process of urbanization, and promotes the development of underground engineering in China ^[20].

2. research progress of related performance of TRD construction method wall

After a large number of engineering practice, the practicability of TRD method has been strongly confirmed. After inserting H-shaped steel, TRD method can not only be used for the protection of building foundation pit, shaft, cutting and other foundation trench excavation, but also can be used as

foundation pit support or partition wall of ultra deep and ultra large foundation pit to replace the high cost concrete bored pile; It can also be used for the underground anti-seepage wall or curtain of embankment, reservoir dam, reservoir and other buildings, especially the anti-seepage curtain for isolating deep confined water; It can also be made into a grid wall as a consensus of foundation reinforcement and liquefaction prevention measures^[21]. Therefore, people's research direction is not only about whether the trd method can be applied, but also more about whether the relevant performance of the wall after the trd method construction meets the safety and stability requirements of deep foundation pit and other projects. Since then, its stability deformation, bearing capacity and permeability have been widely studied, including theoretical calculation, numerical simulation, field monitoring analysis and experimental analysis.

The first is the theoretical calculation. The stability of TRD trough wall is not only the safety basis to ensure the stability of the wall, but also the premise to ensure the construction quality. The stability of the tank wall filled with mud is the decisive factor in the study of the stability of the trd wall, and it is also the main direction of theoretical research on the bearing capacity and stability of the trd wall. Scholars have done relevant research in this regard^[22].

Nash et al.^[23] put forward a stability theory of tank wall filled with mud based on the balance between the static pressure of mud and the force required to prevent wedge-shaped soil from sliding. Under the research background at this time, the trd method has not yet appeared, but the calculation method for the stability of geotechnical foundation with slurry retaining wall is also applicable to the current stability calculation of TRD method groove wall. The groove wall instability is assumed as a wedge, which is the two-dimensional shape of the first groove wall instability, and the failure wedge and plane sliding surface are considered.

Xiayuan et al.^[24], taking the classic two-dimensional wedge-shaped slider model as the research object, proposed the horizontal slice method for evaluating the stability of slurry retaining wall of underground continuous wall, established the 3M equation evaluation model meeting the slice force balance and the 4m equation evaluation model meeting the force balance and moment balance at the same time, proposed the solution method, and verified the effectiveness of 3M equation model and the necessity of slice method.

Jiangpeng et al.^[25] used the safety factor to accurately indicate the stability of the trench. Different depths correspond to different safety factors. The area above the groundwater level is not affected by groundwater when calculating the safety factor. Based on the limit force analysis method and simplified plane sliding model, the safety factor equation including the shear strength of mud is obtained. The safety factor curve of TRD trench is obtained by analyzing the working area of mud shear strength in the trench. Considering the above factors, the calculation method of TRD safety factor is obtained, which provides a theoretical basis for the safe construction of TRD.

Zhou Yuwei^[26] established a load structure model and a stratum structure model, and explored the influence of spatial variability of cement soil on the bearing performance of steel reinforced cement wall composite support structure through Monte Carlo simulation method. In addition, a large number of parameters were analyzed for TRD steel reinforced cement wall random field model to explore its influence on the bearing performance of support structure and the deformation of surrounding soil.

Because the theoretical calculation has been very perfect in the application of soil mechanics, at present, not many mainstream scholars have innovated a special calculation method of TRD construction method wall, and the mainstream theoretical analysis methods are limit equilibrium method and elastic resistance method. Because the limit equilibrium method does not consider the existing displacement of the wall before the support is set in the stage calculation, it does not reflect the continuity of the wall stress in the construction process. When the number of support layers, the softer the stratum, and the greater the wall stiffness, the calculated value is greatly different from the actual value. The elastic resistance law takes into account the influence of soil deformation on the support, idealizes the soil on the back of the wall as a spring, obeys the Winkler elastic foundation beam assumption in the elastic stage, and gradually applies the lateral earth pressure to the wall for

stress and deformation calculation along with the gradual excavation and support and the gradual backfilling process, reflecting the changes in the construction process, and the calculation results are more accurate and in line with the reality. Therefore, as for the theoretical calculation of TRD method, the applicability of limit equilibrium method is not as good as that of elastic resistance method ^[27,28].

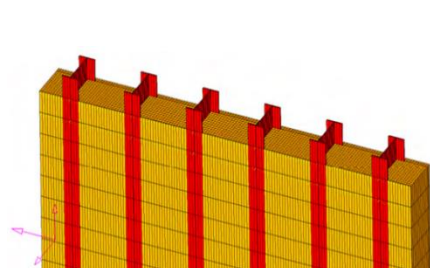
In addition, numerical simulation, field test and engineering case analysis are also the mainstream means to study TRD construction method, and many scholars have conducted relevant research.

For example, in the field test, Zhang Peng et al. ^[28] used five groups of field enclosure tests with different cement ratios to analyze the unconfined compression and permeability of TRD undisturbed cement mixed soil. The test results show that the unconfined compressive strength of cement mixed soil is closely related to its gradation. The unconfined compressive strength of the mixed soil layer will gradually increase as the deformation curve of the mixed soil layer approaches the fuller curve. In the microscopic study, cement fine sand has a larger pore structure, and the average pore area is 2.46 times that of cement clay. The permeability coefficient of cement mixed soil is controlled by the proportion of high permeability fine sand content.

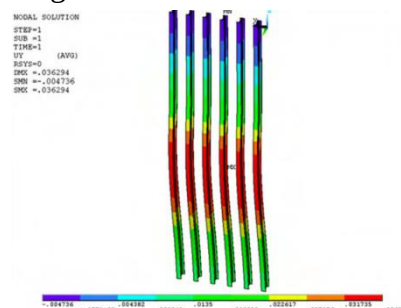
For example, in terms of analyzing engineering cases, huangbingde et al. ^[29] analyzed the strength test data of TRD construction method mixing walls with different depths and thicknesses, and found that there was no significant difference in the strength of cement soil formed by shallow soft clay and deep sand and cement in Shanghai and the appearance of cement soil walls at each layer when the burial depth was 60m. Based on a foundation pit project in Minhang District, Shanghai, Li Cao ^[30] studied the deformation of the surrounding soil caused by the trd construction method during the construction period through the monitoring data, and concluded that the influence of the trd construction method on the deformation of the surrounding soil was divided into two stages: the extrusion deformation stage and the deformation recovery stage. At the same time, it had the characteristics of smaller soil deformation and faster recovery during the construction period.

For example, in terms of numerical simulation, liuyankai et al. ^[31] studied the deformation characteristics of TRD cement soil mixed wall and soil around the foundation pit through the combination of numerical simulation and field monitoring. The field excavation monitoring was carried out and compared with the simulation results. The results show that the maximum lateral deformation of TRD cement soil mixed wall is positively correlated with the excavation depth. With the progress of the construction stage, the maximum settlement value of the ground surface gradually increases. With the increase of the distance from the fence, the settlement value first increases and then decreases. Fang Jianwei ^[10] calculated and analyzed the bearing deformation shape of the traditional construction method and TRD construction method, the stress deformation of the retaining structure before and after the equidistant setting of the section steel, the bending moment and stress distribution of the section steel and cement soil, and the change of the support resistance through finite element software. The new TRD construction method with equal spacing of profile steel reduces the local shear weak surface, has high contribution rate of cement soil stiffness, uniform horizontal force, and the deformation of profile steel and cement soil under external force is more coordinated, which is better than the traditional common method and is more conducive to the safety and stability of the structure. Tan Ke ^[32] and others studied the application of TRD construction method on typical soft soil layers in Shanghai. Based on the foundation pit project of Fengxian small and medium-sized enterprise headquarters building, they used the three-dimensional "m" method to theoretically analyze the interaction and bearing deformation properties of profile steel and cement soil. It was found that due to the difference in stiffness, the maximum horizontal displacement of the wall occurred at the cement soil, and 99% of the bending moment borne by the stiffness of the wall was shared by the profile steel. Conclusions such as the contribution of cement soil should not be considered in the calculation of related problems. The simulation results are also basically consistent with the measured results of the project. The relevant conclusions can clarify the related problems in the engineering design. Based on the foundation pit project of Shanghai international financial center, He Ping ^[33] and others used PLAXIS two-dimensional plane strain finite element to simulate the wall forming process of TRD, compared the field monitoring data, and obtained the results that were more

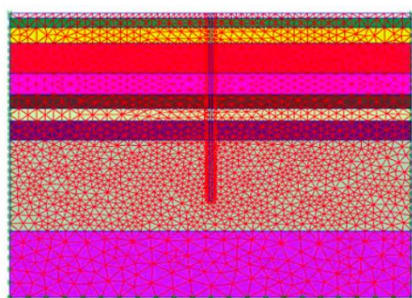
consistent with the measured results, which provided an analysis method for analyzing the impact of TRD wall forming on the environment. The results showed that the greater the wall forming depth, the greater the lateral deformation of soil and surface settlement, and the lateral deformation of soil presented a deformation behavior similar to that of cantilever beam. The numerical models and partial cloud charts or results used in the above studies are shown in Figure 5.



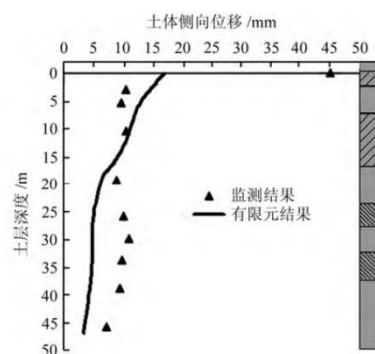
(a) Three dimensional "m" method analysis model of foundation pit supporting structure[32]



(b) Partial simulation results of three-dimensional "m" method analysis model[32]



(c) PLAXIS 2D plane strain finite element model[33]



(d) Partial Simulation Results of PLAXIS 2D Finite Element Method[33]

Figure 5 Typical numerical model and partial calculation cloud chart or results[32,33]

In general, there have been many studies on the relevant characteristics of the trd construction method mixing wall. Most of the studies focus on the impact on the surrounding soil during the wall forming process and the stress coordination characteristics of the steel reinforced cement soil combined support. There are few studies on the stress deformation characteristics of the mixing wall during the excavation process of the foundation pit. This impact will also affect the quality and safety of the project. Scholars need to further study this kind of problem in the future^[34].

3. Research Progress on wall quality of TRD construction method method

Although TRD construction method has many advantages, due to the non-uniformity of mixing and the spatial heterogeneity of in-situ soil itself, the properties of cement soil formed by TRD construction method have a certain degree of variability in space^[35], which makes the quality effect of wall formation questioned to some extent, and many scholars have also conducted relevant research on the quality of wall formation by TRD construction method.

Anguoming et al.^[36] introduced in detail the construction device, the construction principle of continuous wall and the quality of continuous wall of TRD construction method, and compared TRD construction method with SMW construction method. They believed that TRD construction method has a lower appearance height of construction machinery than SMW construction method, and can be used as a retaining wall of cement reinforced soil for temporary facilities. The built wall has the advantages of equal thickness jointless wall and less splash of soil and sand during construction.

Weixiang et al. ^[37] analyzed the advantages and disadvantages of selecting underground continuous wall and TRD method mixing wall as large waterproof curtain in soft soil stratum in Wuhan area, and detected the wall body quality of TRD method mixing wall. The test results showed that TRD method was well applicable in Wuhan area.

Diguoan et al. ^[38] based on Huai'an Yurun International Plaza, studied the wall forming quality of TRD mixing wall in Jiangsu silt and silty sand strata. The research results showed that TRD mixing wall effectively isolated groundwater and ensured the safety of foundation pit excavation.

Wang Fan ^[39] introduced in detail the wall forming principle of TRD method, the control points of construction technology and the detection requirements of the wall quality. Based on the trd project example of Huai'an Yurun square, the paper analyzed the wall forming quality of cement soil mixing wall from the drilling and coring detection, and combined with the construction monitoring data, obtained that the construction method met the design requirements in terms of uniformity, continuity, waterstop and strength, It is considered that the trd construction method has little impact on the surrounding environment and can create good economic and environmental benefits.

Zhang Rui ^[40] compared the grooving quality of the engineering ground wall, the perpendicularity of the ground wall without "TRD" groove wall reinforcement is 1/450, the average filling coefficient is 1.12, and there is a certain "big belly" phenomenon, and there is partial water seepage at the joint. However, the grooving quality of the ground wall reinforced by "TRD" method has been significantly improved, the average perpendicularity is 1/550, the average filling coefficient is 1.07, the surface is smooth, the integrity is good, and the water seepage at the joint is small.

To sum up, under the premise of ensuring the construction quality, the engineering effect of TRD method has been unanimously recognized, and it has obvious advantages over other geotechnical engineering methods.

4. Research Progress on Application of TRD method in different soil conditions

Since the research of TRD construction method in soft soil stratum has undergone a lot of research, and the previous article also quoted many relevant research results on the application of TRD construction method in soft clay stratum, it is not difficult to see that the application effect of TRD construction method in this stratum is very good, so this chapter will not introduce it. The following will introduce the application examples of TRD method in other strata such as silt, sandy soil, pebble and individual special soil.

Chenjieyao ^[41] used silty sand mixed with silty soil widely distributed in Suzhou area as raw material to study the mechanical properties of mineral powder cement soil through mix proportion and indoor tests. Taking the foundation pit project of Maopeng Road Station of Suzhou Metro Line 5 as the research background, using a combination of field measurement and numerical simulation, he obtained that TRD construction method applied to this kind of stratum will produce lateral deformation towards the inner side of the wall (groove section) due to the effect of lateral earth pressure, It makes the vertical deformation of the ground surface fall back, but in general, it achieves good results for application in such strata.

Zhang Mi ^[42] introduced the application of TRD construction method wall in the waterproof curtain construction of deep foundation pit project in Pudong area, Shanghai. The in-situ permeability test and the comparison of the permeability coefficient of undisturbed soil showed that TRD construction method improved the impermeability of each soil layer significantly, especially the sandy soil layer.

Wang Qiang ^[43] pointed out that the trd construction method is difficult to construct in the hard gravel stratum and the stratum containing many obstacles, and proposed the construction methods respectively for the gravel interlayer and deep gravel stratum. Through the methods of local breakthrough pilot hole and interval pilot hole, the innovation of TRD construction technology was realized, which increased the trd construction efficiency and reduced the mechanical wear, and

achieved good results in the actual project, It helps to popularize and apply TRD method in pebble stratum.

Lijingkun^[44] took a deep foundation pit project in the Yellow River alluvial plain as an example, compared the effect of bored pile and TRD construction method through theoretical calculation, and carried out numerical simulation through ABAQUS software, compared the retaining structure formed by TRD construction method and bored pile, and their effect in controlling horizontal displacement, soil mass and settlement of retaining structure is dominated by TRD construction method. Therefore, TRD construction method has the characteristics of good water stop and uniform depth direction, which has a good application prospect in the alluvial plain area of the Yellow River.

Zhaoxiuming and others^[45] based on the deep foundation pit project of a shed renovation project in Harbin, which is close to the operating subway tunnel, applied the trd method to the hard soil layer in the cold area in winter (-5~-30 °C) for the first time. By improving the corresponding treatment measures, they explored the construction method of using the trd method to treat the anchor cable. Through the wall formation detection and field actual excavation, it showed that the trd method could be applied to the hard soil layer in the cold area.

In addition, this paper also selects several typical TRD construction examples under different geographical conditions according to the relevant research papers on the field monitoring of TRD construction method, which are summarized in the following table, as shown in Table 1. According to the maximum allowable value of the deep horizontal displacement of the primary foundation pit support structure is 50mm, it can be seen that the following projects constructed by TRD method meet the design safety requirements.

Table 1 Monitoring value of typical TRD construction method

Project location	Main stratum of the project	Depth of foundation pit	Maximum displacement of supporting structure
Qiantang River, Shangcheng District, Hangzhou [43]	Sandy silt, silt, pebble formation	14.3m	42.0mm
The intersection of the Huai River and the Beijing Hangzhou Grand Canal [49]	Rich sand layer	18.9m	20.8mm
Alluvial plain of the Yellow River [44]	ilty soil, silty clay	16m	4.0mm
Wuhan Soft Soil Region [52]	Silty silty clay layer, silty clay layer	15m	27.2mm
Qinghe District, Huai'an City [39]	Muddy silty clay, silty clay mixed with silty sand	25.65m	39.93mm
Suzhou region [41]	Silty sand mixed with silty soil	18.45m	16.14mm
Guangzhou region	Silt, Silty Silty Fine Sand, Silty Clay	11.3m	17.5mm

To sum up, it is not difficult to see that TRD construction method can be applied to most soil conditions, but some special geological conditions may require corresponding improvement measures and some technological innovation. At the same time, there are relatively common karst areas where there is no literature on the engineering application of TRD construction method. However, it is believed that with the wide application of TRD construction method in various geotechnical

engineering, it can overcome various geological environments, Continuous innovation provides better technical reference for the foundation treatment industry.

5. Research progress of TRD construction method as waterproof curtain

Because the structure formed by TRD construction method is the underground continuous wall as a whole, compared with the traditional construction method, TRD construction method does not consider the soil arching effect of the pile, and it is not feasible to use the traditional technology to construct the supporting pile and water stop curtain when it is excavated below the groundwater level, so in most cases, TRD construction method as the water stop curtain has certain formative advantages, and it also has a large number of engineering applications of water stop curtain in practice. However, it is worth noting that the trd construction method can be used to prevent the infiltration of water through the low permeability design, but if the continuous wall constructed by the trd construction method does not invade the impermeable layer, the base stability and the seepage effect of soil must be evaluated during the design process ^[46]. Therefore, there are also a large number of scholars' research on the application of water stop curtain of TRD construction method.

Zhang Mi et al. ^[42] found through the analysis of a TRD actual project in Shanghai that under this kind of soil, the permeability index of different soil layers is more uniform than that of triaxial mixing pile. According to their indoor and in-situ permeability tests, the permeability coefficient of this construction method is less than $1 \times 10\text{cm/s}$. Through the implementation of the actual project, it is pointed out that the construction speed of the trd method will be affected by the factors such as the depth of the wall and the number of joints of the enclosure wall.

Huang Cheng ^[47] combined with a foundation pit project in Hangzhou, compared and analyzed the construction support effect of TRD method and SMW method. Through the study of the test results, it was found that the retaining wall of TRD method was better than SMW Method in terms of water stop. According to the support effect of the two methods, it is predicted that under the premise that the strength and stiffness of the foundation pit support meet the requirements, the wall support effect of the same TRD construction method will be more ideal.

Li Xing et al. ^[7] introduced the key technologies such as the construction points of TRD method, and verified the practical feasibility of TRD method by studying the implementation of this method in two projects. At the end of the article, they pointed out that this method has great promotion value in the treatment of confined water and other issues.

Chen Chen et al. ^[48] conducted a triaxial permeability test through on-site coring, and studied the influence of cement mixing ratio, curing age and soil layer on the permeability of the wall. The experimental results showed that the cement mixing ratio was 15%, and the wall was the most economical and reasonable; When the age is more than 28 days, the reduction of permeability coefficient will decrease; The enclosure wall formed by TRD method is relatively uniform, and the permeability difference of different parts is small, which is much better than that of SMW method.

Gaoming ^[49] studied and analyzed the permeability characteristics and parameters of the trd wall in the water rich sand layer, established a 3D foundation pit model by using indoor tests, combined with the actual engineering situation, and Midas finite element analysis software, and made a comprehensive analysis and comparison, and obtained relevant conclusions on the anti-seepage and water stop mechanism and structural stability of TRD. When TRD is used as the water stop curtain of the project under study, its wall thickness of 0.8m and wall depth of 50m are the best values, It provides theoretical support for the feasibility of TRD as water stop curtain in water rich sand layer.

To sum up, a large number of literatures have officially stated that TRD construction method as a waterproof curtain has obvious advantages over other mainstream geotechnical engineering methods in both theoretical research and engineering application. The permeability coefficient of the wall formed by TRD construction method can reach $10^{-8}-10^{-7}\text{cm/s}$ ^[50], and the water isolation effect is very good. The soil reinforced by TRD is almost impermeable. If the construction quality can be guaranteed, the hydraulic connection inside and outside the pit can be effectively cut off, It can ensure

that the basic foundation pit is impermeable. It is worth noting that when the TRD construction method is used as a waterproof curtain to penetrate into the bedrock, the underground water can enter the pit through these channels due to the existence of rock joints, weathered bedding of fissures and geological faults. Under the action of high water head difference inside and outside the foundation pit, the groundwater outside the pit will be replenished to the pit through the places where the cracks are developed, so that there will still be some water seepage in the pit^[51]. However, in general, the effect of TRD construction method as a waterproof curtain is worthy of recognition.

6. Conclusion

From its birth to its wide application, TRD construction method has entered China since 2009 and has been developed in China for more than ten years. After a large number of engineering practices, the method has been continuously improved and innovated, updated equipment, strengthened the mechanical properties of equipment such as tunneling, mixing and excavation capacity, and also optimized the quality control, so that TRD construction method can be applied to more geotechnical engineering fields, from the beginning as structural retaining wall and water stop curtain, Up to now, the underground anti-seepage wall or curtain as reservoir dam, embankment, reservoir and other buildings has been widely used in the fields of waste landfill contaminated liquid isolation, soft foundation treatment and so on. In addition, the TRD construction method itself is not complacent in engineering practice. Whenever it encounters problems, it will continue to combine the leading technology in the field of geotechnical engineering to optimize the shortcomings of the construction method itself, such as the TRD construction method combined with the stiffness of the steel wall as the support or partition wall of the large foundation pit, and the new composite support structure composed of TRD construction method and double row piles to provide sufficient stability for the super large and deep foundation pit project. In a word, the gradually localized TRD method will be able to rely on its advantages of wide application range, deep wall formation, high construction efficiency and low project cost. Through continuous engineering practice summary, it will conform to the peak period of large and medium-sized geotechnical engineering construction in the new infrastructure era in China, and explore and improve the relevant construction specifications of TRD method under different conditions, which will promote the continuous development and maturity of the method and make it more and more widely used.

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