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Overview of the Development of Ground Treatment Techniques in China

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Abstract. First, this paper briefly describes the emergence and development of ground treatment techniques in China; second, outlines various ground treatment techniques; third, points out the issues in the research and development of ground treatment techniques; and finally, makes some recommendations.

Keywords. Ground treatment, techniques, issues, recommendations.

1. Introduction

The ground treatment has a long history in China. The use of bamboo, wood and wheat straw to reinforce the ground is recorded. After the founding of the People's Republic of China, especially in the past 20 years, the ground treatment has developed rapidly. In the past 50 years, the development of ground treatment techniques in China has experienced the following two stages:

1.1. The First Stage

From the 1950s to the 1960s, it was regarded as the initial application stage, during which a large number of ground treatment technologies were introduced from the former Soviet Union. The most widely used method is the shallow-seated treatment such as cushion, and other techniques of ground treatment are greatly applied in industrial and civil buildings, such as gravel cushion, sand pile compaction, lime pile, lime-soil pile, chemical grouting, heavy hammer compaction, pre-soaking method and well-point dewatering.

1.2. The Second Stage

From the 1970s to the present, ground treatment is in a new stage of application, development and innovation. A large number of foreign advanced technologies have been introduced and developed, and combined with China's own characteristics, a ground treatment technique and its support system with Chinese characteristics has initially formed, which has reached the international advanced level in many fields. Here comes a brief introduction to this development trend.

2. Ground Treatment Techniques

2.1. Large Diameter Cast-in-place Pile

In the mid-to-late 1970s, large-diameter bored piles were applied to the ground treatment of high-rise and heavy-duty structures in large cities such as Guangzhou, Shenzhen, Beijing, Shanghai and Xiamen. From the 1980s to the early 1990s, it has spread to hundreds of large and medium-sized



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cities and emerging development zones all over China. And such large diameter cast-in-place piles are widely used in soft soil, loess, expansive soil, and special soil ground.

2.2. Composite Foundation

Methods of lime pile, gravel pile, high-pressure grouting, deep mixing, etc. have been widely studied and applied. The research to treat the ground has made great progress by utilizing the industrial residue, waste and urban construction waste. Here are some examples: the use of fly ash and quicklime to develop a two-powder-soil composite foundation; the use of scrap steel slag to develop a steel slag pile composite foundation; the use of urban construction waste to develop a slag pile composite foundation, and so on. The development and utilization of these projects not only save a lot of resources, reduce construction costs, but also explore new ways for improving the environment and reducing urban pollution.

2.3. Underpinning

The underpinning is divided into two categories: reinforcement and correction. The former often adopts measures such as micro reinforced concrete pouring piles, anchor static pressure piles, general pouring piles and jet grouting piles. The latter is a special means of ground treatment that corrects uneven settlement or tilt that has affected the normal use of the building. In the past decades, due to the application and development of the foundation correction by excavating soil and pile foundation selection research, a large number of inclined buildings with strip, raft and pile foundations have been miraculously corrected, with the safety of buildings guaranteed. It saves a lot of construction resources and has broad application prospects in the ground treatment of the existing works.

2.4. Drainage Consolidation

The drainage consolidation method is to set up a vertical drainage body such as a sand drain (bagged sand drain or plastic drainage strip) in the foundation, and then impose load according to the weight of the building itself; or preload on the site before the building is built, so that the pore water in the soil is discharged, the foundation is settled and consolidated, with the strength gradually increased. It can be subdivided into a preloading method, a vacuum preloading method and a vacuum-preloading combined method.

2.5. Heavy Tamping

Heavy tamping method means that the weight of more than ten tons to hundreds of tons drops freely from a height of several meters to several tens of meters, and the soil is subjected to dynamic tamping, which causes forced compaction of the soil to reduce its compressibility and improve strength. This reinforcement method is mainly applicable to coarse-grained soil with particle size greater than 0.05 mm, such as sand, gravel soil, mountain soil, fly ash, miscellaneous fill, backfill, low-saturation silt, micro-expansive soil and collapsible loess. It has no obvious reinforcing effect on saturated silt or cohesive soil.

2.6. Manual Digging Piles Designed as Hollow Piles

In recent years, some urban areas in China have developed and designed manual digging piles as hollow piles. This is the first of its kind in the world. In comparison with solid piles, this pile type can save more than 50% of concrete, and can still meet the strength requirements, meanwhile, reduce the outward transport of mucking, with construction convenience, process safety and structure rationality, showing good application prospects.

2.7. Bored Grouting Pile

The basic principle of drilling and grouting pile is that after drilling with screw drill pipe to the predetermined depth, cement slurry is sprayed out at high pressure at the bottom of the drill pipe, and the drill pipe is raised while spraying until the slurry reaches the predetermined depth without slump

hole. Then, the drill pipe is raised again, the steel cage and aggregate are placed. And then, through the pipe attached to the steel cage, piles are made by high pressure grouting at the bottom of the hole. This method is suitable for grounds such as miscellaneous fill, silt, flowing sand, pebbles. This method is neither affected by the underground water level, nor in need of slurry breast wall, thus having the popularization and application prospects.

2.8. Deep Foundation Pit and its Support System

In recent decades, with the rapid development of China's urban construction, along with the construction of a large number of high-rise buildings, super high-rise buildings, metros, underground garages, underground malls and other large municipal underground facilities, the ground treatment technique known as deep foundation pit engineering has gradually developed. According to relevant data, the buildings with more than 10 floors have exceeded 100 million square meters in only a dozen years in large and medium-sized cities in China, of which nearly 200 buildings have a height of over 100 meters. The data show that the depth of foundation pit of the high-rises and super high-rises that have been built or under construction in China has developed from 6 m to more than 10 m and even 20 m. Since 1980s, about 50,000,000 m³ of underground space has been developed and utilized.

3. Pending Issues

In the past 20 years, China's ground treatment techniques have been greatly developed, but there are still some issues to be addressed, mainly in the following aspects:

3.1. Ground Treatment Method Improperly Selected

There is a certain degree of blindness in selecting ground treatment methods. For example, it is not suitable to use vibrating and compacting methods to reinforce the saturated soft clay ground, and heavy tamping method in combination with other methods such as plastic drain board is better. According to the engineering geological conditions and the principle of ground stabilization, the treatment method should be reasonably selected according to local conditions, and a number of technically feasible schemes should be compared and optimized in depth. Many of the ground treatment methods used in projects are inadequate. Although the engineering problems are solved, the cost is too high, or the duration too long.

3.2. Lower Quality of the Contractor

Due to the rapid expansion of the ground treatment construction team, many contractors are in shortage of the necessary technical training, and skilled workers are scarce. This seriously leads to the low quality of the construction contractor. Of course, the quality of the construction team is also related to the current construction management system. The current system attaches importance to whether the general contractor has high qualifications, and ignores the qualification assessment and management of specific construction entities. The entities that complete the specific construction of projects are often scattered and temporarily pieced together, and it is difficult for the current system to turn these entities into skilled professional teams. The low quality of the construction contractor sometimes causes more serious problems, such as the phenomenon of cutting corners.

3.3. Shabby Construction Machinery and Construction Environment

In the past 20 years, China's ground treatment construction machinery has developed rapidly, and many have formed serialized products. However, compared with the needs of China's engineering construction, the gap is still very large. Shabby machinery is difficult to guarantee good construction quality. Moreover, the construction environment is unsatisfactory, and the entities undertaking the specific construction often do pay little attention to the environmental, occupational health and safety management of each unit.

3.4. Weak Theoretical Application and Quality Inspection

From the perspective of practice-theory-re-practice, practice precedes theory as general law, and civil engineering is no exception. The point is to attach importance to theoretical research and use theory to guide practice. This is very important. The lack of in-depth systematic research on various methods of construction and general theory of ground treatment is a pending issue in development. Another issue is the lack of complete quality inspection means matching the construction method.

4. Recommendations

Recommendations for further development of ground treatment techniques are as follows:

4.1. Strengthen Theoretical Research and Improve Design Level

To strengthen the theoretical research of ground treatment, we must first strengthen the general theoretical research, such as composite foundation calculation theory, design theory based on settlement control to optimize the design concept, etc., and strengthen the research on mechanism of various methods to reinforce the ground, as well as the design calculation theory research, especially emphasizing the research on optimization of design theory. The optimization design of ground treatment includes two aspects: one is the rational selection of ground treatment methods; the other is the optimization design of a certain method. There are large gaps between the actual needs and the current status in these two aspects. Many ground treatment designs only resort to solving engineering problems, but far apart from properly selecting ground treatment methods and optimizing ground treatment design. The development potential is great in the optimization design field of the ground treatment.

4.2. Deepen the Reform of the Construction Management System and Attach Importance to the Development of Professional Construction Teams

The ground treatment construction is highly professional, and it is necessary to improve the professional division of work, and strengthen the education, training, development and improvement of the professional construction team. For each construction method, it requires not only the on-site technicians to master the theory and practical knowledge of ground treatment, but also poses some requirements on the technical workers. Technical workers need to have a comprehensive and systematic understanding of the reinforcement mechanism, material requirements, and reinforcement processes of the construction methods. Through regular assessment, a large number of relatively fixed and qualified professional ground treatment construction teams will be trained.

4.3. Develop and Introduce New Machinery for Ground Treatment and Improve the Construction Capacity of Various Methods

In the civil engineering construction, the bigger gap between China and foreign countries is the construction machinery capacity. The same happens in the field of ground treatment. Although there have been improvements in recent years, the gap is still very large. With the growth of China's overall national strength, the construction machinery for ground treatment will have a great development. While attaching importance to the introduction of foreign advanced construction machinery, we must also pay attention to the development of domestically advanced construction machinery. Only the construction machinery capacity of various construction methods has been greatly improved, can the level of ground treatment be greatly improved. In the process of ground treatment and construction, it should be people-oriented, standardize the operation, and pay attention to the environmental, occupational health and safety management of the workers.

4.4. Pay Attention to the Development of New Techniques and Improve the Level of Comprehensive Application

With the development of ground treatment theory, ground treatment materials, new machinery and new processes, new methods of ground treatment will certainly emerge. Paying attention to the new

method of ground treatment is the need of engineering construction. It is believed that some new ground treatment methods will be surely applied in engineering construction. A new phenomenon should also be noted, that is, various ground treatment techniques and different construction workmanships are being grafted, transplanted, and inter-infiltrated with each other, thus forming another new technology and workmanship, resulting in better technical result. We should pay attention to the comprehensive application of a variety of ground treatment techniques, which should be a very important development direction in the future.

4.5. Develop Ground Treatment Testing Techniques

Ground treatment testing techniques include quality inspection of various ground treatment methods and assessment of ground treatment effects. The development of ground treatment testing techniques will help ground treatment to achieve informatization construction. The development of ground treatment in-situ testing, field testing, and testing techniques is of great importance for improving the level of ground treatment techniques, thus should be given enough attention.

The field of ground treatment is a very active area in civil engineering and a very challenging area. Challenges and opportunities coexist. I believe that in the near future, ground treatment techniques will be greatly improved on the basis of popularization and will be pushed up to a new level.

References

- [1] Han Mei, Shi Liancheng J 2013 (20) *Real Estate Guide* p 346
- [2] Qu Guangxue, Huang Fuling, Bai Zhiming. J 2016 (3) *Sichuan Cement* p 294
- [3] Zheng Xiaopei. J 2016 (7) *Jiangxi Building Materials* p84–85
- [4] Wang Donghui, Ma Xiaochun, Fu Yu. J 2014 (6) *Prospecting Engineering* p 66–71