

Research on the Properties of the Waste Glass Concrete Composite Foundation

Shilong Jia^{1, a}, Kaihui Chen^{2, b} and Zhongliang Chen^{3, c}

¹School of Civil Engineering, Shenyang Jianzhu University, Shenyang, 110168, China

²School of Civil Engineering, Shenyang Jianzhu University, Shenyang, 110168, China

³Shenyang Win Yin New Town Construction Investment Co., Ltd., Shenyang, 110000, China

^a email: 3093866754@qq.com, ^b email: 1139479346 @qq.com, ^c email: 2846491929@qq.com

Abstract The composite foundation of glass concrete can not only reuse the large number of waste glass, but also improve the bearing capacity of weak foundation and soil with special properties. In this paper, the engineering properties of glass concrete composite foundation are studied based on the development situation of glass concrete and the technology of composite foundation.

1. Introduction

A large amount of waste glass that is produced in the process of construction, production and life are treated by two kinds of disposals, namely reusing and landfill. The researches on the reuse of the waste glass start late and are in the preliminary stage. The relevant technologies are also low. The reuse rate of the waste glass is only around 20%, and the rest of waste glass cannot be buried in the soil effectively. In this situation, resources are wasted, and the environment is also damaged seriously.

With the development of the city, a large amount of buildings are constructed. The locations of the buildings are always the sites with good geological conditions. Because land resources are scarce and limited, some of the buildings have to be constructed on the soil with bad geological conditions. In order to meet the bearing capacity and the deformation requirements of foundation, the foundation must be reinforced, and composite foundation technology has been widely used. At present, the natural resources such as the sand and the gravel are mostly used in the foundation reinforcement treatment, which is not conducive to energy conservation, environmental protection and sustainable development strategy.

In this paper, based on a large number of research conclusions that are drawn from the application of waste glass in the construction project home and abroad, the feasibility that the glass concrete is used in composite foundation is discussed, and the engineering properties are studied. A way that is energy-saving, emission-reduction, environmental and efficient is explored for foundation reinforcement.

2. The technologies of composite foundation

As the supporting layer of the foundation under the building, the foundation should meet the requirements of the strength, the deformation and the stability. When the soil condition is good, the natural foundation does not need to be treated. Natural foundation can undertake the upper loads, provide favorable condition for the construction, and saves the cost. When the soil condition is bad, it is



necessary to reinforce the foundation, that is to say, the composite foundation is adopted. The common classification criteria and names of composite ground are shown in table 1.

Table 1: The common classification criteria and names of composite ground

Classification standards	The directions of reinforcement structures	The material of the piles	The strength of the pile
name	Vertical reinforcement composite foundation	Composite foundation of granular material pile	Flexible pile composite foundation
	Horizontal reinforcement composite foundation	Composite foundation of cement-stabilized soil pile	Semi-rigid pile composite foundation
		Composite foundation of concrete pile	Rigid pile composite foundation

The vertical reinforcement composite foundation is the pile composite foundation, and the horizontal reinforcement composite foundation is the reinforced soil composite foundation formed by geosynthetics, Metal grille and so on. The granular material pile is a flexible pile, the cement-stabilized soil pile is a semi-rigid pile, and the concrete pile is a rigid pile.

The scholars in China study the main properties of flexible pile composite foundation, semi-rigid pile composite foundation and rigid pile composite foundation^[1]. The comparison of the properties is shown in table 2.

Table 2: The property comparison of composite foundation with different pile strength

categories	pile	strength	Rigidity	Consolidation velocity of foundation	water permeability	Reducing liquefaction of liquefied layer
Flexible pile	Sand pile, Stone pile	low	low	fast	good	yes
Rigid pile	CFG pile, Plain concrete pile	high	high	slow	poor	no
Semi-rigid pile	Cement soil mixing pile, jet grouting pile	Dual characteristics, the same as the flexible pile when the dosage of cement is small, the same as rigid pile when the dosage of cement is big				

3. Research condition of the glass concrete

The researches on the reuse of the waste glass start earlier in some foreign countries and these countries gain rich theoretical and practical experiences. The waste glass is made of glass asphalt concrete, walling, decorating materials, foam glass and etc^[2]. The waste glass is applied in the civil engineering projects and the environmental and the social economic benefits are well received.

The researches on the reuse of the waste glass start later and the reuse rate is low in China. The researches on the glass concrete are still in the theoretical research stage in China. At present, the achievements are made on the diameter of the glass particles, the replacement rate of the aggregate, the mechanical property, the durability, and the application of the waste glass to the beam and the column. Most of the data and the conclusion are obtained from the test in the laboratory, and are not tested by the practical project.

4. Engineering properties of glass concrete composite foundation

Glass concrete is a new type of concrete which is made of processed waste glass, cement, sand, stone and water. Processed waste glass replaces the sand and the stone in the ordinary concrete by certain proportion. The application of glass concrete to composite foundation not only makes use of a large amount of waste glass, but also improves the bearing capacity of soft foundation.

Through the analysis of a large number of test data and conclusions, when the diameter of the glass particles that is less than 1.18mm^[3] and the proportion of waste glass is between 20% to 40%, the strength of the glass concrete is nearly as the same as the strength of the ordinary concrete. In terms of

the workability, the corrosion resistance and the good freeze-thaw resistance, the glass concrete is better than the ordinary concrete. In terms of the adhesive force between concrete beam and rebar and the short-term stiffness, the glass fine aggregate concrete beam is higher than the ordinary concrete beam. In terms of anti-bending capability and ultimate shear capacity, the glass fine aggregate concrete beam is similar to the ordinary concrete beam^[4]. The failure mechanism of concrete, the shape, lateral deformation, linear deformation, Compressive strain of concrete, stress strain curve of rebar, the long glass concrete column is similar to the long ordinary concrete column. When the slenderness ratios are the same, the bearing capacity of the long glass concrete column increases with the increase of the dosage of the waste glass; when the usages of the waste are the same, the bearing capacity of the long glass concrete column decreases with the increase of the slenderness ratio^[5]. The foundation draw by the comparison of these properties makes the application of glass concrete to composite foundation feasible.

The composite foundation of glass concrete pile is the same as the composite foundation of CFG pile and plain concrete pile, and belongs to the category of rigid pile composite foundation. According to table 2, it can be concluded that the glass concrete pile has the advantages of high strength and stiffness in the process of the foundation treatment. At the same time, it also has the shortcomings, such as slow consolidation of the foundation, impermeable, and cannot eliminate the liquefaction layer. Compared with plain concrete pile, glass concrete pile saves the natural resources such as the sand and the gravel, and the cost of waste glass is also lower than that of the sand and the gravel, which has obvious environmental protection value and economic value. Compared with the CFG pile, both of them involve reuse of the waste materials. The waste glass can only be used after the glass is classified, recycled, treated on the surface of the glass, crushed and sieved, which cost more than the fly ash, but its strength is higher than that of the CFG pile.

(1) To enhance the anti-shear property. The glass concrete pile and the soil between piles bear the upper load together. Because of the high strength and stiffness of the pile, the bearing capacity and shear resistance of the composite foundation are improved, and the occurrence of unfavorable factors such as slope instability and uplift of foundation are effectively avoided.

(2) To improve the durability. The glass concrete composite foundation has the characteristics of corrosion resistance and freeze-thaw resistance of glass concrete. Compared with the ordinary concrete composite foundation, the durability of the glass concrete composite foundation is improved.

(3) To improve the permeability. The permeability of the glass concrete pile is poor. When the glass concrete pile is applied to the composite foundation, foundation leakage can be prevented, and the probability of the occurrence of the piping and the quicksand can be reduced.

(4) To improve the compression feature. Compared with the flexible pile, the glass concrete pile has smaller settlement after the construction and higher compression modulus.

(5) The glass concrete pile has the functions of anti-seismic and decompression. Under the influence of ground motion, the acceleration of composite foundation surface is smaller than that of the original foundation, so the glass concrete pile has obvious anti-seismic effect compared with the ordinary concrete pile.

Because of the direct contact between the glass concrete pile and the soil, it is necessary to consider the influence of glass on the surrounding soil environment when the improvement of poor soil properties is studied. The original use of the waste glass is different. Some of the waste glass is used in medical treatment, agriculture and other fields, such as used for containing drugs, poisons, test chemicals, etc. Some colored glass also contains zinc, copper and other heavy metals, if this kind of glass is used in pile, soil pollution will be caused. Therefore, in the process of the selection of glass, toxic and harmful glass should be removed and to the destruction of the soil environment caused by raw materials should be avoided.

5. Conclusion

The glass concrete pile composite foundation can make the waste glass recycling, which conserves resources, protect the environment. It can be applied to reinforce the foundation with bad geological conditions, and can meet the requirements of the strength, the deformation and the stability.

The glass concrete pile composite foundation can enhance the shear resistance, the durability of the original foundation. The composite foundation treated can be anti-seismic and compress, and can also characterize composite foundation after treatment to seismic decompression, and can effectively prevent the occurrence of quicksand and piping.

Acknowledgements

The authors wish to thank Science and technology program of Liaoning Province (2011222007) and the Planned Science and Technology Project of Shenyang (F12-173-9-00) for sponsoring this research project.

References

- [1] Wang Chong. Analysis of the Anti-seismic Mechanism and Sensitivity of Design Parameters of the Pervious Concrete Pile Composite Foundation [D] Jinan: Shangdong University, 2013.
- [2] Zhang Ni. Experimental Study on Mechanics and Durability of Glass Concrete [D] Shenyang: Shenyang Jianzhu University, 2011.
- [3] Yang Fengling, LiYutao. Study on the Influence of the Dimeter of the Glass Aggregate Particle on the Properties of the Glass Concrete [J] Concrete, 2012 (8): 78-80.
- [4] Wang Zhenwei. Experimental Study on the Waste Glass Concrete Beam [D]. Shenyang: Shenyang Jianzhu University, 2011.
- [5] Zhang Qingbo. Experimental Study on Properties of Compressed Long Columns of Waste Glass Concrete [D]. Shenyang: Shenyang Jianzhu University, 2011.