Study on Collapsible Loess Treated by Compaction Pile

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Abstract. An analysis was conducted on the example of treating collapsible loess in highway engineering, and it was found that the lime soil compaction pile method can reduce the soil subsidence coefficient and compression coefficient, and the larger the compression coefficient, the more obvious the effect and significantly improve the compression modulus of the foundation soil. The compaction pile method can be used to treat collapsible loess with a thickness generally ranging from 5m to 12m, and the maximum thickness should not exceed 15m. The lime soil compaction pile significantly reduces the porosity and permeability of loess by exerting lateral compression on the soil around the pile during the pore forming process, thereby reducing its collapsibility. When the distance between piles S ≤ 3D (D is the pile diameter), the circumferential stress field generated by the compaction of adjacent piles can form an effective superposition. After treatment, the collapsibility coefficient gradually increases with depth and significantly decreases compared to before treatment, with an average reduction of 94%. The deeper the depth, the more obvious the reduction effect. The compression modulus of the foundation has significantly increased, the strength of the soil has been improved, and the compressibility has decreased. The compressive modulus of the foundation increases with depth and then decreases. After treatment, the compression modulus of the foundation significantly increased, with an average increase of 144%. The deeper the depth, the more obvious the increase effect, with a maximum increase of 335%. Lime soil piles form a high-strength pile-soil composite foundation through the dual effects of physical compaction and lime soil consolidation. After being treated with lime soil compaction piles, the collapsibility coefficient is stable, and the treatment effect of collapsible loess is good.

Keywords: Lime soil compaction pile, treatment, collapsible loess

1 Introduction

The collapsibility of loess needs to be solved in highway engineering construction in loess area. Collapsible loess is a kind of unsaturated under compacted soil with large pores and vertical joints. It is soaked by water under certain pressure, and the soil structure is rapidly damaged, resulting in significant additional subsidence, which is very harmful to engineering construction [1].

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In terms of collapsible loess foundation treatment technology, lime soil compaction pile method can effectively eliminate collapsibility and adverse geological bodies and improve bearing capacity. This method uses pipe sinking, impact, explosion expansion and other methods to squeeze holes in the soil, so that the soil around the pile hole is compacted, and then the pile body is formed by tamping lime soil and other materials into the pile hole in layers. The composite foundation of compaction pile is composed of pile body and soil between piles [2]. Lime soil pile compaction pile construction is to carry out deep compaction of the foundation, mainly through the pile forming treatment of the foundation by driving the pipe sleeve. By improving the compactness of the soil, the bearing capacity of the foundation is enhanced, and the stability of the soil is strengthened and improved.

2 Comparative Analysis of Two Common Foundation Treatment Methods

Lime soil compaction pile, cement fly ash gravel pile (CFG pile), and dynamic compaction method are common foundation treatment methods. Through comparative analysis, suitable methods for treating collapsible loess are identified.

Lime soil compaction pile is formed by horizontally compacting holes, using the pile holes to backfill lime soil (or plain soil) layer by layer and compact, so as to improve the compactness of the soil between the piles, eliminate the collapsibility of collapsible loess, and form a composite foundation to jointly bear the load. This treatment method does not require a large amount of earthwork excavation, and the construction process directly reinforces the in-situ soil, with both compaction effect and pile bearing capacity[3].

Cement fly ash gravel pile (CFG pile) is a rigid pile made by injecting a mixture of cement, fly ash, and gravel, forming a composite foundation with the soil between the piles, and sharing the load and reducing settlement through the pile body. The characteristics of rigid piles significantly increase their bearing capacity (up to 2-5 times), but the material cost is high and the construction period is long[4].

The dynamic compaction method relies on the free fall of a heavy hammer to impact the foundation soil, and improves the properties of shallow soil through dynamic compaction or consolidation. It is suitable for unsaturated soil (such as sand and gravel soil). The processing depth is relatively shallow (6-10m), and the effect on saturated clay and high moisture content soil is limited.

The new grouting reinforcement technology is to inject high fluidity grout (such as cement-based materials, chemical grout, etc.) under pressure, fill the cracks or pores of the foundation, form a continuous consolidated body, and improve the overall integrity and bearing capacity of the soil.

Table 1. Comparison of Common Foundation Treatment Methods.

Index	Lime soil compaction pile	Cement fly ash gravel pile (CFG pile)	Dynamic compaction	New grouting technology

Applicable soil type	Collapsible loess, plain fill, and miscellaneous fill with a water content of 12% -25% above the groundwater level	Cohesive soil, silt, sandy soil	Unsaturated gravel soil, sandy soil, low saturation silt	Clay, silty clay, gravel layer, collapsible loess, silty soil (not applicable to humus soil with organic matter>5%)
Processing depth	5-15m	Up to 15m or more	6-10m	Conventional 8-15m, directional grouting technology can reach 30m
Eliminate collapsibility	Completely eliminate	Not Applicable	Partial elimination (requiring high compaction energy)	eliminate
Environmental impact of construction	Low noise and minimal vibration	No vibration, good environmental friendliness	Noise and vibration are high, and it is necessary to stay away from residential areas	Low noise, minimal vibration, and less than 3% overflow of waste slurry (chemical treatment is required for pollution)

The cost comparison of several foundation treatment methods is as follows:

The main material used for lime soil compaction piles is lime soil, which has a low cost and can be locally sourced. The equipment is a diesel hammer sinking machine (≤ 500000 yuan), with a comprehensive cost of 8000-12000 yuan per 100 square meters.

The cost of using cement, fly ash, and crushed stone for CFG piles is relatively high. The equipment includes a long spiral drilling rig and a mixing plant (≥ 2 million yuan), with a comprehensive cost of 25000 to 40000 yuan per 100 square meters.

The dynamic compaction method does not use specialized materials, and the equipment is a dynamic compaction machine (800000 to 1.5 million yuan), with a comprehensive cost of 15000 to 25000 yuan per 100 square meters.

The cost of chemical grout used in the new grouting technology is high, and the equipment is a high-pressure grouting pump (≥ 1.5 million), with a comprehensive cost of 30000 to 60000 yuan per 100 square meters.

The comparison of construction efficiency and duration of several foundation treatment methods is as follows:

Lime soil compaction pile: integrated construction of drilling and compaction, single pile processing time ≤ 30 minutes, no maintenance period required, and can be tested 24 hours after construction.

CFG pile: requires mixed material mixing (≥ 60 minutes/time) and pumping process, single pile construction ≥ 1 hour, and 28 day age testing.

Dynamic compaction method: single point processing time ≤ 5 minutes, but multiple compaction cycles (3-5 times) are required, with an interval of 3-7 days (pore water pressure dissipation).

New grouting technology: drilling grouting solidification phased operation, single point treatment ≥ 2 hours, chemical slurry solidification takes 48-72 hours.

By comparing common foundation treatment methods as shown in Table 1, it is analyzed that the depth of lime soil compaction pile treatment can reach 15m, and the collapsibility of collapsible loess can be completely eliminated through compaction. Especially suitable for the treatment of collapsible loess foundation in northwest and north China, with both reinforcement and waterproof stability. Lime soil compaction pile has the advantages of low cost, short construction period, and environmental protection.

3 Lime Soil Compaction Pile Method

The lime soil compaction pile method is an engineering technology that uses hammering or vibration to drive steel pipes into the soil to form pile holes, improves the soil structure through lateral compaction, and then backfills lime soil (lime and plain soil mixed in a volume ratio of 2:8 or 3:7) in layers inside the pile holes and compacts them, finally forming a composite foundation together with the soil between the piles[5].

The lime soil compaction pile method has achieved the dual goals of improving foundation strength and eliminating collapsibility, and has become the preferred solution for foundation treatment in loess areas[6].

The thickness of collapsible loess layer treated by compaction pile method is generally 5m~12M, and the maximum thickness should not exceed 15m. This method can be used to treat self weight collapsible loess foundation with various highway grades and collapsible grades of class II and above [7]. This method is usually used in the following cases:

(1) Collapsible loess foundation treatment of abutment, back of abutment and high retaining wall (height ≥ 6m).

(2) The impact of dynamic compaction on nearby buildings, structures or other facilities, and it is inconvenient to take vibration reduction (isolation) measures.

(3) The route is located in the loess gully, and the operation of large machinery such as dynamic compaction is difficult, or the dynamic compaction construction poses a threat to the stability of the natural slope.

Lime soil compaction piles or dry mixed cement gravel compaction piles are generally used for collapsible loess foundation treatment of expressways and class I highways, and lime soil compaction piles or plain soil compaction piles can be used for other classes of highways[8].

3.1 Lime Soil

Priority should be given to using fine-grained silt (with a particle size of ≤ 0.075mm and a proportion of ≥ 50%), and its plasticity index should meet the technical requirement of Ip ≥ 4. A low plasticity index (such as Ip<3) can lead to insufficient bonding strength of the mixture, and the pile is prone to structural collapse after forming.

It is strictly prohibited to mix organic impurities such as humus and plant roots, and the organic content must be less than 5%. Before entering the site, screening treatment is required to ensure that the maximum particle size is ≤ 15mm (it can be relaxed to 20mm under special geological conditions, but it needs to be confirmed by the design unit).

Fresh block shaped quicklime (CaO content ≥ 80%) is used, with a block size controlled between 20-50mm. After crushing, it is filtered through a 5mm sieve to remove unripe particles.

The dosage of quicklime is strictly controlled within the range of 5 ± 0.5% by mass ratio. When the dosage exceeds 6%, the expansion stress generated by the lime hydration reaction will cause cracks in the pile, leading to later softening by immersion and reducing the bearing capacity of the foundation[9].

Lime should be pre digested 24 hours in advance, and after digestion, it should be sorted by a vibrating screen to remove incompletely digested lime nuclei. The dissolution rate should reach over 90% to avoid the occurrence of "ash explosion" in the later stage of the pile.

Adopting a secondary mixing process: the first dry mixing time is ≥ 3 minutes to ensure uniform mixing of lime and soil; The moisture content during secondary wet mixing should be controlled at 18-22%, and the total mixing time should be ≥ 5 minutes.

Set up a three-level screening system for particle size control: primary vibrating screen (aperture 30mm), magnetic separation for iron removal, and fine screen (aperture 15mm). Oversized particles must undergo secondary treatment using a jaw crusher to ensure a particle size qualification rate of ≥ 95%.

Adopting the "Two Stirring and One Pressing" process: after the first compaction, repeat stirring with an interval of 2 hours, and finally apply a final pressure of 300-500kPa. The compactness of the pile body is tested using the ring knife method, with a compaction coefficient of λ c ≥ 0.97.

Real time monitoring of quicklime dosage, EDTA titration detection is carried out every $200m^3$ of mixed material, and the deviation of calcium ion concentration is controlled within ± 0.3mol/L.

When encountering groundwater seepage, immediately add 3% cement for emergency solidification treatment. If the moisture content exceeds the standard, it can be adjusted by sun drying or adding quicklime powder.

Engineering practice data shows that when the lime content is increased from 5% to 7%, the 28 day unconfined compressive strength of the pile decreases by 12-15%, and the permeability coefficient increases by 2 orders of magnitude.

3.2 Pile Spacing Control

Due to the fact that compaction piles rely on lateral compaction of soil to eliminate the collapsibility of collapsible loess, their spacing has a significant impact on the compaction effect and is an important indicator in scheme design[10].

The excessive spacing between piles leads to stress shadow areas. When the spacing between piles is greater than 2R (R is the effective compaction radius), a compaction blind zone appears. At 3.5D (D is the pile diameter), the soil porosity ratio between piles only decreases by 15%.

By setting up a 3 × 3 test pile group and using the following method to detect the optimized spacing:

Exploration well sampling method: Dig an exploration well between piles to collect undisturbed soil and detect the boundary of the compacted area.

Micro deformation monitoring: burying vibrating wire strain gauges to capture the distribution of soil displacement field.

The final determination of the effective superposition critical condition: when the distance between piles is ≤ 2.5D, the dry density of the soil between piles increases from 1.45 to 1.65g/cm ^{3}; The optimal spacing criterion is δ s ≤ 0.015 and Es ≥ 15MPa.

When encountering local weak interlayers, adjusting the spacing to 0.8S (where S is the design pile spacing) and adding 2 additional ramming operations can improve soil stiffness.

Plum shaped pile arrangement may cause insufficient diagonal compression. To verify the cumulative effect of compression in the 45 ° direction, the constraint condition of ≥ 0.5S from the edge pile to the outer edge of the foundation should be determined to avoid stress diffusion loss.

The increase in moisture content during the rainy season leads to a 12-18% decrease in compaction efficiency, and the spacing can be dynamically reduced by 10-15%.

When determining the spacing between compacted piles, it should be noted that smaller spacing is not necessarily better. A spacing that is too small may lead to pile necking, soil uplift between piles, and a decrease in compaction coefficient. The compaction pile has already caused compaction of the surrounding soil during the pile forming process. The compaction effect is significant within a range approximately equal to the pile diameter. During the construction of the surrounding piles, it is not advisable to overlap the significant compaction area to avoid soil uplift between the piles and reduce the compaction effect. Of course, excessive spacing between piles can also reduce the compaction effect.

3.3 Piling

Squeezing piles can be formed by pre drilling, compacting and expanding the pile, or by using the sinking tube compaction method.

Predrilling, Compaction and Expansion Method. The predrilling compaction method is suitable for hard plastic loess layers above the groundwater level with a natural moisture content of ≤ 18%, as well as special strata that can penetrate through gravel interlayers (particle size ≤ 100mm, content < 30%).

Construction process: pile position layout, drilling of Φ 300mm guide hole, dynamic compaction at the bottom of the hole (compaction energy 1500kN • m), layered filling

(1.2m per layer), compaction and expansion inside the hole (hammer diameter Φ 600mm), and section by section wall protection.

Key control indicators:

Hammer drop distance: 8-12m;

Compaction frequency: 6-8 blows per layer;

Control of compaction diameter: Through penetration monitoring, the final two impacts have a penetration of ≤ 50mm.

Immersed Tube Compaction Method. Suitable for plastic silty clay with a moisture content of 20-24%, with a processing depth of ≤ 10m using conventional equipment and a processing depth of up to 15m using dual tube linkage technology.

Construction process: pile driver in place, sinking pipe to design elevation, pulling pipe 0.5m and inserting it back, layered filling (0.8m per layer), vibration compaction (frequency 28Hz), full hole back pressure compaction.

Key control indicators:

Vibration acceleration: ≥ 0.8g;

Vibration retention time: 30-45 seconds per layer;

Monitoring of soil uplift: Surface uplift ≤ 20mm during adjacent pile construction.

Comparison of Pre drilling Rampage Expansion and Compaction Methods and Immersed Tube Compaction Methods.

Comparison of Construction Techniques.

The pre drilling, compaction and expansion method adopts the process of drilling first and then compaction and expansion. The pilot hole is formed by pre drilling, and then the compacted pile body is formed by layering and compacting the filling material (such as lime soil, sand and gravel). During the compaction process, the free fall impact force of a heavy hammer is used to gradually expand the hole and compact the surrounding soil layer by layer, forming a composite foundation.

The sinking tube compaction method uses vibrating sinking tube equipment to directly penetrate into the soil layer[12]. During the process of pulling out the tube, the filling material is layered and compacted by vibration to form a continuous compacted pile body. The drilling and filling of the immersed tube are completed synchronously, and the soil compaction is achieved through the lateral compression of the immersed tube[13].

Comparison of Applicable Conditions.

(1) Soil adaptability

Pre drilling method: suitable for processing collapsible loess with a depth of more than 15m, especially advantageous when the groundwater level is high or there is a hard interlayer.

Immersed tube method: commonly used for handling shallow (within 10m) loose sand, silt, and collapsible loess, with limited penetration ability into hard soil layers.

(2)Environmental impact

Pre drilling method: Drilling first reduces vibration and causes less disturbance to surrounding buildings.

Immersed tube method: The vibration noise is high, which may cause liquefaction of adjacent soil or settlement of structures.

Comparison of Processing Effects.

(1) Density and uniformity

Pre drilling method: By layer by layer compaction and expansion, the compactness of the filling material can be accurately controlled, and the uniformity of the pile body is good.

Immersed tube method: Due to the influence of the verticality of the immersed tube and the speed of the filling material, it is easy to cause pile necking or pile breakage.

(2) Effectiveness of eliminating collapsibility

Pre drilling method: Combined with lime soil backfilling, it can effectively eliminate the collapsibility of deep loess and significantly improve the bearing capacity of the foundation after treatment.

Immersed tube method: It has a significant effect on eliminating shallow collapsibility, but deep layer treatment needs to be combined with other processes.

Economic Comparison.

(1) Construction cost

Pre drilling method: requires additional drilling equipment, has a longer construction period, and has a higher overall cost.

Immersed tube method: simple equipment, fast efficiency, suitable for large-scale construction, and more economical.

(2)Maintenance costs

Pre drilling method: The stability of the pile is strong, the risk of later settlement is low, and the maintenance cost is relatively small.

Immersed tube method: There may be local uneven settlement, and quality inspection and later monitoring need to be strengthened.

When the compaction depth is within 12m, it is not advisable to pre drill holes. The diameter of the compaction hole should be 0.3m to 0.45m, because the former requires more soil than the latter in terms of pre drilling volume. Under the same compaction effect, the former requires more filling material in the hole than the latter. When the required processing depth is not too large, the sinking tube compaction method is more economical for pile forming. When the depth of compaction treatment exceeds 12m, pre drilling holes can be drilled with a diameter of 0.25m to 0.30m. The diameter of the pile formed after compaction and expansion should be 0.50m to 0.60m. The advantages of the pre drilled hole compaction method are low construction noise, minimal vibration impact, and the ability to reduce the impact of long-term vibration on the surrounding area during long pile construction. The specific comparison between the pre drilled hole compaction method and the immersed tube compaction method is shown in Table 2.

Table 2. Comparison and analysis of pre drilled hole compaction and expansion method and immersed tube compaction method.

Comparison Item	Predrilling, compaction and expansion method	sinking tube compaction method
Processing Depth	8-25m	5-15m
Pile Diameter	600-1200mm	400-800mm

Soil Disturbance	Lateral compaction is predominant (disturbance radius 1.5D)	Vertical compaction is the main method (disturbance radius 0.8D)
Work Efficiency	12-15 pieces/shift	20-25 pieces/shift
Noise	85dB（noise reduction shed required) 105dB (noise barrier required)	105dB (noise barrier required)
Single Pile Bearing Capacity	600-1200kN	300-800kN

4 Treatment Effect of Lime Soil Compaction Pile

The collapsible loess foundation of a certain highway was tested and treated with compacted lime soil piles, which were formed using the sinking tube compaction method[14].

The comparison of the collapsibility before and after the treatment of compacted lime soil piles on loess foundation is shown in Table 3. After treatment, the collapsibility of most soil layers is eliminated (the collapsibility coefficient is less than 0.015), and the soil strength (compression modulus) is significantly improved, while the compressibility decreases.

Table 3. Comparison of foundation collapsibility before and after lime soil compaction pile treatment.

Sampling depth h (m)	Natural foundation soil before treatment					Soil between piles after treatment		
	Natural moisture content (%)	Dry density (g/cm^3)	Collapsibility coefficient	Compressibility factor (MPa^{-1})	Modulus of compressibility (MPa)	Collapsibility coefficient	Compressibility factor (MPa^{-1})	Modulus of compressibility (MPa)
1.0	9.4	1.42	0.123	0.374	5.331	0.010	0.180	9.47
2.0	8.7	1.38	0.106	0.606	3.271	0.006	0.177	9.735
3.0	8.8	1.45	0.096	0.172	11.5	0.008	0.138	13.03
4.0	9.2	1.44	0.088	0.327	6.025	0.011	0.219	8.12
5.0	10.5	1.42	0.528	1.261	1.465	0.012	0.278	6.38
6.0	12.6	1.52	0.766	0.365	5.235	0.022	0.237	7.53
7.0	13.6	1.52	0.774	0.967	1.927	0.024	0.228	7.87

4.1 Improvement Effect on Collapsibility

Significant Reduction in Coefficient of Collapse. After processing, the coefficients of each depth of collapse decreased to below 0.024 (original value of 0.028-0.774), with a decrease of 53% -99%. Especially at a depth of 6-7 meters, the collapsibility coefficient decreased from>0.7 to 0.022-0.024, indicating that the lime soil compaction pile effectively eliminates the collapsibility of deep loess. This is because the squeezing effect of the pile body destroys the large pore structure of loess, reducing the migration channels for dissolved salts in water. As show in figure 1.

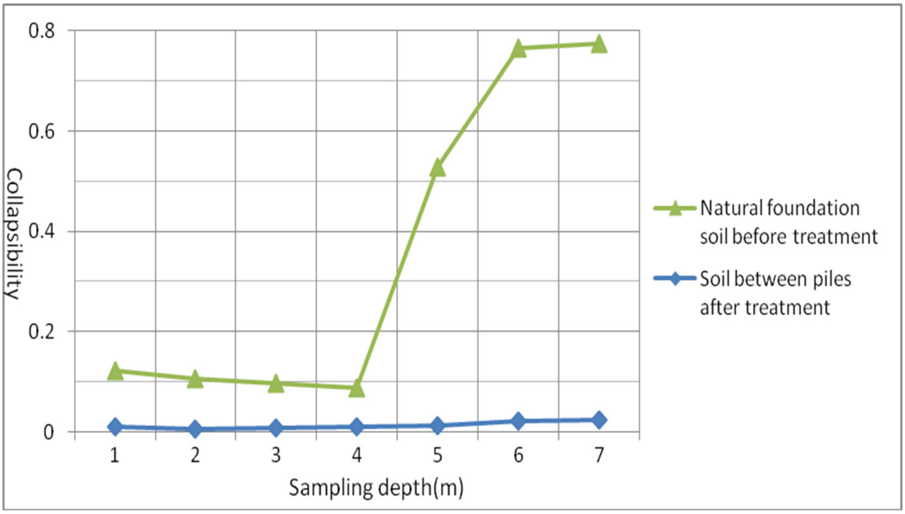

Fig. 1. Variation of collapsibility coefficient with depth before and after treatment.

Depth Difference in Processing Effect. The shallow (1-3m) collapsibility coefficient decreases to 0.006-0.010, with an elimination rate of>90%.

The deep (5-7m) collapsibility coefficient still exists at 0.012-0.024, which may be related to pile length limitations or the influence of groundwater level.

4.2 Compressibility change characteristics

Overall Optimization of Compression Coefficient. As shown in Table 4, the data on the variation of soil compression coefficient before and after the treatment of lime soil compaction piles indicate a significant improvement in the compressibility of the soil between piles, which is in line with the collaborative bearing mechanism of composite foundations[15].

Table 4. Changes in Foundation Compression Coefficient Before and After Treatment with Lime Soil Compaction Pile.

Depth (m)	decrease before treatment (MPa^{-1})	decrease after treatment (MPa^{-1})	compression coefficient reduction
1.0	0.374	0.180	52%
2.0	0.606	0.177	71%
3.0	0.172	0.138	20%

Local Abnormal Phenomena. The compression coefficient at 5.0m increased from 1.261 to 0.278, but still meets the requirements for foundation bearing capacity. The compression modulus at 4.0m decreased from 6.025MPa to 8.12MPa. Possible reasons: Uneven pile material or insufficient local compaction.

4.3 Correlation of Key Parameters

Moisture Content and Treatment Effect. After treatment, the moisture content remains at 8.7-13.6%, which meets the control standard of<24% as required by the specifications. The deep layer (6-7m) has a higher moisture content (12.6-13.6%), corresponding to a larger residual value of the collapsibility coefficient, which confirms the sensitivity of moisture content to treatment effectiveness.

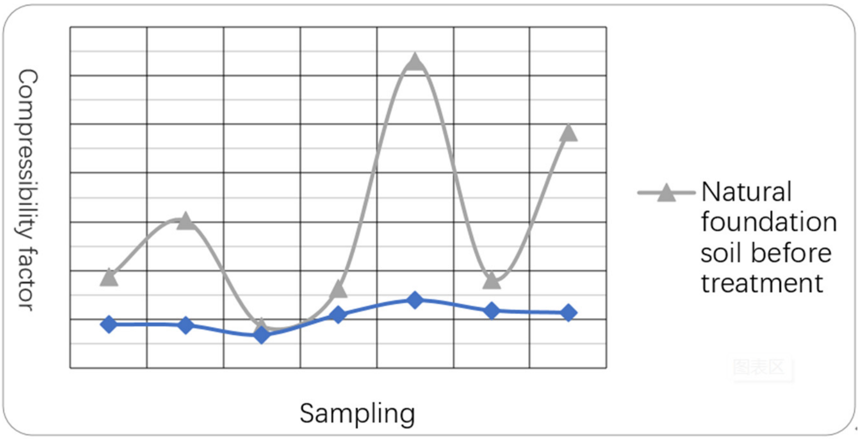

Fig. 2. Variation of compressibility coefficient with depth before and after treatment.

After being treated with lime soil compaction piles, the compression coefficient decreases and the compressibility decreases. After processing, the compression coefficient gradually increases with depth and significantly decreases compared to before processing, as shown in Figure 2. The average reduction rate reaches 52%, and the greater the compression coefficient, the more obvious the reduction effect. The maximum reduction rate reaches 78%.

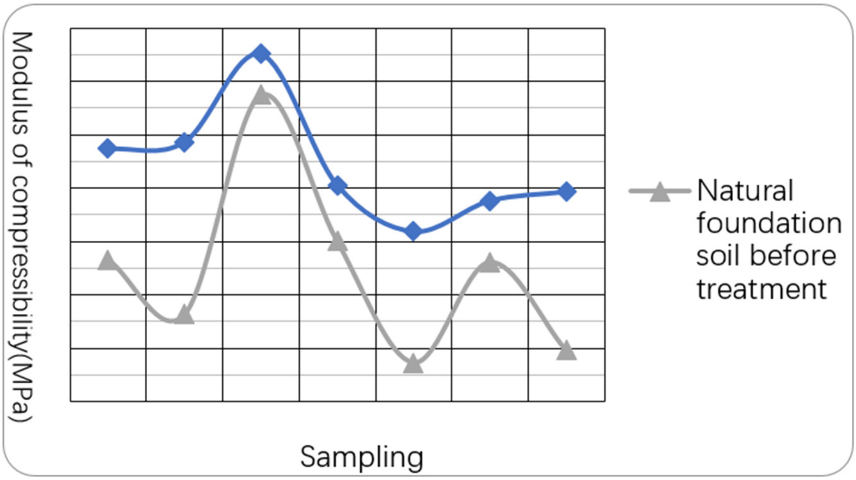

Fig. 3. Variation of foundation compression modulus with depth before and after treatment

As show in figure 3. After the lime soil compaction pile treatment, the compression modulus of the foundation is significantly improved, the soil strength is improved, and the compressibility is reduced. The compression modulus of foundation increases with depth and then decreases. After treatment, the compression modulus of the foundation is significantly improved, with an average increase of 144%. The deeper the depth, the more obvious the effect is, and the maximum increase is 335%.

The collapsibility coefficient and compression modulus of the lime soil compaction pile in the fifth year after treatment are shown in Table 5.

Table 5. Foundation collapsibility coefficient and compression modulus after 5 years of lime soil compaction pile treatment

Sampling depth (m)	Soil between piles in the 5th year after treatment		
	Collapsibility coefficient	Compressibility factor (MPa^{-1})	Modulus of compressibility (MPa)
1.0	0.007	0.087	19.723
2.0	0.004	0.105	19.233
3.0	0.006	0.057	23.472
4.0	0.007	0.094	17.232
5.0	0.007	0.078	14.012
6.0	0.011	0.083	16.551
7.0	0.013	0.081	16.851

After being treated with lime soil compaction piles, the collapsibility coefficient stabilized at ≤ 0.013 in the fifth year, and the collapsibility was completely eliminated. Under long-term bonding reactions (such as the formation of compounds such as calcium silicate from lime and clay minerals), the soil structure's ability to resist water softening continues to increase, and there is no phenomenon of collapsible rebound. After 5 years, the compression coefficient of the soil further decreases and stabilizes in the range of 0.05-0.10 MPa^{-1} due to self weight consolidation and cement precipitation. Due to the continuous consolidation and bonding strengthening of the soil, the compression modulus ranges from 6-13 MPa in the initial stage after treatment to 14-20 MPa in the fifth year after treatment.

5 Conclusions

The lime soil compaction pile method can eliminate the collapsibility and improve the bearing capacity. After the treatment of lime soil compaction pile, it can be concluded that the collapsibility coefficient is reduced and the collapsibility elimination effect is better; The higher the compression coefficient, the more obvious the effect, and the lower the compressibility; The compression modulus of the foundation is significantly improved, and the strength of the soil is improved.

Lime soil compaction pile technology in collapsible loess foundation treatment of highway engineering can effectively improve the bearing capacity of foundation soil, but when using this technology for construction, it is necessary to carefully investigate and analyze the specific situation of the construction site, and reasonably select the method of soil pile compaction construction in combination with the actual situation, so as to ensure the rationality and effectiveness of the construction method, so as to ensure the construction quality of highway engineering.

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