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# Cause Analysis and Rectification Practice of Settlement Problems in Football Fields with High Fill Subgrade

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**Abstract: In the construction of landscape engineering, the construction quality of high fill areas directly affects the overall stability of the project. For large-area sites such as football fields, non-standard backfill treatment and construction technology tend to induce quality hazards including settlement and collapse. Based on the practical construction experience of the football field in Shenyang Evergrande Green Town, this paper elaborates the settlement and collapse problems occurred during the construction of the football field, deeply analyzes the core causes, summarizes targeted rectification measures and practical experience, and extracts key management points in construction. It provides practical references for the construction and settlement control of football fields in high fill areas of cold northern regions, and also offers experience for construction quality control, project risk prevention and whole-process management of similar landscape projects, so as to improve the construction quality and project management level of landscape engineering and avoid similar settlement hazards.**

**Keywords: Landscape Construction; High Fill; Football Field; Settlement Problem; Cause Analysis; Rectification Practice; Cold Northern Regions**

## 1. Project Overview

Shenyang Evergrande Green Town is located in Shenbei New District, Shenyang City. A standard football field is provided as one of the core supporting facilities. As the core landscape and functional area of the project, the football field serves for leisure, exhibition and supporting use, designed to meet owners' leisure and sports needs while achieving landscape presentation effects. The design elevation of the football field is higher than the original ground level, requiring soil backfilling up to 3 m to reach the design elevation, so as to meet the construction and application requirements of the football field.

The overall construction period of the project is from April 2019 to August 2019, among which the football field construction phase is from May 2019 to July 2019. The construction scope includes backfill works, structural layer paving and artificial turf installation. The football field adopts a standard site specification, and its structural layer is designed with reference to asphalt road standards. From top to bottom, it consists of artificial turf surface course, 100 mm-thick asphalt concrete layer, 200 mm-thick cement-stabilized macadam layer, and 300 mm-thick graded macadam subbase. The overall structure conforms to the construction specifications for landscape football fields. Strict quality control was implemented during structural layer construction to ensure compliance with design standards.

However, obvious uneven settlement occurred after the completion and handover of the football field, resulting in wrinkling and damage of the surface artificial turf and local collapse in some areas, which seriously affected the normal use and landscape effect of the football field. Based on the whole construction process of the football field in this project, this paper analyzes the causes of settlement and collapse in detail, sorts out rectification measures and practical experience, and provides a practical reference for the construction of football fields in similar high fill areas.

The project is located in a cold northern region with a high groundwater level (approximately 1.5 m deep). The minimum temperature in winter can reach −20 ℃, and the temperature in summer is relatively high, with obvious freeze-thaw cycles. Such special climatic and geological conditions bring certain difficulties to backfill construction and settlement control of the football field. Meanwhile, the project had to balance construction progress during implementation, leading to simplified procedures in some links, which eventually caused

settlement and collapse of the football field. This also made us deeply realize the importance of construction specifications in high fill areas.

## 2. Specific Manifestations of Settlement Problems in the Football Field

After the completion of the football field in Shenyang Evergrande Green Town, obvious settlement was gradually detected during subsequent operation and inspection, showing obvious characteristics of uneven settlement. The specific manifestations are as follows:

First, local collapse occurred on the site, especially in the area east of the central axis, which was closely related to the thawing of frozen soil blocks in the backfill. The surface artificial turf in this area was wrinkled and damaged, and sunken in some parts due to settlement, failing to maintain flatness and seriously impairing the appearance and function of the site. Second, the site flatness was seriously out of tolerance. Measured by a level, the maximum deviation between the settled area and the design elevation reached 278 mm. The settlement in the area east of the central axis was more significant due to the thawing of frozen soil blocks, forming obvious local depressions. Third, site drainage was affected. Settlement caused abnormal site slopes and local water accumulation, which could not be drained timely on rainy days and further aggravated site damage.

Through on-site investigation and data measurement, the site elevation was accurately detected with a level, and an isobath map of the collapsed area was drawn. It was confirmed that the most serious settlement occurred east of the central axis, where frozen soil blocks were concentrated in the early backfill. The maximum settlement depth reached 278 mm, with typical uneven settlement characteristics: surface asphalt concrete cracking, loosening of graded macadam subbase due to settlement, detachment between cement-stabilized macadam layer and asphalt layer in some areas, and stretching and damage of artificial turf, which failed to meet normal use requirements.

In addition, the settlement showed obvious regional differences. The area west of the central axis had relatively slight settlement with only a few fine cracks because of fewer frozen soil blocks in the backfill. In contrast, the area east of the central axis suffered prominent settlement due to concentrated frozen soil blocks and insufficient compaction in the early stage, forming an uneven settlement pattern of “heavy in the east and light in the west”, which brought great difficulties to later rectification.

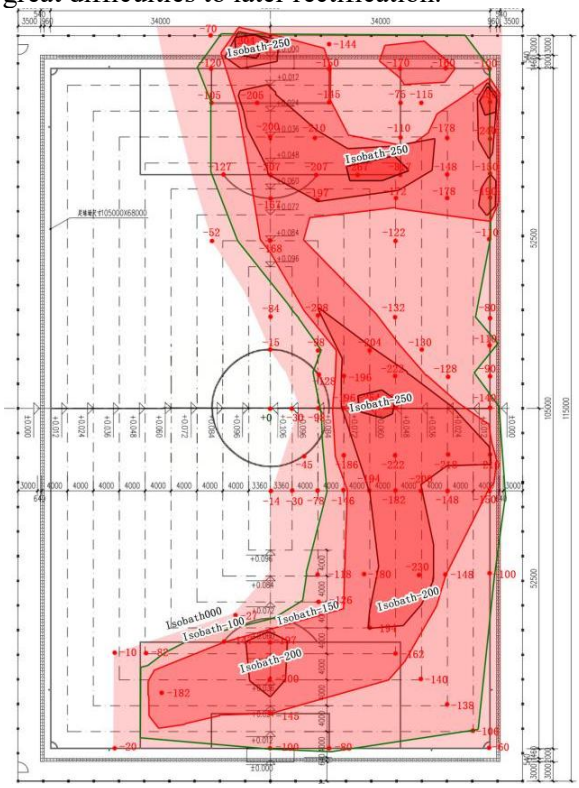


**Figure 1. Settlement Observation Drawing of Football Field, Shenyang Evergrande Green Town**

## 3. Analysis of Core Causes of Settlement Problems in the Football Field

Combined with the whole construction process and on-site investigation, through detailed inspection of the settled area, data verification and review, it is determined that the core causes of settlement are concentrated in three aspects: backfill treatment, construction technology and material selection, all of which are closely related to inadequate implementation of construction specifications. The specific analysis is as follows:

### 3.1 Non-Standard Selection and Treatment of Backfill, Creating Inherent Hidden Dangers for Settlement

The football field required high fill construction with a backfill height of 3 m. To achieve earthwork balance and save construction costs, the project used spoil excavated from the main building foundation pit as backfill, which had not been strictly screened or treated, containing a large number of frozen soil blocks and with high

moisture content. Since construction was carried out in winter and the groundwater level was high (1.5 m deep), frozen soil blocks in the backfill could not thaw in time and were directly used for high fill construction without air-drying or harmless treatment.

In the winter construction stage, frozen soil blocks were in a frozen and consolidated state, which could temporarily maintain certain structural strength without obvious quality defects. However, in summer, rising temperatures gradually thawed the frozen soil blocks, loosening the soil structure and significantly reducing bearing capacity. In addition, the backfill was not compacted in layers, increasing voids between soil particles and failing to form a stable stress system, eventually resulting in uneven settlement [1].

The area east of the central axis had a high proportion of frozen soil blocks in the backfill, and the soil shrinkage and deformation after thawing were more prominent, making it an area concentrated with settlement and collapse, which was significantly different from the western area. This phenomenon fully indicates that the quality of backfill materials is a key factor determining the stability of the site [2].

### 3.2 Non-Standard Construction Technology and Inadequate Layered Rolling

During construction, due to tight construction schedule, there was a tendency of "emphasizing progress over quality", and layered backfilling and layered rolling were not strictly carried out in accordance with construction specifications, which became the direct inducement of settlement. According to landscape engineering construction specifications, backfill in high fill areas shall be rolled in layers, with each layer not exceeding 300 mm in thickness, and fully compacted by a road roller to ensure qualified soil compaction.

To speed up construction progress, layered rolling was not implemented on site. Instead, 3-m-thick backfill was placed at one time without layered paving, and only simple tamping was adopted without full compaction by a road roller, making it difficult for the backfill to meet the design compaction requirements [3].

The construction team did not conduct layered inspection on the backfill, failed to identify potential risks such as internal voids and frozen soil blocks in a timely manner, and blindly carried out upper structure construction without foundation bearing capacity test. Limited by site conditions, the road roller could not work normally, and only manual simple tamping was used in the early stage, resulting in far from satisfactory compaction and poor interparticle bonding. The soil was prone to compressive deformation under structural load and external environment, eventually leading to site collapse [4].

Although graded macadam subbase, cement-stabilized macadam layer and asphalt layer were paved in strict accordance with design requirements during structural layer construction to ensure qualified construction quality of each layer, the insufficient stability of the lower backfill foundation made it unable to provide effective support when upper structure load was transferred to the soil, eventually causing overall settlement and collapse of the site, showing a state of "qualified upper structure but invalid lower foundation" [5].

### 3.3 Lack of Material Control and Unscientific Use of Frozen Soil Blocks

In this construction, there were obvious omissions in material control, mainly reflected in two aspects: first, backfill was not strictly screened, and spoil from the main building foundation pit was directly used, which had high moisture content, many impurities and a large number of frozen soil blocks, and was directly used for high fill construction without air-drying, screening or other harmless treatment; second, the quality inspection of backfill was inadequate, and unqualified materials such as frozen soil blocks and sludge were not detected.

After complete thawing of frozen soil blocks, the integrity of the soil structure was damaged, and the overall bearing capacity dropped sharply, making it difficult to meet the stress requirements of the site [6].

Later review shows that after frozen soil blocks thawed in summer, the soil at corresponding positions shrank significantly, forming local voids, which further led to uneven stress on the upper structure and induced local collapse. Meanwhile, due to the uneven distribution of frozen soil blocks in the backfill, the settlement in the eastern area was significantly higher than that in other areas, forming an uneven settlement situation, with out-of-tolerance site flatness and prominent water accumulation in rainy days [7].

## 4. Rectification Measures and Practice for

**Settlement Problems in the Football Field**

In view of the settlement and collapse of the football field, a targeted rectification plan was formulated based on actual site conditions, and rectification was carried out in phases with a balance between rectification effect and cost control. The specific measures and practice are as follows:

### 4.1 Preliminary Investigation and Detection

The project team first organized professional technicians to conduct a comprehensive survey of the settled area, accurately measured the site elevation with a level and drew a settlement contour map to determine the scope, depth and distribution characteristics of severely settled areas, focusing on marking the deformation of the eastern area with concentrated frozen soil blocks. Meanwhile, backfill samples were taken for testing to analyze key indicators such as moisture content and compaction, confirming that settlement was caused by insufficient layered compaction and reduced bearing capacity due to thawing of frozen soil, providing data support for subsequent treatment [8].

### 4.2 Zonal Rectification with Priority for Severely Settled Areas

For the area east of the central axis with the most serious settlement, the surface artificial turf, asphalt layer and cement-stabilized macadam layer were removed layer by layer to expose the lower graded macadam subbase. An excavator was used to clean loose soil and frozen soil debris in the depressed area. Then graded macadam was relaid and compacted in layers in accordance with specifications, with a single layer thickness controlled within 300 mm to ensure qualified subbase compaction. Afterwards, the cement-stabilized macadam layer, asphalt layer and artificial turf were restored in sequence to restore the site to a flat state [9].

For the area west of the central axis with slight settlement, local patching was adopted: the surface artificial turf and asphalt layer were uncovered, the depressed area was filled with asphalt mixture, and the artificial turf was relaid after compaction to ensure that the site flatness met design requirements. During rectification, the thickness and paving quality of each structural layer were strictly controlled to avoid new settlement hazards caused by rectification construction.

### 4.3 Rectification Effect and Follow-up Tracking

After rectification, the settlement of the football field was initially controlled, and the site flatness basically met design requirements, capable of meeting normal use functions. However, during follow-up tracking, slight settlement still existed in some areas, mainly because the deep backfill was not fully compacted and the soil shrinkage after thawing of frozen soil blocks was not completely stable. To this end, a regular inspection mechanism was established, and the site elevation was regularly detected with a level to track settlement changes and handle slight settlement problems in a timely manner to avoid the expansion of hazards.

In this rectification, an economical and efficient scheme was prioritized to avoid large-scale rework, and the rectification cost was minimized on the premise of ensuring quality. However, due to non-standard backfill construction in the early stage, certain deviations in site flatness still existed after rectification, and slight water accumulation still occurred in some areas on rainy days, failing to fully achieve the ideal effect. This has become one of the most profound lessons in this construction.

## 5. Summary and Reflection on Construction Experience

Based on the practical experience of settlement problems of the football field in Shenyang Evergrande Green Town, and through reviewing the whole construction process and rectification practice, the core points and experience lessons for football field construction in high fill areas are summarized, and the importance of construction specifications is deeply recognized, as detailed below:

### 5.1 Strictly Abide by the Principle of Layered Backfilling and Layered Rolling to Consolidate Foundation Quality

In high fill site construction, layered filling and layered compaction are the core processes to ensure soil compaction and control settlement, and also the basic requirements for landscape engineering construction. In this project, the layered rolling system was not strictly implemented, and one-time stacking was adopted, resulting in insufficient compaction and induced settlement. Based on practical experience, the thickness of each layer of high

fill backfill should be controlled within 300 mm, fully compacted by a road roller to ensure that soil compaction meets requirements; soil with high moisture content should be air-dried in advance to reduce moisture content before compaction, so as to avoid deformation caused by loose soil [3].

The effective compaction depth of a road roller is about 300 mm, and exceeding this thickness makes it difficult to ensure compaction quality, so the layered thickness shall not exceed the specification limit. This requirement is not a formal provision, but engineering experience formed based on soil stress characteristics. Ignoring this requirement will inevitably lead to insufficient compaction and induce later settlement deformation [4].

### 5.2 Strictly Control Backfill Quality and Prohibit the Use of Unqualified Materials

The quality of backfill materials directly determines the long-term stability of high fill areas. An important inducement of settlement in this project was the use of foundation pit spoil containing a large number of frozen soil blocks without pretreatment. Therefore, unqualified fillers such as untreated frozen soil and sludge are strictly prohibited in high fill construction. Backfill must be screened and air-dried to ensure that moisture content and gradation meet requirements; soil containing frozen soil blocks must be fully thawed, air-dried and purified before use to avoid soil shrinkage and bearing capacity reduction caused by frozen soil thawing [2,6].

### 5.3 Strengthen Construction Process Control and Eliminate Simplified Processes

Even with a tight construction schedule, key processes shall not be arbitrarily simplified during construction, especially core links such as layered compaction, material inspection and foundation bearing capacity test. In this project, the failure to carry out bearing capacity test led to the failure to identify frozen soil hazards in a timely manner; the failure to implement layered rolling resulted in insufficient soil compaction, both of which are important causes of settlement. Therefore, the control system should be improved in subsequent construction, process quality standards should be clarified, special personnel should be assigned to on-site control, key links should be strictly checked, and the management idea of emphasizing progress over quality should be abandoned [3,4].

### 5.4 Pay Attention to the Impact of Climatic Factors on Construction and Optimize Construction Arrangement

The temperature in Shenyang is low in winter with widespread frozen soil. Winter backfilling operations are prone to quality defects, which will lead to subsequent diseases if not properly handled [10]. Climatic impacts on backfill quality should be fully considered during construction, and untreated frozen soil should be avoided for backfilling in winter. Meanwhile, the temperature is high in summer and frozen soil thaws rapidly. Early prediction should be made on thawing settlement risks, construction processes should be reasonably arranged, and the peak period of frozen soil construction in winter should be avoided to ensure backfill quality and compaction effect [7].

### 5.5 Establish a Sound Settlement Monitoring Mechanism and Dispose of Hidden Dangers in a Timely Manner

A regular monitoring system should be established for high fill football field construction. Regular elevation observation should be carried out with a level, and a settlement change curve should be drawn to identify slight settlement hazards at an early stage and prevent minor problems from escalating. Targeted repair technologies can be adopted for sports fields with uneven settlement to effectively control disease development and restore service functions [11]. In this project, the lack of a sound monitoring mechanism led to the failure to detect settlement signs caused by frozen soil thawing in a timely manner, resulting in the expansion of problems and increased treatment cost and difficulty [8,9].

## 6. Conclusion

The core of football field construction in high fill areas of landscape engineering lies in controlling backfill quality, strictly implementing layered rolling specifications, and strengthening construction process control. The settlement problem of the football field in Shenyang Evergrande Green Town is essentially caused by inadequate implementation of construction specifications and lack of material control. It also makes us deeply realize that every requirement in construction specifications is experience summarized from engineering

practice. Only by respecting specifications and strictly implementing them can we avoid quality hazards such as settlement, ensure project quality and extend service life. The experience and lessons summarized from this project can provide a practical reference for the construction of football fields in similar high fill areas in cold northern regions, help the industry avoid similar quality problems, and promote the improvement of landscape engineering construction quality.

**References**

[1] Zhang C L. Mechanism and treatment technology of uneven settlement of high fill subgrade. Highway Engineering, 2022, 47(3): 112-116.
[2] Li Y, Wang J H. Experimental study on thaw settlement characteristics of high fill site in seasonal frozen soil region. Journal of Glaciology and Geocryology, 2022, 44(2): 310-317.
[3] Li J. Study on compaction quality control of backfill in landscape engineering. Landscape Architecture, 2023(4): 88-92.
[4] Li C. Settlement control technology of sports field foundation in cold northern regions with freeze-thaw cycles. Sports Science Research, 2023, 44(2): 76-81.
[5] Li M Z. Analysis on settlement deformation law of high moisture content backfill foundation. Construction Technology, 2023, 52(6): 90-93.
[6] Li S. Treatment of base diseases of high fill artificial turf football field. Urban Mass Transit, 2024, 27(S1): 366-369.
[7] Zhao Y. Stability analysis of high fill subgrade under freeze-thaw cycles. Low Temperature Architecture Technology, 2024, 46(1): 125-128.
[8] Wang H. Research on settlement monitoring and early warning technology of high fill site. Geotechnical Investigation & Surveying, 2024, 52(2): 67-72.
[9] Chen X. Quality control points of high fill construction for landscape sites. Modern Landscape Architecture, 2024, 21(3): 77-81.
[10] Zhou M. Construction defects and rectification measures of winter backfilling in northern China. Building Technology, 2024, 55(4): 456-459.
[11] Huang Z Q. Engineering practice of uneven settlement repair technology for sports fields. Construction Technology, 2024, 53(8): 102-105.