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# Lifting Grouting Technology for Settlement Control of Existing Operating Subway Tunnels

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**Abstract:** This paper focuses on the settlement issues of existing operating subway tunnels, delving into their causes, the principles of lifting grouting technology, and construction techniques. Settlement causes are analyzed from four aspects: construction quality, geological conditions, subway operations, and surrounding environment. Lifting grouting technology addresses settlements through filling, reinforcement, and lifting. The construction technique covers preparation, hole layout, grouting procedures, and monitoring. This research offers a technical foundation and practical guidance for controlling settlement in operating subway tunnels.

**Keywords:** Existing operating subway tunnels, settlement control, grouting lifting technology, construction technology.

## 1. Introduction

### 1.1. Research Background and Significance

Urbanization has led to growing city populations and severe traffic congestion. As an efficient, fast, and eco - friendly urban rail transit mode, subways play a crucial role in alleviating traffic pressure, optimizing transport structures, and enhancing city images. Tunnel settlement negatively impacts subway operations. Structurally, it can cause lining cracks, deformations, or collapses, threatening tunnel stability. Operationally, it alters track geometry, reducing ride smoothness and increasing derailment risks.

Lifting grouting is a key solution for tunnel settlement. By injecting grout into the ground below or around tunnels, it fills soil voids, enhancing soil strength and stiffness for tunnel lifting and settlement control. This restores tunnel elevation and track smoothness, ensuring subway safety. Compared to reconstruction, it's simpler, less disruptive, and cheaper, with proven effectiveness in practical applications.

### 1.2. Research Content and Methods

This paper explores the principles of lifting grouting technology, analyzing its mechanisms in controlling settlement in existing tunnels. It looks at grout diffusion in soil and soil - grout interactions. It also examines construction processes like material selection, equipment Commissioning, hole layout, and pressure control. Moreover, it establishes an evaluation system to assess post - grouting settlement control, track smoothness, and structural safety, combining theoretical analysis, numerical simulation, and field monitoring.

## 2. Analysis of Settlement Causes in Existing Operating Subway Tunnels

### 2.1. Construction Quality Issues

Construction quality is vital for tunnel stability. shield machine selection and lining quality are key. Improper shield machine selection increases ground disturbance, while lining defects like voids reduce tunnel strength, leading to settlement.

### 2.2. Geological Factors

Geological conditions, especially groundwater level changes, significantly impact tunnel stability. High groundwater levels reduce soil effective stress, weakening soil strength and leading to tunnel settlement.

### 2.3. Impact of Metro Operations

Train operations cause vibrations, applying dynamic loads to tunnel structures. Factors like train braking and track irregularities aggravate this effect, increasing settlement risks.

### 2.4. Influence of Surrounding Environment

Urban underground space development, such as underground malls or parking lots, alters soil structure and stress around tunnels. Construction techniques like shield tunneling and pipe jacking can cause ground deformation and tunnel settlement.

## 3. Principles of Lifting Grouting Construction Technology

### 3.1. Mechanism of Lifting Grouting

Lifting grouting lifts tunnels by injecting grout into the ground below to fill voids and strengthen soil. It involves filling, reinforcement, and lifting. Filling voids improve soil bearing capacity, reinforcement boosts soil strength through physicochemical reactions, and lifting elevates tunnels via grout pressure.

### 3.2. Principles of Different Grouting Methods

Common grouting methods include static pressure grouting, high - pressure jet grouting, and fracturing grouting. Static pressure grouting uses hydraulic, pneumatic, or electrochemical principles to inject curable grout. High - pressure jet grouting cuts soil with high - pressure jets, forming solid masses. Fracturing grouting uses high - pressure fluid to fracture the formation, improving grout injectability and diffusion.

# 4. Lifting Grouting Construction Technology

## 4.1. Construction Preparation

Pre - construction geological investigation is crucial. It involves in - depth investigation of tunnel - surrounding geological conditions using various means.

Obtaining information such as lithology, soil structure, and soil parameters at different depths through geological drilling.

## 4.2. Grouting Hole Layout and Drilling

Grouting hole layout impacts grout diffusion and lifting effects. The principle of uniform and symmetrical distribution applies, with holes arranged bilaterally and centrally under the tunnel. During drilling, ensure verticality to avoid deviations, and clear holes of debris.

## 4.3. Grouting Construction Process

Grouting equipment installation must follow operating procedures. Equipment like grouting pumps and stirrers are installed stably, with connected pipelines properly sealed. Grout preparation is crucial, with accurate material measurement as per designed ratios. Grouting is carried out by inserting grouting tubes to designed depths, with pressure and flow rate controlled according to construction requirements.

## 4.4. Construction Monitoring and Control

Monitoring and controlling key parameters during grouting ensures construction safety and effectiveness. Tunnel deformation monitoring involves measuring settlement, displacement, and convergence. Grouting pressure and volume are strictly controlled within design ranges.

# 5. Conclusions and Prospects

This study thoroughly analyzed settlement causes in existing subway tunnels and systematically discussed the principles and techniques of lifting grouting. It identified main settlement causes and revealed grouting - related characteristics and principles. The research on construction technology covered preparation, hole layout, grouting processes, and monitoring.

As subway construction continues to develop, settlement problems in existing tunnels will remain a key concern. Lifting grouting technology, being an important means to solve tunnel settlement, is expected to have broad prospects for further research and application.

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