

# Study on comprehensive utilization and management of tunnel slag in Expressway

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**Abstract.** Based on the investigation of the comprehensive utilization technology of tunnel slag in expressway, the author finds that combining with the characteristics of the project, planning scientific management content, formulating reasonable utilization principles, and implementing the measures and control of the tunnel slag gravel yard and the waste slag yard can improve the recycling utilization rate of tunnel slag, reduce the amount of tunnel slag waste, reduce the land occupation and damage the ecological environment.

## 1 Introduction

The excavation of tunnels in highway construction in mountainous areas will produce a lot of waste tunnel slag, which will easily cause ecological damage and soil erosion. In order to solve the problem of tunnel slag, the current practice is to strengthen the classification, processing and use management of tunnel slag, improve the recycling rate of tunnel slag, reduce the volume of tunnel slag, so as to reduce the occupation of land and damage the ecological environment. Based on the investigation results of the comprehensive utilization technology of tunnel slag in expressway, the author finds that the comprehensive utilization effect of tunnel slag can be achieved by formulating the principles of tunnel slag utilization and implementing the management and control measures of "two fields" of tunnel slag macadam field and waste slag field through the "three stages" of planning design, bidding and construction, which has certain guiding and promotion significance.

## 2 "Three stage" tunnel slag management content

Before the comprehensive utilization of tunnel slag, the construction unit shall take the "overall planning of the owner", "planning in advance" and "strict implementation" as the guiding principles, and organize the planning and implementation of the comprehensive utilization of tunnel slag as a whole. According to the different characteristics of the design, bidding and construction stages, the management content is uniformly deployed.

### 2.1 Design stage management procedure

*(1) The design unit shall include the allocation and utilization of tunnel slag and the disposal of waste slag into the design documents, and clarify the utilization principle and mode of tunnel slag in combination with the type of design surrounding rock.*

*(2) The design unit shall incorporate the utilization of tunnel slag into the balanced allocation of earth and stone work, and clarify the technical parameter requirements for the application of tunnel slag to the subgrade filling of main works, the backfilling of bridge and culvert abutment back, the filling area and the filling of back pressure berm.*

*(3) The design unit makes statistics on the amount of tunnel slag that can be processed and used in the pavement crushed stone aggregate, and analyzes the economic benefits.*

*(4) In the process of construction drawing budget preparation, for the project involving the utilization of tunnel slag, the unit price of the project considers the full and reasonable utilization of tunnel slag and reduces the cost.*

### 2.2 Bidding stage management procedure

*(1) In combination with the division of civil construction sections, binding bidding is adopted to bind subgrade or pavement works with long and large tunnel works. In the process of construction drawing budget preparation, for the project involving the utilization of tunnel slag, the unit price of the project considers the full and reasonable utilization of tunnel slag and reduces the cost.*

*(2) In the bidding document and the contract, it is clearly agreed that the relevant work contents of the participating units related to the utilization of tunnel slag, and the relevant responsibilities are written into the general special contract terms of the bidding document.*

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## 2.3 Construction stage management procedure

(1) *The construction unit shall make a reasonable construction organization plan, try to advance the tunnel construction, plan and set up the tunnel slag processing production line in advance, so as to create conditions for the full utilization of tunnel slag.*

(2) *Combined with the design and field investigation, considering the temporary land use, economic transportation distance, environmental protection, water and soil conservation and other factors, optimize the location of the tunnel slag processing production line and waste slag yard.*

(3) *According to the design documents, the construction unit shall formulate a detailed scheme for the utilization of tunnel slag, and make reasonable adjustment in the implementation process in combination with the dynamic change of tunnel surrounding rock and the actual construction progress of subgrade, bridge and culvert works.*

(4) *The construction unit shall make full use of the tunnel slag in asphalt pavement, cement pavement, masonry protection and drainage, stone filled embankment, back filling of bridge and culvert abutment, back filling of retaining structure, filling area and other engineering structures and parts. The gravel, machine-made sand and stone powder produced by the tunnel slag processing shall meet the relevant parameter requirements of relevant design and technical specifications and standards when specifically applied to the construction.*

## 3 Utilization principle of tunnel slag

### 3.1 Principle of priority utilization

According to the performance requirements of the structure and parts of the tunnel slag utilization on the gravel, sand, stone powder and other materials, combined with the surrounding rock conditions of the tunnel, the tunnel slag stone should be fully utilized in different levels. It is suggested that it should be applied to the graded aggregate of asphalt concrete and cement concrete first, then to the water stable base of the pavement, gravel cushion, masonry structure, and finally to the subgrade filler and knot. Backfill behind the structure, and finally consider the application in the filling area, back pressure berm filling, etc.

### 3.2 Classification and use principle

According to the code for rock test of Highway Engineering (JTG e41-2005), the surrounding rock is simply identified, and its physical properties are determined by water content, water absorption, expansion and collapse resistance tests, and its mechanical properties are determined by uniaxial compressive strength, uniaxial compression deformation, shear strength, point load strength and flexural strength tests. Then the surrounding rock is classified and its main purpose is determined.

## 4 "Two field" measures control

### 4.1 Management of gravel field

The management of gravel field is mainly to implement the control measures in site selection, equipment and processing technology selection, quality control, water and soil conservation and environmental protection.

(1) *Site selection requirements for gravel yard.*

1) It shall meet the land occupation requirements of the tunnel slag storage area, processing area and finished product area, and the transportation distance between the gravel yard and the tunnel mouth, the waste slag yard and the mixing station shall be appropriate;

2) It is convenient for soil and water conservation, vegetation restoration and environment beautification.

(2) *Reasonably determine the model of macadam processing equipment.*

1) It is necessary to consider the adaptability of the equipment to the tunnel slag rock to ensure the processing quality and production capacity.

2) Try to choose equipment of uniform specification for maintenance.

(3) *Hole slag processing technology.*

1) Process selection:

The classification and grade of surrounding rock are quite different. According to the mechanical, physical and chemical characteristics of surrounding rock, the stone processing technology should be selected, the crushing machinery and mechanical combination should be reasonably selected for gravel production, and the efficient vibrating screen machinery should be used for gravel screening and the reasonable size and screen ratio of vibrating screen holes should be selected, so as to meet the requirements of matching stone quality of subgrade filler and pavement aggregate grade. Different requirements.

2) Processing machinery and equipment:

The main mechanical equipment used for stone processing are: feeder, jaw crusher, cone crusher, impact crusher, vertical shaft impact crusher, vibrating screen machine, spiral sand washing machine and sand making machine.

3) Production process of three-stage broken surrounding rock

Three level standardized process flow for processing broken surrounding rock: feeder jaw crusher → Shaker cone crusher → Impact crusher or vertical shaft impact crusher (+ dedusting equipment) → Shaker (+ dedusting equipment) → Finished product (graded crushed stone)

5mm aggregate → Spiral sand washing machine → System sand machine → Finished product (machine-made sand)

(4) Quality control method of surrounding rock used as sand and stone aggregate

The common quality problems of sand and stone aggregate are: multiple crushing, separation, mixing, pollution and the content of soft particles exceeds the standard, etc. in addition, there are the control problems of water content, fineness modulus and stone powder

content of sand. The specific control methods are as follows:

1) Quality control of surrounding rock base material

The quality of base metal can be guaranteed by testing the compressive strength of rock, controlling the mud content (including mud block), controlling the whole process of mixed debris and controlling the content of soft particles.

2) Production process control

The process control measures include crushing system control, screen washing system control, needle and flake particle control, water content control of fine aggregate and fineness modulus control of fine aggregate.

3) Establish inspection and acceptance system for finished products

Formulate the inspection system for production and storage of finished aggregate, prevent aggregate crushing, separation and mixing, prevent finished aggregate pollution, and conduct field inspection for the content of machine sand and stone powder, fineness modulus, mud content of gravel, grading and other indicators.

(5) Soil and water conservation and environmental protection

In the construction process of the gravel yard, the key point of environmental control is the soil and water conservation of the tunnel slag yard and the environmental protection of the tunnel slag processing yard.

1) Requirements for soil and water conservation of tunnelling slag yard

a) Before the construction of tunnel slag filling, a certain number of drainage ditches shall be set around the tunnel slag storage yard to divert the surface water during the rainfall to the outside of the storage yard through the drainage ditch, and the intercepting ditch shall be well constructed to prevent the rainwater from forming runoff on the surface of the new abandoned tunnel slag to scour the new surface and cause pollution under the tunnel slag storage yard.

b) During the stacking process of tunnel slag, the construction shall be carried out in strict accordance with the paving and rolling procedures, and it is strictly prohibited to pave the new slag layer directly without rolling. During the spreading process of the slag layer, according to the construction progress, a slope potential of low inside and high outside will be formed. A certain number of gullies will be set up on the drainage ditch around the stacking yard to deposit the soil in the water step by step through the drop.

c) Grasp the weather change and local flood situation in time, and do a good job of dredging the drainage ditch and collecting channel around the stacking yard in advance to ensure the drainage ditch and other facilities are dredged.

d) Green vegetation protection shall be carried out on the mountain slope around the tunnel slag yard to reduce soil erosion and rainwater erosion on the slope.

e) Hardening treatment shall be carried out for the ground in the area of tunnel slag storage yard, and drainage ditch shall be set to prevent rainwater from scouring the ground and access road.

2) Requirements for environmental protection of tunnel slag processing plant

a) The waste water, waste oil and other harmful substances of tunnel slag processing machinery, equipment and machinery as well as domestic sewage shall be collected and treated in a centralized way, and shall not be directly discharged into rivers or other waters, nor poured into the land near the drinking water source, so as to prevent pollution of water source and soil.

b) It is forbidden to burn linoleum, rubber, plastic, leather, trees, dead grass, all kinds of packing bags and other substances that may produce toxic or harmful smoke or odor at the construction site of the processing plant.

c) In the process of hole slag processing, watering equipment (fog gun machine or watering cart) shall be used for watering operation to reduce dust in the processing site and secondary pollution of aggregate finished products.

d) In the production process of crushed stone and machine-made sand, the part with more dust (screening workshop and sand making workshop) shall be closed locally or as a whole as much as possible, and professional dust removal equipment such as fog gun shall be set inside for dust reduction. If no sealing measures can be made, the induced air dust removal equipment shall be used for dust reduction.

e) In the processing plant area close to the residential area, the crushing workshop and screening workshop with high noise shall be equipped with sound insulation walls to control the noise generated by the system within the allowable range of environmental protection standards.

f) The buildings, trees, pipelines, water and electricity facilities that should not be removed near the tunnel slag processing plant shall be protected.

g) After the completion of hole slag processing, the processing equipment, surplus materials, garbage and various temporary facilities shall be cleaned up in time, and the site shall be reclaimed.

3.2 Waste disposal site management

The management of the waste disposal area is mainly to implement the control measures on site selection and soil and water conservation.

(1) waste disposal site selection

1) site selection principle

a) save land, occupy less arable land and protect natural landscape.

b) the capacity of the waste disposal site is basically consistent with the amount of waste slag.

c) it is convenient for soil and water conservation, vegetation restoration and environmental beautification.

(2) water and soil conservation protection measures

a) the intercepting and drainage system shall be arranged along the boundary of the land, the runoff shall be led into the grit chamber through the drainage ditch, and the sediment shall be discharged into the nearby drainage system after sedimentation in the grit chamber, and the mortar rubble slag retaining wall shall be set at the foot of the slope. The size of the grit chamber shall

be determined according to the actual treatment water volume, and its inlet and outlet shall be staggered.

b) The toe of waste slag slope shall be protected by mortar rubble retaining wall. Sand and pebble inverted filter drainage layer shall be set at the bottom of the back of the retaining wall. Water holes shall be set on the wall at a certain distance, and expansion joints shall be set every 10m. At the same time, the monitoring and measurement of retaining wall shall be done well, problems found shall be reported in time, and technical personnel shall be organized to adjust the protective measures.

c) After the completion of drainage and retaining works, the topsoil within the area occupied by the slag yard shall be stripped and stacked in the corner of the spoil yard without affecting the slag, and necessary protective measures shall be taken.

## **5 Consideration on the establishment of comprehensive utilization and management of tunnel slag**

### **5.1 management node for comprehensive utilization of tunnel slag**

The effectiveness of comprehensive utilization and management of tunnel slag is mainly reflected in three aspects: whether the "three stages" of design, bidding and construction are smoothly connected, whether the management measures of gravel field are efficient, and whether the environmental protection measures of gravel field and waste slag field are in place.

(1) in the design stage, sufficient planning and budget shall be carried out to provide financial support for the construction stage. In the bidding stage, reasonable bid sections shall be divided to provide feasibility guarantee for the construction stage, so as to promote the implementation of engineering measures in the construction stage. The seamless connection of the three is the basic guarantee for the effectiveness of comprehensive utilization and management of tunnel slag.

(2) From site selection to equipment and process selection to quality control, the targeted site design, process selection and quality inspection according to different surrounding rock grades and quantities directly affect the actual utilization rate of tunnel slag, which is the key link to improve the utilization rate of tunnel slag.

(3) The environmental protection measures of gravel yard and Waste Disposal Yard have a direct and far-reaching impact on the environment during the construction period and even the operation period. They are also the key areas supervised by the environmental protection department, which must be paid enough attention to, and the final management effect can be achieved by integrating the environmental protection concept into the management system.

### **5.2 deficiency and regret of comprehensive utilization management method of tunnel slag**

Although the management method of comprehensive utilization of tunnel slag fully considers the possible problems in various management links and puts forward corresponding management measures, due to the current limited survey technology, the complexity of tunnel engineering and other practical reasons, there are many uncertainties in the project, the site situation changes rapidly, and it may be necessary to temporarily adjust the site location and quantity, processing technology and so on. Methods can't be all inclusive.

There is not much research on the comprehensive utilization and management of tunnel slag in China, and the management ideas put forward by the author can only serve as a reference. It is hoped that the on-site construction personnel will innovate and improve again to make it more reasonable and practical.

## **6 conclusion**

Based on the research results of comprehensive utilization technology of tunnel slag in expressway, the author finds that through planning design, bidding and construction "Three-stage" management content, to achieve smooth connection of procedures, to formulate the principle of tunnel slag utilization, to determine the clear use of tunnel slag, and to implement the processing management measures of tunnel slag macadam yard and the environmental management and control measures of waste slag yard, it is a comprehensive utilization of tunnel slag. The management idea with better effect is used together, and has certain guidance and promotion significance.

It is hoped that the corresponding management system established by the above management ideas can fundamentally improve the comprehensive utilization rate of tunnel slag, reduce the impact of disposal on the environment, and reduce the project cost and construction cost. Of course, due to the limited level, we only hope to throw a brick to attract jade. We will discuss together to better apply the management ideas and methods of comprehensive utilization of tunnel slag in the engineering practice.

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