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Application of oblique-inserting slab-pile wall in highway slope

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Abstract
As a new type of highway slope retaining form developed with the landscape planting method, the oblique-inserting slab-pile wall has achieved certain development in recent years. On the basis of comparative and analysis of traditional vertical type slab-pile wall, this thesis confirms the merits of oblique-inserting slab-pile wall. The design concept and method of oblique-inserting slab-pile wall were analyzed; the construction technology and quality control measures of the wall were put forward. The article provides scientific basis and valuable experience for the same kind of slope support.

Keywords: oblique-inserting slab-pile wall; oblique-inserting slab; design; construction technology

Introduction
With the development of the social economic and the improvement of people's awareness of environmental protection, ecological environmental problems caused by highway construction have been emphasized by highway designers and managers. It seems to have become an important subject in the engineering construction today. Supporting and retaining structure is an important part in highway construction. Slap-pile wall has special advantages of small scale engineering, well retaining ability. So the slap-pile wall was widely used in highway construction in mountainous area. However, the structure forms of traditional slab-pile wall retaining plate are vertical and totally enclosed. It not only has the disadvantage of large engineering and poor drainage effect, its shape also not fit to the concept of the green channel and environmental protection. Oblique-inserting slab-pile wall is that the vertical retaining plate is changed into the slab-pile plate and space can be formed between the board and the wall. It is not only small amount of engineering, can meet the requirements of greening. In the role of slope support well, oblique-inserting slab-pile wall also improves environment, restore the landscape, so as to achieve coordination with the environment. Generally speaking, the slab-pile wall can be used to support cut slope and embankment slop in normal areas, inundated areas and earthquake areas, as well as landslide areas. This paper studied oblique-inserting slab-pile wall with theoretical analysis method, in ordering to provide new ideas, new ways, and new methods for the above slop, which has special requirements for landscape greening.

2. The Characteristics of the Oblique-inserting Slab-pile Wall
Ordinary slab-pile wall with vertical baffle, although has good supporting effect, closed structure. In addition, the shapes are blunt and cannot be combined with greening measures, so the appearance is poor. The oblique-inserting slab-pile wall is a new type of pile wall structure, which is combines with the method of green landscape in recent years. The soil can be backfilled between retaining plate and wall back, and then green measures can be carried out. So the landscape can be well improved and the environment can be beautified. Compared with the traditional slab-wall, the oblique-inserting slab-pile wall has the following advantages:

2.1The Supporting and Retaining Effect is Obvious
The bottom of the oblique baffle and the vertical baffle form a certain angle, and there is a certain distance on the upper. This new type of retaining structure can not only resist the lateral earth pressure, but also can play the role of soil pressure transfer between the two plates, which can further improve the supporting effect.

2.2 The Connection Form between the Pile and the Plate are Optimized
The PVC tube is used to replace the link bar and pre buried. After the steel bar is lowered to the pile hole, the PVC pipe is pulled out, and the embedded steel bar is inserted into the hole. The process can effectively ensure the construction quality.

2.3 Small Engineering Quantity
Oblique-inserting slab-pile wall no need to set the filter layer, and retaining plank is shorter 10% ~15% than the traditional vertical plank, and total project amount is lower than 10% or so.

2.4 The Economic Benefit is Obvious
Because of the small engineering quantity of the oblique inserting plate, the construction cost of the project can be saved about 10% compared with the vertical plate construction.

2.5 The Structure is more safe and stable
Because of the wall protection without dismantling, the structural stability is improved to some extent. Meanwhile, the omission of the process of filter layer can effectively avoid water damage, which is caused by the construction or material quality problems. Therefore, the safety of slab-wall structure can be further improved.

2.6 Beautiful Appearance
Wall green planting can not only improve the highway landscape, but also can satisfy the requirement of traffic psychology and vision, thus improve the safety of traffic.

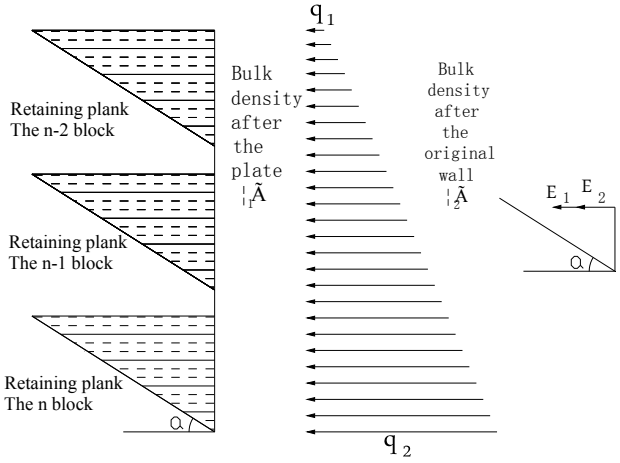
3. The Design and Calculation of Oblique-inserting Slab-pile

Pile design is similar with traditional anti-slide pile, the main difference lies in the pile of domestic embedded stirrups, so as to connect with inclined plate conveniently. Connection between pile and slab is design issue. Generally speaking, they can be connected with U shaped or L shaped steel bars. In addition, the form of "lug" is used occasionally.

The design of the oblique-inserting plate is based on the force analysis and calculation of the traditional vertical baffle, and the influence of the inclination angle of the plate is analyzed specially. The calculation models are usually divided into two kinds: coulomb's earth pressure calculation method and the unloading arch calculation method. It is generally believed that the earth pressure calculated by the latter method is obviously smaller than that of the former. Therefore, the coulomb's earth pressure calculation method is often used in engineering practice. The different connecting forms of the retaining plank can be simplified as simply supported plate model and two hinged model. In engineering, the former model is often adopted.

3.1. The Calculation of Oblique Inserting Plate as Simply Supported Plate

Assuming that the inclined plate owes rigid plate, the angle between retaining plate and the horizontal direction is α degree, the center distance between the two ends of the baffle is l, the earth pressure is calculated by coulomb's earth pressure under uniform load. The maximum soil pressure at the bottom retaining plate was used as the uniform load for the imposed load on the retaining plate. Force diagram as follows:



Assuming q is uniform load:

$$q = (E_1 + E_2)\sin\alpha + G\cos\alpha$$

$$= [\frac{1}{2}\gamma_1 H^2 K_\alpha - \frac{1}{2}\gamma_1 (H-h)^2 K_\alpha + \frac{1}{2}\gamma_2 h^2 K'_\alpha]\sin\alpha + \frac{1}{2}\gamma_2 h^2 \cos\alpha$$

Which:

$$E_1 = \frac{1}{2}\gamma_1 H^2 K_\alpha - \frac{1}{2}\gamma_1 (H-h)^2 K_\alpha$$

$$E_2 = \frac{1}{2}\gamma_2 h^2 K'_\alpha$$

$$G = \frac{1}{2}\gamma_2 h^2$$

In the formula:

E_1—the earth pressure produced by γ_1;

E_2—the earth pressure produced by γ_2;

G—self-weight of soils;

H—The distance from the first n board to the top of the pile;

K_α—Active earth pressure coefficient back of pile soil;

K'_α—Active earth pressure coefficient back of plate fill;

h—Fill height inside the board;

α—Angle between plate and horizontal direction.

The maximum bending moment and the maximum shear force of the retaining plate appear in the span and the two ends of the plate. Respectively as:

$$M_{max} = \frac{1}{8}ql^2$$

$$Q_{max} = \frac{1}{2}ql$$

3.2 Calculation of the Oblique Inserting Plate for the Fixed End

Uniformly distributed load formula as follows, but the maximum bending moment M_{max} and maximum shear Q_{max} of the plate are respectively:

$$M_{max} = \frac{1}{24}ql^2$$

$$Q_{max} = \frac{1}{4}ql$$

3.3Optimal tilt angle analysis of retaining plank:

Taking the rigid retaining plate as an example, the same kind of soil is assumed to be the same as the soil after the soil and the wall. Supposing that $\begin{cases} M_{max} = \frac{1}{8}ql^2 \\ Q_{max} = \frac{1}{2}ql \end{cases}$ or $\begin{cases} M_{max} = \frac{1}{24}ql^2 \\ Q_{max} = \frac{1}{4}ql \end{cases}$ get maximum, when the center distance of the two ends of the baffle plate is l as a fixed value, the maximum of Q is satisfied. According to the extreme value formula:

$$q = (E_1 + E_2)\sin\alpha + G_2\cos\alpha$$

$$= [\frac{1}{2}\gamma_1 H^2 K_\alpha - \frac{1}{2}\gamma_1 (H-h)^2 K_\alpha + \frac{1}{2}\gamma_2 h^2 K'_\alpha]\sin\alpha + \frac{1}{2}\gamma_2 h^2 \cos\alpha$$

$$= \sqrt{[\frac{1}{2}\gamma_1 H^2 K_\alpha - \frac{1}{2}\gamma_1 (H-h)^2 K_\alpha + \frac{1}{2}\gamma_2 h^2 K'_\alpha]^2 + (\frac{1}{2}\gamma_2 h^2 \cos\alpha)^2}$$

$$\bullet \sin(\alpha + \beta)$$

Which:

$$\beta = \arctan\frac{\gamma_2 h^2}{\gamma_1 H^2 K_\alpha - \gamma_1 (H-h)^2 K_\alpha + \gamma_2 h^2 K'_\alpha}$$

So, when:

$$\alpha = \frac{\pi}{2} - \beta = \frac{\pi}{2} - \arctan\frac{\gamma_2 h^2}{\gamma_1 H^2 K_\alpha - \gamma_1 (H-h)^2 K_\alpha + \gamma_2 h^2 K'_\alpha},$$ the bearing capacity (bending moment and shear force) of the retaining plate is the largest, which is the optimum angle of the retaining plate.

4 The Construction Technology of Oblique-inserting Slab-pile Wall

The general construction procedure as follows:

Construction Preparation→ Pile Hole Boring→ Pouring Concrete→ Inclined Inserting Plate Construction→ Planting Living.

Specifically:

Pile Hole Boring includes: Locking Wellhead Construction→The Pile Hole Excavation→Put up Wall

Template→Pouring Concrete Wall→By Digging to Design Elevation.

Pouring Concrete includes: Manufacture and Installation of Steel Bar Cage→Pouring Concrete

Pouring Concrete Wall includes: Precast Slab and Concrete Beam→Preparation before Installation→Inclined Insert Plate Installation

5 Conclusion

Oblique-inserting slab-pile wall is not only beautiful appearance, obvious retaining effect, and has significant economic and ecological benefits. On the one hand, it solves the problem of water drainage, but also improves the stability of pile wall structure. Greening design of wall of retaining structure is the inevitable requirement of building "ecological highway", and it is also the trend of the development of highway construction in the future, having broad application prospects. Because the greening design research of oblique-inserting slab-pile wall starts late, the technology and the theory is not mature, the related experience is lack, the research and the discussion of the related subject is necessary. Therefore, it is recommended to carry out the following aspects of the study:

(1) The connection between the oblique inserting plate and the pile is the key to maintaining the inclined pile retaining wall structure stability and it is also the design and construction of the difficulties. It is necessary to strengthen the research in this area.

(2) Its research field has been related to the stress distribution law of the simple soil model and structural stress system research, but the research on complex soil and undisturbed soil is still blank. It is suggested that build entity model gradually to carry out situ test and study on the distribution law of soil pressure in complex soil model.

(3) The new engineering technology needs a new standard system to be standardized, in order to achieve further promotion and application, and thus better for the engineering services.

At present, the related calculation of oblique-inserting slab-pile wall and design is still using the old standard, it does not meet the requirements obviously.

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