EJGE

Geo-Grid Wrapping Eco-Bags Reinforced Retaining Wall by In-Situ Test

Liang Jia
Shaanxi Railway Vocational Institute, Weinan, Shaanxi, 714000, China
e-mail: styjialiang1982@163.com

ABSTRACT

In this paper, on-site monitoring test was done on the flexible structural form of geo-grid wrapping eco-bags reinforced retaining wall as expressway slop protection from an expressway test section in China. The test results and analysis are concluded that vertical soil pressure curve of each monitoring layer was non-linear correlated with reinforced belt length, showing obvious single peak graphic; Lateral soil pressure at a certain range from the wall surface increased initially and then decreased with the filling height increased, and however that at 13 meters away increased always and didn't decrease; Each layer reinforced belt strain in the wall increased with increase of filling load; strain curves of geo-grid wrapping wall face initially increased and then decreased gradually; Position of potential failure surface of the reinforced retaining wall may be located between 4 meters and 6 meters away from the wall surface

KEYWORDS: high reinforcement retaining wall; vertical soil pressure; lateral soil pressure; geo-grid belt tensile strain

INTRODUCTION

Geo-grid wrapping ecological bags reinforced retaining wall consists of mesh filling bags wrapped by reinforced belts, with each geo-grid wrapping layer connected by link rods, the soil in mesh bags should be suitable for the local shrub, seeds and other plants in order to form green ecological wall after construction for several months. To prevent the solarization aging of exposed wrapped geo-grid face, the wall surface can be hung with three-dimensional mesh cover via sprinkler irrigation slope protection. As the eco-bags from the wall are made of water-permeable materials, and the permeability coefficient of the retaining wall surface is the same as that in the wall, therefor it does not need special water drainage and guide facilities. This reinforced retaining wall is lighter than other structural forms, and can reduce the cost of foundation treatment [1]. With the clayey embankment construction technique, this retaining structure can effectively shrink the slope toe, save land and reduce cost. It can also absorb the cohesive soil deformation, help isolate surface water and strengthen the deformation resistance capacity.

The relevant study has been done by some scholars for in-situ test and experimental test. Xu Guilin [2] based on a new steel mesh geo-grid reinforced retaining wall for in-situ monitoring test on Hunan province expressway slope protection engineering in China, obtained the vertical and lateral soil pressure distribution and reinforced belts deformation of this structure form at each layer filling construction. Lin Yuliang et al. [3] experimented on flexible grid reinforced retaining wall for analyzing the engineering behavior characteristics and working mechanism. Liu Ze [4] studied green reinforced gabion retaining wall to gain the distribution of vertical and lateral soil pressure, reinforcement tensile strain and lateral deformation. Yang Guolin [5-6] based on a dynamic loading model on geo-grid reinforced retaining wall experiment to get the dynamic behavior characteristics: lateral and vertical acceleration and mean shift variation with the height of the wall. Mo Jiezhen [7] gained the in-situ test analysis on the stepped geo-grid reinforced retaining wall from Heyuan-Longchuan expressway test section in China, Guangdong province to get the reinforcement belt tensile force, distribution of soil pressure, wall deformation and foundation stress. Yang Guangqing [8] did in-situ test from construction to service period on the structural form of wrapping grid face retaining wall to get its foundation stress, lateral soil pressure, reinforcement belt tensile force and wall surface lateral deformation, analyzed the structure stress, deformation and behavior mechanism.

In this paper, on-site monitoring test was done on the structural form of geo-grid wrapping eco-bags reinforced retaining wall as expressway slop protection. According to in-situ test data during the filling construction of this retaining wall, the vertical soil pressure of each filling layer, the lateral soil pressure of wall sides and reinforced belt tensile strain variation versus height, position and time were all recorded and analyzed, and based on these results, the potential breaking surface of this retaining structure can be predicted and estimated.

ENGINEERING SURVEY AND TEST PROPOSAL

The in-situ test field for geo-grids wrapping eco-bags retaining wall slope protection engineering located in 9th contract section of Zhe-Shao expressway, China. Both sides of test section program are farmland, in order to reduce slop toe and save land, geo-grid wrapping eco-bag reinforced retaining wall was chosen as slop protection. The height of retaining wall is 12.5 meters. The retaining wall monitoring spots and measuring test components of embankment section were arranged as shown in Figure 1, test program items and number of test components was seen in table 1.

Table 1: The quantity sheet of components in monitoring section

Test Item	Test Component	Arranged Location

Vertical Soil Pressure	Vertical Soil Pressure Measuring Box	Under 1st,3rd ,5th,7th layer geo-grid buried every 2.50 meters along grid length
Lateral Soil Pressure	Lateral Soil Pressure Measuring Box	Under 2^{ed},4th ,6th,8th layer buried at 0.5 meter and13 meters away from the wall surface
Material Tensile Strain	Flexible Displacement Meter	Under 1st,3rd ,5th,7th layer geo-grid buried every 2.50 meters along grid length and buried on wall surface

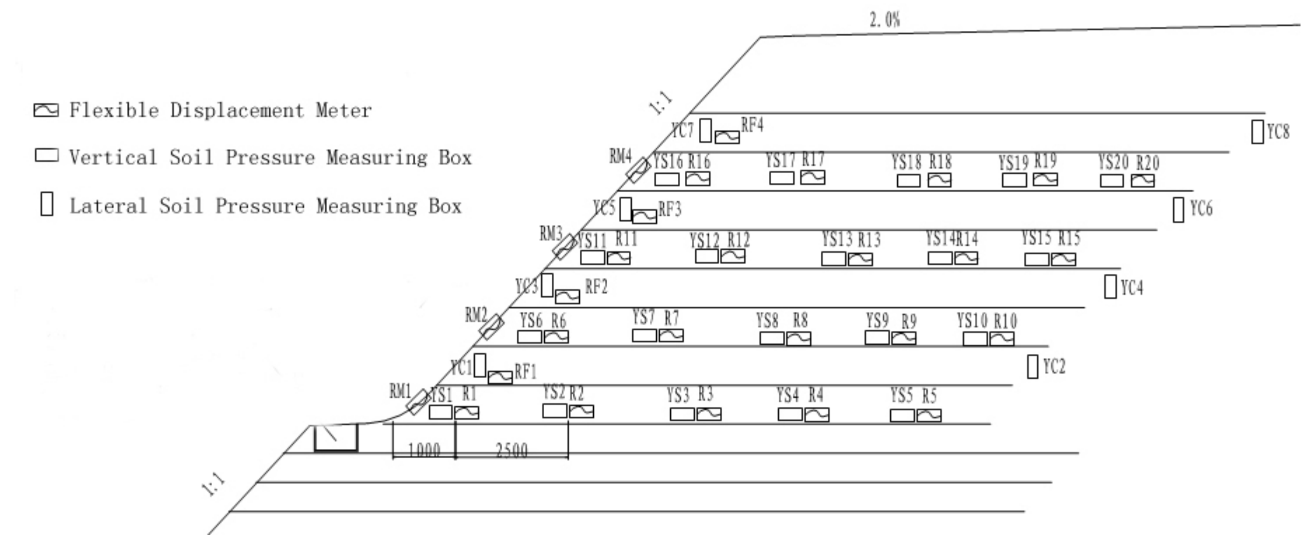


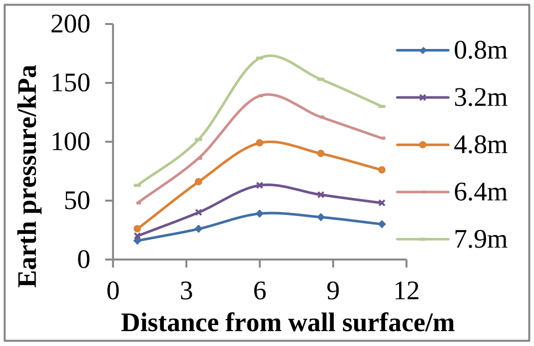
Figure 1: The arrangement plan of embankment monitoring test components

As shown from Fig.1, geo-grid wrapping eco-bag reinforced retaining wall is divided into two levels of geo-grid layers: the lower wall has 5 layers geo-grid with height of 0.6 meters, the upper wall has 8 layers geo-grid with height of 1.5 meters, up where the 1.5 meters high filling soil without geo-grid was covered over the upper wall, the wall slop ratio is 1:1 and in this paper the upper wall was selected as test object for in-situ test. Flexible displacement meter components and vertical soil pressure measuring boxes were buried every 2.50 meters along the inner side of the retaining wall at 1 meter to the centerline of the route, and from the bottom to top of upper wall at every 2 layers geo-grid. Lateral soil pressure measuring boxes were embedded at 0.5 meters and 13 meters distant from the wall surface and at every 2 layers. And on the wall surface of upper wall flexible displacement meter components were located at every 2 layers from bottom to top.

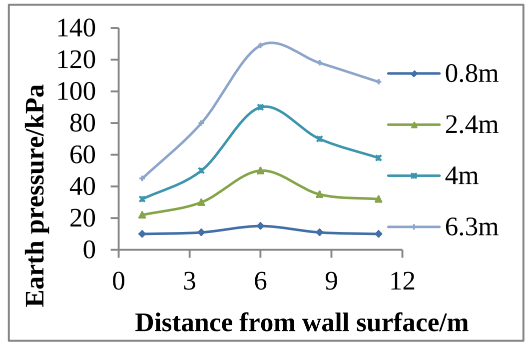
TEST RESULTS AND ANALYSIS

Monitoring Results and Analysis of Vertical Soil Pressure

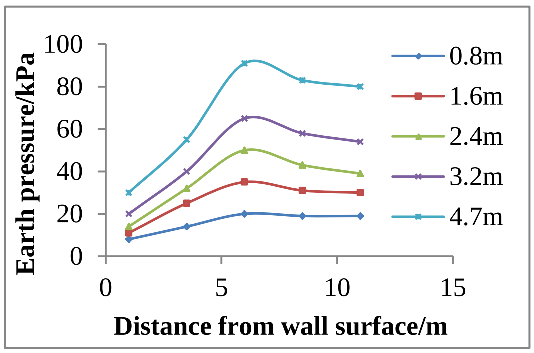
The distribution of every monitoring layer vertical soil pressure of embankment section at different filling height is shown in Fig. 2. From Fig. 2 we can see:



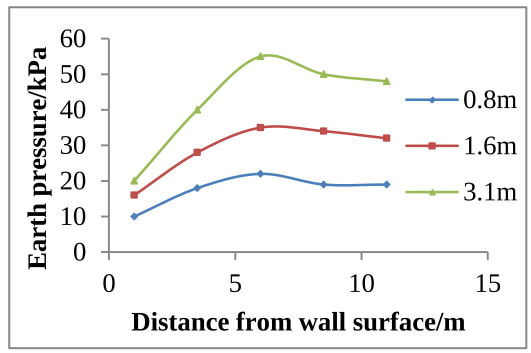
(a) The first layer



(b) The third layer



(c) The fifth layer



(d) The seventh layer

Figure 2: The variation of vertical soil pressure at different position (annotation: all graphic legend represents depth of filling above the first layer, the third layer, the fifth layer and the seventh layer)

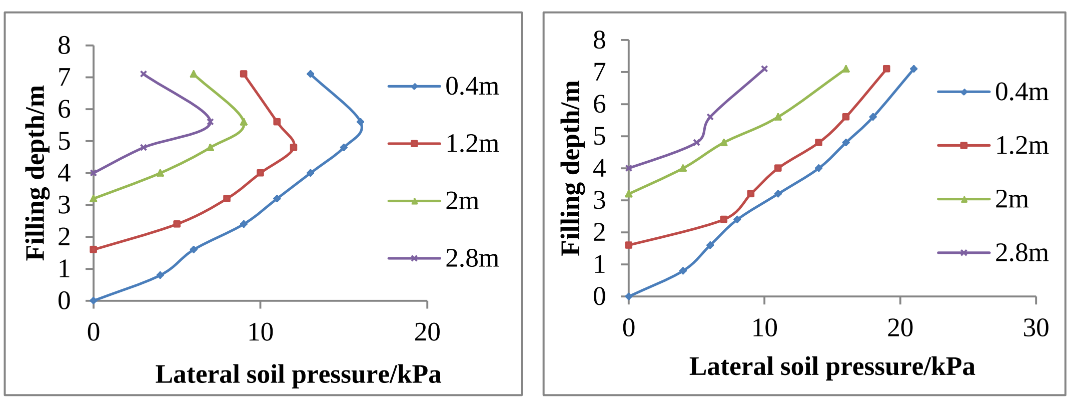
(1) The non-linear correlation of retaining wall vertical soil pressure curves have increased with the increase of the retaining wall height. Each layer vertical soil pressure variations with reinforced grid belts length are non-linear correlation, initially increased rapidly and then decreased slowly, maximum value of the curves are all basically at 6 meters distance from the wall surface, showing obvious single peak phenomenon and that vertical soil pressure away from the wall were significantly larger than that near the wall. Results analysis of non-linear vertical soil pressure curves are as follows: for one reason the retaining wall is flexible structure, the occurring lateral displacement with interaction between reinforced material and soil caused soil arching phenomenon, which decreased the vertical soil pressure near the wall; for another reason the lateral soil pressure behind the wall back interacted over the reinforced grid soil to produce overturning moment, which led to non-linear distribution of vertical soil pressure.

(2) After the completion of filling construction, the test values distribution of each layer vertical soil pressure were uneven, the average value was much lower than that calculated in accordance with the theoretical formula $\sigma_y=\gamma H$ (γ =1.97 g / cm^3). Among them, the test values at 6 meters distant from wall surface got the largest and most closed to the theoretical value. There is results analysis: buried

flexible geo-grid created membrane effect to generate lifting support, improving the vertical stress distribution and reducing vertical soil pressure on the foundation due to soil self-weight load, and also the calculating theory about vertical soil pressure based on the semi-infinite solid foundation so it's are not fully applicable to the embankment with a certain width on which can be generated by the longitudinal deformation.

Monitoring Results and Analysis of Lateral Soil Pressure of Wall Sides

Fig. 3 shows wall sides' lateral soil pressure variation curves versus the different wall height. From Fig. 3 (a) it can be seen at 0.5 meters away from the wall the lateral soil pressure with the increase of wall height increased initially and then decreased, the increase and decrease rate of every monitoring layer lateral pressure match consistently, and at 5 meters filling height (higher level) lateral soil pressure appeared decreasing. Fig.3 (b) shows at 13 meters away from the wall side lateral soil pressure increased always with the increase of height, there is no decreasing and the increase rate difference of every monitoring layer is not much. Reasons analysis for results are that the soil pressure in vicinity of flexible retaining wall is different from that of rigid retaining wall, flexible retaining wall has inclined angle, which in the filling construction with small ramming machine resulted in uneven compaction. With filling height increased, filling compaction degree near the wall surface side increased and soil pressure increased, when it reached a certain height, lateral soil pressure reduced to a certain degree due to unloading effect of flexible deformation of the wall surface side. And at the distance of 13.0 meters near the wall back, it didn't appear this decreasing phenomenon.



(a) Behind the wall surface side (b) Behind reinforcement retaining wall back side

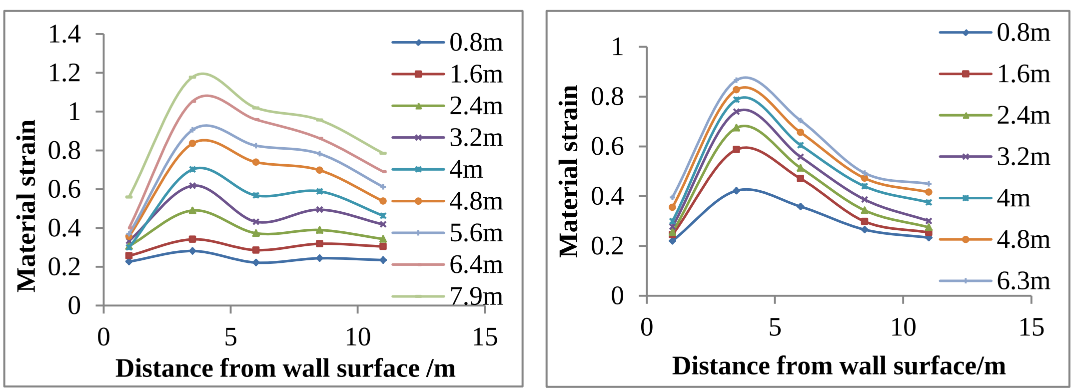
Figure 3: Variation diagram of lateral soil pressure with the height of fillings

Monitoring Results and Analysis of Reinforced Belt Tensile

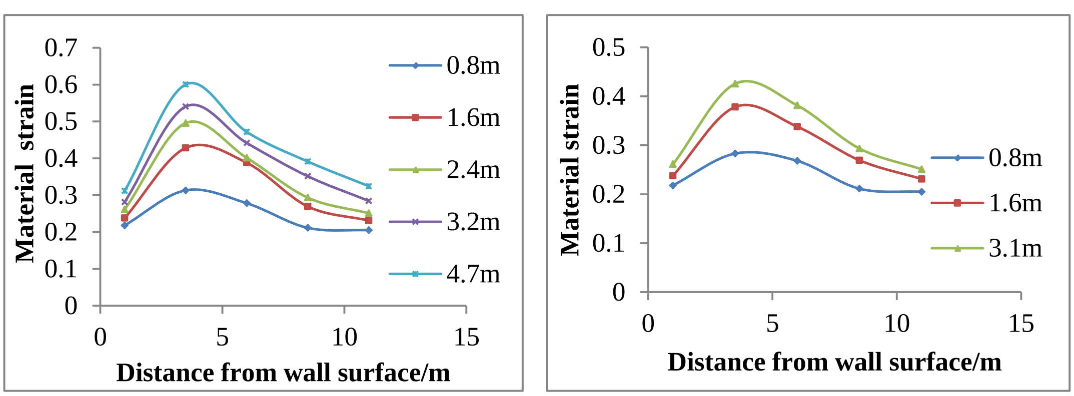
Strain

Fig. 4 shows the distribution of tensile strain of every monitoring layer on embankment section and variation curves of tensile strain versus time, filling height:

(1) From Fig. 4 it can be shown the reinforced material strain of each monitoring layer strain increased unevenly with the increase of the filling height under the same filling loading. And reinforced strain of each monitoring layer increase with the increase of filling load, at the same layer all reinforced belt deformation reached the maximum at 4 meters distant from the wall surface and at 6 meters reached the sub-maximum value, along length of grid the strain mostly increased initially and then decreased, showing the single peak graphic and increasing rate is faster than decreasing rate. The different layer's strain are different, the lower material were buried, the larger tensile strain reached, so the fist layer got the largest strain distribution curve and the maximum value is 1.2%. Reasons may be of the use of geo-grid wrapping eco-bag structure, which produced a "string bag" membrane effect to reduce the strain nearest from the retaining wall. Compared with other layers, the first layer tensile strain curve showed double peak graphic when the filling height is less than 4.0 meters, and with filling height increased, the double peak gradually transformed into single peak curve.



(a) The first layer (b) The third layer



(c) The fifth layer (d) The seventh layer

Figure 4: The variation of reinforced material tensile strain at different position (annotation: all graphic legend represents depth of filling above the first layer, the third layer, the fifth layer and the seventh layer)

(2) By the Fig.4, the tensile strain of the reinforced material tends to be stable after the completion of the filling construction.

(3) The theory for potential failure surface arguments have no conclusion yet, Yang Guangqing mentioned in the literature [7], the measuring method of potential failure surface distribution curve is close to 0.3H method at the lower part of the retaining wall, and however it's close to potential failure surface of Rankin's soil pressure theory for the upper wall. Lin Yuliang believes in the literature [4] that the potential failure surface of reinforced retaining wall can be determined according to the maximum strain location of the reinforced material.

In this paper, by Fig.4 it can be known vertical soil pressure at 6 meters from the wall is larger (compared with other points of measurement), and by the static soil pressure formula $p_0=K_0\gamma z$ it can be known the lateral soil pressure value is also larger. From Fig.3, the tensile strain of the reinforced material at 4 meters is larger (compared with other points of measurement), and if solid deformation coordinated with that of reinforced material, the larger solid tensile strain can be obtained here. In summary, there may be a peak value of solid lateral pressure and tensile strain between 6 meters to 4.0 meters from the wall surface, which is also the location of potential failure surface.

The main function of geo-grid wrapping wall surface is to bear the residual lateral soil pressure, prevent the soil from extruding through the lateral side, strengthen and fix the reinforced belt, and guarantee the design standard of the wall shape and appearance. If the wall surface didn't exist any deformation, tensile force of reinforced belt would not work, and the wall surface mainly bear the static soil pressure; if wall surface occurred displacement away from the wall sides, tensile force of reinforced belt would gradually act on the soil to close to the state of equilibrium and decrease lateral soil pressure.

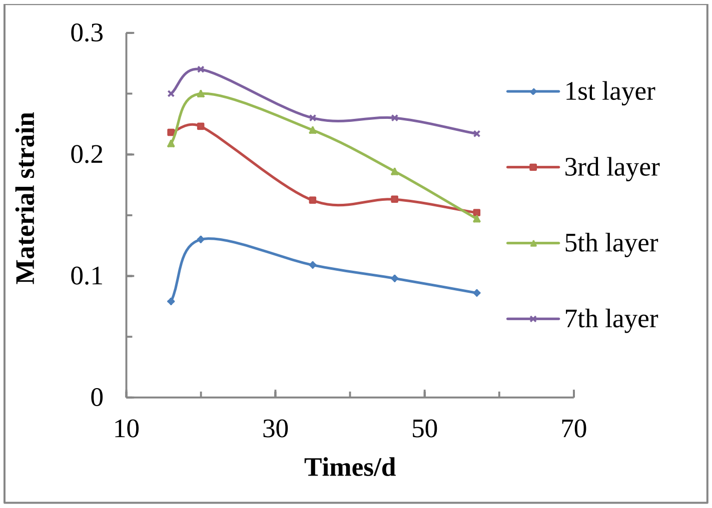


Figure 5: The variation of reinforced materials strain of geo-grid wrapping wall face versus the time

Fig.5 shows curve of reinforced geo-grid material strain of wrapping wall surface versus time in test section. From Fig.5, it can be seen the wrapping wall face material strain gradually increased with filling load increased at the first and third layer and when the filling height increased the strain decreased gradually. Reasons for that are as follows: at the two layers from the upper wall the eco-bags extruded the wrapping reinforced belts to increase the material tensile strain, and however with the filling height and load increased, the solid lateral deformation and reinforced belt lateral deformation occurred on the wall surface to release the wrapping geo-grid belt stress and decrease the material strain on the wall surface.

CONCLUSIONS

1) The vertical soil pressure of retaining wall basement increased gradually with the increase of the height of retaining wall. The vertical soil pressure curve of each monitoring layer was non-linear correlated with reinforced belt length, showing obvious single peak graphic and the maximum value posited at the central part or longer location, and the pressure away was larger than that near the wall surface.

2) The lateral soil pressure at 0.5 meters from the wall surface increased initially and then decreased, and decreasing inflection point located at the filling height of 5meters. The lateral pressure at 13 meters away from the wall surface increased with the filling height increased always and didn’t decrease in the filling construction.

3) Each monitoring layer reinforced belt strain increased with increase of filling load, at the same layer the reinforced material deformation reached the maximum at 4.0 meters away from the wall surface, and got the sub-maximum value at 6 meters, along the geo-grid length showing the single peak curve.

4) The position of potential failure surface of the reinforced retaining wall may be located between 4 meters and 6 meters away from the wall surface.

5) The reinforced belt strain curves of geo-grid wrapping wall face increased initially and then decreased gradually with the filling load increased.

REFERENCES

[1] Chen changlin, Yao Mingshan. Geogrid technology generality. Port & Waterway Engineering. 1998,2: 51～58.

[2] Liu Ze,Yang Guolin, Huang Xiangjing.Test study on the reinforcement characteristics of steel mesh. Industrial Construction Vol. 41,No. 5,2011, 93-98.

[3] LIU Ze, YANG Guo-lin, SHENG Chao, XU Jian-nan. Reinforced earth retaining wall of green gabion by field test. Journal of Central South University (Science and Technology). 2012,02:709-716.

[4] LIN Yuliang, YANG Guolin, XU Guilin. Engineering behaviors of geogrid reinforced earth retaining wall of flexible surface. Journal of Central South University (Science and Technology). 2013,04: 1532-1538.)

[5] Guolin Yang, Xiangjing Huang, Yuliang Lin.Test study on engineering properties of gabion structures[C]. Advances in Environmental Geotechnics Proceedings of the International Symposium on Geo-environmental Engineering in Hangzhou, 2009: 834-839:805-811.

[6] YANG Guo-lin,LIN Yu-liang,LI Yun. Test study on dynamic deformation behavior of new earth retaining walls. Journal of vibration and shock.2010, 29(1):223-227.

[7] YANG Guang-qing, LÜ Peng, PANG Wei, ZHAO Yu. Research on geogrid reinforced soil retaining wall withwrapped face by in-situ tests. Rock and soil mechanics. 2008,02:517-522.

[8] Mo Jiezhen,He Guangchun,Wang Chengzhi,Zhou Shiliang. Study on a stepped retaining wall with geogrid reinforcement by using site test and numerical analysis.(China civil engineering journal, 2008,05:52-58.