The engineering example of anti-seismic wrap-styled reinforced earth retaining wall in Guangtong to Dali Railway

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ABSTRACT: The engineering example is located in Yun Nanyi station of Guangtong to Dali Railway, where is the seismic area with high intensity of 8 degrees. The structure is wrap-styled reinforced earth retaining wall. In order to analyze the anti-seismic behaviors; the field test of wrap-styled reinforced earth retaining wall was carried out. This paper also takes out the shaking table test and numerical simulation to analyze the acceleration amplification, dynamic earth pressure, geogrid strain and potential fracture plane for the wrap-styled and normal reinforced earth retaining wall under different earthquake acceleration. It shows that the seismic wave is weakened along the wall upwards due to the effect of wrapping so the wrap-styled reinforced earth retaining wall has better earthquake resistance. Also the potential fracture plane will move backwards with the increase of the peak acceleration.

Keywords: Wrap-styled reinforced earth retaining wall; Engineering example; Seismic characteristics

1 STRUCTURE CHARACTERISTICS

The structure of wrapped reinforced earth retaining wall is mainly composed of three parts: reinforcement, filling and panel[1]. Geosynthetics reinforced earth retaining wall for Geogrid, the soil covered, in the laying of each layer of Geogrid on filling and compaction, the outer end of the geogrid rollback after a certain length, then put another layer of Geogrid on the floor[2]. The Yun Nanyi station of Guangtong to Dali Railway is adopted wrap-styled reinforced earth retaining wall. The wall is about 11.6 meters high and each layer is 0.3 meters thick and is raised by layer. In this paper, taking the wrap-styled reinforced earth retaining wall in a station of Guangtong- Dali line as the background, the seismic behavior of reinforced earth retaining wall with reinforced soil is compared and analyzed by shaking table model test and numerical analysis.

2 THE SITE TEST

The Yun Nanyi station of Guangtong to Dali Railway, at the mileage of DK120+140 ~ DK120+200, is located in the high intensity earthquake area (8 degrees), this section of the project is the station subgrade, subgrade to fill through, the maximum fill up about 11.6m. The survey area is a mountain tectonic rift basin topography, terrain is relatively flat, undulating, ground elevation is 1980 ~ 1990m, the relative elevation of about 10m; the gentle slope is reclaimed into farmland. Test section covered with Quaternary new artificial fill (Q4ml), alluvial Lake (Q4al+l) soft soil, soft soil, silty clay slope residual silty clay (Q4dl+el) group (Qps), as well as loose silty clay (expansive soil). The underlying bedrock is Permian (Pβ1) tuff, basalt. The field test works started in Oct., 2015 and completed in Oct., 2016 ,the experiment achieved good results. The results show that: ① the size of the basement earth pressure and the distribution along the cross-section in the reinforced soil; ② the size of the earth pressure at different depths of the reinforced soil and its distribution along the length of the reinforcement; ③The overall settlement deformation observation, the ordinary fill part of the settlement observation, and make the corresponding comparison; ④the deformation of the reinforced concrete at different depths and its distribution along the length of the reinforcement; ⑤ the horizontal deformation of the reinforced soil as a whole; ⑥ the horizontal deformation of the wall panel observation.

Fig.2.1 The wrap-styled reinforced earth retaining wall

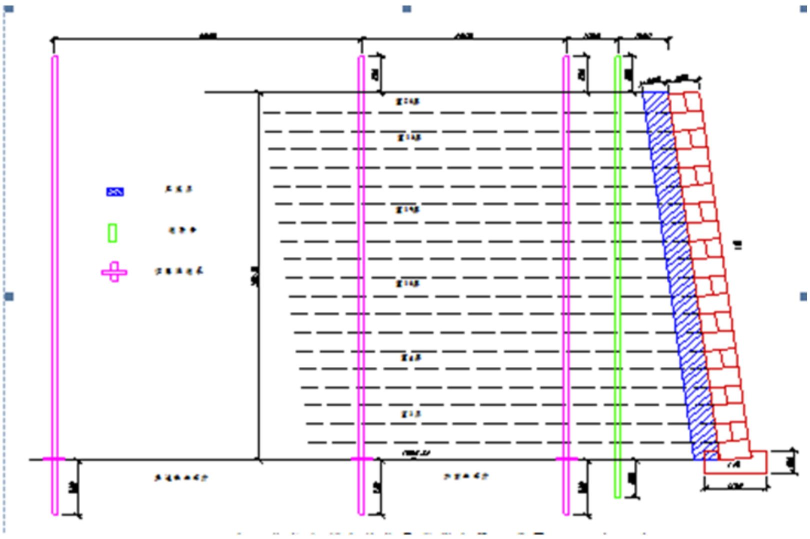

Fig.2.2 The Field Test

3 SHAKING TABLE TEST

3.1 *Experimental model*

In order to study the seismic behaviors of the reinforced earth retaining wall, the shaking table test was carried out based on the Yun Nanyi station site test section of Guangtong to Dali railway, and select the typical cross section as the prototype. The prototype is a 10m high wrapped reinforced earth retaining wall with a width of 8m, a geogrid length of 8m, a spacing of 0.5m between the upper and lower layers, and a concrete panel of 0.6m. According to the cross-section model in a station of Guangtong to Dali railway, and determine the geometric similarity ratio. The test model size is 2.8m × 1.5m × 2.0m (length × width × height), which is tested in two groups, one of which is a wrap-styled reinforced retaining wall(as show in Fig3.1) and the other is a reinforced earth wall(as show in Fig.3.2), wall panels for prefabricated concrete blocks assembled, thick 30cm.

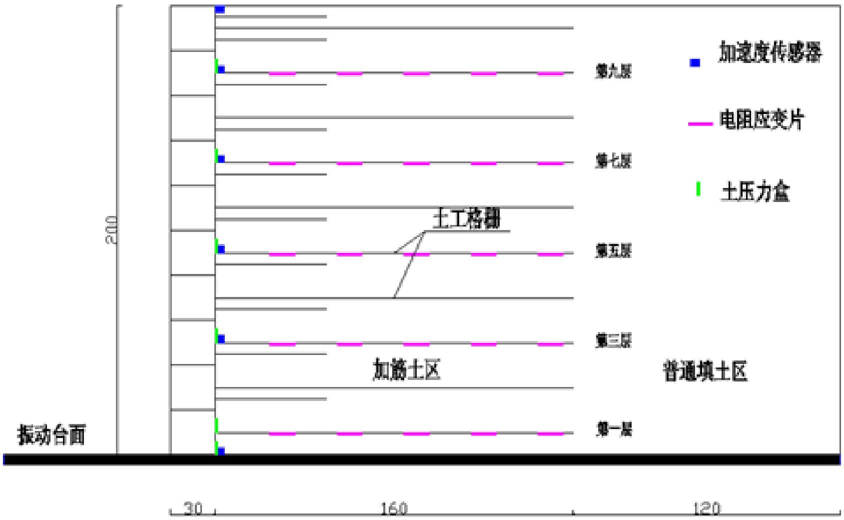

Fig.3.1 The wrap-styled reinforced earth retaining wall

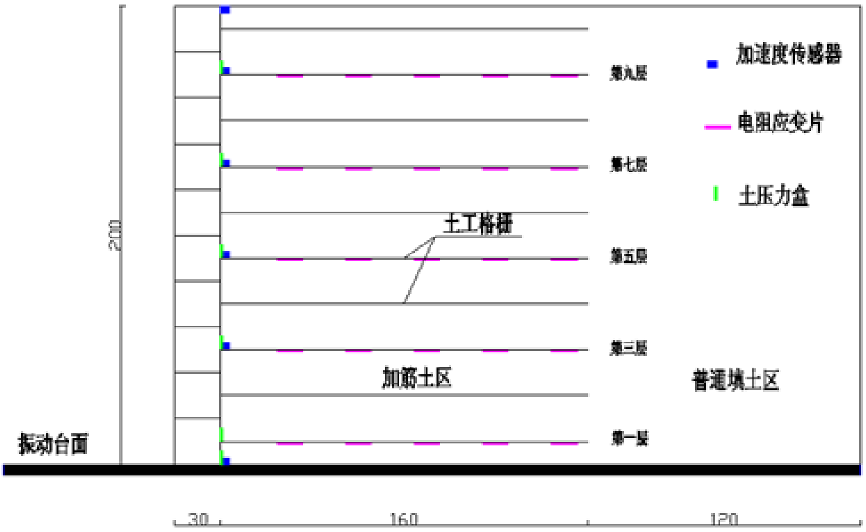

Fig.3.2 The common reinforced earth retaining wall

3.2 *Experimental result*

1. The acceleration magnification measurement results of wrap-styled reinforced earth retaining wall and ordinary reinforced earth retaining wall at time scaling factor of 3.95 DR wave are shown in Fig. 3.3 and Fig. 3.4..

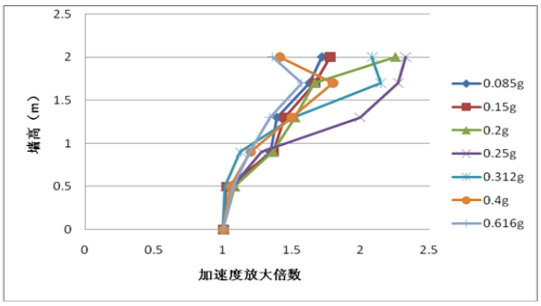

Fig. 3.3 Distribution of acceleration magnification of packaged reinforced earth retaining wall model

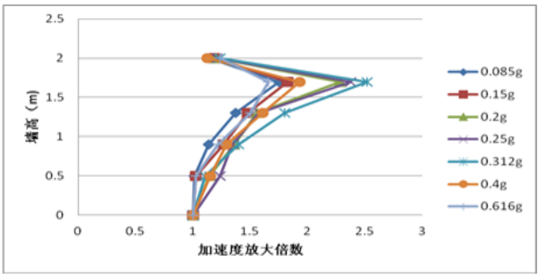

Fig.3,4 Distribution of acceleration magnification of common reinforced earth retaining wall model

According to the comparison of the acceleration magnification distribution curves of the two experimental models, the acceleration amplification distribution curve of the wrapped reinforced earth retaining wall and the ordinary reinforced earth retaining wall are basically the same: The maximum values occur at the wall height 1.7m, and the lower acceleration amplification increases linearly with the wall height, and the upper part decreases linearly. From 0.312g to 0.085g in the seismic peak acceleration, with the increase of seismic peak acceleration and acceleration amplification curve gradually slow, which are located in the same wall high acceleration amplification increases with increasing magnitude; From 0.616g to 0.312g in the seismic peak acceleration, with the increase of seismic peak acceleration and acceleration amplification curve becomes steeper, which are located in the same wall high acceleration amplification decreases with increasing magnitude.

2. The dynamic stress measurement results of wrapped reinforced earth retaining wall and ordinary reinforced earth retaining wall at time compression ratio of 3.95 DR wave are shown in Fig. 3.5 and Fig. 3.6..

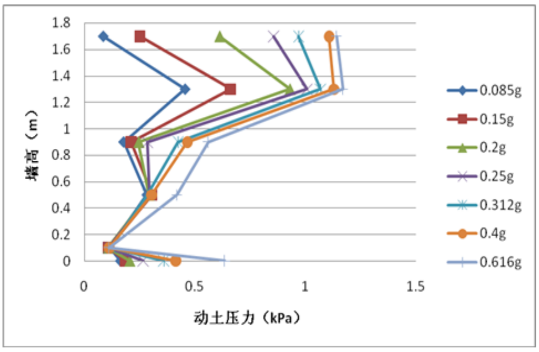

Fig.3.5 Calculation of dynamic stress distribution of parcel packaged earth retaining wall model

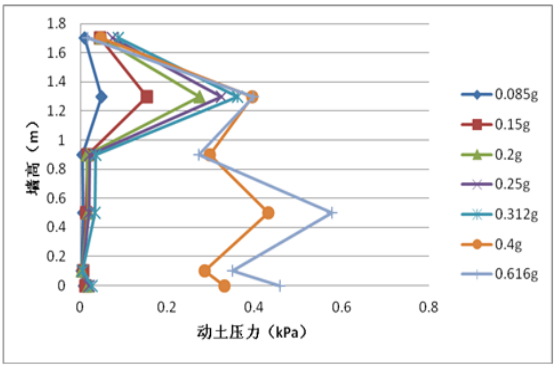

Fig.3.6 Dynamic Stress Distribution of Common Reinforced Earth Retaining Wall Model

According to the measured results of the two model tests, earth pressure is present at both panels under seismic load. This is due to the seismic load, the reinforced soil will produce a certain amount of subsidence, resulting in soil arch extrusion panel, and wall panels relative to the reinforced soil is rigid, it is because of the difference of soil deformation of the wall plate and the wall after produced this earth pressure. But this soil pressure stress value is very small, the maximum value is only 1.1695kPa. The earth pressure in reinforced earth retaining wall panel should be considered in seismic design, which should be taken into account in the horizontal seismic force of wall panels in earthquake outside, also need to consider the soil pressure generated by the earthquake. This requires the wall panels to be wrapped with reinforced earth retaining walls need to be connected firmly, so that it can prevent the earthquake was thrown out.

3. The strain test data and strain distribution of the third floor geogrid of wrapped reinforced earth retaining wall and ordinary reinforced earth retaining wall at time compression ratio of 3.95 DR wave are shown in Fig 3.7 and Fig. 3.8.

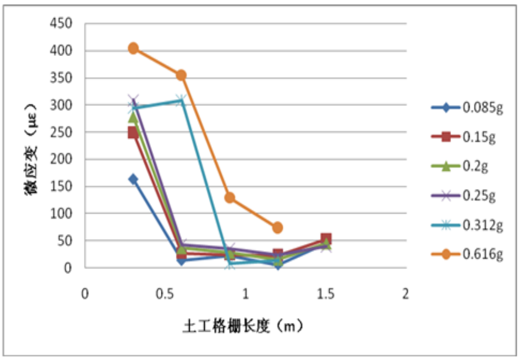

Fig 3.7 The wrapped reinforced earth retaining wall third layer of geogrid strain distribution

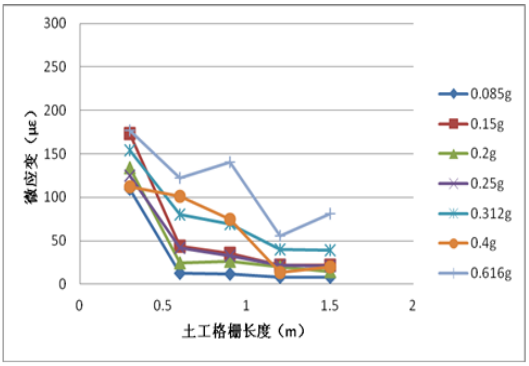

Fig 3.8 The ordinary reinforced earth retaining wall third layer of geogrid strain distribution

It can be shown from Figer 3.5 and Figer 3.6 that with the increase of the peak acceleration of the countertop, the dynamic strain at the same position is increased except for the individual measuring points, and the strain is the maximum at 0.3m from the wall panel. At 0.085g, 0.15g, 0.2g, 0.25g and 0.312g, the dynamic strain distribution curve is basically the same, and the strain is drastically reduced from 0.3m-0.6m to the wall panel. In the 0.6m-1.5m section is also linearly reduced but the change is slow; at 0.4g, the abnormal, the maximum strain is less than 0.15g, 0.2g, 0.25g, 0.312g when the maximum value of 0.3m away from the wall panel -1.2m, the strain is linearly decreasing and slightly increased in the range of 1.2m-1.5m. When the strain is 0.616g, the dynamic strain distribution curve is W-shaped, and the population decreases gradually. Under the effect of peak acceleration, the maximum strain of dynamic strain was 109.33με, 173.01με, 133.89με, 124.55με, 154.19με, 112.00με, 177.41με respectively.

According to the analysis above, under the action of the earthquake peak acceleration, the strain of the geogrid in the two models basically increases with the increase of acceleration.

4 NUMERICAL SIMULATION

4.1 *Numerical model*

The reinforced soil is divided into two parts: the soil elements and reinforcement elements. The reinforced earth organisms is consist of soil elements, reinforced material units and contact element. Considering the friction between the soil and the tendon, the contact unit produces relative slip along the interface with the stress. In this paper, the geogrid as a reinforced material of the retaining wall is divided into soil units, reinforced elements and contact element.

4.2 *Analysis of acceleration amplification factor*

In ANSYS, acceleration spectra can be obtained if two shifts of the para shift spectrum are performed.

The acceleration magnification obtained by ANSYS post-processing are shown in Table 4-1, Figure 4.1, and Fig. 4.2.

Table 4-1 Acceleration amplification factor of finite element model

Earthquake magnitude / Wall height	0.1g	0.2g	0.3g	0.4g
0	1.00	1.00	1.00	1.00
1.2	1.05	1.06	1.21	1.24
2.4	1.21	1.61	1.87	1.75
3.6	1.42	1.92	2.15	2.11
4.8	1.55	2.14	2.44	2.38
6.0	1.60	1.98	2.35	2.33

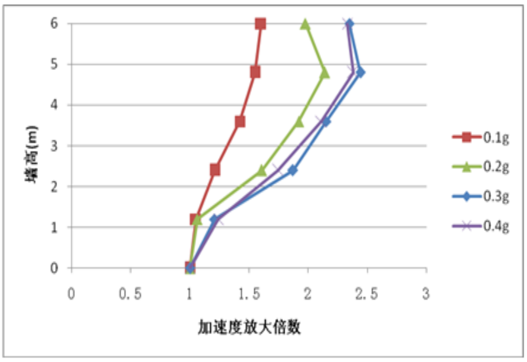

Figure 4.1 Finite element model acceleration magnification with wall height distribution

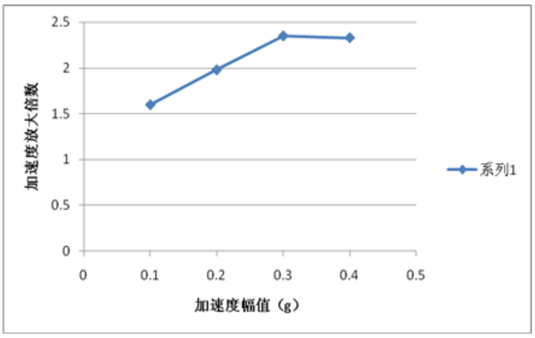

Figure 4.2 The wall top point acceleration magnification with the acceleration amplitude change

It can be seen from Fig.4.1 and Fig. 4.2 that, in the condition of 0.1g, 0.2g, 0.3g and 0.4g, the acceleration magnification of each wall is higher than 1, which has obvious acceleration amplification effect. And when the maximum magnification of acceleration occurs at 0.3g, the maximum value is 2.44.

When the local vibration peak acceleration is at 0.1g, the acceleration magnification increases linearly with the wall height, When the earthquake peak acceleration is 0.2g, 0.3g, 0.4g, the acceleration amplification curve appears inflection point at the wall height 4.8m (0.8H), and the lower acceleration amplification increases linearly with the wall height, and the upper part decreases linearly with the wall height.

When the earthquake peak acceleration is between 0.1g and 0.3g, the acceleration magnification of the same wall high position increases with the increase of input acceleration, and increases linearly with the increase of input acceleration; When the earthquake peak acceleration is between 0.3g and 0.4g, the acceleration magnification does not increase with the increase of input acceleration, or approximately decreases linearly or even slightly. This may be due to the increase of the input earthquake peak acceleration, the soil shows obvious nonlinear characteristics, and the filtering effect of soil layer is gradually enhanced. Thus, the peak value of acceleration is no longer linearly increasing or even decreasing.

4.3 *The potential fracture surface in finite element*

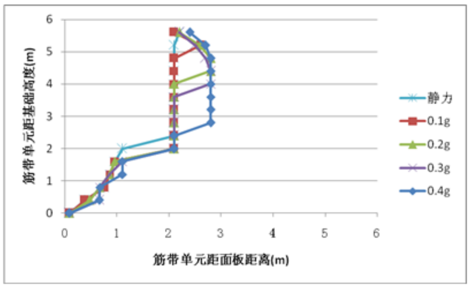

Fig 4.3 Potential rupture of retaining wall under various magnitudes

As can be seen from Fig.4.3, the potential rupture surface of the retaining wall has a similar shape under the influence of static and various magnitudes, and in the static case, the potential failure surface of the retaining wall is an approximate 0.3H type, which agrees with the experimental results of Sun Yuqi , Xiong Zhenghong and Deng Rongji. The poly line is roughly composed of two straight lines, which have been drawn from the wall bottom line, and the angle between the horizontal plane is about $45°+\frac{\phi}{2}$, Another line is parallel to the vertical panel, The intersection of its top end and the top of the wall is about 0.35H of the wall.

When the seismic peak acceleration is 0.1g, the fracture surface of the retaining wall is similar to the static rupture surface at 4.8m below the wall height, When the wall height is above 4.8m, the part of the fracture surface is a curve that increases first and then decreases ,and the maximum value appears at the distance from the panel 2.6m, and finally the top face is 0.35H away from the panel.

When the peak acceleration of the earthquake is 0.2g, the rupture surface of retaining wall is below 4m height of wall and 0.1g fracture surface is similar to the wall height of 4m or more part of the rupture surface shape is a vertical line with a panel and a curve, vertical. The line appears at 2.8m (0.47H) from the panel. The curve ends up by a distance of 0.36H from the top panel.

When the peak acceleration of the earthquake is 0.3g, the fracture wall of the wall is 3.6m below the wall and 0.2g fracture surface is similar to the wall height of more than 3.6m part of the rupture surface shape is a vertical line with the panel and a curve, The vertical line appears at 2.8m (0.47H) from the panel. The curve ends up by a distance of 0.36H from the top panel.

When the peak acceleration of the earthquake is 0.4g, the fracture surface of the retaining wall is similar to the rupture surface of 0.3g in the wall of the wall height of 2.4m, and the part of the rupture surface is more than 2.4m above the wall. The shape of the rupture surface is a vertical line and a curve parallel to the panel. The vertical line appears at 2.8m (0.47H) from the panel. The curve ends up to the top face of the panel 0.4H.

From the analysis, it can be seen that with the increase of earthquake peak acceleration, the maximum tensile force of tendon band appears less and less from the panel 2.1m,, and more and more from the panel 2.8m, namely the potential failure surface of retaining wall with the increase of peak acceleration extends to the wall of the trend, in the static approximation for 0.3H, to 0.4g when the potential failure surface is close to 0.47H.

4 CONCLUSION

Through the shaking table test, comparative analysis of the wrapped reinforced earth retaining wall and ordinary reinforced earth retaining wall draw the following conclusions.

Because of wrapping end, the wrapped reinforced earth retaining wall can propagate seismic wave along the wall and weaken during amplification. Compared with common reinforced earth retaining wall, wrapped reinforced earth retaining wall has better seismic performance.

According to the shaking table test and numerical analysis, it shows that the potential failure surface of reinforced earth retaining wall has the trend of extending behind the wall with the increase of peak acceleration. Under static conditions, the potential fracture surface is close to 0.3H , and at 0.4g, the potential rupture surface is near 0.47H.

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