Study on Dynamic Characteristics of Multistage Lattice Reinforced Soil Retaining Wall under Cyclic Load

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Abstract. As a new type of retaining structure, Gabion reinforced retaining wall has been gradually applied in China, but the current research mainly focuses on ground motion loads, and less studies on the impact of vibration loads such as environment, for the dynamic characteristics of Gabion reinforced retaining wall under cyclic dynamic loads. The spatial distribution characteristics of dynamic response and vibration energy of Gabin reinforced retaining wall slope and their variation with frequency were obtained through laboratory model tests. The research results show that: (1) the attenuation of dynamic strain along depth is mainly concentrated in the second and third retaining walls below the ground, the attenuation phenomenon of the lowest retaining wall is not significant, and the attenuation of dynamic earth pressure along the slope is mainly in the third retaining wall, which is within 10m away from the power source. (2) Acceleration tends to decay along vertical lines, and both dynamic strain and acceleration amplitude increase significantly with the increase of equipment operating frequency.

Keywords: Gabing reinforced earth retaining wall; cyclic load; dynamic response test; vibration energy

1 INTRODUCTION

In recent years, the scale of national construction projects has increased rapidly, and complex geological conditions in mountainous areas have brought challenges to engineering construction. Gabion reinforced earth retaining wall has the advantages of ecological protection, beauty, stability and economy, and has been widely used in foreign countries. Yang Guolin[1]studied the effects of dynamic load amplitude, vibration frequency, reinforcement amount and filling density on the deformation of retaining wall in laboratory model tests. Guler and Fakharian[2-3]studied the dynamic characteristics of the panels and abutments of complex reinforced earth retaining walls. In order to

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evaluate the performance of Gabion reinforced retaining wall slope under cyclic vibration load, this paper tests the dynamic strain, dynamic earth pressure and acceleration characteristics of retaining wall under different flotation equipment operation modes through simulated laboratory tests under cyclic load, which provides reference for the application of reinforced retaining wall.

2 DESIGN OF MODEL EXPERIMENT

In this paper, a new mine slope treatment project in Fengxin, Jiangxi Province is used as a prototype for model tests. Considering the existing test equipment and site conditions, the geometric similarity ratio of 1:30 was selected. Geometric length, elastic modulus and density are taken as basic physical quantities, and then similar constants of other physical quantities are derived by using Buckingham π theorem[4], so that the model system and the prototype system can still meet the test requirements although there is a deviation in the strict similarity. The details are shown in Table 1.

Table 1. Model similarity ratio

No.	Physical quantities	Similarities	Similarity constants	No.	Physical quantities	Similarities	Similarity constants
1	L	C_L	1：10	6	μ	$C_\mu = 1$	1:1
2	E	C_E	1:4	7	P	$P = (C_l)^2 C_E$	1:3600
3	ρ	C_ρ	1:1	8	g	$C_g = 1$	1:1
4	c	$C_c = C_E$	1:30	9	a	$C_a = 1$	1:1
5	φ	$C_\varphi = 1$	1:1	10	σ	C_ρ	1:4

The test model is mainly composed of the Gabion retaining wall assembled with stones and the backfill soil (silty clay) behind the wall. The average value of the basic physical parameters of the backfill soil is shown in Table 2. The test model adopts the bottom-up 7-layer filling method. The position of the test sensor is shown in Figure 1. Refer to Guan Wei et al. [5] Sinusoidal cyclic loads are used to simulate mechanical loads to reflect cyclic characteristics and load effects. The simulated load is 5KN, 6KN, and the frequency is 3, 6, 9, 12, 15Hz, and the orthogonal combination is used as the loading condition.

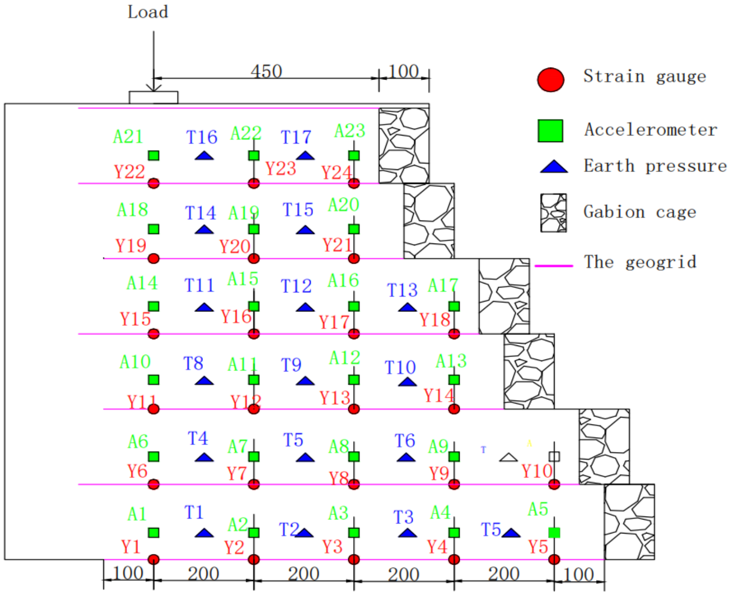

Fig. 1. Location of the sensor

Table 2. Physical and mechanical index of backfill

Category	Density	Moisture content	Compression modulus	Permeability coefficient
Silty clay	$1.82 g\cdot cm^{-3}$	1.87 %	7.04 MPa	$5.36\times10^{-6} cm\cdot s^{-1}$

3 ANALYSIS OF TEST RESULTS

3.1 Dynamic Response Analysis of Reinforced Soil System

Dynamic Strain Time History Response Characteristics

As shown in Figure 2, by drawing the distribution curve of dynamic strain response peak along the buried depth, it is found that the distribution curve of geotechnical strain along the wall height is unimodal or bimodal. The peak value appears in the middle of the retaining wall at all levels, and the closer to the retaining wall, the more obvious, but the overall attenuation is top-down. The vibration load is gradually transferred to the lower geogrid, resulting in larger strain on the upper layer and smaller strain on the lower layer. Tensile properties and stiffness decrease with depth. The strain growth of the first retaining wall at the bottom is affected by the constraint effect. In the frequency range of 3~15Hz, the peak amplitude of dynamic strain is small, indicating that the reinforced soil structure can effectively reduce the dynamic stress of the foundation bed, and has a good reinforcement effect.

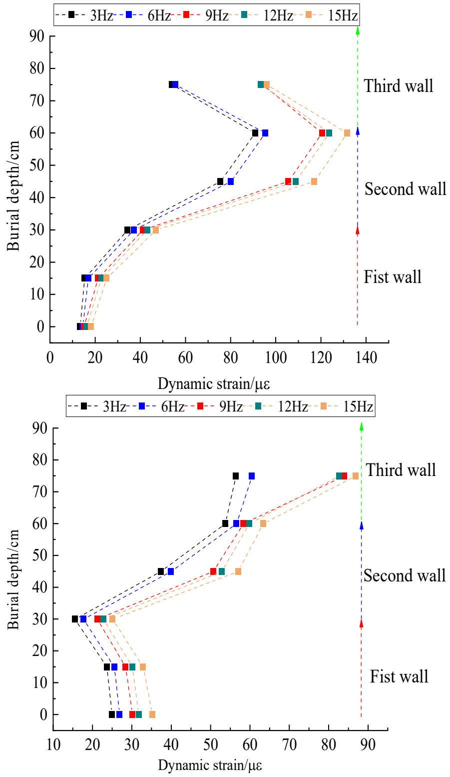

Fig. 2. Distribution of grid dynamic strain along wall height (0、20cm away power)

Time History Response Characteristics of Dynamic Earth Pressure.

As shown in Figure 3, according to the distribution curve of peak earth pressure response, it can be seen that the test point closest to the loading site has the largest force, and the attenuation trend is obvious from top to bottom, and the attenuation rate gradually decreases, with the maximum attenuation rate being about 62.6%. The attenuation range of dynamic earth pressure is mainly within 10m from the power source, and the pressure of the first layer at the bottom increases slightly due to the increase of mechanical density. The vertical dynamic earth pressure changes little under different frequencies and is not affected by the number and frequency of loads. The soil mass in the middle has a double peak value, which gradually decreases along the wall direction and the reinforced end. Quality control and displacement monitoring should be emphasized to reduce the influence of soil displacement when the pressure at the connection of retaining wall drops.

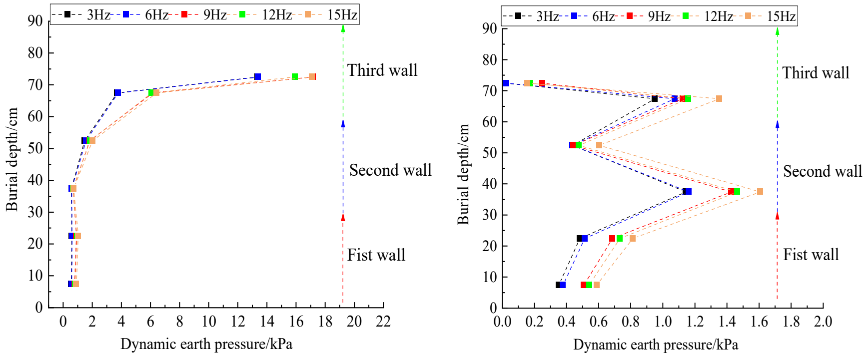

Fig. 3. Distribution of peak earth pressure at different frequencies(20、40cm away power)

Acceleration Time-history Response Characteristics

Acceleration is an important index to evaluate the dynamic characteristics of structures. The acceleration curves of each measuring point at different frequencies are plotted. As shown in Figure 4, due to the large rigidity and good integrity of the reinforced body, the attenuation rate is maximum in the surface range, while the attenuation of the secondary retaining wall and below the bottom of the layer gradually slows down. The vertical acceleration increases significantly with the increase of loading frequency, and the change of loading frequency has a significant effect on the vertical acceleration.

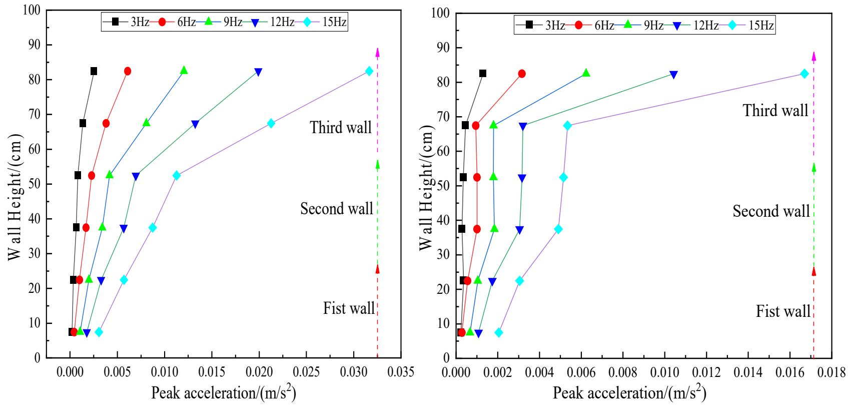

Fig. 4. Acceleration peak distribution at different frequencies (0、40cm away power)

4 CONCLUSION

Through laboratory model test, the slope of Gabion reinforced retaining wall is studied, and the results are as follows:

The strain distribution of geogrid is unimodal or bimodal, and the peak value is concentrated in the middle of each retaining wall, but the overall attenuation trend is top-down. Therefore, in the design and construction, attention should be paid to controlling the force in the middle of the retaining wall at all levels and the flatness of the reinforcement laying to ensure that the force distribution of the grille is uniform.

The attenuation of dynamic earth pressure mainly occurs in the third retaining wall. Combined with the practice, it can be seen that the main bearing range of earth pressure is within 10 m from the power source, which needs special attention in the actual design and construction. The acceleration decreases along the vertical line, and the dynamic strain and acceleration amplitude increase with the increase of the equipment operating frequency.

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