Dynamic Characteristics Numerical simulation of Sea Entrance Soil under Dynamic Load

Hongru Li*, Shenni Wang, Liang Cheng
Xi'an University of Technology, Loess Soil Mechanics and Engineering Key Laboratory of Shaanxi Province, Xi’an, 710048, China

Abstract: The traditional numerical simulation method of sea entrance soil dynamic characteristics has some problems, such as the low simulation value and the poor accuracy of the numerical simulation. In order to improve the above situation, a new numerical simulation method based on dynamic load is built. Through three steps of soil grid partition, finite element model establishment and load setting scheme selection, the finite element description of sea entrance soil dynamic characteristics is completed based on dynamic load theory. Through the three steps of dynamic characteristic numerical determination, simulation boundary condition determination and damping setting, the construction of a new numerical simulation method for the sea entrance soil dynamic characteristics is completed. The simulation application environment and design contrast experiment results show that compared with the traditional methods, the new method can completely improve the problem of low total numerical simulation and poor accuracy of numerical simulation.

Key words: Dynamic Load; Sea Entrance Soil; Dynamic Characteristics; Numerical Simulation; Grid Division; Finite Element Model; Setting Scheme; Damping Setting.

0 Introduction

Traditional numerical simulation method of sea entrance soil dynamic characteristics used the slope dynamic failure mechanism to obtain the time history curve of the dynamic stability coefficient, and the obtained the numerical simulation basis through the calculation method of the slope dynamic stability of the [1-2]. This method makes the most of the advantage of the numerical calculation software, and comprehensively analyzes the dynamic response characteristics and corresponding deformation characteristics the point of view of dynamics, which provides a theoretical support for the numerical simulation of the sea entrance soil dynamic characteristics. However, with the development of scientific and technological means, the traditional methods gradually reveal the shortcomings of the low simulation value and the poor accuracy of numerical simulation. In order to solve the above problems, a dynamic load correlation theory is introduced to improve the design of grid partition and finite element modeling of the sea entrance soil. The new numerical simulation method for the sea entrance soil dynamic characteristics makes full use of the advantages of the original method, and exerts the advantage of strong stability of the dynamic load theory. In order to highlight the new simulation method has certain practical value, the simulation method is applied to the environment, and the contrast experiment is designed.

1 Finite element description of sea entrance soil dynamic characteristics under dynamic load

1.1 Grid partition of sea entrance soil under dynamic load

Considering the symmetry of the sea entrance soil, the grid partition model is established from half of the soil structure and foundation. The maximum width of the soil grid model is 6 m, the embankment slope 1:1.5, and the height is 6 m, of which the asphalt pavement thickness is 0.15 m. It is assumed that the bottom of the model is x and y constraints, the cross section of the model is 30 m wide and the model vertical value is 10 m [3-4]. The model is silty soft soil, groundwater is located on the surface of the model, under the and on the two sides of the soft soil model are impervious bedrock, the top surface is free drainage, the geogrid is laid on the bottom of the model, and the thickness of the sand cushion is 0.5 m. The basic parameters of the calculation model of soft soil reinforced embankment are shown in Table 1.

Table 1 Basic parameters of the grid partition model

Material Science	Thickness d/m	Densityρ/(kg m^{-3})	Modulus of elasticityE/MPa	Poisson ratio v
The surface layer	0.16	2500	1400	0.3
Embankment filling	5.55	1800	10	0.3
A grille	-	1800	4200	0.4
Sand cushion	0.5	1900	8	0.26
Silt soft soil	10	1850	-	0.42

1.2 The establishment of the finite element model of sea entrance soil under dynamic load

After establishing the grid partition model of the sea entrance soil, the finite element model of sea entrance soil under dynamic load is established by abaqu software, as shown in Figure 1. The analysis process of abaqu software is more complex and can be applied to different problems in different fields. It can provide program interface for dynamic load and soil model of estuary, and contains a lot of material constitutive relations and models. Soil model can define different material properties according to the needs [5-6]. In addition, abaqu also provides some useful units, such as thin film element, shell element, rigid element, infinite element and beam element, and also including some special unit chain units, such as the reinforcement element, reinforced concrete structure or load model structure to reflect the interaction of soil and pipe construction problems, the use of these special units in solving specific problems is very convenient and efficient.

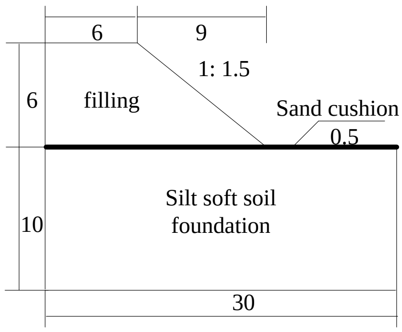

Figure 1 Finite element model of sea entrance soil under dynamic load

1.3 Dynamic load setting selection of sea entrance soil

Simulating the construction of the sea entrance soil, the model fill is divided into three layers according to the order of construction. The thickness of each layer is 2 m, that is, 3 stages loading. The filling time is 90 days. The loading process is shown in Figure 2, the load setting is applied to the unit life and death function provided by the abaqu [7-8]. According to the loading process of soil in Figure 2, it can be known that when loading at 3rd, 6th, 9th, 12th and 15th months, the loading condition of dynamic load will change sequentially. According to the different results of each change, the selection of the dynamic load setting of the soil inlet can be completed.

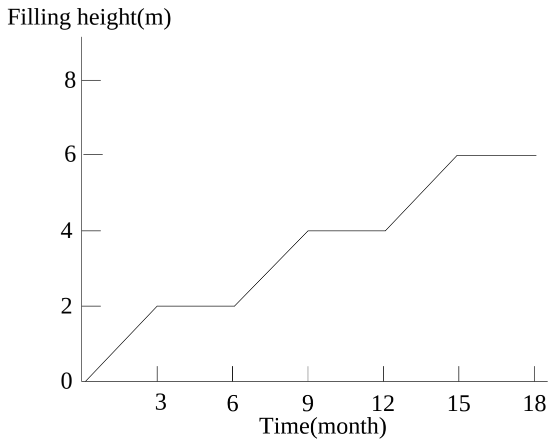

Figure 2 Loading process of sea entrance soil under dynamic load

2 Implementation of numerical simulation method for dynamic characteristics based on finite element description

2.1 Determination of the sea entrance soil dynamic characteristics

The dynamic characteristic value of the sea entrance soil is an important index to describe the stability of the soil. Under the action of dynamic load, the structure of soil mass, the spacing of soil particles and the energy of particle molecules are changed. Usually, the dynamic load is considered to be a strong external force intervention. With the increase of external force, the structure of the sea entrance soil gradually changes towards a looser state [9-10]. The spacing of soil particles varies from the first few nanometers to tens of nanometers to dozens of nanometers under the premise of the continuous vibration of the soil particles. Particle molecular energy always kept at a low level in the initial stage, with the exertion of strong external force intervention, more and more particles of the sea entrance soil vibrated, and the energy of the molecule itself increased with the increase of vibration. Set α to represent the soil structure at the entrance to the sea, β represents the spacing between the soil particles, γ represents the molecular energy of particles. α, β and γ can be used to express the sea entrance soil dynamic characteristics.

$$[C]=\alpha[M]+\beta[O]+\gamma[B] \qquad (1)$$

In the upper formula, $[M]$ represents the change in the sea entrance soil structure, $[O]$ represents the change of space between soil particles, $[B]$ represents the change of particle molecular energy.

2.2 Determination of boundary conditions for numerical simulation of sea entrance soil dynamic characteristics

The boundary condition of the numerical simulation of the sea entrance soil dynamic characteristics is a decisive factor for the simulation results. In general, the simulation results can be divided into two kinds: the SV wave result and the SH wave result. Among them, the results of SV wave have two simulated boundaries of longitudinal wave and transverse wave [11-12]. The main movement of transverse wave, similar to seismic wave, is a point as the center is the wave source. On this basis, there are many different lateral effects on the numerical simulation results of the sea entrance soil dynamic characteristics, each transverse influence can act as a transverse fracture. The main motion of the longitudinal wave is similar to the vibration produced by the vertical excavation, produced only a slight vibration on the surface of the beginning, with the increase of mining depth, finally have a regular wave effect on the numerical simulation results of the sea entrance soil dynamic characteristics [13-14]. The SH wave can also be called the deep simulation of the boundary wave. The numerical simulation results of the sea entrance soil dynamic characteristics will produce multiple approximations under the limitation of the SH wave boundary condition. Finally, the simulation results that are closest to the real results can be obtained by accumulating the approximate values. The principle of determining the boundary conditions of a specific numerical simulation is shown in Figure 3.

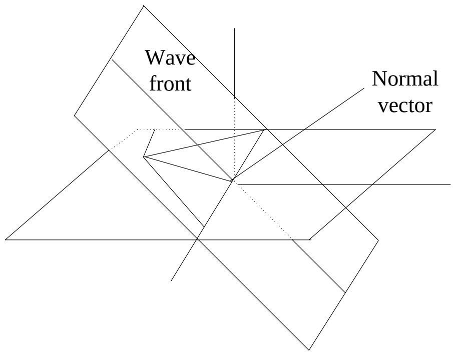

Figure 3 The principle of boundary condition determination for numerical simulation of sea entrance soil dynamic characteristics

2.3 Damping setting based on finite element method to describe dynamic characteristics

The formation of soil damping at the entrance to the sea is mainly due to the internal friction of the material and the possible sliding of the contact surface [15]. In the dynamic load conditions, the finite element numerical dynamic characteristics of the sea entrance soil is based on the numerical damping setting. Using the determined dynamic characteristic value $[C]$ as an operational independent variable, ξ as the dependent variable, and using local hysteresis damping principle of the relationship between the two descriptions. The local lag damping principle usually takes 0.8 as the basic operation coefficient, which can be expressed as χ. Under the fixed degree of freedom condition, the damping description is completed by a specific constraint relation. By using the above variables, the damping setting results of the soil characteristics of the sea entrance soil can be expressed as:

$$\xi = \frac{1}{2}\left(\frac{[C]}{\chi} + \beta\varpi\right) \qquad (2)$$

Among them, ϖ is the free coefficient which satisfies the local hysteresis damping principle, and its maximum value is usually not more than 50. By using the result of damping setting, the numerical simulation results of the dynamic characteristics of the soil under the dynamic load can be expressed as:

$$R=\frac{(\alpha[M]+\beta[O]+\gamma[B])\bullet\sqrt{[C]^{3}}}{\sum_{n=1}^{n}\frac{1}{2}\xi\bullet\beta\varpi d\xi}/\frac{[C]}{\chi} \tag{3}$$

Among them, n represents an arbitrary natural number, and its minimum value is 1, and the maximum is not more than 100.

3 Experimental results and analysis

This process has completed the construction of numerical simulation method for the sea entrance soil dynamic characteristics of under dynamic load. In order to verify the practical value of the new method, two computers with the same configuration are used as the experimental object. One of them took the new simulation method as the experimental group, and the other was carried with the traditional simulation method as the control group. Before the start of the experiment, the experimental parameters are set up according to the table below.

3.1 Experimental parameter setting

Table 2 Experimental parameter setting

Experimental parameters	Experience group	Control group
Total dynamic load/T	8.54×10^{7}	8.54×10^{7}
Soil stability coefficient at the entrance to the sea	0.97	0.97
Dynamic characteristic data type/c	Ⅳ	Ⅳ
Prediction accuracy of numerical simulation/%	87.26	87.26
Numerical simulation coefficient	6.43×10^{-5}	6.43×10^{-5}
Load dynamic coefficient	3.81	3.81

The parameters in the above table represent the total amount of dynamic load, the stability coefficient of the sea entrance soil, the data type of dynamic characteristics, the accuracy of numerical simulation, the numerical simulation coefficient and the load dynamic coefficient. In order to ensure the fairness of the experiment, the parameters of the experimental group and the control group remained consistent.

3.2 Comparison of the total number of simulated numerical values

After setting the parameters, a special method is used to record the numerical value of the simulation in the experimental group and the control group, and the specific experimental situation, as shown in the following figure.

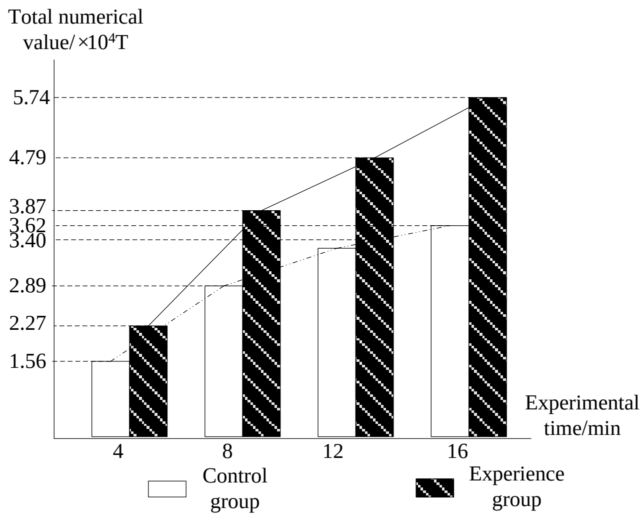

Figure 4 Comparison of the total simulation values (low frequency)

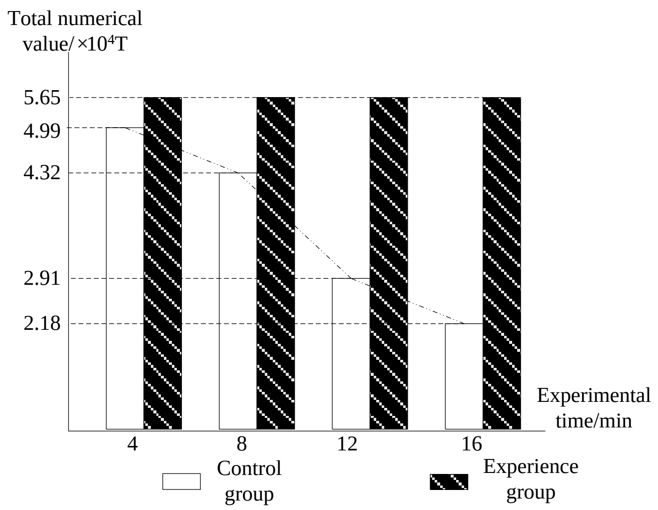

Figure 5 Comparison of the total simulation values (high frequency)

Figure 4 is a contrast diagram of the total numerical value of the experimental group and the control group at low frequency. The analysis of Figure 4 shows that, under the influence of low frequency, the total amount of simulated numerical value in the experimental group and the control group increases with time. However, the rising trend of the experimental group was significantly higher than that of the control group. When the experiment time reached 16min, the total number of simulated numerical values of the two groups reached the maximum. At this time, the parameters of the experimental group were 5.74×10^4T, which was far greater than 3.62×10^4T of the control group. Figure 5 is a contrast diagram of the total numerical value of the experimental group and the control group at high frequency. The analysis of Figure 5 shows that, under the influence of high frequency, the total amount of numerical simulation in the experimental group is always in the level state. The total amount of simulated numerical values in the control group showed a significant downward trend. When the experiment time was 4min, the parameters of the control group reached the maximum value of 4.99×10^4T, which was much lower than the 5.65×10^4T of the experimental group. Therefore, it can be proved that the numerical simulation method of the sea entrance soil dynamic behavior under the applied dynamic load can completely improve the problem of the low numerical value of the simulated numerical value.

3.4 Accuracy comparison of numerical simulation

The following figure is a comparison diagram of the accuracy of the numerical simulation in the experimental and control groups.

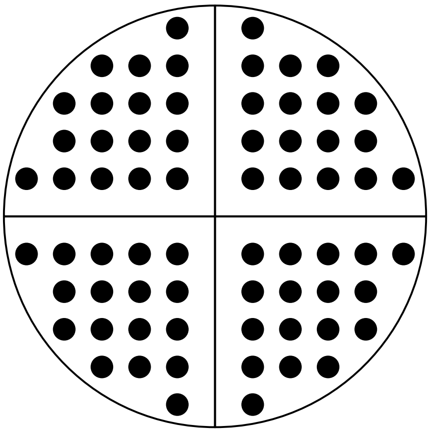

Figure 6 Accuracy comparison of numerical simulation (Experimental group)

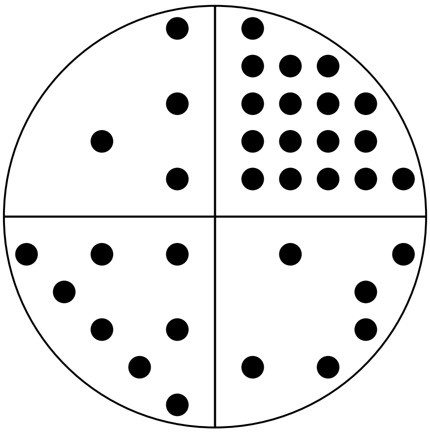

Figure 7 Accuracy comparison of numerical simulation (Control group)

In the above figure, the black dots represent the accuracy of numerical simulation. The more uniform the distribution of the dots, the higher the accuracy. Analysis of Figure 6 shows that the black dots in the experimental group all keep the same number and the same distribution uniformity in the four detection ranges, and the dots in each detection range always remain highly symmetrical. Analysis of Figure 7 shows that the number and distribution state of the black dots in the control group are always different in the four detection ranges, and the dots in each detection range cannot be kept symmetrical. Therefore, it can be proved that the numerical simulation method under the dynamic load into Haikou can solve the problem of the poor accuracy of the numerical simulation.

4 Conclusion

A new numerical simulation method for dynamic characteristics of sea entrance soil under dynamic loading is proposed in this study. The original method is improved in the aspects of determining boundary conditions and determining the dynamic characteristics of estuaries. By comparing the experimental results, it is proved that the new method is of higher practical value than the traditional method.

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