Earth Sciences
2018; 7(3): 138-143
http://www.sciencepublishinggroup.com/j/earth
doi: 10.11648/j.earth.20180703.15
ISSN: 2328-5974 (Print); ISSN: 2328-5982 (Online)

Characteristics and Evaluation of Coral Mixed Soil Base

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To cite this article:
Ju Yanfei, Min Daogui. Characteristics and Evaluation of Coral Mixed Soil Base. *Earth Sciences*. Vol. 7, No. 3, 2018, pp. 138-143.
doi: 10.11648/j.earth.20180703.15

Received: May 14, 2018; **Accepted**: June 4, 2018; **Published**: June 15, 2018

Abstract: With the human activities gradually into the ocean, especially the implementation of the strategy of the Belt and Road, engineering construction will be more and more involved in the coral sand foundation, and the survey of foundation design specification, has not yet listed coral reef types of geotechnical, field test research on characteristics of coral sand foundation scholars both at home and abroad. However, after the coral reefs are artificially disturbed and blown into the land area, the mixed land foundation with coarse and fine grained soil is formed. In this paper, the characteristics of non-uniform and weak interbedded coral soil are obtained by dynamic field touchdown, pit exploration, particle analysis and Rayleigh wave method. Through triaxial shear tests with different porosity ratios, the results show that the shear strength index of coral sand is higher than that of natural silt sand and silt, and the coralline sand has certain cohesion. Through field loading plate test and dynamic contrast analysis, the reasonable loading plate impact depth, dynamic agent number and coral hybrid bearing capacity of soil foundation has good correlation, and through the analysis of dynamic agent number and the foundation bearing capacity, dynamic agent number and the experience formula of the modulus of deformation, and research has certain reference value to similar projects.

Keywords: Coral Mixed Soil, Rayleigh Wave Method, Void Ratio, Shear Strength, Load Plate Test, Dynamic Contact, Depth of Influence, Foundation Bearing Capacity

1. Introduction

Coral sand is a special kind of rock and soil medium, mainly distributed in warm waters on both sides of the equator. There are about 110 countries in the world with coral reef waters. With the human activities gradually to the sea, more and more involved in the coral sand foundation engineering construction, how to correctly understand and know the engineering properties of coral sand foundation bearing capacity characteristics, in particular, is the concern of the engineering construction personnel.

Sun-ZongXun [1], [2] coral reef engineering geology is presented according to the characteristics of coral reefs, and summarizes the mechanics characteristics of coral sand foundation, high void ratio, high friction Angle and low strength, particle crushing is the main factors influencing the deformation and strength characteristics of coral sand, Huo-Yingxi [3] and others in the red sea coral reefs packing of compaction effect, Wang-Baofeng [4] on frequency coral sand foundation settlement are studied, and Yan-YuPing [5] and others in the Bahamas coral reef engineering geology features, zhao-TingHuan [6] on the coral reef engineering geology are discussed. She YinPeng [7] obtained the conclusion that coral sand shows a special shear stress-displacement curve, and the internal friction Angle increases with the increase of particle size.

At present, there is not a lot of experimental research on the bearing capacity of coral sand foundation. Zhu-changqi [8] et al analyzed the bearing capacity characteristics of coral sand foundation through N10. Yong-kang Yang [9] and other coral detritus sand foundation bearing capacity is studied through field experiment, Peter li [10] coral sand foundation is obtained by plate loading test, such as load transfer depth of about 2 ~ 3 times the diameter of the bearing plate width or, radius horizontal load for 1 ~ 2 times of bearing plate width or diameter. After the coral reefs are filled with artificial disturbance, the ground is formed by the combination of coral fragments and coral fine grained soils, similar to the mixed soil foundation. Chang –ShiPiao [11] et al. pointed out that the mixing soil was large due to the size distribution of grains, and the size of coarse particle size was very different, which often resulted in false evaluation due to improper classification. Xu-ning [12] first proposed that further experimental studies should be carried out on coral clastic mixed soil, especially silt. In this article, through the contrastive analysis of the dynamic and static load test, obtained the correlation of stroke and the foundation bearing capacity, to quickly and efficiently detect the coral hybrid bearing capacity of soil foundation, has the extremely positive significance, and also can provide the reference for the similar engineering and scientific research.

2. Site Characteristics Study

A field land area is shown in figure 1.

Figure 1. *The field land.*

In order to study the characteristics of the site, dynamic contact detection, particle analysis, Rayleigh wave method and other methods were used to study the site respectively.

2.1. The Dynamic Penetration Test

The dynamic penetration test is adopted to detect coral sand foundation, will be layered soil size by number of hammer (as shown in figure 2), the number of the test results show that the adjacent soil layering difference is bigger, poor soil uniformity and moving between adjacent points out several change is bigger, no continuous distribution of the soil.

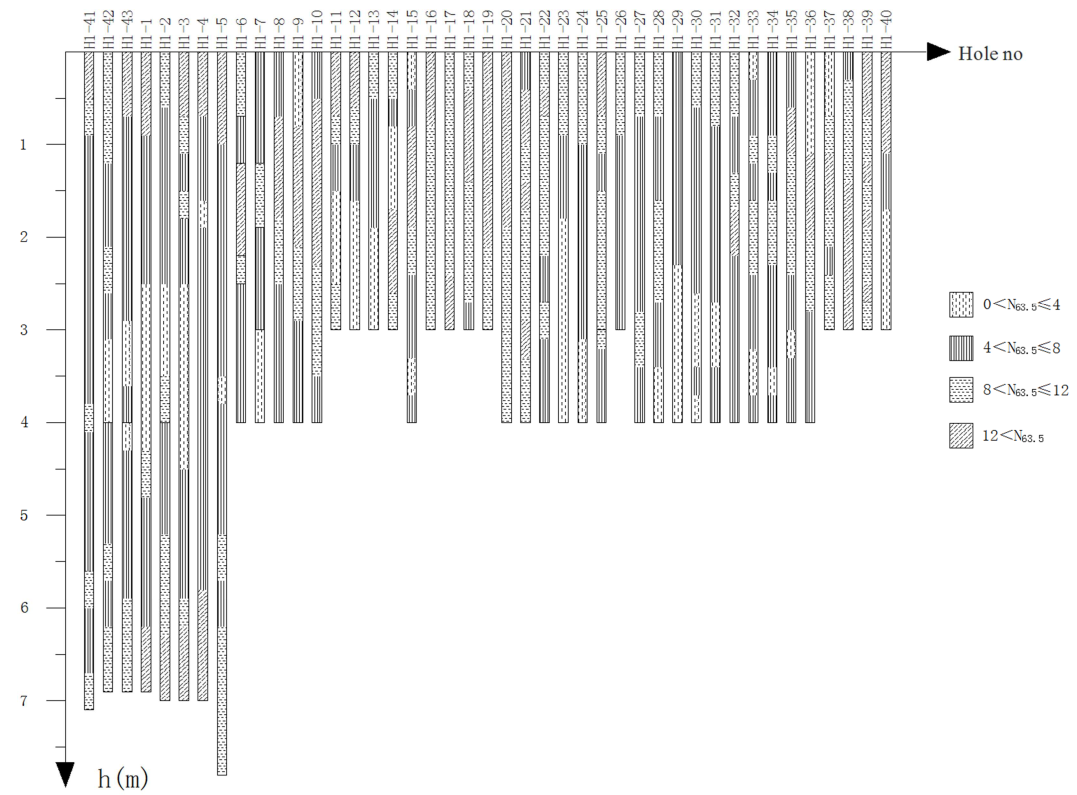

Figure 2. *Ground hammer dynamic hierarchical maps.*

It can also be seen from figure 2 that there is a soil layer of $N_{63.5}$ that is less than 4 strikes in the field formed after blowing and filling, and the soil thickness and burial depth of this layer are unevenly distributed. Further statistical analysis was conducted on the hammer strikes of each dynamic contact point, and it was shown that the standard value of dynamic contact hammer strikes in the field was 2.38 to 10.47 strikes, and the variation coefficient was 0.28 to 1.47, indicating that the soil uniformity of the blown fill foundation was poor.

2.2. Particle Analysis

In order to understand the granule grading of the field, the pit sampling was carried out, and the results of the indoor particle grading analysis were as follows.

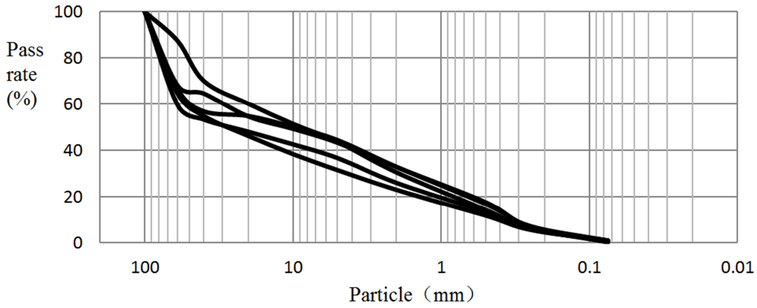

Figure 3. *Particle size distribution curve of coarse particle concentration.*

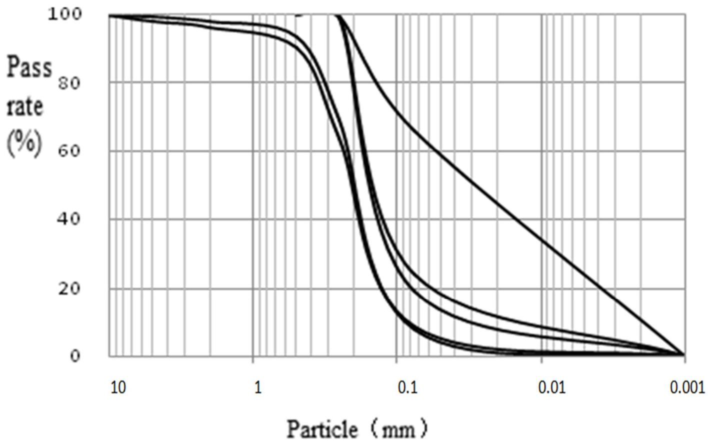

Figure 4. *Particle size distribution curve of fine particle concentration.*

Can be seen from the above test pit particle analysis experiment: coral sand formation of landform, coarse particle concentration area debris inside mixed gravel thickness, mainly composed of sand, gravel, large particles, particle size in more than 10 mm, grain fine, the particle size under 0.075 mm, poor sorting characteristics, fine particle concentration area generally for sand, silt and silt. According to the general distribution law, the soil in the field is characterized by mixed soil.

Based on the above soil and gradation characteristics, the site is the uneven foundation of the coral mixed soil.

2.3. Rayleigh Wave Method

Ju-Yanfei et al. [13] studied the detection technology of Rayleigh wave method in sand soil. The uniformity of soil can be tested by Rayleigh wave method on site. Using the Rayleigh wave velocity and frequency curve obtained from the test into Rayleigh wave velocity and depth curve, the curve reflects the point at which the change rule of the law of the medium change with depth, inflection point, the point mutation features reflect the geological mechanics properties of formation.

In field test of 20 points, according to data from the field, to extract the dispersion curves of inversion obtained each point Depth-Wave velocity (H – V) curves, figure 5 for typical inversion H - V curves, and the test wave velocity and point out number of comparison and analysis, as shown in table 1.

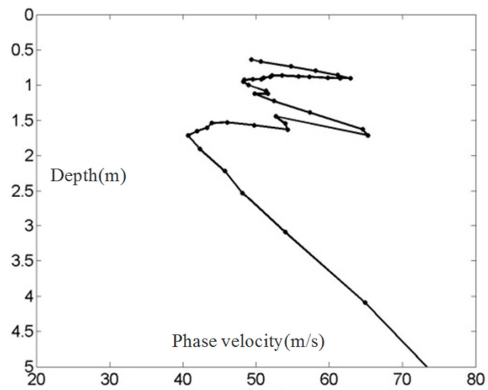

Figure 5. *Depth-Wave velocity curves.*

Table 1. *Speed statistics.*

Hole no.	Dynamic sounding hammer (blow)	The average wave velocity (m/s)	Standard deviation	Variable coefficient
1#	8.71	201.75	26.23	0.13
2#	6.32	199.40	39.88	0.20
3#	6.16	196.23	43.17	0.22
4#	5.61	189.44	58.73	0.31
5#	5.52	185.32	33.36	0.18
6#	5.51	185.09	61.08	0.33
7#	4.53	186.93	71.03	0.38
8#	4.94	185.57	74.23	0.40
9#	4.74	183.40	82.53	0.45
10#	4.74	176.15	72.22	0.41
11#	3.83	164.84	95.61	0.58
12#	3.97	165.69	87.82	0.53
13#	4.33	172.84	89.88	0.52
14#	4.51	167.33	97.05	0.58
15#	4.39	166.66	83.33	0.50
16#	3.67	165.93	102.88	0.62
17#	3.32	163.41	116.02	0.71
18#	3.68	166.08	112.93	0.68
19#	3.54	166.29	124.72	0.75
20#	3.14	164.33	133.11	0.81

As can be seen from figure 5 and table 1:

Measured 20 points in inversion of shear wave velocity of 163.41 m/s ~ 201.75 m/s, the inversion of shear wave velocity test point on the vertical variation range is larger, the variation coefficient is larger, uneven ground foundation soil, it has been proved in the dynamic penetration test.

Based on the above analysis, it can be concluded that the coral sand foundation formed by blowing is a mixed soil uneven foundation, and soft intercalation is common.

3. Triaxial Shear Test of Coral Mixed Soil

Three axial shear tests were performed on different pore ratios of coral mixed soils. Before the test, different pore ratio tests were obtained by adjusting the compaction work. In this study, 66 groups of different pores were compared, and the shear strength was obtained by triaxial shear test respectively. After the test, statistical analysis was conducted according to the categories of porosity ratio of 1.0, 0.9~1.0, 0.8~0.9 and 0.8, and the relationship between pore ratio and shear strength was shown in table 2.

Table 2. *The relation between pore ratio and shear strength.*

NO	e	c (kPa)	φ (°)
1	>1.0	11.15	8.26
2	0.9~1.0	15.85	31.36
3	0.8~0.9	29.67	33.07
4	<0.8	34.75	36.04

It can be seen from table 1 that the pore ratio has a certain correlation with the shear strength index, and the smaller the porosity is, the higher the shear strength index is.

Changshi [11] et al. recommended natural soil physical and mechanical indicators, as shown in table 3.

Table 3. *Physical and mechanical indexes of natural soil.*

great soil group	e	c (kPa)	φ (°)
	0.5~0.6	8	36
silt	0.6~0.7	6	34
	0.7~0.8	4	28
	0.4~0.5	10	30
	0.5~0.6	7	28
floury soil	0.6~0.7	5	27
	0.4~0.5	12	25
	0.5~0.6	8	24
	0.6~0.7	6	23
	0.4~0.5	42	24
	0.5~0.6	21	23
	0.6~0.7	14	22
	0.7~0.8	7	21
	0.5~0.6	50	22
	0.6~0.7	25	21
Silty clay	0.7~0.8	19	20
	0.8~0.9	11	19
	0.9~1.0	8	18
	0.6~0.7	68	20
	0.7~0.8	34	19
	0.8~0.9	28	18
	0.9~1.0	19	17
	0.7~0.8	82	60
	0.8~0.9	41	30
clay	0.9~1.1	36	25
	0.8~0.9	94	65
	0.9~1.1	47	35

Comparison table 2 and table 3, it can be seen that the coral sand than the general shear strength indexes of natural powder sand and silt shear strength index is higher, especially the coral sand has certain cohesive force, void ratio below 0.9 coral sand cohesive force of more than 30 kpa, close to the level of silty clay to clay. Illustrate the processed coral sand foundation has better ability in the stability of slope in the engineering construction, especially in excavation, slope engineering, can use the coral sand this feature reasonable excavation slope rate.

4. Evaluation of the Bearing Capacity of Coral Mixed Soil

Loading plate test is the most intuitive foundation bearing capacity, reliable detection methods, but the method for testing for a long time, the cost is higher, the scene is often through the dynamic and static agent and other in-situ test to determine the bearing capacity of foundation. For coral mixed soil foundation, the current lack of in situ test and comparison of loading plate test data, the author after 47 place with its dynamic and static load test of contrast, establish dynamic ground stroke, the corresponding relationship between the bearing capacity of foundation soil to be used for rapid and accurate determination of the coral mixed foundation bearing capacity of soil foundation.

4.1. The Loading Plate Has Reasonable Influence on Depth

Top load to the soil through loading plate, the effective stress in soil and decreased with depth, so the influence of the loading plate depth is limited, to determine the reasonable loading plate influence depth, characteristic value of base bearing capacity for effective analysis and influence depth range of dynamic agent number correlation is necessary. Zhai-hongyun [10] et al. studied the relationship between the settlement of load test and the size of the bearing plate, and also indicated that the impact depth of the load plate was limited.

Field the 47 set of loading plate test, load test in situ into action after penetration tests ($N_{63.5}$), 1.0 b, respectively 1.5b, 2.0b, 2.5b, 3.0b depth within the scope of the dynamic ground stroke compared with loading plate test result, the average figure in the b as the loading plate width, $N_{63.5}$ for certain depth scope through the length and the wall friction modified moving average number, f_0 as the characteristic value of subgrade bearing capacity, the result is shown in figure 6 ~ 10.

According to the figure 6 ~ 10, characteristic value of base bearing capacity and dynamic agent number correlation coefficient changing with depth, according to the correlation coefficient of 2.0 b within the scope of the agent number average $N_{63.5}$ and characteristic value of subgrade bearing capacity f_0, the correlation between the best. Therefore, it can be determined that the reasonable influence depth of the coral mixed soil foundation loading plate is twice as wide.

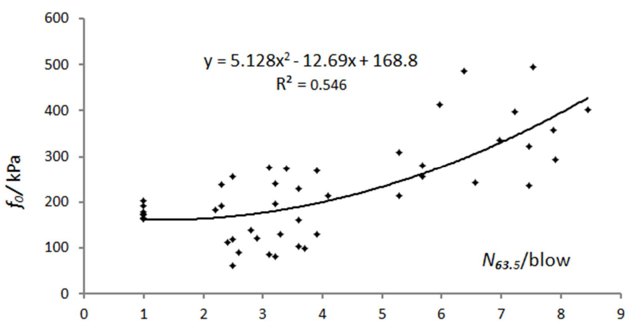

Figure 6. *Relationship between f_0 and $N_{63.5}$(1.0b).*

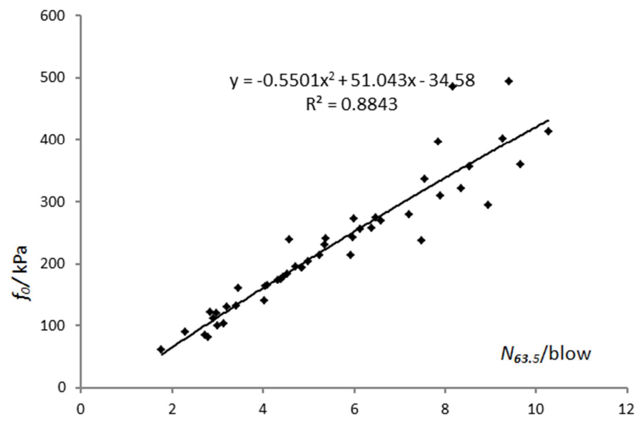

Figure 7. *Relationship between f_0 and $N_{63.5}$(1.5b).*

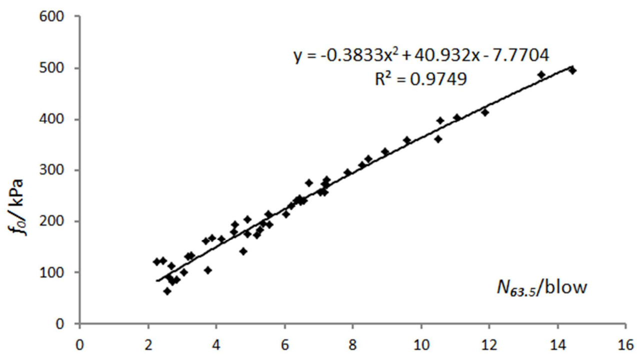

Figure 8. *Relationship between f_0 and $N_{63.5}$(2.0b).*

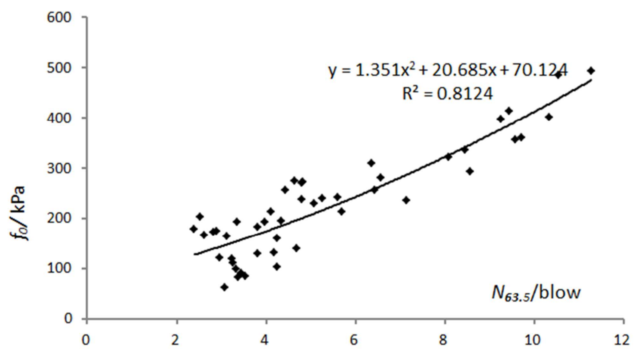

Figure 9. *Relationship between f_0 and $N_{63.5}$(2.5b).*

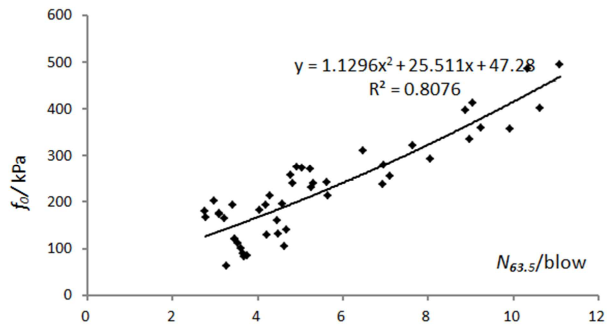

Figure 10. *Relationship between f_0 and $N_{63.5}$(3.0b).*

4.2. The Dynamic Probe Number Evaluates Foundation Bearing Capacity

According to figure 8, the mathematical model expressions of the experimental results of the plate load test and the hammer number of the dynamic contact test are shown in equation (1).

$$f_0 = -0.383\mathrm{N}_{63.5}^2 + 40.93N_{63.5} - 7.770 \quad (1)$$

In order to simplify the calculation, the relation of figure 7 is simplified to a linear relation as shown in equation (2),

$$f_0 = 37.37N_{63.5} + 19.5 \quad (2)$$

By comparison of dynamic contact and static load test, the correlation between N63.5 and foundation deformation modulus can be established, as shown in figure 10.

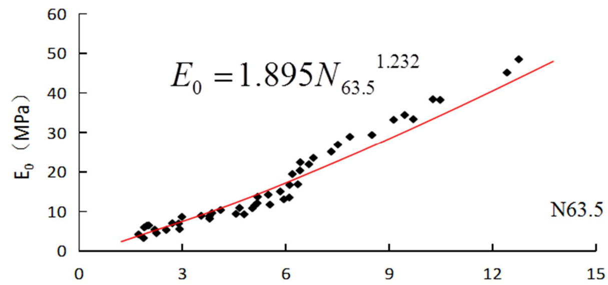

Figure 11. *Relationship between E_0 and $N_{63.5}$.*

Figure 11 by

$$E_0 = 1.895N_{63.5}^{1.232} \quad (3)$$

In the equation, E_0 is calculated for the deformation modulus (MPa) of the plate load test.

For easy reference, the above relations are simplified into table 4.

Table 4. *Foundation bearing capacity and deformation modulus and dynamic detecting hammer number corresponding relation.*

$N_{63.5}$(blow)	**2**	**4**	**6**	**8**
f0(kPa)	94.2	169.0	243.7	318.5
E0(MPa)	4.5	10.5	17.2	24.6
$N_{63.5}$(blow)	10	12	14	16
f0(kPa)	393.2	467.9	542.7	617.4
E0(MPa)	32.3	40.5	48.9	57.7

5. Conclusion

The following conclusions can be drawn from the comparative analysis of site characteristics, triaxial test, load plate test at the same point and dynamic permeability test at different pores in the room.

1) the mixed land foundation of coral is uneven, and soft interbedded layer is common
2) than ordinary natural coral sand silt shear strength index of soil shear strength index, porosity ratio is less than 0.9, the coral sand the cohesive force of more than 30 kpa, close to the level of the silty clay to clay.
3) the reasonable impact depth of the composite coral subgrade load plate is twice the width of the plate.
4) there is a correlation between the number of dynamic probes and the bearing capacity and deformation modulus of foundation, which can quickly and accurately evaluate the bearing capacity of coral mixed land.

References

[1] Sun Zongxun, Zhao Huanting. Coral reef engineering geology - new scienc [J]. Hydrogeology and Engineering Geology, 1998 (1): 1-4.

[2] Sun Zongxun, Research on the nature of coral sand engineering in the Nansha Islands [J]. Tropical Marine, 2000, 19 (2): 1-8.

[3] Huo Ying Xi, Wang Weizhi, Qiu Qinchang, Li Yan, et al. Compaction effects for reclamation fill of coralline in Red Sea region. Port and Watermay Engineering, 2010, 446 (10): 82-87.

[4] Wang Baofeng, Chen Liang. A Coastal Coral Sand Foundation Settlement Case Study. Project Quality, 2016, 34 (8): 78-81.

[5] Yan Yupin, Ke YouQin. Introduction to coral reef engineering geology characteristic and foundation treatment. Resources and environmental engineering, 2008 (22): 47-49.

[6] Zhao HuanTing, Song ChaoJin, LuBo. At the beginning of coral reef engineering geology theory. Journal of Engineering Geology, 1996, 4 (1): 86-90.

[7] She-Yinpeng, LYU Yaru, LI Feng, Yuan-Jiamin. Experimental analyses of shearing mechanism of coral sand [J]. Journal of PLA University of Science and Technology (Natural Science Edition), 2017, 2: 29-35.

[8] Zhu Changqi, Liu Congquan. Research on the nature of coral sand site in xisha yongxing island [J]. Rock and Soil Mechanics. 1995, 16 (2): 35-41.

[9] Yang-Yongkang, Yang-Wu, Ding-XueWu, Xie-ShuLing, eng-ChunYan, Experimental study on the bearing capacity of coral debris sand in xisha islands [J]. Journal of guangzhou university (natural science edition), 2017, 6: 61-66.

[10] Li Yangyang, Fang Xiangwei, Huang xuefeng, Song Pin, Su Faxin. Study of Plate Load Model on coral sand foundation [J]. Journal of Chongqing university of technology (natural science), 2017, 10: 114-121.

[11] The editorial board of the engineering geological handbook. Engineering geological manual (the fourth edition) [M]. Beijing: China construction industry press, 2006.

[12] Xu Ning. Talk about the engineering geology of coral reef soil [J]. Journal of geotechnical engineering, 1989, 11 (4): 81-88.

[13] Ju YanFei, Min Daogui, Guan Xin. Method of detecting soft clay mass in sandy soil based on Rayleigh wave [J]. Port and waterway Engineering, 2018, 3: 159-165.