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Dissipation Law of Pore Water in the Prepress Process of Sandy Well Based on FLAC^{3d}

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ABSTRACT

Consolidation and drainage method of soft soil foundation has extensive engineering application. A 3D numerical model of drainage in the sandy well is established, Biot consolidation theory and fluid and solid coupling algorithm are adopted. The dynamic changes of pore water pressure Around the sandy well in the consolidation process are analyzed. The diameter and spacing of the sandy well are studied for the influence law of the drainage effect; the conclusions reveal that the spacing of the sandy well has more influence on the dissipation of the pore water pressure than the diameter of the sandy Well; when the diameter of the sandy well reaches to certain degree, it is obscure to improve the effect of the drainage. The conclusion on the research has great guidance significance on reasonable arrangement of sandy well and efficiency of the drainage engineering.

KEYWORDS: soft soil; sandy well; prepress; pore water pressure; numerical simulation

INTRODUCTION

The distribution of soft soil is extensive in china, especially in the southeastern coastal areas. The character of these soft soils includes low strength, high compressibility, low penetrability, and easy appearing plastic flow, etc. [1-3]. If the character of soft soil is understood insufficiently, the selection of handling method is incorrect and the control of technology is undemanding, then Large settlements and local Collapse of the foundation can be taken place. So the building on the foundation will be treated seriously. For example, when open traffic happens in the highway engineering, the phenomenon of the head, pavement and large settlement, etc. are taken place. The draining consolidation method of sandy well is a processing method of soft foundation,and its application and research are successful in the recent ten years. It has very spread application in the southeastern coastal areas and Yangtze River Delta region[4-5].the crucial factors of the method include the spacing, radius and drainage condition of sandy well. They all have great influence on drainage effects, even the consolidation process is influenced. The research on the distribution and evanescence law of pore water pressure in the soft soil around the sandy well has great significance to improve the understanding. Three dimensional drainage numerical simulation model of sandy well is established by using FLAC3D in the text. The Biot consolidation theory and fluid-structure coupling computation are adopted, the dynamic variable condition of the pore water pressure distribution in the consolidation process is analyzed.the influence of both them on the drainage effects is studied by adjusting the radius and spacing of sandy well.

THEORETICAL MECHANISM

The prepress drainage of sandy well is equably entered into the drainage channel, it can be packaged sandy or plate. Then the horizontal drainage pipeline is set. The surcharge press is applied on the pipeline or it is vacated after the film is covered. The weight of accumulation body is adopted for the former; the atmospheric pressure is adopted as loading for the latter. Under the external loading, the pore water in the soft soil outflows upward along the channel. Percent of void gradually drop, degree is raised, the strength parameter and property is improved, the theoretical model of the drainage in sandy well is shown in Fig.1.

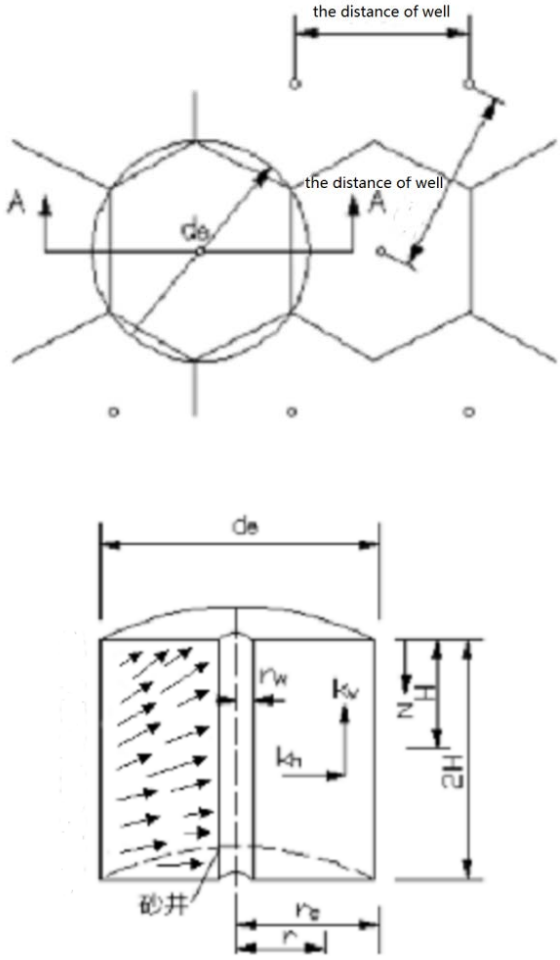


Figure 1: the drainage drawing of sandy well

The element of soil mass in the influential range of sandy well is selected,its seepage stress balance is analyzed according to mass conversation law,the element mass is shown in Fig.2.

Figure 2: flow equilibrium drawing of seepage element

In Fig.2, q represent flow rate; and in the process of drainage and consolidation, the variation of soil mass volume is namely discharge capacity of pore water.

$$\Delta V = \Delta Q \tag{1}$$

The horizontal and vertical seepage balances are considered.

$$\frac{\partial V}{\partial t}dt = \frac{\partial q_z}{\partial z}dxdz \cdot dt + \frac{\partial q_x}{\partial x}dzdx \cdot dt \tag{2}$$

$$\Delta V = e(\frac{1}{1+e_0}dxdz) \tag{3}$$

where e is void ratio at the moment t.e_0 is the void ratio at the moment t_0.substituting equation (3) into (2),equation (4) can be expressed as:

$$e(\frac{1}{1+e_0}dxdz) \cdot dt = \frac{\partial q_z}{\partial z}dxdz \cdot dt + \frac{\partial q_x}{\partial x}dzdx \cdot dt \tag{4}$$

According to compression test curve,equation (5) can be shown as the following:

$$\frac{\partial e}{\partial t} = a\frac{\partial u}{\partial t} \tag{5}$$

where a is compression coefficient, from equation (4) and (5),equation (6) is expressed as the following:

$$\left(\frac{a}{1+e_0 k}\right) \cdot \frac{\partial u}{\partial t}dxdz \cdot dt = \frac{\partial q_z}{\partial z}dxdz \cdot dt + \frac{\partial q_x}{\partial x}dzdx \cdot dt \tag{6}$$

$$\frac{\partial^2 u}{\partial t^2} = \frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z} \tag{7}$$

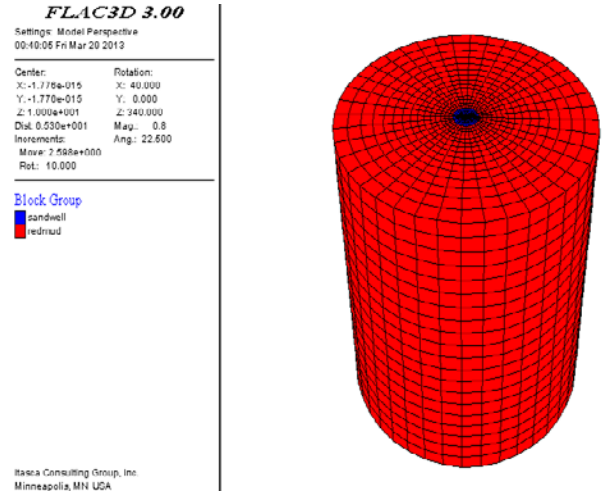
Substituting equation(7) into equation(6), equation(8) can be obtained:

$$Cv\frac{\partial u}{\partial t}=\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2} \tag{8}$$

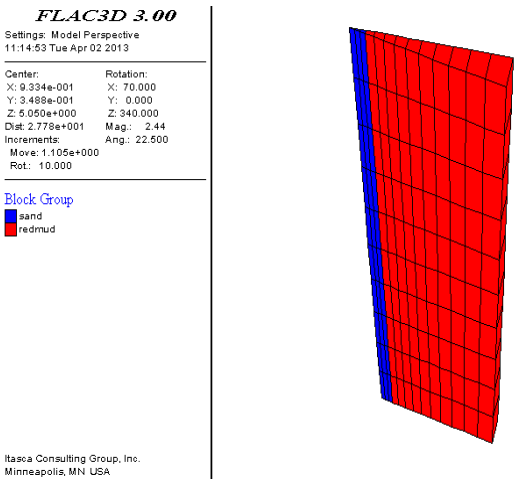
The equation (8) is the control equation of the seepage and consolidation.the consolidation settlement can be fulfilled to improve the effective stress by reducing the pore water pressure. The above differential equation can be solved by setting the correct boundary condition and using the finite difference method[6].

SIMULATION MODEL AND CALCULATION RESULTS

FLAC3d software is adopted,the single well model of sandy well drainage is established by using command stream.the model network is shown as Fig.3.



a. the standard drainage model of sandy well



b. The symmetric profile of the model

Figure 3: The numerical model of sandy well drainage

The red portion in Fig. 3 represent soft soil element.central blue portion represent the sandy well;the setting top surface represents free drainage boundary.around boundary represents waterproof boundary.because the whole model is symmetric about central axis.a sectorial elect is selected as Fig.3(b). Other parameters are shown as Table 1

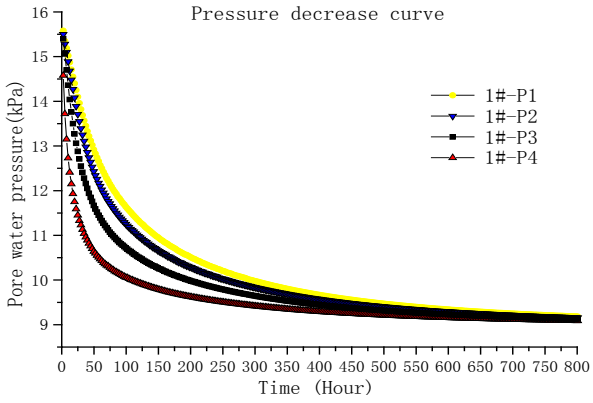
Table 1: the material parameter

item	thick	Unit weight	Bulk modulus	e	M	Ks(cm/s)	loading
Soft soil	10m	12.5	0.045	1.95	1.09	0.77E-5	10kPa
Sandy well	-	-	10	-	-	2.5E-3	

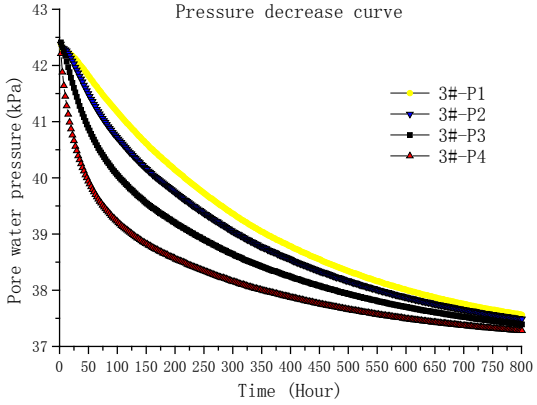
In comparison,the diameter of sandy well is set as 7cm,10cm and 15cm. The ratio n of sand drain space to diameter is 10, 15 and 20,respectively. Four monitoring profiles are set in the vertical axis of sandy well. Every monitoring profile is set as four monitoring point from the far to near, accumulatively,16 monitoring point is set. The variable condition of the pore water pressure in every monitoring point is began to monitor after the loading is applied, the calculative results are shown as Table 2.

Table 2: The variable condition of the pore water pressure in each monitoring point

Position number	1part				2 part				3 part				4 part			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
center distance	0.4	0.65	0.9	1.15	0.4	0.65	0.9	1.15	0.4	0.65	0.9	1.15	0.4	0.65	0.9	1.15
Surface distance	9.1	9.1	9.1	9.1	7.5	7.5	7.5	7.5	6	6	6	6	4.2	4.2	4.2	4.2

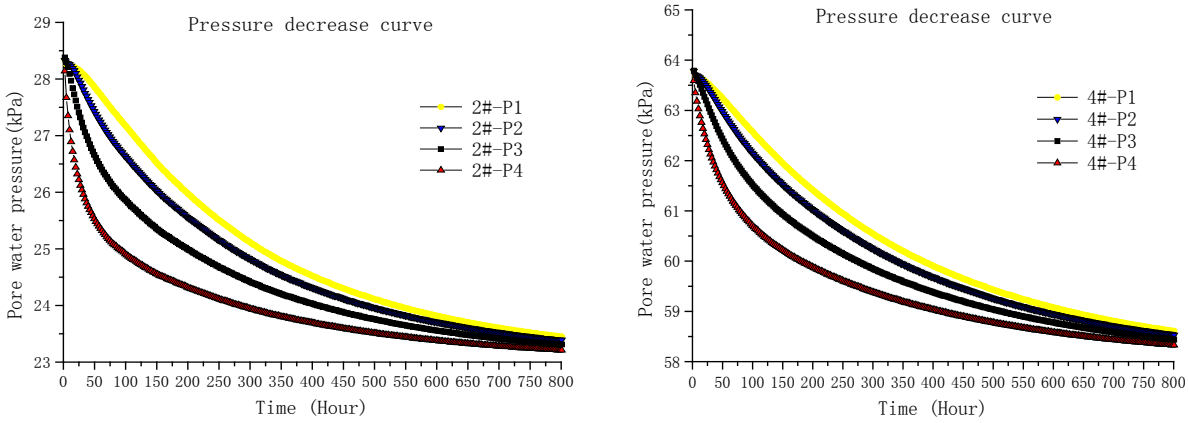


(a)1#



(c)3#

Figure 4: *Continues on the next page*

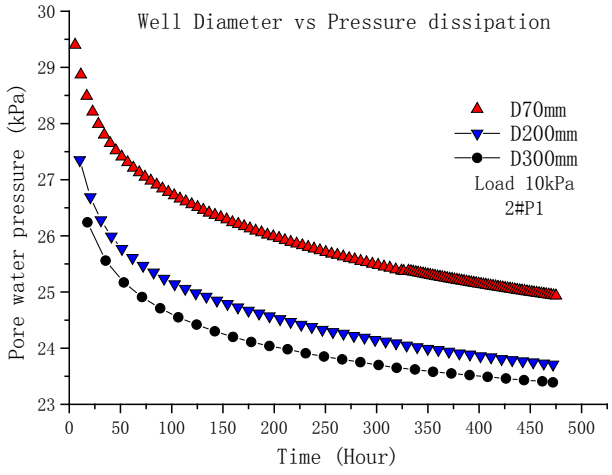


(b)2# (d)4#

Figure 4: The dissipate curve of pore water press in four monitoring profiles

It can be seen from Fig.4, the dissipation rate of pore water near the ground surface is faster,this is because its seepage path is shorter and the curve is steeper. It can be seen from the monitoring curve of different position in the same depth that the drainage ratio gradually increases as the transverse instance from the vertical well increases.when the seepage is tend to stable,the pore water pressure in the different depth is equal stable to natural pore water pressure. The super pore water pressure is tend to 0.

By altering the diameter of well and influential distance, the drainage effective comparison in the different sandy well is obtained. Its calculative curve is shown as Fig 5.



(a)2#

Figure 5: *Continues on the next page*

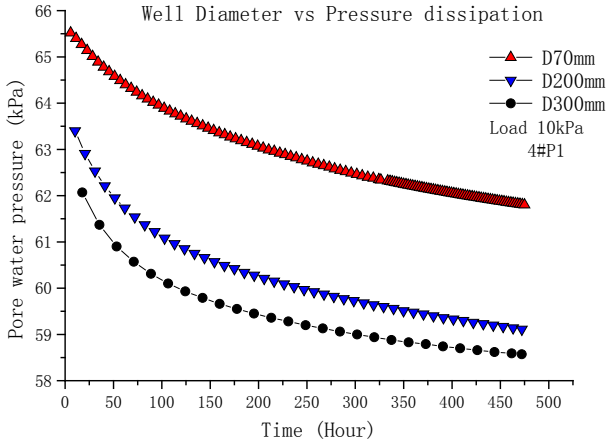


Figure 5: the curve of the pore water pressure vs time

It can be seen from the relation curve between the radius of sandy well and pressure dissipation,when the diameter of sandy well increase from 70mm to 200mm,the dissipation of pore water pressure accelerates apparently. The drainage effect improve apparently;when the diameter of sandy well increase from 200mm to 300mm,the difference between them at the same instance reduces to 2kPa, the amplification is reduced apparently relative to 70mm.it can be concluded that when the diameter of sandy well increases further,its contribution to the dissipation of pore water pressure is even fewer.so it will not cause any practical significance.

CONCLUSIONS

A 3D numerical model of drainage in the sandy well is established by Flac3d, the dissipate law of pore water pressure in the soft soil in the process of drainage is analyzed. The magnitude relation of the pore water in the different position is investigated,the single variable control method about altering the single well diameter is adopted.the dissipate curve of pore pressure in the different diameter is derived.from these curves ,the conclusions can be drawn that when the diameter of sandy well is added to 200mm from 70mm,it has great improvement to drainage effect,but when the diameter of sandy well is improved further,its contribution to the dissipation of the pore water is fewer,so the correct selection for the diameter and instance of sandy well is very crucial to improve the drainage efficiency.

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REFERENCES

1. Shi Yu-jin.the research on the distance of the prebagged sany well in the foundation of expressway[D]. China University of Geosciences,2002.(In Chinese)

2. Yangzong Zhou,Wenxiang Peng, Zhenbin Peng. Displacement Distribution of Tunnel Beside the Foundation Pit[J]. *Electronic Journal of Geotechnical Engineering*, 2016.21(1):239-246.
3. LU Zhao-jun.The failure mechanism of soils and its theoretical computations [J]. *Chinese Journal of Geotechnical Engineering*, 1989, 8(6) : 65—74. (In Chinese)
4. Bipul C.Hawlader, Balasingam Muhunthan,Goro Lmai.Viscosity effects on one-dimensional consolidation of clay[J]. *International Journal of Geomechanics*, September 2003:99-I 10.
5. Indraratna B, Redana I W. Plane strain modeling of smear effects associated with vertical drains. *Journal of Geotechnical Engineering*. ASCE,1997,123(5):474-478.
6. Abhijit Deka. Analysis of Pile Group under Lateral Load [J], *Electronic Journal of Geotechnical Engineering*, 2016,21(2):542--550.
7. GUO Feng-yong,SHI Yu. Simulation of settlement of soft ground of highway by FLAC3D[J]. Journal of Tianjin Institute of Urban Construction, 2005, ll(4) : 263-266. (In Chinese)
8. XU Yong-fu, Dong Ping. Fractal models for soil-water characteristics of unsaturated soils[J].Rock and Soil Mechanics, 2002,23(4): 400－405.(In Chinese)
9. Lin Lu-sheng, Jiang Gang.Research on slope stability method under rainfall in infiltration[J]. Engineering Journal of Wuhan University, 2001,34(1): 42-44.(In Chinese)
10. Li Zhao-ping, Zhang Mi. Effects of rain infiltration on transient safety of unsaturated soil slope[J]. *China civil engineering Journal*, 2001,34(5): 57-61.(In Chinese)

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