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Research Article

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Simulation and Evaluation of the Pore Water Pressure Variations with Groundwater Levels Variations at the Depths

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Abstract

Simulation and Evaluation of the Pore water pressure (P) variations with the Depths, which did carefully by the Viet Nam Standard "TCVN 4197:2012"; "TCVN 8723:2012" and "TCVN: 8721: 2012. Research results presented particularly for Permeability Coefficient (χ) obtained 1.00E-08; whereas the minimum value has only shown 2.00E-09 at 0.5 kg/cm2 and 8.0 kg/cm2 at 24.3m depths. On the other hand, the pore coefficient (ε) variations decreased gradually as the increasing depths; whereas the minimum value obtained 0.685 at 27.3m depth. Moreover, standards viscosity (B) and Compaction density (ζ) increased gradually as the depths increased gradually. From the analysis, simulation of the Pore water pressure with depths was calculated particularly with remarkable results, which as done by the Plaxis 3D software, so results presented in 360 kN/m2 at 4.0m and minimum value of 20 kN/m2 at 38.0m depth. In conclusion, research results can be applied and credited affections to the construction deformation. Moreover, research results can be used as useful references for engineers of Civil, Geology, researchers, and scientists in the future.

Keywords: Permeability Coefficient, Pore Coefficient (Void Ratio), Standards Viscosity, Pore Water Pressure, Groundwater Levels With Depths

Introduction

In recent years, research presented in the evaluation for pore water pressure variations particularly. However, some research still presented limitations. The tsunami created big pore water pressure and resulted in sediment deformation (IP) method was used for the calculation of the permeability coefficient of unsaturation soil with time, and results presented time decreased as increasing flow [1, 2]. Evaluation of the flow-independent viscosity in soil has been shown clearly which related to structure of the soil, time, factors… and so on. Results presented slope of saturation decreased with increasing time of rehabilitating deformation [3]. Research on the permeability coefficient of bentonite is described particularly as consideration time variations at 250C; 1000C and 1050C temperatures. The temperature can't be over 1050C of bentonite of the deep layers [4]. Results on the determination of the Chloride diffusion coefficient of concrete are one of the most to evaluate the affected degree of reinforcement. So there is no affection for concrete in many chloride environments [5]. A novel finite volume flow (FFV) method, the radial flow (RF) method, and equations are presented particularly for the permeability coefficient. The final results show no change and stability of the permeability coefficient [6]. Discretized Clay Shell Model (DCSM) of clay described clearly the permeability coefficient obtained maximum values as the effective stress coefficient α =1; whereas it is necessary to consider errors in the relationship between depths and permeability coefficients. [7]. The developed two-phase depth-integrated SPH-FD model used to calculate the propagation of flow and wave in soil, results presented time and pore water pressure change remarkable during deformation [8]. The Pore water pressure flows from top to bottom ground by negative to positive pressure, which is supported by the ISW model. Results presented remarkable changing in pore water pressure needed to build the structure of the ground (sea bed) [9, 10].

Methodology and Results

Materials and Standards

Samples Preparations

Samples were collected carefully in the Field and then protected in the cover same ensure the natural moisture which same as the initial state. The samples used were measured with sizes 15x15x19cm and through the sieve with 0.005mm for Clay and 1mm diameters for Sand. All of the samples were put in the Oven and dried after 24 hours at 1050C temperature before determination, measurements, and calculations The 15 samples were used to determine permeability coefficient characteristics; whereas 8 samples were for using void ratio, standard viscosity, and compaction density experiments for each borehole "BH1, BH2, BH3". A total of the samples has been used in this research are 87 samples. Sizes of the samples are designed in the Viet Nam standards.

Soil Properties and Standards

Soil properties were determined in this research which defended on the Viet Nam Standard. Locations collected the samples and experiment, which was done in Hon Dat town, Kien Giang province in Viet Nam at latitude 10001’22’’N; 105005’28’’E, and the Laboratory at Kien Giang CIC Group. The Viet Nam Standard was used to calculate values which included “TCVN 4197:2012 –Soil Laboratory methods for determination of the Plasticity Limit and Liquid Limit”; and “TCVN 8723:2012 - Soil for hydraulic engineering construction - Laboratory test method for determination of permeability coefficient of soil; and “TCVN: 8721: 2012 - Soils for hydraulic engineering construction - Laboratory test method for determination of maximum and minimum dry volumetric weight of non-cohesive soil”.

Field surveys were measured at three boreholes “BH1, BH2, and BH3”, which was shown by the Viet Nam Standard “TCVN 9301:2012 for the Field Method and the Standard Penetration Test “SPT”. After analyzing the results, there are 7 layers of the ground, which included Layer 1 to Layer 7 (see Table 1).

Table 1: Soil Properties With the Maximum Values

Layers	Soil Properties	Descriptions
1	z=+1.3m	Fill and mixed-gravel; black -brown
2	z=-5.2m; γ_w = 1.406(g/cm^3); γ_{dn} = 0.449(g/cm^3); Wc = 67.94%; W_d = 43.52%; Φ=2^{0}28’; C = 0.046(kg/cm^2)	Mixed clay; grey
3	z=-7.8m; γ_w = 1.889(g/cm^3); γ_{dn} = 0.938(g/cm^3); Wc =45.73%; W_d = 23.15%; Φ=14^{0}44’; C = 0.411(kg/cm^2)	Clay; brown with a little yellow
4	z=-15.2m; γ_w = 1.926(g/cm^3); γ_{dn} = 0.968(g/cm^3); Wc =45.95%; W_d = 23.25%; Φ=16^{0}34’; C = 0.480(kg/cm^2)	Clay; grey
5	z=-17.7m; γ_w = 1.969(g/cm^3); γ_{dn} =1.030(g/cm^3); Wc =45.01%; W_d = 23.17%; Φ=19^{0}28’; C = 0.586(kg/cm^2)	Clay; brown
6	z=-29.5m; γ_w = 1.910(g/cm^3);Φ=16^{0}2’; C = 0.303(kg/cm^2)	Semi-clay, grey, white and brown
7	z=-40m; γ_w = 1.858(g/cm^3);Φ=27^{0}35’; C = 0.018(kg/cm^2)	Sand; brown and yellow

**Note*: z is level of the gound; γ_w (g/cm^3) is wet density above the groundwater level; γ_{dn} (g/cm^3) is floating density below the groundwater level; Wd (%) is plasticity limitation; Wc (%) is Liquid limitation; Φ (^{0}) is the internal friction angle; C (kg/cm^2) is cohesive force.*

Permeability Coefficient (χ) With the Different Depths (D, Meter)

Experiments in the laboratory to determine the Permeability Coefficient (χ) have been done carefully to obtain the best results. These experiment measurements shew particularly by the Slowly Compressive Test or "Confined Compression Test", which included in 15 samples with 5 different loading levels (0.5 kg/cm2; 1.0 kg/cm2; 2.0 kg/cm2; 4.0 kg/cm^2; and 8.0 kg/cm2). Results presented particularly the variations of the values which changed from 1.00E-08 to 2.00E-09. The maximum value obtained is 1.00E-08; whereas the minimum value has only shown 2.00E-09 at 0.5 kg/cm2 and 8.0 kg/cm^2 at 24.3m depths.Permeability Coefficient increased gradually as the increasing of depth (see Fig.1).

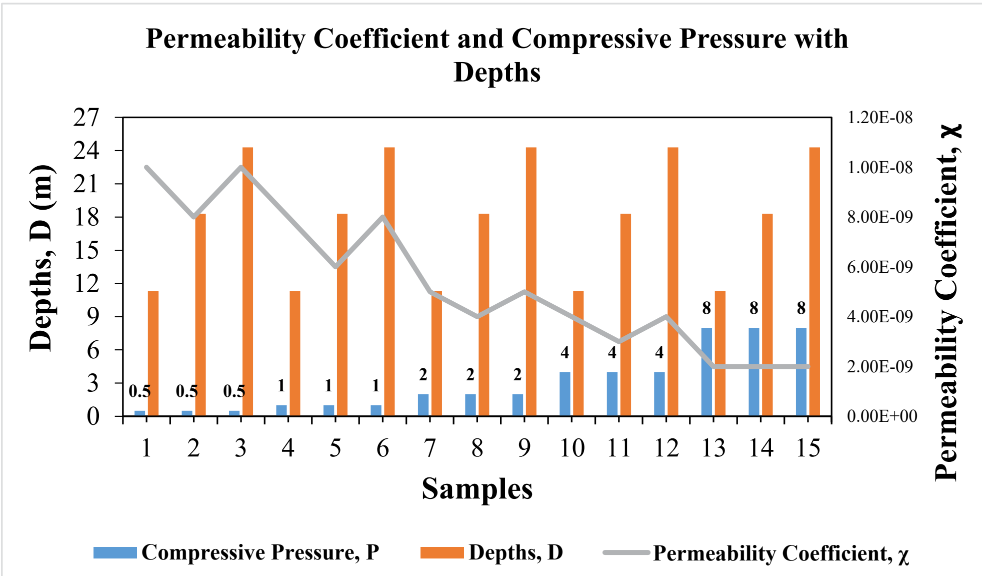


Figure 1: Permeability Coefficient and Compressive Pressure with Depths (boreholes "BH1, BH2, BH3")

Void Ratio "Pore Coefficient" (ε) With the Different Depths (D, m)

Void ratio "Pore coefficient" variations were calculated carefully by the "Confined Compression Test" at a slow speed within 24 hours to obtain the best results. From figure 2, it is easy to see variations of pore coefficients particularly, which included 0.881 at 7.5m depth of the borehole "BH1", whereas the maximum value of 2.558 at 4.5m depth of the borehole "BH2", and the final value of 0.737 at 11.3m depth of the borehole "BH3". In general, the pore coefficient variations decreased gradually as the increasing depths. The minimum value obtained was 0.685 at 27.3m depth (see Fig.2)

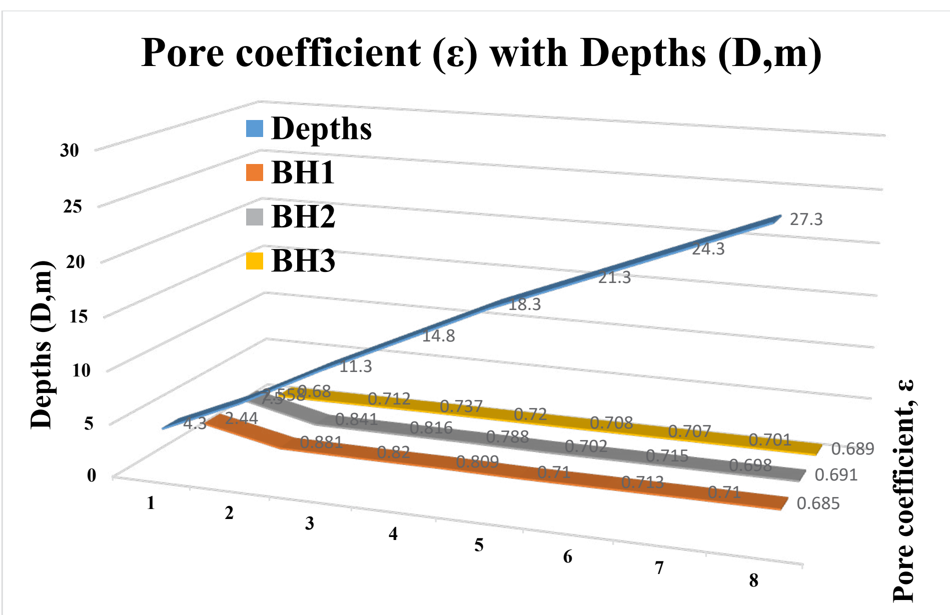


Figure 2: Void ratio "Pore coefficient" (ε) with Depths (boreholes "BH1, BH2, BH3")

The Standard Viscosity (B) with Depths (D, m)

The experiment for determination of the Standard Viscosity (B) with Depths (D, m) has been measured carefully by the Liquid and Plasticity limitation experiments. It is clear to see variations of the maximum and minimum values with the increasing depths. At 7.5m depth, B obtained 0.27 of the borehole "BH1"; whereas this value increased by 2.08 at 4.8m depth of the borehole "BH2". On the other hand, the borehole "BH3" is up to 2.03 at 23.8m depth. Moreover, the borehole "BH1" was determined fully from 4.3 to 27.3m, but at 33.3m to 39.6m depths of the borehole "BH2" didn't show any values. In contrast, there was no calculated value from 29.8 to 39.6m depths. In conclusion, standards viscosity increased gradually as the depths increased gradually (see fig 3).

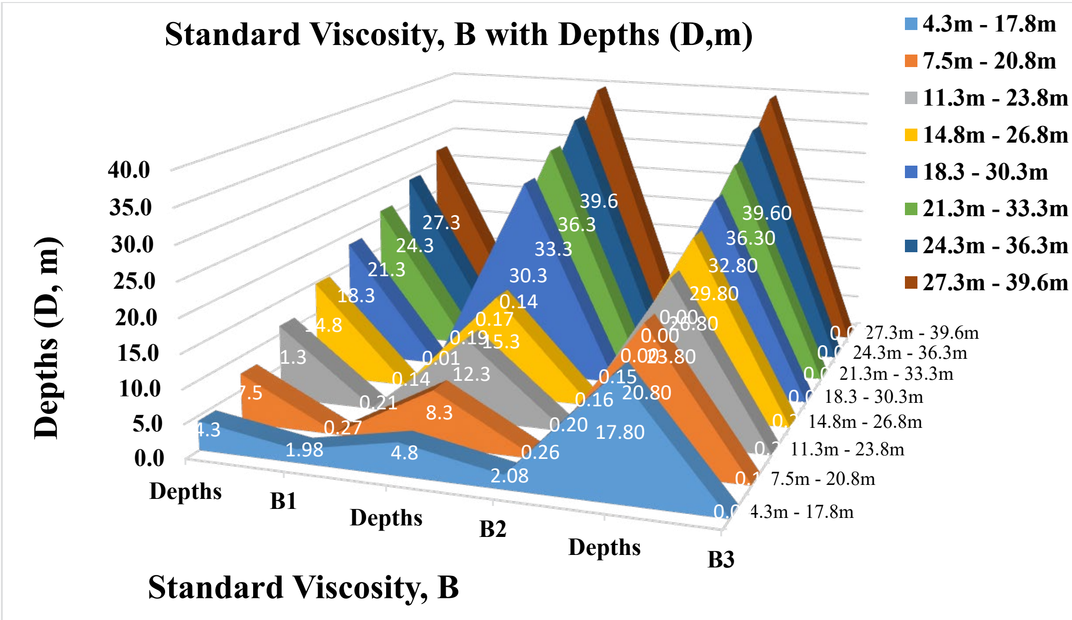


Figure 3: Standard Viscosity, B with Depths (D, m) at Boreholes "BH1, BH2, BH3"

Compaction Density (ζ) with Depths (D, m)

The experiment of measurements of Compaction Density or "Maximum Dry density" has been careful to show the best results. This experiment was done by the "Standard Compaction Tool" which was made in Viet Nam Standard. Results were recorded at depths from 4.3m to 27.3m; 4.8m to 30.3m; and 17.8m to 26.8m of the Clay layer and Mixed-Clay, no values for Compaction Density ζ1; ζ2; and ζ3; whereas at 33.3m; 36.3m and 39.6m depths obtained the increasing value of 0.57; 0.61; and 0.64. On the contrary, at 29.8m; 32.8m; 36.3m; and 39.6m depths of the Sand layer obtained gradually increasing values of 0.55; 0.58; 0.60; and 0.62. Moreover, the maximum value presented is 0.64 at 39.6m depth of the Compaction Density ζ2. Finally, the results of Compaction Density variated lowly and increased gradually as the increasing depths (see fig 4).

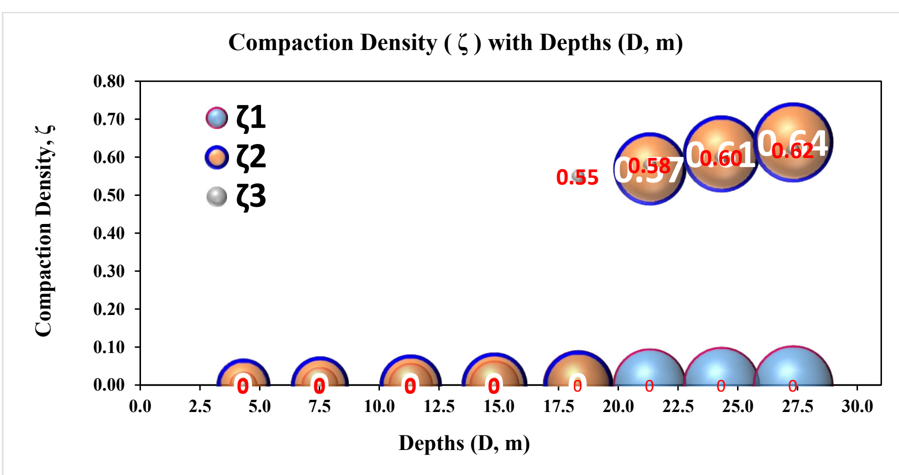
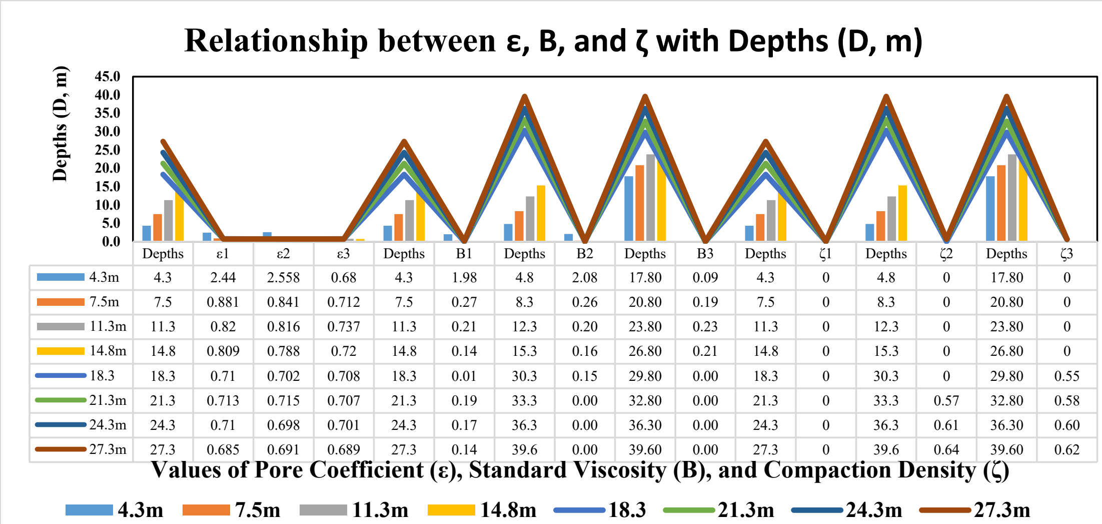


Figure 4: Compaction Density (ζ) with Depths (D, m) at Boreholes "BH1, BH2, BH3"

Relationship Between Pore Coefficient (ε), Standard Viscosity (B), and Compaction Density (ζ) at Three Boreholes (BH1, BH2, BH3)

From the results of figure 5, it is easy to see the Pore Coefficient (ε) and Standard Viscosity (B) increased gradually; whereas compacted with the Compaction Density (ζ) decreased slowly with the increasing depth variations.



	Depths	ε1	ε2	ε3	Depths	B1	Depths	B2	Depths	B3	Depths	ζ1	Depths	ζ2	Depths	ζ3
4.3m	4.3	2.44	2.558	0.68	4.3	1.98	4.8	2.08	17.80	0.09	4.3	0	4.8	0	17.80	0
7.5m	7.5	0.881	0.841	0.712	7.5	0.27	8.3	0.26	20.80	0.19	7.5	0	8.3	0	20.80	0
11.3m	11.3	0.82	0.816	0.737	11.3	0.21	12.3	0.20	23.80	0.23	11.3	0	12.3	0	23.80	0
14.8m	14.8	0.809	0.788	0.72	14.8	0.14	15.3	0.16	26.80	0.21	14.8	0	15.3	0	26.80	0
18.3	18.3	0.71	0.702	0.708	18.3	0.01	30.3	0.15	29.80	0.00	18.3	0	30.3	0	29.80	0.55
21.3m	21.3	0.713	0.715	0.707	21.3	0.19	33.3	0.00	32.80	0.00	21.3	0	33.3	0.57	32.80	0.58
24.3m	24.3	0.71	0.698	0.701	24.3	0.17	36.3	0.00	36.30	0.00	24.3	0	36.3	0.61	36.30	0.60
27.3m	27.3	0.685	0.691	0.689	27.3	0.14	39.6	0.00	39.60	0.00	27.3	0	39.6	0.64	39.60	0.62

Figure 5: Relationship Between Pore Coefficient (ε), Standard Viscosity (B), and Compaction Density (ζ) at Three Boreholes (BH1, BH2, BH3)

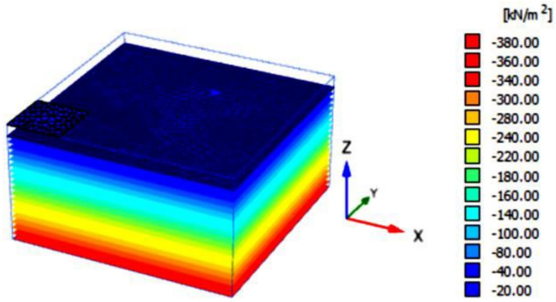
Setting Up Data of the Numerical Model

The PLAXIS 3D software (the finite element method) is built on the Mohr-Coulomb theories. In this research, the groundwater level variations varied from 0.0m to 40.0m; Active loading levels are put at the ground and they have been simulated as a reinforcement concrete structure; which sizes 15m in length, 15m in wide, and 4m. Moreover, the operation process of the software is defended in two stages, which include the first stage with no activated loading and the final stage with loading. However, the finite element method was used for design and calculation at the specific locations, meshing, soil properties, loading process…and so on. All of these processes are designed carefully to obtain the best results. There are two stages to run loading, which include the first stage (initial stage) and the second stage (end stage or loading stage). The groundwater level variations have been designed at 0.0m; 4.0m, 5.0m, 8.0m, 10.0m, 13.0m, 15.0m, and 26.0m; 28.0m, 32.0m, and 38.6m depths.

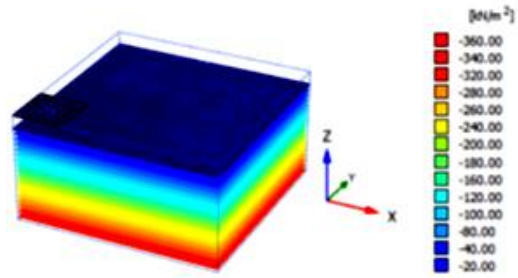
On the other hand, the values of the operation process of the numerical model include density on the groundwater levels (§w = 17.5 kN/m^3); whereas density is under the groundwater levels (§w1 = 18.5 kN/m^3); Young‘s modulus (constant) (Y = 1.104 kN/m^2); Poisson’s coefficient p' = 0.2; Cohesion coefficient D’ref =35 kN/m2; Internal friction angle (ϕ' = 150); Lateral pressure coefficient of the ground (Δ0 = 0.5); Stiffness of the ground K” = 0.9.103 kN/m2; Stiffness of the structure (building or loading) K’” = 0.2; Strength (S’ref = 30 kN/m2); Thickness of building (T = 1meter); Young‘s modulus of the building T1 = 2.105 kN/m2; Poisson’s ratio of the structure D12 = 0.12.

Numerical Model Pore Water Pressure (P) with the Different Depths (D, m) (Brinkgreve R. B. J (2014)

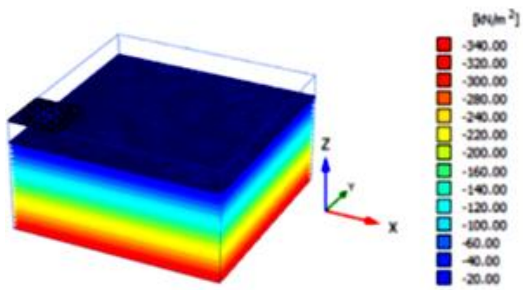
Pore water pressure (P) with Depth (D, m) variations determined carefully from 0.0m to 40.m depths. Results show clearly the maximum values which are corresponding to 360 kN/m^2; 350 kN/m^2; 320 kN/m^2; 300 kN/m^2; 270 kN/m^2; 250 kN/m^2; 140 kN/m^2; 120 kN/m^2; 80 kN/m^2; 20 kN/m^2. In conclusion, pore water pressures decrease gradually as the depths increase remarkably.



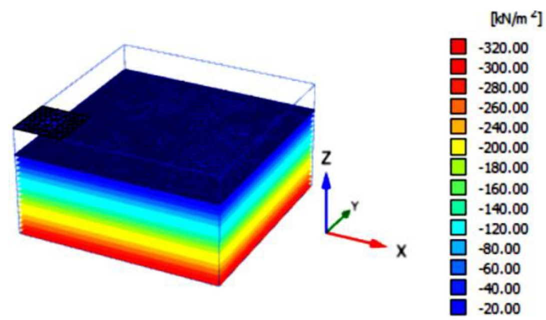
z = 0.0m; -4.0m ; Pore water pressure P = -360 kN/m^2



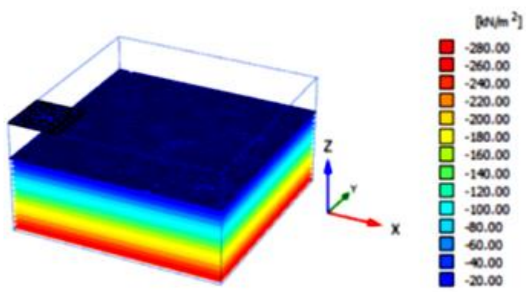
z = -5.0m; Pore water pressure P = -350 kN/m^2



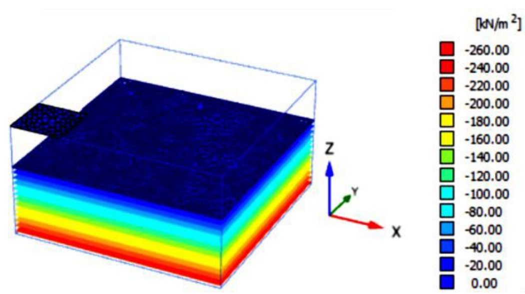
z = -8.0m; Pore water pressure P = -320 kN/m^2



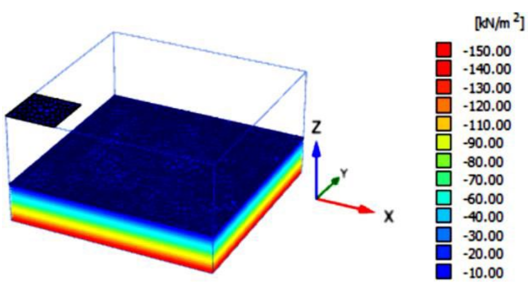
z = -10.0m; Pore water pressure P = -300 kN/m^2



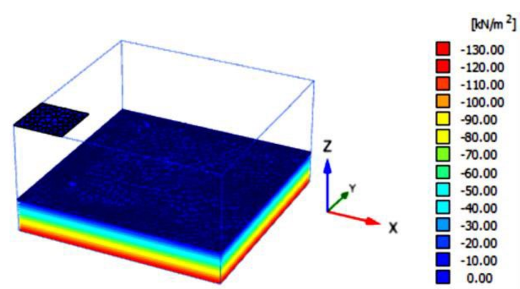
z = -13.0m; Pore water pressure P = -270 kN/m^2



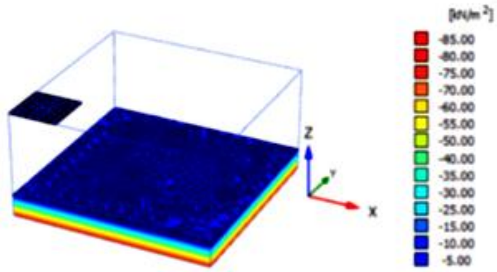
z = -15.0m; Pore water pressure P = -250 kN/m^2



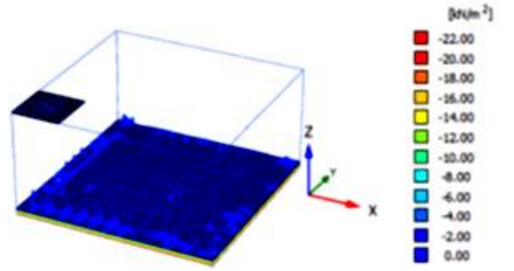
z = -26.0m; Pore water pressure P = -140 kN/m^2



z = -28.0m; Pore water pressure P = -120 kN/m^2



z = -32.0m; Pore water pressure P = -80 kN/m^2



z = -38.0m; Pore water pressure P = -20 kN/m^2

Discussions

From the above analysis, the evaluation of pore water pressure variations needs to calculate carefully, because these research values are related to water variations and this affection resulted in deformations of soil and soft ground for the building. However, some values still changed lowly and so it is safe to use and apply for the design or construction of the building with other loadings. The pore water pressure of soil in this research varied clearly as the depths of the groundwater level variations changed. Moreover, we can credit any location of groundwater levels of the ground.

Conclusions

Evaluation of the Pore water pressure (P) variations with the Depths, which did carefully by the Viet Nam Standard "TCVN 4197:2012"; "TCVN 8723:2012" and "TCVN: 8721: 2012. Research results described clearly for changing of values which included the permeability coefficient, pore coefficient, standards viscosity, and compaction density. In general, pore water pressure decreased gradually as the increasing of depth; whereas the pore coefficient (void ratio) varied less lowly.

Conflict of Interest

I certainly do not have any conflicts of interest with anyone in the results of this article.

This result is my own product during the time of research and discovery. If there is anything wrong with this guarantee, I take full responsibility for the policy of the Journal.

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