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The Emphasis for Hydrostatic Pressure In Soft Soil Area

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Abstract
Soft soil is a type of land with high volume water content and this creates many problems related to the structure construction on it. Stabilizing procedure and reinforcement for this type of land affects to the foundation. The usage of hydrostatic pressure to support the structures on soft soil area can be applied based on the water contents. The lab testing was conducted to obtain the density values of the soil through Compaction Test and California Bearing Ratio (CBR) Test. Analysis onto the area, water content and material were carried out and the results showed that all samples using plastic containers indicated higher value of hydrostatic pressure compared to aluminium containers. Therefore, the hydrostatic pressures can be act to the structure based on the soils density and the area of the structures.

Keywords: soft soils, hydrostatic pressure, floating structure.

1. Introduction

Soft soils is an insubstantial land; a land with high volume of water and thus possess high level of stickiness. Therefore, this soil does not possess enough strength to support structure construction on it. The problem with basic of structure in this land is caused by high of water in soil that leads to the failure of structure in that area. However, this high volume of water containment can be manipulated to support the weight of a structure if hydrostatic pressure being highlighted aside of the strength of the land itself.

Practically, soft soils are not suitable for any structure construction or civil engineering work. The risk is structure damage due to land settlement. Structure built on this type of land will definitely suffer obvious damages. Cast in place is very rarely used in construction on soft soils area. Fixed cage or cell (casing) is usually needed to avoid the risk of necking however, this will make the cast becomes more expensive and directly it will increase the cost for the construction of the structure. This research was done to prove that hydrostatic pressure force can support the weight of a building with suitable design on soft soils.

Mikio T. and Yoshihiko T.(1995) defined that the wave drifting force acting on a very large floating structure based on three dimensional panel method. Based on experimental testing, this study was determined that the hydrodynamic forces can be balancing the structure under hydrostatic pressure. Masashi K. (1996) studied on a very large structure also consider the airport size. The hydro elastic behaviour concept indicated that structure will be very flexible and elastic deformations may be more important than the rigid body emotion. The actions on damaging analysis to the steel and slabs also important to verify its safety while an airplane collision (Osamu M. et al. (2001)). Therefore, the force can be act as a platform to loading the structures on it.

Many researchers consider on structure properties actions but the hydrostatic details were not enough in hydraulic part. Based on experimental research, the concept of Buoyancy and Hydrostatic was applied to consideration of building load on soft soil. This paper employed the hydrostatic pressure as stated below:

$$P = \rho gh \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

Hydrostatic is hydraulic branch that relates with the pressure in non-moveable liquid. Non-moveable liquid does not have any gap between the molecules in it. The liquid's direction of force is precisely angled with the surface where the liquid react. Pressure, p, caused by liquid bulk is included in a container is :

$$P = \frac{liquid\ bulk\ in\ container}{container\ cross\ section\ area} \ldots\ldots\ldots\ldots(2)$$

$$P = \frac{\rho ghA}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where,
P = pressure (kN/m^2)
ρ = density (kg/m^3)
g = gravity (m/s^2)
h = high (m)
A= Area (m^2)

1.1 The Existing Floating Structures

Floating structures have been applied in many countries for multiple purposes and needs. Among them are:(i) Floating Bridge (Lacey V. Murrow Bridge -2018 m, Evergreen Point Bridge -2310 m, Homer Hadley Bridge -1771 m, Norwegian Floating Bridges, and Yumemai Bridge that was built using two hollow steel pontoons sized 58 m x 58 m x 8 m), (ii) Floating Airport (Mega-Float in Tokyo Bay, Japan and Floating Runway in Haneda Airport), (iii) Floating Houses (*Ooms Bouwmaatschappij Company*, *Netherlands* -has built 8 out of 500 floating houses that were planned to be built in the outskirts of Amsterdam City. The houses can withstand storm and strong winds can be placed up to 100 m from land), (iv) Other Floating Structures (Floating restaurant built on 24 m x 24 m x 3.2 m sized pontoon located in Yokohama, Japan, a hotel known as *Koh Chang Lagoona* located in Thailand is built with the floating concept and it is the first hotel in Asia that used this concept in hotel construction and designing. This hotel was modelled on ship design and an island with buoyancy concepts has been built in *Onomichi*, *Hiroshima*, *Japan* with the size of 130 m x 40 m x 5 m (E. Watanabe et al.(2004)).

Based on the floating structures in other countries, same concept can be apply for soft soils in our country because the value of soil density is much higher than density of water. The concept used in conducting this research was predicated to the basis architecture and ship design. Ship building concept was selected because it is suitable with the different types of medium.

2. Materials And Methods

The present study involved the determination of the state of soft soils through Compaction Test and California Bearing Ratio (CBR) Test (density value and bearing capacity). The penetration test was conducted using two containers with different size. Then, data were analyzed to obtain the hydrostatic pressure that act to the container.

Data collection was about soil condition in the study area; Research Centre of Soft Soils (RECESS). Compaction Test and California Bearing Ratio (CBR) was conducted to obtain the density value and bearing capacity of soils. Testing was conducted to the four different soils conditions which are 100% soil, 100% soil + 10% water, 100% soil + 20% water and 100% soil + 30% water.

This loading test was done in container having size 60 cm x 60 cm and fill with soil height as 25 cm. Apart from that, there are two containers that were used to place the load which would be imposed on soil namely aluminum container having size 24.5 cm x 14.2 cm x 6.5 cm and plastic container having size 32 cm x 26.5 cm x 21 cm. This diversity was selected to get clearer description about this research because size container could also influence the penetration value of soils. For aluminum container, the maximum loading was 160 N, while plastic container can accommodate until 300 N. Load that have been used in this testing was iron and the density was 7900 kg/m^3.

3. Result and Discussion

The CBR results are shown in Table 1. Bearing ratio value and density of soils were decrease with the addition water content. This means that the water can reduce the strength of soil. But, some cases, the action of water pressure was helpful to support some area of a building and any mega construction on it.

Table 1 OMC, CBR and density value

No	Soil (%)	Water (%)	OMC (%)	CBR (%)	Density (kg/m3)
1	100	0	20	62	1598
2	100	10	23.1	53	1562
3	100	20	24.5	42	1553
4	100	40	26.3	28	1450

Penetration test was carried out for two different type and size of containers. It was carried out for all samples by using maximum loading, 160 N for aluminum container and 300 N for plastic container.

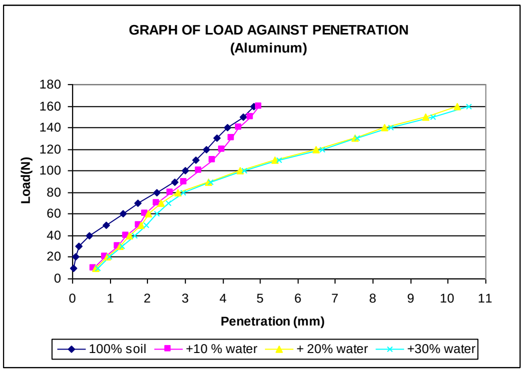

Figure 1 Graph of load against penetration for all sample (Aluminum)

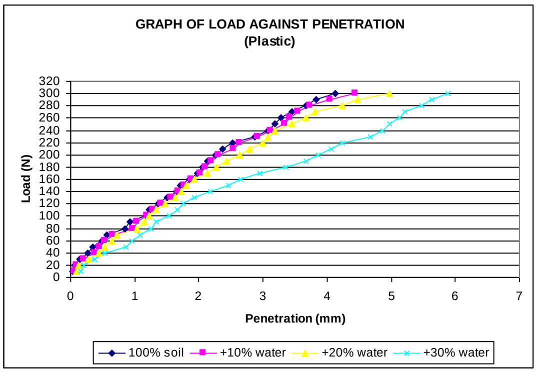

Figure 2 Graph of load against penetration for all sample (Plastic)

Figure 1 and Figure 2 shows that load against penetration for all samples that were 100% soil, 100% soil + 10% water, 100% soil + 20% water and 100% soil + 30% water that use aluminum and plastic containers. Besides that, the penetration value increase with the expansion loading and expansion of water content. At the same time, the penetration value for plastic container would be smaller than aluminum container. The smaller area container has more potential to settle because the load distributions are limited compared to the larger area which means that the load can be distributed with more pressure area.

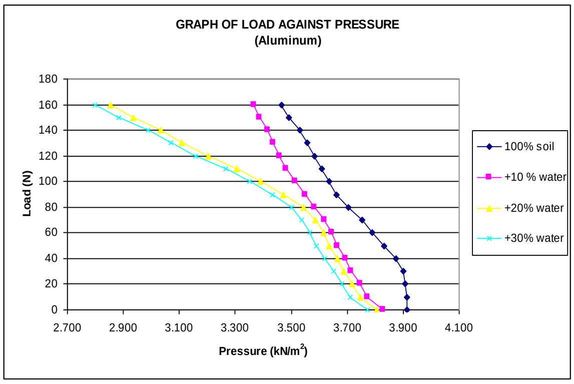

Figure 3 Graph of load against pressure for all sample (Material : Aluminium)

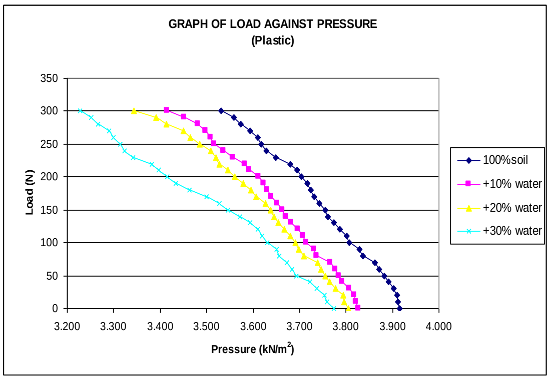

Figure 4 Graph of load against pressure for all sample (Material : Plastic)

The pressure value for each sample in plastic container did not shows the failure to accommodate the load whereas the aluminum container shows the failure when soils was added with 20% and 30% of water (Figure 3 and Figure 4). So, sample with lower water content gave higher pressure and this shows that the water content can decrease the strength of soil capacity.

All samples showed that the plastic container gave higher pressure compared to the aluminium container with the same loading. This shows that the plastic container with the wider area have more potential to accommodate the higher loading because of the hydrostatic pressure that acts on it was higher.

It has been shown that area with high water content like soft soils has the same potential with floating structures to be developed. It is based on the higher density of soils compared with density of water. Nevertheless, much detailed study about floating concepts and adjustment to the building's design in order to achieve the suitable shape for structures to be built on soft soils.

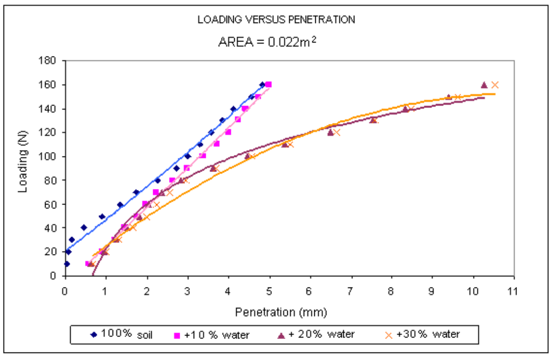

Figure 5 Graph of load against penetration for all sample with area 0.022m^2

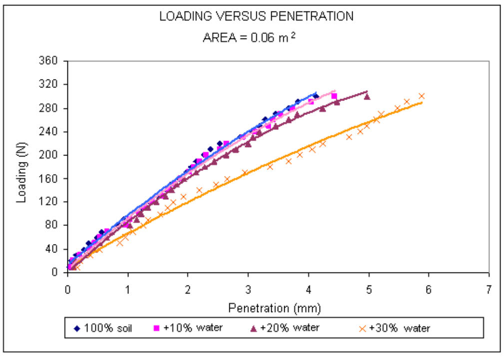

Figure 6 Graph of load against penetration for all sample with area 0.06m^2

According the data in Figure 5 and Figure 6, the calibration graphs (Figure 7) can be determined in order to modify any water content and load on soft soil condition smartly.

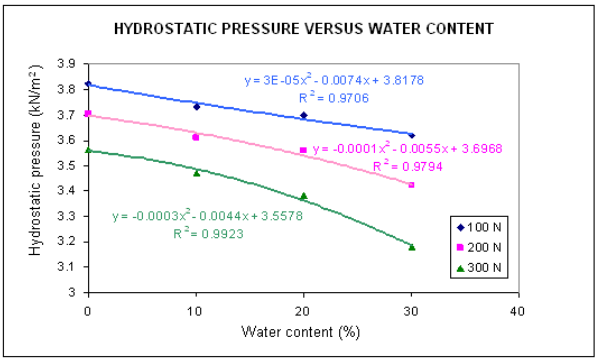

Figure 7 The calibration graph for hydrostatic pressure based on water content and load

4. Conclusion

The results showed that pressure would decrease with the expansion of water content. Therefore, the area of the materials that have been used influenced the pressure value that act to the structure on it. The suitable combination of area, height of sample and material, application water pressure concept useful to built the building or any structures on soft soil site. This condition cause by their factors will give the value of pressure that act onto structures which would be built. Besides that, it is also important to determine the most suitable shape for stability of the structure will be built by using hydrostatic pressure.

As a conclusion, construction problems in soft soils area that have high water content can be overcome with the application of the pressure concept while the development of structure was carried out. The construction technique with the usage of this idea can be used as a guide to the engineers in conducting designing works of a structure on this soil. Furthermore, it has a potential prospect be a new innovation brand in the field of engineering path.

5. References

Osamu, M., Takumi K., Takao, Y., Kazuo K., Takuya, F and Akira, K.(2001). Damage Analysis of Super Large Floating Structure in Airplane Collision. Offshore and Polar Engineering.11, 1053-5381.

Mikio, T. and Yoshihiko T. (1995). Wave Drifting Forces on Very Large Floating Structures. Offshore and Polar Engineering. 5, 1053 – 5381.

Mashashi, K. (1996). A Precise Calculation Method for Hydrostatic Bahaviours of Very Large Floating Structures.Workshop on Water Waves and Floating Bodies.

Watanabe, E., Wang, C.M., Utsunomiya, T. and Moan, T. (2004).Very Large Floating Structures: Applications, Analysis and Design.Core Report: National University of Singapore.

K.C Kok dam Khairul Anuar Kassim (2001). "Modification and Stabilisation of Malaysian Cohesive Soils" in C.F Lee and C.K Lau "Soft Soil Engineering." A.A Balkena Publisher.

Head, K.H. Manual of Soil Laboratory Testing, Volume 1: Soil Classification and Compaction Tests. Pentech Press :London.

Che Wil, M. F. (2006). *Simulasi terhadap enapan tanah di Pusat Penyelidikan Tanah Lembut (RECESS) Malaysia*.KUiTTHO: Thesis.

Mainal, M. R. (1990). *Asas Senibina Kapal : Kestabilan Kapal*. Pg. 3 - 10: UTM: Johor Bahru, Malaysia.