Relationships between N value and parameters of ground strength in the South of Vietnam.

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ABSTRACT: In Japan, for designing the foundation of a structure, the N value from Standard Penetration Test investigation has been applied and become generalization. From N value, many methods for estimating other soil parameters are also proposed. Especially for small-scale buildings which are usually limited in budget, instead of applying SPT, Swedish Weight Sounding Test has been applied to reduce the cost and time of soil investigation. To confirm the applicability of SWS in Vietnam, both SPT and SWS data have been collected from 7 different sites around Ho Chi Minh City. The results show that the estimated N value from SWS test is smaller than these measured by SPT. It is also shown that the characteristic of soils in Vietnam is quite different from those in Japan, especially clayey soil. Therefore, in case of applying SWS test in Vietnam, it is necessary to find a converted formula for soil parameters from N value.

1 INTRODUCTION

Recently in Ho Chi Minh City as well as in Hanoi, there are many cases of unequal settlement in houses which influence the safety of not only people in the house but also the neighbourhood. It is said that the main reason of these cases is lack of soil investigation. Though Vietnam’s government has established that “Houses over 3-storey, or the construction area over 250m2, must have soil investigation before constructing”(Circular 39/2009/TT-BXD), the soil investigation is usually neglected due to limit budget.

In Japan, for small-scale building such as houses, instead of using SPT for soil investigation, SWS test is applied. The cost for SWS is not only much cheaper than SPT but investigation time is also much shorter than SPT. Base on SWS investigation result, N value can be determined. With many proposed methods to estimate other soil parameters from N value in Japan, designers can easily have a suitable plan for the building’s foundation to avoid the unequal settlement, which make the building slanted or collapsed, and other different problems.

To apply SWS method in Vietnam, the tolerance of N value must be confirmed and the characteristic of the soil should be understood. In this paper, a comparison of N value between SWS and SPT is shown and the characteristics of the soil around Ho Chi Minh City have been estimated base on investigated data.

2 SURVEY OVERVIEW

2.1 Locations of investigated sites

7 sites in and around Ho Chi Minh City has been investigated by SWS and SPT method. Besides, various of soil tests are also performed. Figure 1 shows the location of investigated site while table 1 shows the contents of investigations.

<table>
<thead>
<tr>
<th>Case</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWS and SPT</td>
<td>7 sites.</td>
</tr>
<tr>
<td>SPT and soil tests</td>
<td>Water content, correlations, direct shear test, quick compression test.</td>
</tr>
</tbody>
</table>
3 RELATIONSHIP BETWEEN SWEDISH SOUNDING TEST RESULTS AND ESTIMATED SOIL PARAMETERS

3.1 SWS and SPT

In Japan, based on the following equations, from SWS results, N value is estimated. These equations are conducted from the results of examinations shown in Figure 3 (JGS, 2004). From this figure, it is easy to recognize that these equations were set by estimating the average of measured value.

\[
N = 2W_{sw} + 0.067N_{sw} \text{ (sandy soil)} \quad (1)
\]

\[
N = 3W_{sw} + 0.05N_{sw} \text{ (clayey soil)} \quad (2)
\]

Where \(N\): N value; \(W_{sw}, N_{sw}\) : SWS results.

Figure 4 shows the relationship between N value from SPT (\(N_{SPT}\)) and estimated N value from SWS results (\(N_{SWS}\)). From this figure, it can be seen that \(N_{SWS}\) value have tend to be smaller than \(N_{SPT}\). This tendency is quite different from the one show in Figure 3. Therefore, it can be said that when applying equation (1) and (2) in Ho Chi Minh City, the estimated N value from SWS method underestimates the measured value.
3.2 N value and c, φ

Figure 5 shows formulas, which are generally used in Japan, to estimated internal frictional angle from N value. The relationship between N value and unconfined compression strength, which is most popular used in Japan, is also shown in Figure 6. It can be found that the estimated internal frictional angle was set as the average measure value, while the estimated unconfined compression strength was set as the minimum measured value.

\[ \phi = 15 + \sqrt{15 \cdot N} \]  
(Specifications for highway bridges: \( N \geq 5 \))  

\[ \phi = 15 + \sqrt{20 \cdot N} \]  
(Oosaki)

[Unconfined compression strength \( q_u \)]  
\[ q_u = 12.5N \]  
(Terzaghi & Peck)  

\[ q_u = 12.5N \]  
(Oosaki)

**Figure 5.** Relationship between N value and internal frictional angle in Japan.  
**Figure 6.** Relationship between N value and unconfined compression strength in Japan.  
**Figure 7.** Relationship between N value and internal frictional angle in Ho Chi Minh City.  
**Figure 8.** Relationship between N value and unconfined compression strength in Ho Chi Minh City.
Figure 7 shows the relationship between N value and internal frictional angle from direct shear test of more than 40 investigated sites in Ho Chi Minh City, while the relationship between cohesion from above direct shear test and N value is shown in Figure 8. In these figures, the estimated value based on formula (3) and (4) are also indicated.

From these figures, it is easily found that the estimated value has tendency to be overestimated compared with measured data. It means that when applying formulas which are proposed in Japan for calculating soil parameters in Ho Chi Minh City, it may cause some results in dangerous settings.

4 INVESTIGATION RESULTS

From 3., in case of estimating N value from SWS results or soil parameters (c, φ) from N value in Ho Chi Minh City, the estimated formulas, which are generally applied in Japan, are not suitable to appraise. Therefore, to figure out the characteristics of the ground in Ho Chi Minh City, many results of physical test collected from soil investigation reports in that location have been applied.

4.1 Depth distribution of N value and water content

Figure 9 shows the depth distribution of N value and water content of clayey soil. Due to investigated sites, a very soft clay layer is distributed around up to GL-20m and around this depth, the water content is about 4 times compared with others. Besides in layers which have such high water content like that, it can be found that N value is large, comparatively.

![Figure 9. Relationship of depth and N value, water content (clayey soil)](image)

(i) Depth distribution of N value
(ii) Depth distribution of water content

Figure 10. Relationship of depth and N value, water content (sandy soil)

![Figure 10. Relationship of depth and N value, water content (sandy soil)](image)

(i) Depth distribution of N value
(ii) Depth distribution of water content
On the other hand, N value and water content distribution in depth of sandy soil is shown in Figure 10. The N value has stronger tendency to be in proportion to the depth than clayey soil.

By comparing the results in Figure 9 and Figure 10, there is no significant different in the deposition depth of sandy and clayey soil. It can be imaged that in the target area, the layer structure are in a state where the sandy soil and clayey soil are mixing in confusion. If so, in construction of buildings etc., a detail soil investigation is desirable in these areas. Especially, for the soft clayey soil near-surface is assumed to be lack of bearing capacity, have excessive settlement, it is very important and necessary to figure out the existence of these layers.

4.2 Soil consistency

As notice above, to confirm the appearance of clayey layer with high water content, low N value is indispensable in construction work. To figure out these existences, it is needed to understand the soil consistency as well. The indicator in the following formulas shows that by comparing with the natural water content, the compressibility of soil can be comprehended.

\[
I_p = w_L - w_p \\
I_L = (w_n - w_p)/I_p \\
I_c = (w_L - w_n)/I_p
\]

Where \( I_p \): plastic index (%), \( w_n \): natural water content (%), \( w_L \): liquid limit (%), \( w_p \): plastic limit (%), \( I_L \): liquid index (%), \( I_c \): consistency index (%)

Figure 11. Relationship of liquid limit and plastic index.

In particular, the plasticity chart, which shows the relationship between liquid limit and plastic index, is a convenient chart in understanding the compression of soil. Figure 11 shows the plasticity chart in relevant location. In this figure, the data of clayey soil is plotted. From the figure, it can be found that there are clayey soils which have plastic index value less than the one in A line proposed by Casagrande (\( I_p = 0.73(w_L-20) \)). These investigated results are concluded from data of high water content depth base on depth distribution of water content. The clayey soil, which is under A line, for example soil with poor interface effect as grains of silt, is called “lean” clayey soil. These soils are full of compressive
and normally content lots of organic component. In the other side, clayey soils in which plastic index is over A line, the interface effect is large, are called “fat” clayey soil. From Figure 11, it is easily to separate the clayey soils which should be noticed for construction work from the plasticity chart.

Figure 12 shows the relationships between natural water content and liquid index as well as consistency. It can be recognized that “Lean” clayey soils have liquid index $I_L$ over 1.0 and minus consistency index value. It can be assumed that as natural water content $w_n$ is bigger than liquid index, these clayey soils have high water holding property. However, “Lean” clayey soils have high compression which can be presumed that these clayey soils in relevant location are humus. In the other hand, the distribution of liquid index $I_L$ of “fat” clayey soils is normally around less than 0.5. Due to the water holding property is just a half compared with that of “lean” clayey soils, these clayey soils can be supposed to be in overconsolidated status.

4.3 Activity and clay mineral

From 4.2, it can be easily to separate clayey soils with high compression by using plasticity chart. However, for more convenient in designing, estimated value are recommended. As mentioning above, to find out the reasons estimating formulas generalized in Japan can’t be applied in Ho Chi Minh City, the differences of clayey soils’ characteristic are focused on.

In Figure 13, the relationship between plastic index $I_p$ and clayey content rate (grain size is smaller than $5 \times 10^{-6}$m). The ratio of $I_p$ and clayey content rate is called “activity”, considered the scale of surface effect of one particular. The activity of clayey soils in Japan, normally is from 1 to 2, is higher than others in foreigner country (JGS, 1964). Further, the activity, which is depended on kinds of clay mineral, can be indicated as following:

$$A = \frac{I_p}{P_{2\mu}}$$ (3.4)

Where, $A$: activity, $I_p$: plastic index, $P_{2\mu}$: content rate of grain size which is smaller than 2 $\mu$ (in this paper, this value is applying with grain size less than 5 $\mu$).

From figure 13, it can be also found that the activity of clayey soils in target area is 0.5 for “fat” clayey soils and is about 1.5 for the “lean” one (due to gradient of each). Comparing with “fat” clayey soils in Japan, this value is much smaller. It also means that the types of clay mineral composed by clayey soils in both countries are quite different.

![Figure 13. Relationship of clay content and plastic index](image)

Figure 14. Mineral components of clayey soils gathered from Osaka Bay and Mekong River basin.
Base on activity, it can also estimate the differences between clayey soils in Japan and in Ho Chi Minh City. Figure 14 shows the content mineral components of clayey soils gathered from Osaka Bay and Mekong River basin (Saburo Aoki, 2010 and Nguyen Quang Hai, etc, 2005). While the main ingredients of clayey soils gathered in Osaka Bay are Chlorite and Illite, Mica and Smectite seem to be the highest components of clayey soils in Mekong River basin. Kaolinite can combine with hydrogen to bond crystallization which can make the grain size bigger, while mineral close to Mica such as Illite have ion bond weaker than hydrogen bond. From this, it can be expected that the characteristic of clayey soils’ strength in Japan and Vietnam is quite variance.

5 CONCLUSION

From the above analysis, some conclusions have been apparent as following:

_It is difficult to apply SWS results and relationships between N value and soil parameters which are generalized in Japan, into soil condition in Ho Chi Minh City area._

_Estimating method for soil parameters:_
For small-scale structures such as houses, the thinking of neglecting details soil investigation is the same in both Japan and Vietnam. However, after some analysis, it has been figured out that some estimating methods in Japan can not apply directly into Vietnam. From now on, by collecting more data in soil investigations, not only some simple estimating methods will be fabricated but the application of SWS method is also considered.

_Separation of dangerous ground base on plasticity chart:_
Base on collected data in the South of Vietnam, by applying the plasticity chart, the separation of dangerous ground such as humus was confirmed. For further relationships, it is necessary to confirm the overconsolidated status of the soils in the future.

_Variance of clay mineral in Vietnam and Japan:_
Base on compared results of clay gathered in Mekong River basin and Osaka Bay, it has been recognized that the main components of clay mineral is quite different between Vietnam and Japan. In deep mixing method, it is very important to determine the opponents of clay mineral due to relation in type of cement, strength development and constrains of construction.

6 REFERENCES


