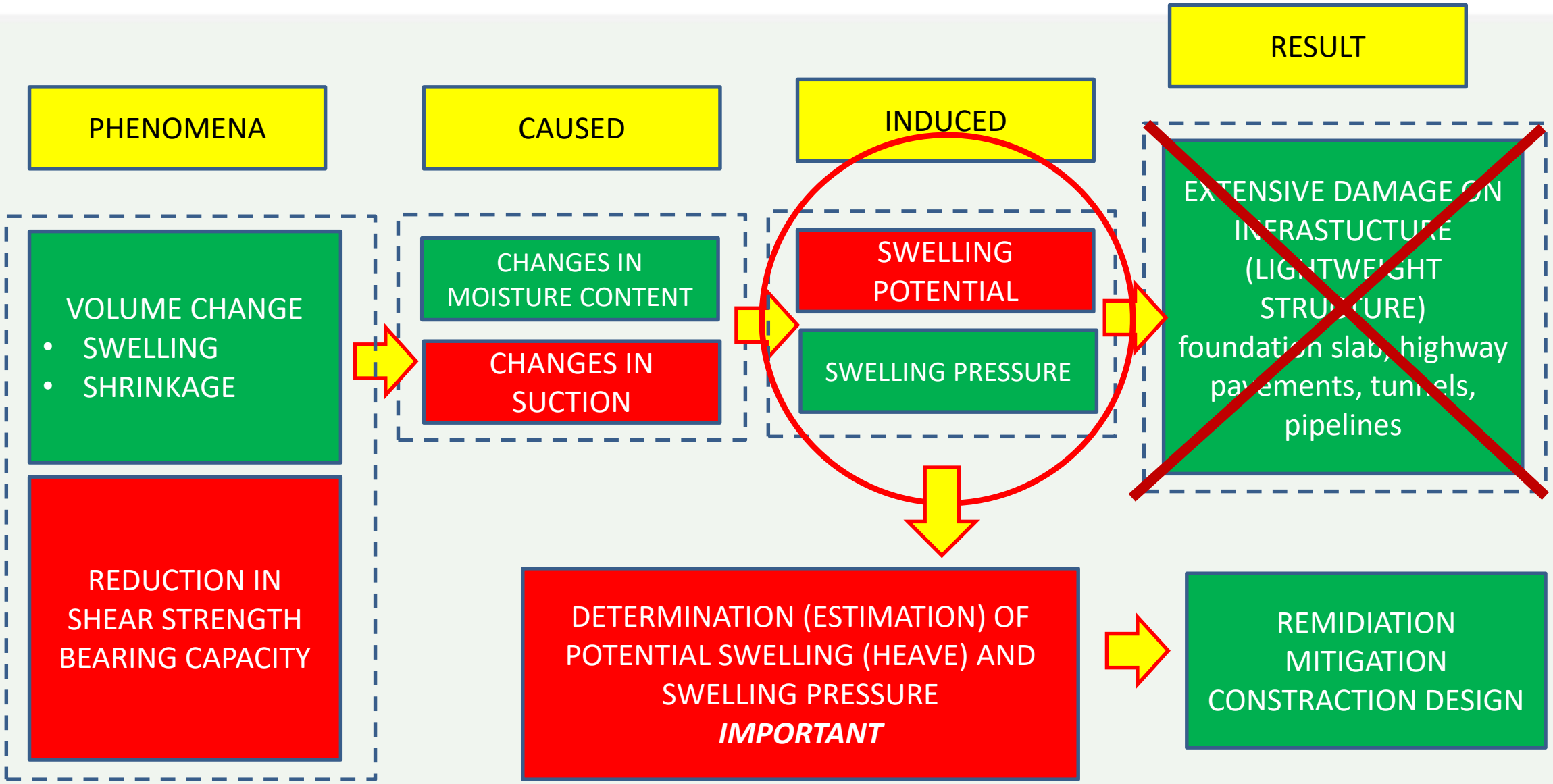
Predicting Heave on The Expansive Soil

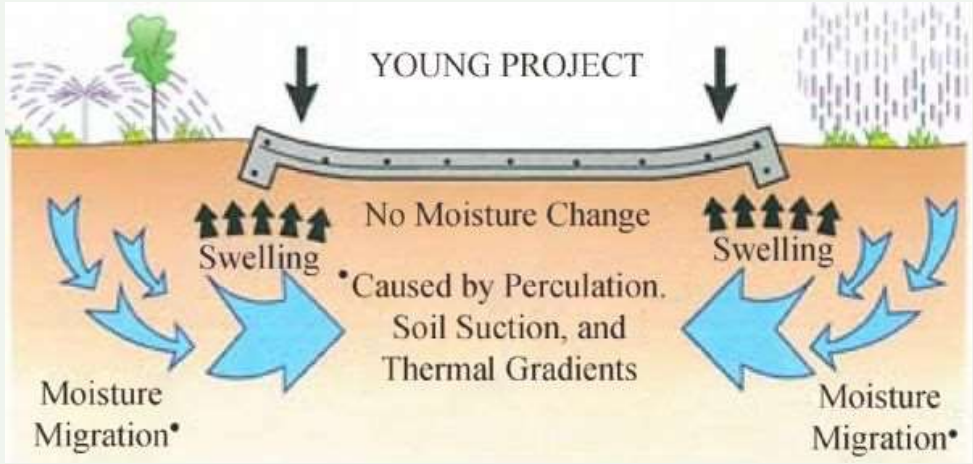
Willis Diana, *Anita* Widianti, *Edi* Hartono, and *Agus Setyo* Muntohar

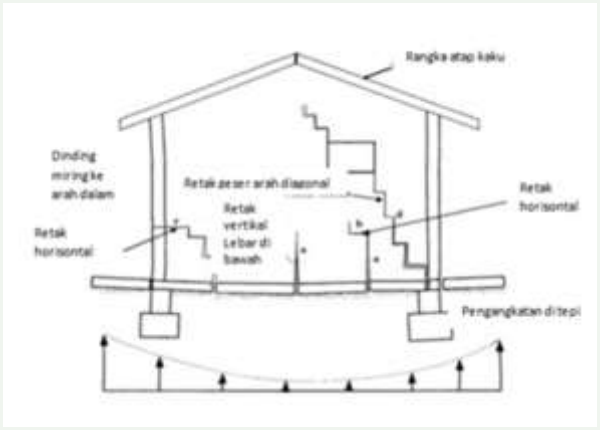
Civil Engineering Department, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia
willis.diana@umy.ac.id

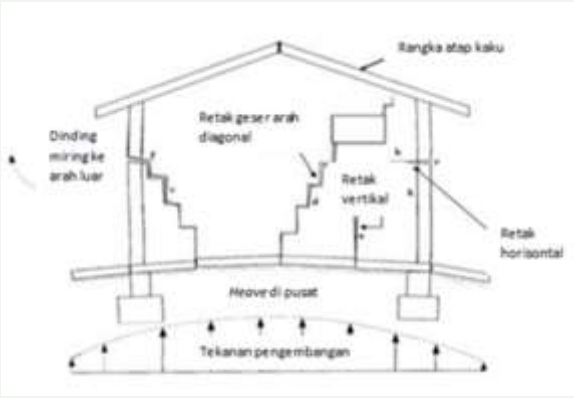
EXPANSIVE SOIL PROBLEMS

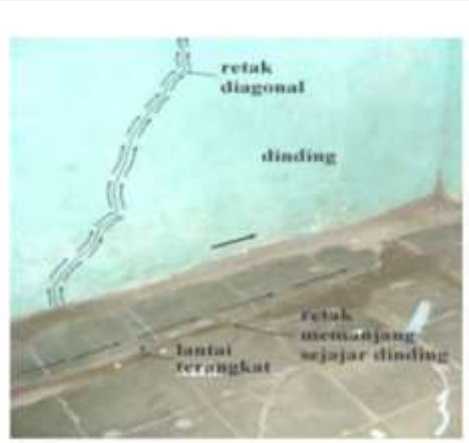


INFRASTRUCTURE DAMAGE IN EXPANSIVE SOIL

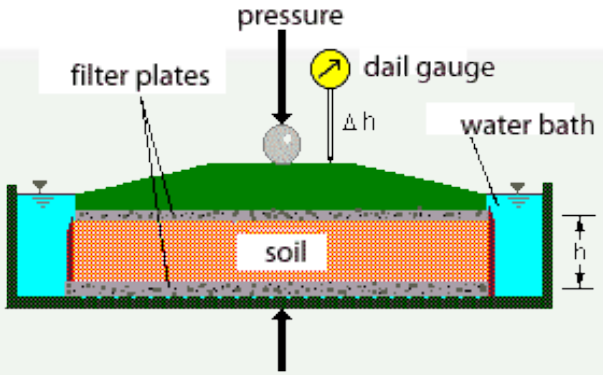








OEDOMETER TEST AND THE HEAVE PREDICTION



THE MOST POPULER TEST IN MEASURING THE SWELLING POTENTIAL AND SWELLING PRESSURE

- testing equipment is commonly available in most soil mechanics laboratories,
- the simplicity of its operation,
- most geotechnical engineers are familiar with the testing methods

THERE ARE VARIOUS METHOD TO DETERMINED THE SWELLING PRESSURE (3 METHOD I.E, CS, CV, SO).

- The swelling pressure obtained from the three oedometer method was different

numerous numerical methods have been developed for the estimation of heave (swell in the vertical direction), but few of these methods have been validated experimentally, and there is limited amount experience regarding the reliability of the available prediction methods

THE HEAVE PREDICTION METHOD

Marr et al. Method

Marr et al. proposed a practical method to predict the vertical movement (heave) of the soil base on changes in water content. A simple method for predicting vertical strain (ε_v) as a function of changes in water content (Δw) at a given total applied vertical stress (σ_v) was proposed.

$$\Delta H = H_0 \times \frac{\Delta w \times C_{\varepsilon,w}}{100}$$

where,

ΔH = the ground surface movement (heave),

H_0 = the thickness of soil layer,

Δw = changes in water content,

$C_{\varepsilon,w}$ = slope of swelling line,

Nelson et al. Method

$$C_H = \frac{\%S_A}{\log\left[\frac{\sigma'_{cv}}{(\sigma'_i)_A}\right]} \qquad \Delta H = HC_H \log\left[\frac{\sigma'_{cv}}{\sigma'_{vo}}\right]$$

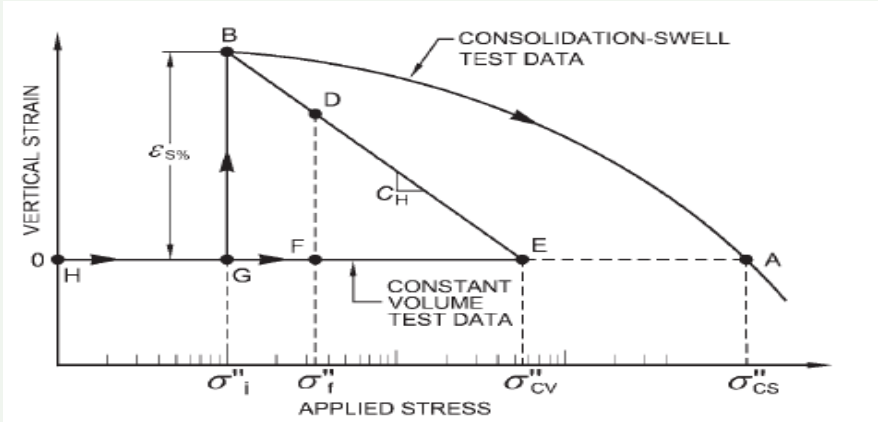
where,

$\%S_A$ = percent swell corresponding to the particular value of σ''_i expressed as a percent,

C_H = heave index,

σ'_{cv} = swelling pressure from constant swell test,

σ'_{vo} = vertical stress at the midpoint of the soil layer for the condition under which the heave being computed



EXPANSIVE SOIL PARAMETER

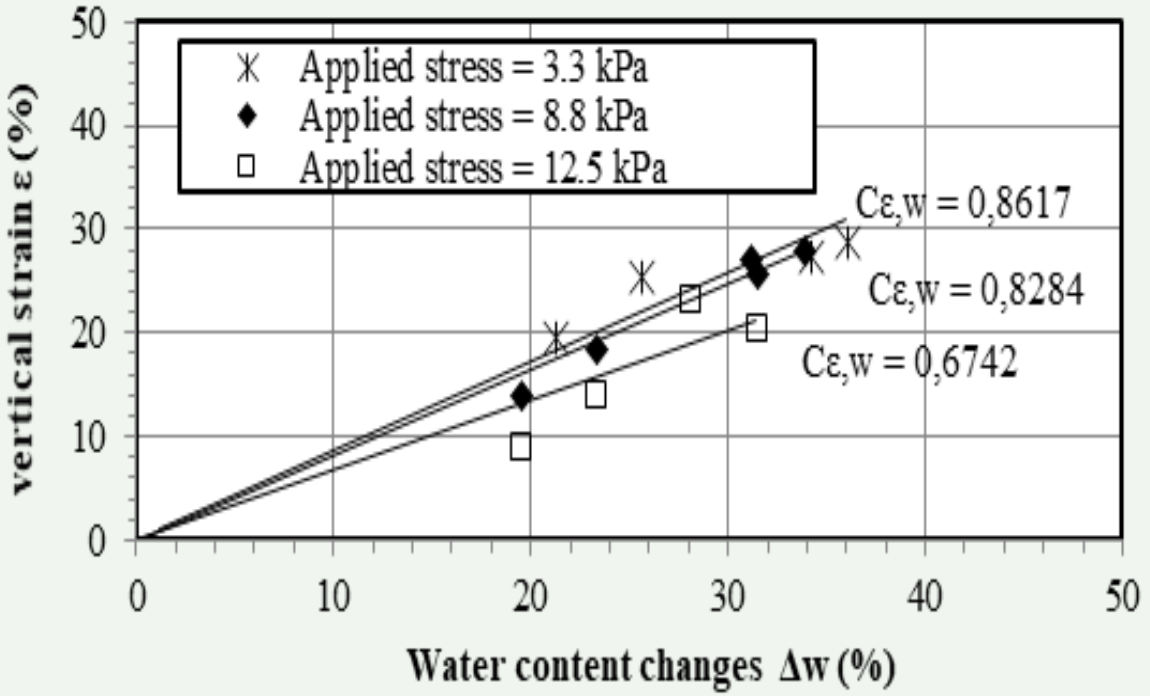
Table 1. Geotechnical properties of the materials.

Soil Properties	Value
Specific gravity	2.65
Liquid limit (LL); Plastic Limit (PL); Shrinkage Limit (SL) (%)	94.39; 34.58; 11.63
Percentage finer < 2µm (%)	96.32
USCS and AASTHO classification	CH & A-6-7
Maximum Dry Density (kN/m3)	12.26
Optimum Moisture Content (%)	35.55
Swelling Pressure (CS method) (kPa)	140

Table 2. The free field heave measured in the heave test on laboratory

Depth (cm)	0	10	20	30	40	50
Heave (cm)	10.89	8.44	6.35	4.55	1.74	0

THE OEDOMETER TEST RESULT



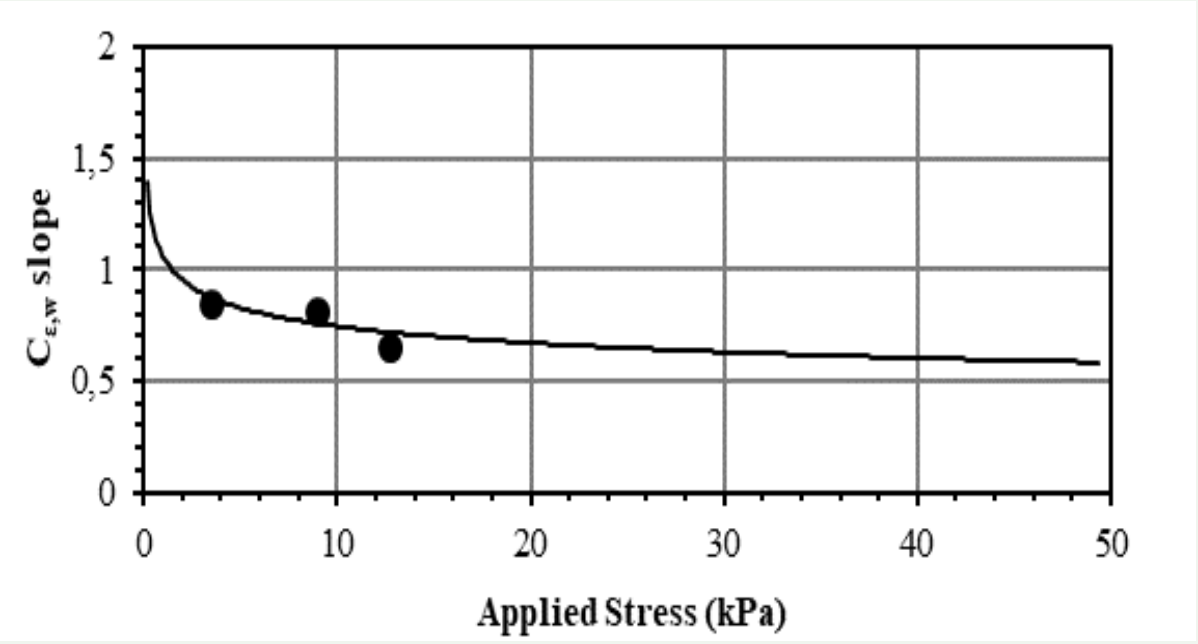


Fig. 2. (a) Response of strain to change in water content observed in swell test, (b) Relation between slope of $C_{\varepsilon,w}$ and applied stress

OEDOMETER TEST RESULT

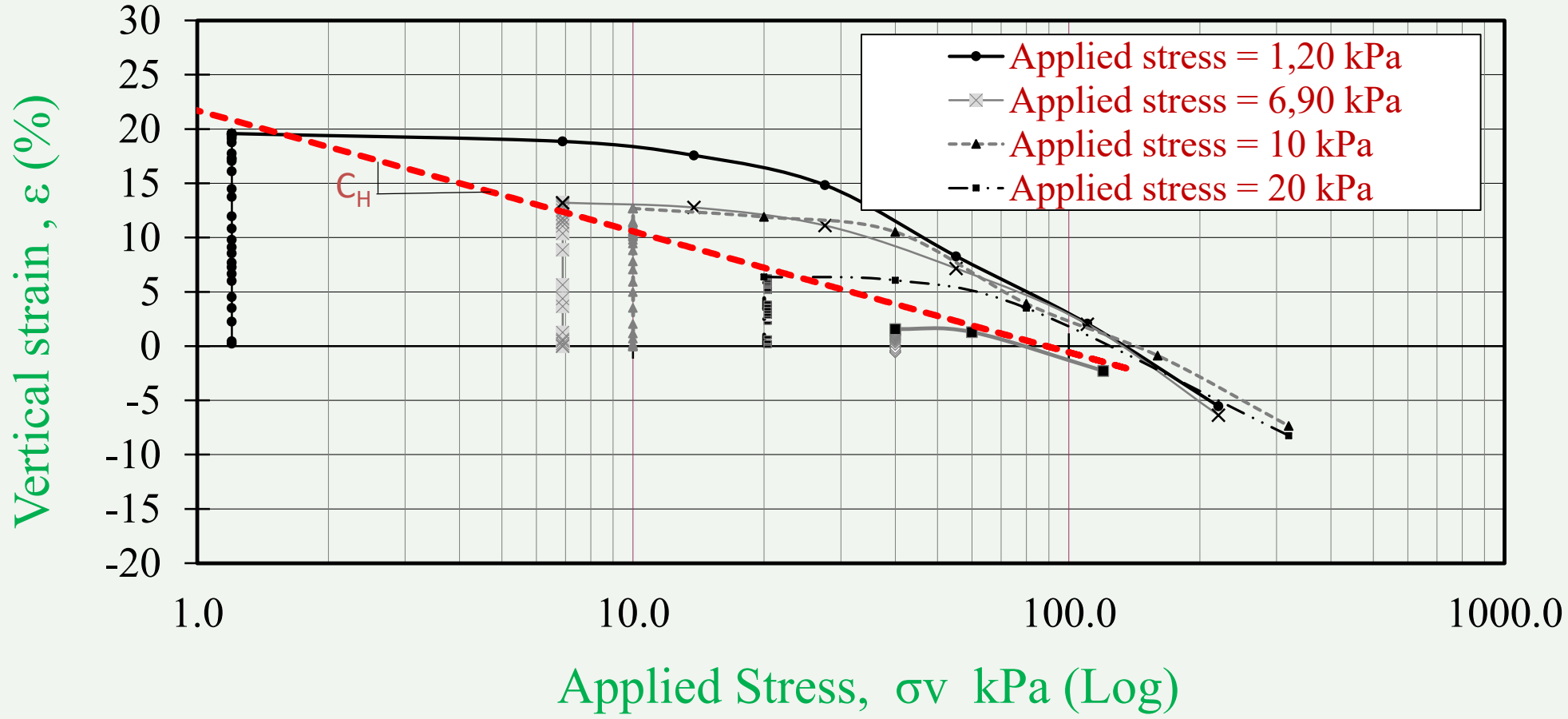
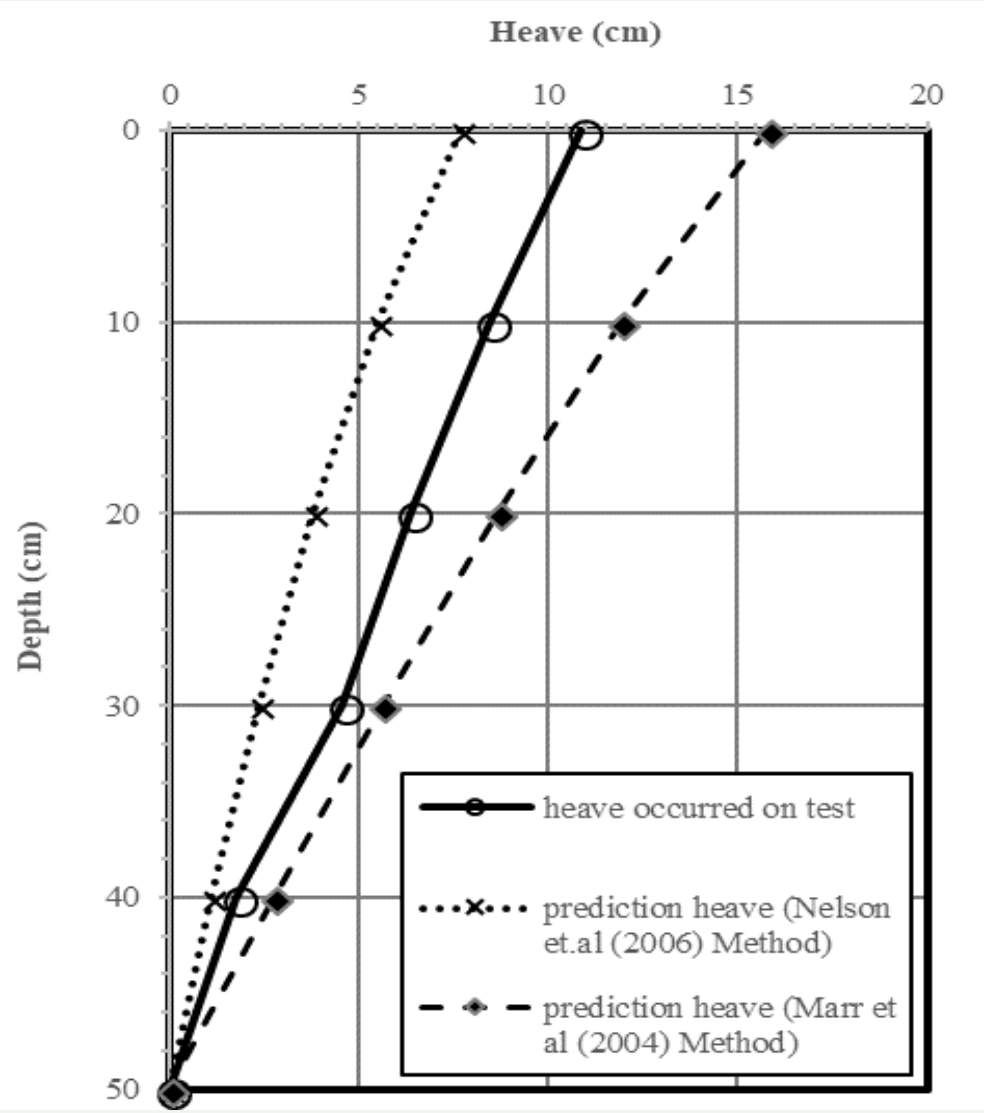


Fig. 3. The oedometer test results for different value of applied forces.

THE HEAVE PREDICTION RESULT



a. Both Marr et al. method [3] and Nelson et al. method [14] provided predictions that lie below and above the heave measurements, respectively. These two prediction methods provided results that represent low and upper bound predictions of the true soil heave movement in the laboratory. However, Nelson et al. prediction method was closer to the heave measurements. The difference between Nelson et al. Prediction and Marr et al. prediction with heave measurement about 29,50% and 45,02%, respectively. The high prediction by Marr et al. method can be attributed to the swell pressure parameter did not take into account in heave prediction, only considering applied stress, strain, and water content changes. It does not consider the nonlinear nature of the variation of heave or applied stress throughout the thickness layer. .
b. Both prediction method can be used to estimate heave since the initial soil condition (water content and dry density) and applied stress are the same condition between sample used in oedometer test and soil samples that compacted in the heave testing box.

RESULT AND DISCUSSION

The advantage of the **Marr et al. predictions** methods is

- that method can be made using only water content data,
- the data resulted from fairly routine geotechnical laboratory test
- most geotechnical engineering laboratory are well equipped to set up and run the test.

But,

- the test procedures take a long time (time-consuming) to set up and run the shrink-swell test.
- the test procedure needs a lot of specimens that identical and it is difficult to ascertain whether that specimen prepared are identical.

The CH parameter that used in **Nelson et al.**

- prediction methods are more rigorous, and its bases on consideration of both applied stress and suction as well as water content.

But

- need both CS and CV test to determine the CH parameter, in routine geotechnical laboratory, only CS test is conducted, hence only CS swelling pressure is measured. One of the proposed methods for determining CH parameters was the m method, as used in this study.
- the heave prediction using Nelson et al. method is influenced by the quality of the oedometer test results, the accuracy in determining the CV swelling pressure and the CH parameter.

Conclusions

- This study presented not only heave prediction method base on oedometer data but also the comparison between free field heave measurement with the heave prediction. The parameter that needs to predict the heave by used oedometer data has determined. The limitation and the advantage of each prediction method were identified.

- Based on the result obtained, the conclusions as following, the heave prediction result showed similar trends as those observed in the laboratory heave measurements, both Marr et al. method and Nelson et al. method provided predictions that lie below and above the heave measurements, respectively. However, for the Ngawi expansive soil that used in this study, Nelson et al. prediction method was closer to the heave measurements. The difference between Nelson et al. Prediction and Marr et al. prediction with heave measurement in the laboratory about 29,50% and 45,02%, respectively.

- The study contributes to our understanding of heave prediction methods using data from oedometer test and some factors that must be considered in predicting the heave of expansive soil. Further studies need to be carried out to validate this heave measurement with others heaves prediction method.

Acknowledgement

This paper is part of research sponsored by Ministry of Research, Technology, and Higher Education in 2017–2018 under *the National Strategic Research Grant* number DIPA-042.06.1401516/2018.

UMY

UNIVERSITAS
MUHAMMADIYAH
YOGYAKARTA

Unggul & Islami