Bounding surface plasticity model parameters for Bagdad soils

Paramètres du modèle de plasticité de surface de délimitation pour les sols de Bagdad

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ABSTRACT: The attempt of this paper is to provide and determine essential properties and input parameters that the bounding surface plasticity model requires and utilizes for Baghdad clay in order to be used in non-linear soil behavior analyses under static and dynamic conditions. Site investigations were carried out and undisturbed samples of high quality were obtained from the capital city at depths of 3-3.5 m, 5-5.5m and 7-7.5 m. A series of advanced soil laboratory tests were then performed under K_0-consolidated compression and extension conditions. The obtained soil laboratory test results were then used in a computer algorithm in order to evaluate soil properties and compute input parameters for the Iraqi clayey soil that are required for the bounding surface plasticity model.

RÉSUMÉ : La tentative de ce document est de fournir et de déterminer les propriétés essentielles ainsi que les paramètres requis et utilisés dans le modèle de la plasticité de surface de délimitation pour les sols et argiles de Bagdad afin d'être utilisé dans les analyses non linéaires de comportement des sols dans des conditions statiques et dynamiques.
Études et enquêtes sur le terrain ont été effectuées et des échantillons intacts de haute qualité à des profondeurs de (3 à 3,5 m), (5-5,5 m) et de (7 à 7,5m) ont été obtenus des sols de la capitale (Bagdad).
Une série de tests de pointe du sol sous des conditions de compression et d'extension K_0-consolidés ont ensuite été effectuées. Les résultats obtenus en laboratoire des sols d'essai ont été ensuite utilisés dans un algorithme informatique afin d'évaluer les propriétés du sol, et de calculer les paramètres d'entrée pour le sol argileux irakienne qui sont nécessaires pour le modèle de plasticité de surface de délimitation.

1. ESTABLISHMENT OF MODEL PARAMETERS

1.1. *Introduction*

The bounding surface plasticity model, as developed by Dafalias and Herrmann (4.1), is a versatile constitutive relation that can account for the behavior of clayey soils under various loading conditions. It is currently well established as a reliable algorithm for static and dynamic applications on condition of adoption of appropriate input parameters.

1.2. *Site investigation*

A scheme was developed in order to obtain representative high quality undisturbed and disturbed soil samples from central Baghdad, the capital city of Iraq in order to obtain the required input parametrs for the model.

1.3. *Drilling and sampling*

Drilling is done by the use of continuous flight augers, undisturbed samples are obtained by using Shelby tubes and an appreciable amount of disturbed soil (enough for conducting soil classification tests) is also extracted. The samples obtained were waxed, sealed and transported to the soil mechanics laboratory of the College of Engineering of the University of Baghdad in order to conduct further laboratory tests on them.

1.4. *Testing program and results*

As shown in Figure (1), A series of classification, engineering and ultrasonic tests are performed in this study. Classification tests are conducted first, in addition to physical and chemical tests. Physical tests comprise of specific gravity, Atterberg limits, and hydrometer tests while engineering tests that are carried out include standard consolidation tests, cyclic consolidation tests and triaxial tests according to the following conditions:

- K_0 consolidated undrained triaxial compression tests (K_0CUCT → OCR=1 and 2).
- K_0 consolidated undrained triaxial extension tests (K_0CUET → OCR=1).
- Isotropically consolidated undrained triaxial compression tests (ICUCT → OCR = 1, 1.2 and 5).
- Isotropically consolidated undrained triaxial extension tests (ICUET → OCR = 1, 1.2 and 5).

Figure 2 shows the soil type according to the Casagrande chart, Table 1 summarizes the results of the ultrasonic tests while Figures 3 and 4 show the conventional and cyclic consolidation test results. Table 2 presents the results of these consolidation tests. Plates 1 and 2 show the testing setups for the triaxial tests, Figures 5 to 7 show the test results and Table 3 shows the angle of internal friction obtained from these triaxial tests.

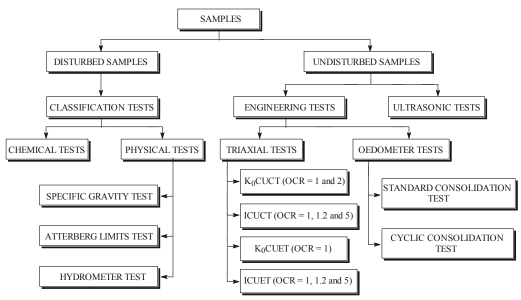

Figure (1) The testing program.

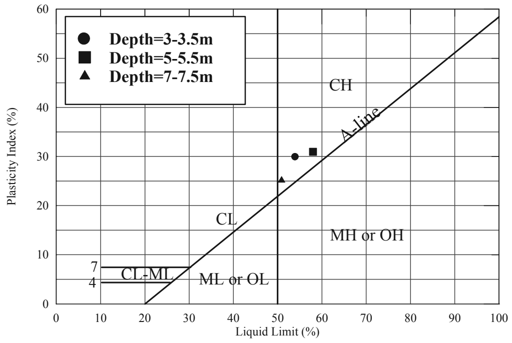

Figure 2. Soil type using Casagrande chart.

Table (1) Results of ultrasonic tests

Depth (m)	ν_p (m/sec)	ν_s (m/sec)	E (kP_a)	G (kP_a)	υ	K (kP_a)
3-3.5	412	134	1.01×10	35104	0.44	2.85×10^5
5-5.5	1238	516	1.4×10^6	511212	0.40	2.26×10^6
7-7.5	966	998	1.28×10	483608	0.32	1.17×10^6

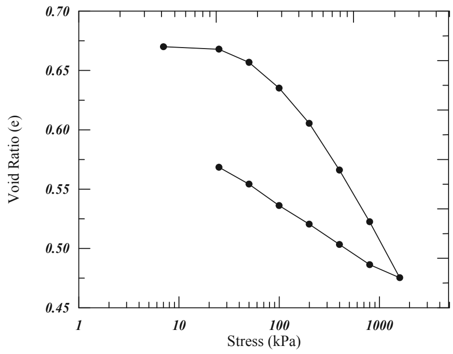

Figure 3. Results of a Standard Consolidation Test at Depth (5-5.5 m).

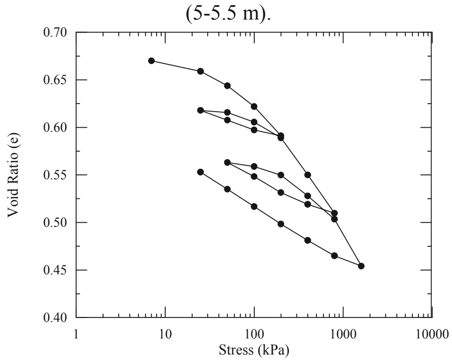

Figure 4. Results of a cyclic consolidation test at depth (5-5.5 m)

Table (2) Results of standard consolidation tests

Depth (m)	C_c	C_s	P_c	P_o	*OCR*
3-3.5	0.162	0.001	250	47.5	5.26
5-5.5	0.156	0.037	115	68.7	1.67
7-7.5	0.300	0.048	155	145.5	1.065

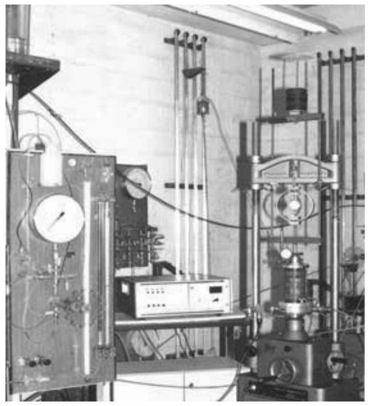

Plate .1. Triaxial setup for anisotropic consolidation.

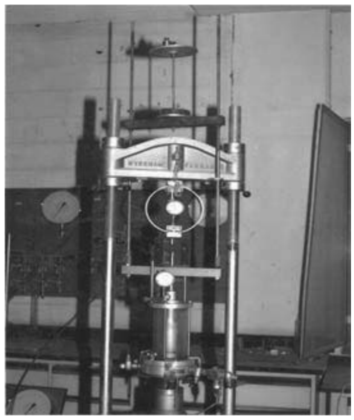

Plate 2. Complete triaxial setup for extension test.

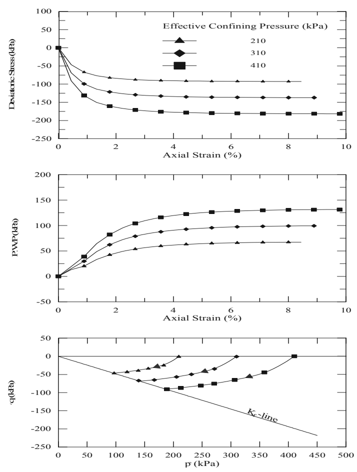

Figure .5. Results of isotropically consolidated undrained triaxial extension tests at depth (5-5.5 m).

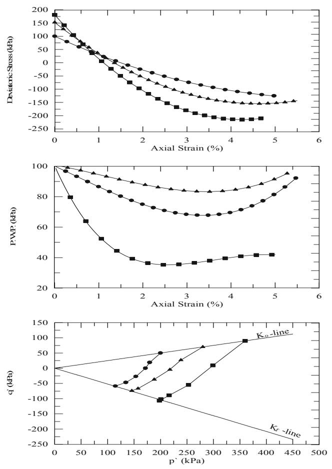

Figure (6) Results of K_o-consolidated undrained triaxial extension tests at depth (5-5.5 m)

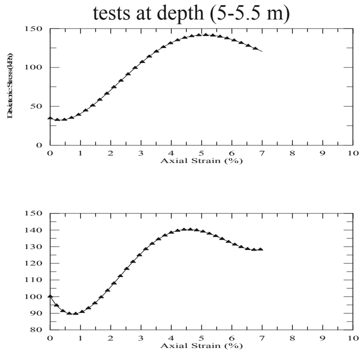

Figure (7) Results of a K_o-consolidated triaxial compression test of overconsolidated soil (OCR = 2) at Depth (5-5.5 m)

Table (3) Values of Angle of Internal Friction ϕ′

Depth (m)	*Isotropically consolidated specimens*		*K_0-consolidated*
	Compression CIUCT	*Extension CIUET*	*Compression CK_0UCT*
3-3.5	29°	27°	28°
5-5.5	29°	29°	28°
7-7.5	32°	28°	31°
ϕ'_{av}	30°	28°	29°

Figures 8 to 10 show the calibration outcomes when following the procedures outlined in reference (4.2).

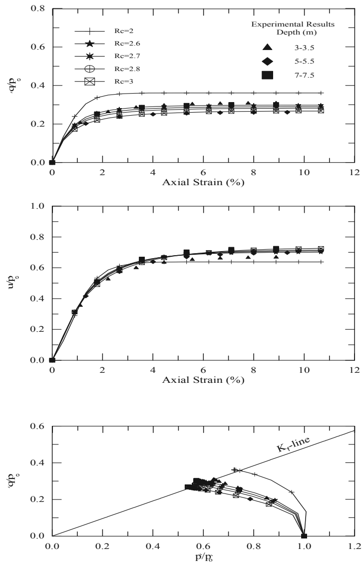

Figure (8) Calibration of parameter R_c for Baghdad brown silty clay (BBSC) soil

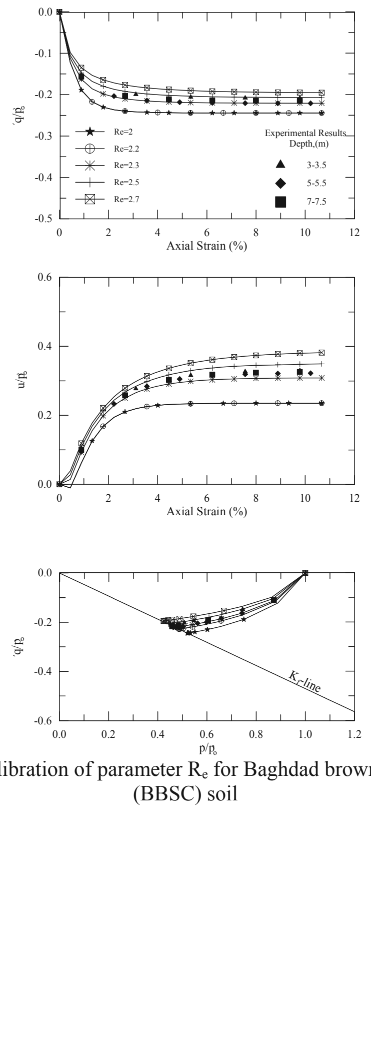

Fig.(9) Calibration of parameter R_e for Baghdad brown silty clay (BBSC) soil

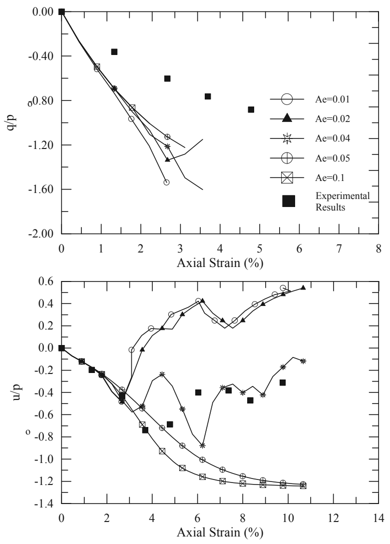

Figure (10) Calibration of parameter A_e for Baghdad brown silty clay (BBSC) soil

Table 4 outlines the full set of parameters obtained from the testing program on the extracted samples from the central Baghdad area soil after conducting the necessary calibration procedures outlined in reference (4.2).

Table (4) Complete set of obtained input parameters of Bounding Surface Plasticity Model for Baghdad brown silty clay (BBSC) soil

Parameter	Value	Parameter	Value
λ	0.064	R_e/R_c	0.85
κ	0.017	A_e/A_c	0.80
M_c	1.2	C	0.0
M_e/M_c	0.676	S_p	1.0
ν	0.4	m	0.02
R_c	2.7	h_e/h_c	0.5
A_c	0.05	h_c	2.0
T	–0.1	h_o	1.5

2. CONCLUSIONS

A set of Bounding Surface Plasticity Model parameters are established from high quality comprehensive site investigation and laboratory testing programs. The parameters presented in Table 4 are further successfully used in prediction/observation studies on foundation problems in the central Baghdad city area (4.3).

3. ACKNOWLEDGEMENTS

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4. REFERENCES

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