Slope Stability of T-shape Analysis

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***Abstract*-A two-dimensional (2D) finite difference method was adopted to find the factor of safety (FOS) against failure of embankments over T-shape deep mixing column over soft soil. the factors affecting the factor of safety (FOS) against failure of embankments over T-shape deep mixing column over soft soil includes the spacing, size, and friction angle, cohesion of soft soil, height of embankment, and existence of ground water. Based on numerical models, various reductions for deep mixing columns can be proposed for the preparation of factor of safety (FOS). The reduction factor for factor of safety (FOS) of 0.90 is used to convert calculated factor of safety (FOS) by this study. Further, the existence of the water table will reduce the factor of safety then establish it without groundwater table which would reduce the shear strength of the foundation work. The chosen factor of safety (FOS) is highly dependent on the engineer's judgement and past experience.**

***Key Words*- Soft soil, Numerical analysis, Embankment, Soil bearing capacity, T-Shape column**

I. INTRODUCTION

Problems of slope instability of soft soil can be overcome by the geotechnical engineers. A number of ground improvement techniques have been successfully adopted to prevent deep- seated slope failure, such as sand compaction piles, stone columns, geo-textiles, and deep mixed columns.

The new factors of safety and their results and a suitable information according to software models. technique to overcome the instability of soft soil is T-shape deep mixing columns which are broadly described below as the project format. hence in this method we had given the detail information regarding the various

T-shape deep mixing column method is perhaps the newest numerical method used for solving sets of different software models. The slope instability of embankments may develop locally, near the facing, within the embankment, or through foundation soil may get fail, It is also called as global slope failure due to weak foundation existing under the embankment.

Many researchers have done studies on the applicability of TDMC for soft soil improvement. The studies focused on laboratory model test, numerical analyses, field tests, and analytical solution.

This paper presents the detail study on the behaviour of TDMC in the 2-D Plaxis software. The results and discussion of factor of safety and with water embankment first time performed in is discussed. The results of the tests indicated that the T-shape column can be reinforced partially to improve the load carrying capacity adequately.

II. INSTALLMENT METHOD

T Shape deep mixing column Deep cement/lime mixing column is a foundation technique where a binder material cement is injected into the ground for soft soil stabilization. T Shape deep mixing columns is constructed in the soft soil and on which embankments /building foundation laid as results this would prevent foundation of the embankment/ building foundation form the deformation and will give stability.

a) Material model and parameters

The embankment fill, the foundation soils, and the columns were modelled as linearly elastic-perfectly plastic materials with Mohr-coulomb failure criteria. The elastic properties have an insignificant effect on the factor of safety calculation and, therefore, these properties are required by 2-D Plaxis.

The equivalent parameters for the improved area were estimated based on the area average of these parameters of these parameters from T-shape deep mixing column and the soft soil as follow:

$$C_{eq} = C_c * a_s + C_s(1- a_s)$$

Where a_s is the area replacement ratio by T shape deep mixing column over the overall soft soil area; $C_{eq,}$ C_c and C_s are the equivalent cohesion and the cohesion of the column and the soft soil. Under an embankment, however, the stress concentration ratio of 1 is reasonable and safe.

As soft soil is mostly normal or under-consolidated, it is more critical or and embankment over the soft soil under an undrained condition than under a drained condition. Therefore, undrained cohesion was assumed for the soft soil in the study.

The installation of T-shaped deep mixing column may change the properties of the soft soil; however, numerical study have shown that such properties changes are minimum, as specially 2D-PLAXIS is used to install T-shape deep mixing columns. Therefore, the changes of the properties of soft soil is include the in this study.

b) Model size

The sizes of the model and mesh were determined on the basis of several trials, during which the mesh was progressively refined to 0.25 m and its horizontal boundary was extended such that zones did not influence the development of the failure surface. The size of the mesh is presented in fig. for the individual column and equivalent area. Results from these trials showed that the side boundary on the right should be extended to 14 to 24 m beyond the toe the embankment.

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c) Boundary conditions

It was assumed that the sand was underlain by 2m and a rigid hard soil and the contribution of the firm layer was considered to be negligible for the instability of the embankment. Thus, the bottom boundary was set at this depth. Nodes on the two vertical boundaries were fixed against horizontal movement but allowed to move freely in the vertical direction.

d) Computation of factor of safety

In the numerical study, 2D-PLAXIS software adopted to solved for the factor of safety(FOS) value of slope stability

For each trial analysis by 2D-PLAXIS, the same factor of safety value is applied to the strength parameters of soil and column in the individual T-shape columns method and numerical method. By adjusting height of the embankment boundary condition factor of safety analysed and also by adjusting cohesion and friction angle of embankment for the numerical analysis method.

III. ANALYSIS OF RESULTS

The number of factors influencing the factor of safety against failure of embankment over T-shape deep mixing columns to improving soft soil, including the spacing, size, and friction angle of embankment T-shape deep mixing columns, the cohesion of soft soil, and the height of embankment fill. The influence of each factor on the factor of safety is presented below. The results from numerical method are calculated.

a) FRICTION ANGLE OF EMBANKMENT

The T-Shape deep mixing column was modelled as a cohesion less material, which has only friction angle. The influence of the friction angle of the embankment fill material on factor of safety of the embankment over TDMC improved soft soil shown in fig. the result show that better quality embankment material yielded a higher factor of safety for the embankment system. Furthermore, consideration of the ground water table with respect to embankment the friction angle of embankment is increase with increase in factor of safety of TDMC.

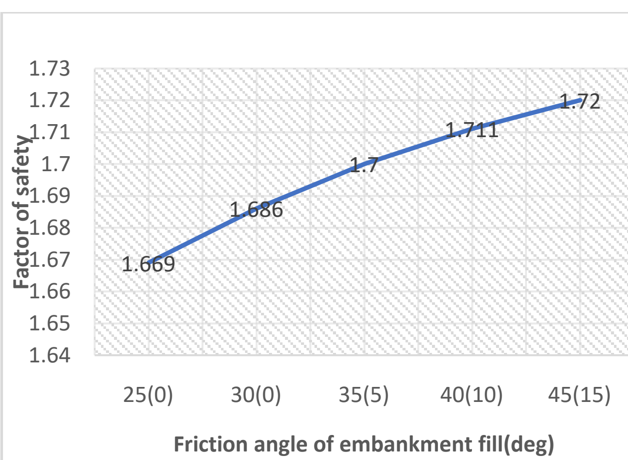

Fig.1 friction angle of embankment fill(deg)

b) SIZE OF TDMC

In which the TDMC column has two parts:

Flange of TDMC

Web of TDMC

Flange of TDMC:

The width of the Flange TDMC is about 1.08,1.2,1.32,1.44 and more. The width is twice of the width of the web of TDMC (D_2 = 2D). the influence of the width of flange of TDMC on the factor of safety is shown in fig. it is shown that an increase of the width of the Flange of TDMC increased the factor of safety values of embankment system. The results from the equivalent area model had the similar trend as those from the T- shape individual column model. When the width of the flange is increase the factor of safety is increasing. and that is shown in fig.

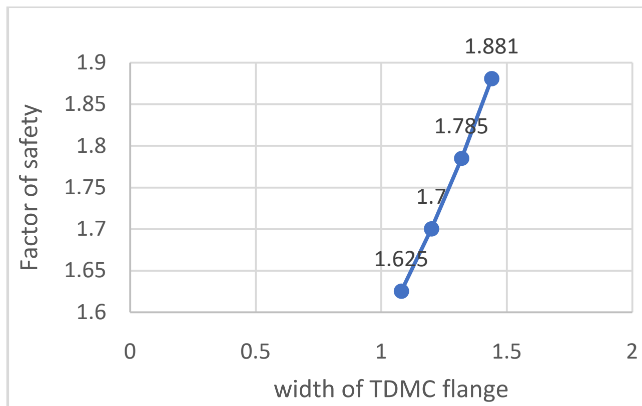

Fig. 2 width of TDMC flange

The Depth of flange range is 1 to 5 and more. Various depth of flange is adopted. As above the sizes of the flange of the TDMC graph are shown. As well as the depth of the flange of TDMC are shown in fig.it is show that an increase the depth of flange of TDMC to increasing the factor of safety and that can the stability of a soft soil increase.

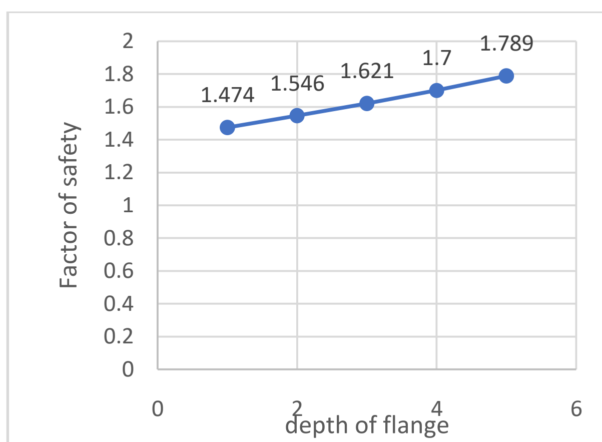

Fig.3 depth of flange

c) Spacing of TDMC

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The various spacing of TDMC between two columns about 1.8m, 2m, 2.2m, 2.4m. that's various space using the making of the TDMC column analysis. And factor of safety v/s spacing graph is shown in fig. that is show that an increase the centre-to-centre spacing of column of TDMC is the reduced the value of factor of safety. The result from the equivalent model had the similar trend as those from the individual T-shape column.

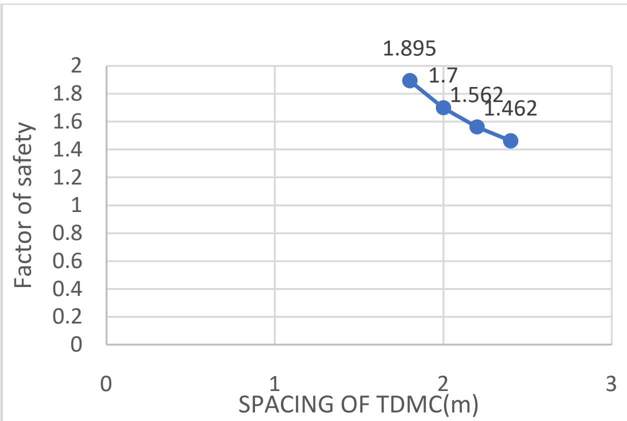

Fig.4 spacing of tdmc

d) cohesion of soft soil:

The influence of the drained cohesion of the of the soft soil on the factor of safety shown in figure. An increase of the drained cohesion of the soft soil increased the factor of safety values of the embankment over TDMC the equivalent area model yielded higher factor of safety than the individual T -shape column. the difference became the larger when the drained cohesion of the soil increased it is shown that the benefit of the drained cohesion of the soft clay became less significant when the cohesion was higher than 30 Kpa. because the slip surfaced developed was shallow were in the improved foundation contribution of the foundation becomes less important.

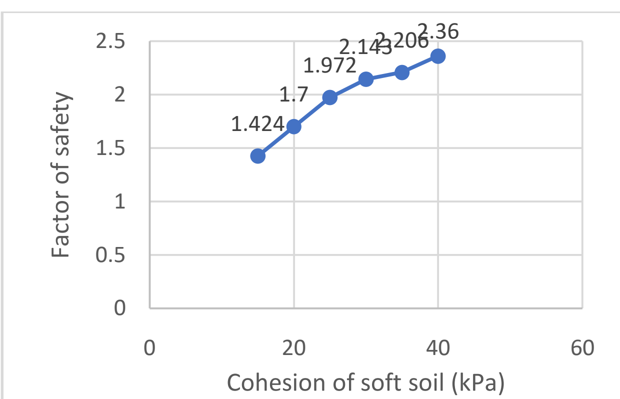

Fig. 5 cohesion of soft soil

e) HEIGHT OF EMBANKMENT FILL

The influence of the height of the embankment on the factor of safety is shown in fig. It is correct that the factor of safety decreased with an increase of the height of the embankment. The factor of safety computed by the equivalent model were higher than those by the individual T-shape column. The equivalent model and individual T-shaped column difference became larger when the height of embankment increased.

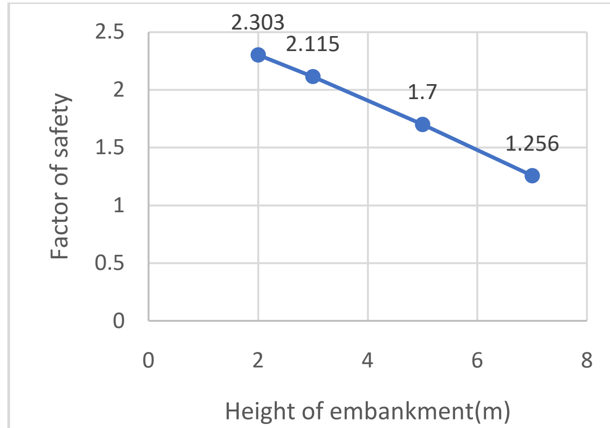

Fig. 6 height of embankment

f) Cohesion of TDMC equivalent:

The influence of the cohesion of the TDMC on the factor of safety is shown in figure. it is show that the factor of safety increased with an increase of the cohesion of the TDMC equivalent. The various cohesion of the TDMC equivalent range 65Kpa to 160Kpa. Generally, the factor of safety is computed by equivalent area model were higher than the individual T-shape column. And their difference became larger when the cohesion of the TDMC equivalent increased.

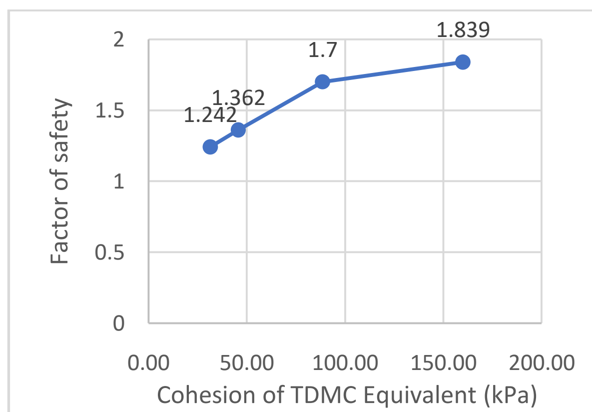

Fig. 7 cohesion of tdmc equivalent

IV. CONCLUSIONS

In study of the TDMC, Tow-dimensional finite difference analyses were conducted to find the factor of safety (FOS) against deep-seated failure of embankments/any structures over T-shape deep mixing column based on the individual T shape column model and the equivalent area model. Based on the numerical analyses, the following conclusion can be drawn.

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1. The strength, spacing, and size of TDMC, the cohesion and depth of soft soil, and the friction angle and the height of the embankment fill all the factor of safety values against deep seated failure of the embankment.
2. A Reduction factor (ß) is take 0.9 to the factor of safety value of calculated based on Equivalent area method
3. A factor of safety calculated using the equivalent area model were higher those calculated using the individual T-shape column model.

All above given conclusion are only applicable 2D stability analysis of embankments over TDMC-improved soft soil due to deep seated failure, in with TDMC consider as walls in the individual T-shape column method.

REFERENCES

[1]. 2D PLAXIS software

[2]. Field Investigations on Performance of *T*-Shaped Deep Mixed Soil Cement Column–Supported Embankments over Soft Ground. Song-Yu Liu, M.ASCE1; Yan-Jun Du2; Yao-Lin Yi3; and Anand J. Puppala, M.ASCE4

[3]. Consolidation Calculation of Soft Ground Improved by T-shape Deep Mixing Columns Lei Chen1 and Songyu Liu2 1Ph.D Candidate, Institute of Geotechnical Engineering, Southeast University, Nanjing 210096, China; clove.chenlei@gmail.com2Professor, Ph.D, Institute of Geotechnical Engineering, Southeast University, Nanjing 210096, China;

[4]. Numerical simulation of load transfer mechanism of T-shaped soil-cement deep mixing column Peisheng Xi1,a, Xiaotao Zhang1,b*, Bo Liu1,c 1Department of civil engineering, Anhui jianzhu university, Hefei, Anhui, 230601

[5]. Two-dimensional deep-seated slope stability analysis of embankments over stonecolumn-improved soft clay Sari W. Abusharar, Jie Han ∗Dept. of Civil, Environmental, and Architectural Engineering (CEAE), the University of Kansas, 1530 West 15th St., Lawrence, Kansas 66049–7609, USA

[6]. Two-dimensional deep-seated slope stability analysis of embankments over stone column-improved soft soil Sari W. Abusharar, Jie Han ∗Dept. of Civil, Environmental, and Architectural Engineering (CEAE), the University of Kansas, 1530 West 15th St., Lawrence, Kansas 66049–7609, USA

[7]. 3D numerical analysis on bearing tests of T-shaped cement-soil deep mixing column composite foundation Yi Yaolin Liu Songyu(Institute of Geotechnical Engineering,SoutheastUniversity,Nanjing 210096,China)

[8]. Additional Stress Distribution Behavior of T -shaped deep mixing column composite foundation under embankment load

[9]. Analysis of effect of T shaped bidirectional soil cement deep mixing columns reinforcing soil foundation

[10]. Ascertainableness of T-shape and bi-directional cement-soil deep mixing column construction Technique and machine parameterXI Pei-sheng, WANG Zhi-gang(Anhui Institute of Architecture and Industry Hefei 230001,China)

[11]. Comparison between T-shaped deep mixing method and traditional deep mixing method for soft ground improvement LIU Song-yu,ZHUZhi-duo,XI Pei-sheng,YI Yao-lin (Institute of Geotechnical Engineering,SoutheastUniversity,Nanjing 210096,China)

[12]. Numerical simulation of bearing capacity and load transfer behavior of single T-shaped deep mixing column YI Yao-lin1,LIU Song-yu1,LI Tao2,WANG Gang2(1.Institute of Geotechnical Engineering Southeast University,Nanjing 210096,China;2.Wuhan New

[13]. Settlement Behavior of T-shaped Deep Mixed Column Composite Foundation Under Embankment Load

[14]. MONITORING AND ANALYSIS OF COMPOSITE FOUNDATION REINFORCED BY T-SHAPED BIDIRECTIONAL SOIL-CEMENT DEEP MIXING PILE UNDER EMBANKMENT LOADS ZHU Zhiduo,XIPeisheng,ZHANGBafang,ZHOULihong,ZHUZhihua (Institute of Geotechnical Engineering,SoutheastUniversity,Nanjing,Jiangsu 210096,China)

[15]. Generalized column method for calculation of settlement of T-shaped deep mixed column composite foundation under embankment load YI Yao-lin, LIU Song-yu, DU Yan-jun (Institute of Geotechnical Engineering, Southeast University, Nanjing 210096, China)

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