GEOTECHNICAL ENGINEERING PROJECT DAY 2000

A Presentation of Best Geotechnical Engineering Undergraduate Projects in Sri Lankan Universities

December 20, 2000
At ICTAD Auditorium

Organised by the
SRI LANKAN GEOTECHNICAL SOCIETY

SLGS

Message from the President of the Sri Lankan Geotechnical Society

The Sri Lankan Geotechnical Society (SLGS) has as one of its objectives the promotion of research and development activities within the country. As a means of achieving this objective there is no better starting point than beginning with our students. With this in mind, the Society has decided to commence this year an annual event in which our undergraduates and young engineers will be called upon to present their work to a wider audience of Senior Members. This will provide them with an opportunity to learn at first hand not only the research methodology but also how best to present their results.

It is proposed to evaluate each paper for

- Originality of the work
- Technical content
- Practical applicability
- Presentation
- Soundness of Conclusions
- Adequacy of reference to previous work

This year seven papers of high quality have been received, and it is our wish that with this beginning we will be able to see even better papers in the years ahead, and ultimately a vast improvement in the practice of geotechnical engineering in the country.

Prof. B.L. Tennekoon
President, Sri Lankan Geotechnical Society

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Comparison of Methods of Improvement of Compressibility Properties of Peat

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ABSTRACT: Peats are formed by the disintegration of plant and organic matter and are of very high void ratios and very large water contents. As peats are of very high compressibility and low shear strength, peaty soils do not provide any favorable conditions for construction on them.

Engineering properties of peat can be improved by preloading with a surcharge or by mixing with an external cementitious material such as lime. In the research reported here both methods of improvements were imposed on laboratory samples. The process of preloading in the field was simulated in the laboratory by carrying out loading, unloading and reloading tests in a conventional consolidation setup. Peats were mixed with lime in the laboratory and the resulting remoulded samples were also subjected to similar tests.

Test results indicated that both the primary consolidation and secondary consolidation characteristics can be improved significantly by applying both lime mixing and preloading. In addition, experimental setups were developed using the existing facilities to measure both the settlement and pore water pressure dissipation simultaneously to get an accurate picture about the consolidation behaviour of peat, which exhibits considerable amounts of secondary consolidation.

1. BACK GROUND

Rapidly developing country or a country which bears a rapidly increasing population, demands a substantial amount of new infrastructure and buildings. These buildings and infrastructure may have to be built on whatever the existing land where the sub soil conditions may not be very sound. In an around Colombo and suburbs most of the land with good sub soil conditions have been already used and most of the new infrastructure facilities and buildings will have to be erected on areas underlain by soft soils such as peat.

Peat contains the remains of dead vegetation and organic matter in various stages of decomposition. Thus peat posses very high water contents, high compressibilities and very low shear strengths. Due to these inherent properties, peaty soils do not provide any favorable conditions for constructions on them.

If structural loads are to be transmitted to these peaty soils, the above mentioned undesirable properties will have to be improved to prevent potential disasters. The shear strength will have to be increased and the compressibility will have to be reduced. Alternatively, the structural loads could be transmitted to an underlying stronger stratum with the help of pile foundations. However, for infrastructure facilities such as roads occupying a large plan area, for service lines such as sewer lines and water supply lines, and for moderately loaded buildings provision of pile foundations will not be an economical solution.

Improvement of engineering characteristics of peat imply the improvement of strength and stiffness of peat. Engineering properties of peat could be improved by either densification or solidification. Densification of peat through the reduction of void ratio could be achieved through preconslidation by preloading with a soil fill. A soil fill of appropriate thickness will be placed on the peat and kept there for a sufficient time allowing peat to consolidate under the weight of the fill. Once the necessary degree of consolidation is achieved a fill causing a stress equivalent to or greater than the intended structure will have to be removed. The main critisism against the preloading method is the rather long time period required for the process.

Mixing the part with an external cementitious material such as lime or cement over its entire depth could help to solidify the peat and improve its strengths and stiffness. Such deep mixing techniques have been tried with inorganic soils quite widely in countries such as Japan, Sweden, Singapore and China. Addition of lime or cement to the insitu soil and mixing, has shown to be a very effective and reliable way of achieving a rapid improvement of engineering properties of the soil. This paper presents the improvements achieved with lime mixing in a peaty soil and compares it with the improvements achieved with preloading.

2. LABORATORY TEST PROGRAMME

In order to study and compare the effect of preloading and lime mixing in the improvement of the compressibility characteristics of peat, four conventional tests were conducted with different types of specimen obtained from the same undisturbed sampling tube. The four specimens used are;

1. An undisturbed peat specimen
2. An undisturbed peat sample with a center lime column.
3. A remoulded peat with the addition of 15% lime(by weight)
4. A remoulded peat without any addition of lime

The peat sample mixed with lime was prepared in the laboratory by thoroughly mixing the undisturbed peat sample with 15% of lime using a hand mixer simulating the deep mixing technique. To compare the effects of the addition of lime another sample was remoulded using the hand mixture over the same time. In addition, an undisturbed specimen and an undisturbed specimen with a central lime column were also prepared. All the specimens were taken through the same series of loading, unloading and reloading increments. In most occasions, the stresses were doubled at the end of the loading (or reloading) increment and were halved during the unloading. Considering the presence of significant secondary consolidation effects in peat, tests were conducted with 2 week long load increments, instead of the conventional 24 hour increments.

3. DISCUSSION ON THE RESULTS

Using the data obtained from the four consolidation specimens;

(a) e Vs. log (σ) plots were done over loading unloading and reloading increments, and the gradients; compression index C_c and recompression index C_r were obtained.
(b) Coefficient of volume compressibility m_v were evaluated over all the loading and reloading increments.
(c) Coefficient of secondary consolidation were obtained over all the loading and reloading increments.

3.1 Effects of preloading

This effect is illustrated with the help of data obtained from the undisturbed peat and remoulded peat specimens. Reduction of m_v with preloading is depicted in Figure 1. The m_v values over the reloading increments were much smaller than in the loading increments. This illustrated the effect of reloading in reducing the primary consolidation characteristics. Another notable feature is that over the loading increments, the coefficient of volume compressibility decreased with the stress level. However, over the reloading increments the coefficient of volume compressibility slightly increased with the stress level (Figure 1). As the stress level in the reloading increments approaches the maximum previous consolidation pressure, the m_v values gets near to the curve corresponding to virgin loading. The m_v values were plotted in a log scale with the view of highlighting the effects where the values varied over a large range.

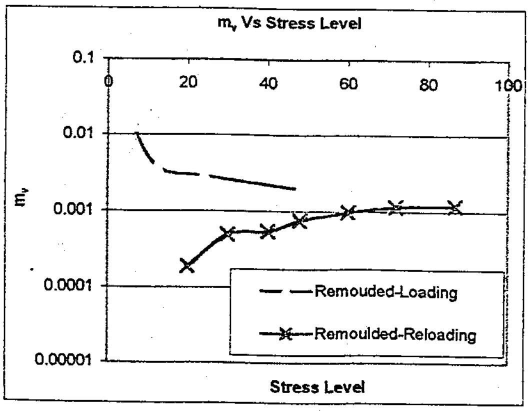

Figure 1- Reduction of m_v with Stress Level

The graphs of settlement Vs log (time) (for example Figure 2) illustrated that the secondary consolidation settlements continued at an increasingly rate without tapering off as in the case of inorganic soil. This indicates that the coefficient of secondary consolidation C_α increased significantly with time. Also, the maximum C_α values obtained with a load increment increased with the stress level (Table 1). However it can be noted that over the reloading increments the C_α values were much smaller (Table 1). This is a clear indication that the preloading will cause significant reduction in secondary consolidation characteristics.

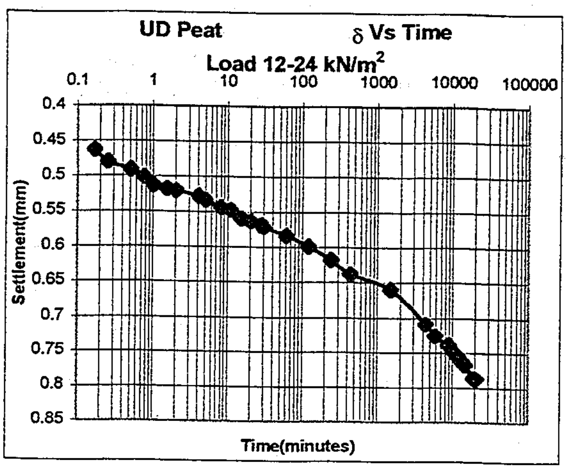

Figure 2 - A Typical Settlement Vs Log (time) Plot

Stress	Cα			
	UD Peat		Remoulded Peat	
	Loading	Reloading	Loading	Reloading
6	0.02		0.03	
12	0.0175		0.03	
24	0.024		0.033	
48	0.03		0.034	
20(RL)		0.0035		0.005
30(RL)		0.004		0.0082
40(RL)		0.005		0
48(RL)		0.0025		0.002

Table 1 - Variation of C_α with Stress Level

3.2 Effect of deep mixing with lime

The effect of deep mixing of lime is evaluated in the laboratory tests by the comparison of the data obtained from the specimen of remoulded peat without lime with that of the specimen remoulded with the addition of 15% lime.

The influence of preloading and lime mixing on primary consolidation characteristics were compared using the m_v Vs stress level plot in Figure 3.

The comparison of Figure 1 and Figure 3 clearly indicate that both the preloading and lime mixing has caused significant reduction in the coefficient of volume compressibility. The level of reduction of m_v observed were of the same order. In other words, the lime mixing can improve the primary consolidation properties of the peat to the same level.

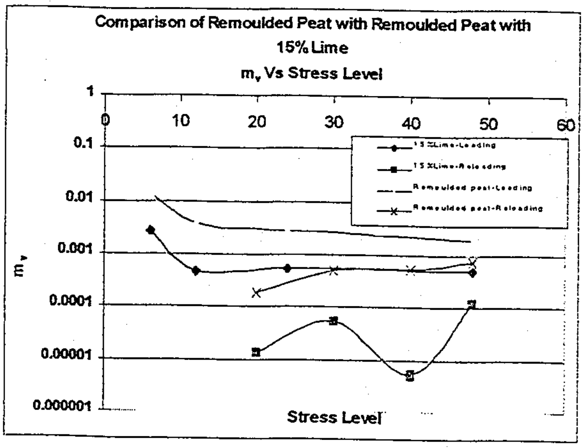

Figure 3 - Variation of m_v with Stress Level (Peat Mixed with Lime)

The coefficient of secondary consolidation C_α also was significantly reduced in the peat remoulded with the addition of 15% lime, when compared with the untreated peat as shown in Figure 4. It is seen that the secondary consolidation coefficients were reduced by an order of magnitude through the mixing with lime.

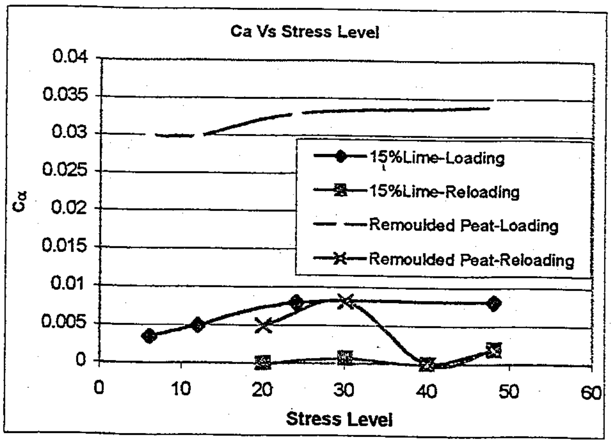

Figure 4 - Effect of Lime Mixing

4. IMPORTANCE OF PORE WATER PRESSURE MEASUREMENTS

The conventional Terzaghi theory of consolidation and classical plots of settlement vs log(time) and settlement vs root time are not readily applicable to peat. Peat deviate from the normal soil due to its high water content and resulting in very high secondary consolidation settlements (Figure 2). Therefore, it is impossible to find the time corresponding to 100% primary consolidation using a log(time) plot. As such, it would be necessary to measure both the settlement and pore water pressure simultaneously to get an accurate picture about the progression of consolidation.

In order to monitor the pore water pressure dissipation and settlement simultaneously, two different experimental arrangements were prepared in the laboratory. They are;

1. Large peat sample with stand pipe type piezometers
2. Consolidation test with pore water pressure measurements using the facilities of the Triaxial setup

4.1 Large peat sample with piezometers

A large peat sample was enclosed within a PVC tube, with drained conditions provided at both ends.Two stand type piezometers were installed at the mid depth of the peat sample to enable the pore water pressure measurement. Settlements were measured using a dial gauge connected to a measuring frame. The arrangement is depicted in Figure 5 .

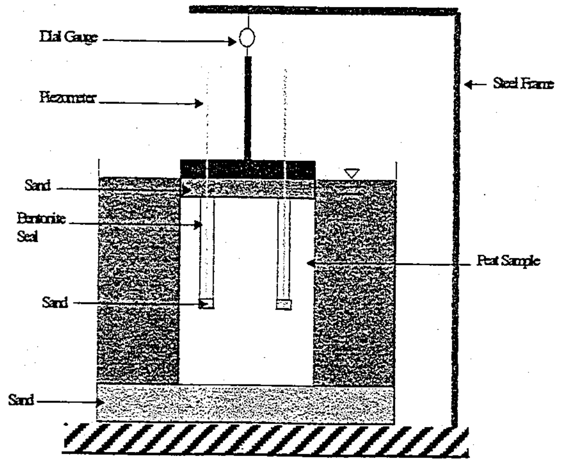

Figure 5 - Test Setup

The main problem with this type of open hydraulic type piezometer is that it has a rather long response time.

4.1 Consolidation test with Pore Water Pressure measurements using the facility of Triaxial setup

To overcome the shortcomings in the experiment described above, another experimental setup was developed where both settlement and pore water pressures were measured simultaneously. For this purpose the consolidation specimen was prepared inside a 69.5 mm diameter GI cylinder. Specimen was prepared to have drained condition at the top and undrained condition at the bottom. Top plate was provided with holes facilitating drainage and the bottom plate was provided with a central hole that was connected to the pore water pressure measuring arrangement. Bottom plate was made to have a water tight connection with the cylinder by using two 'O'rings. A schematic diagram of the arrangement is presented in Figure 6.

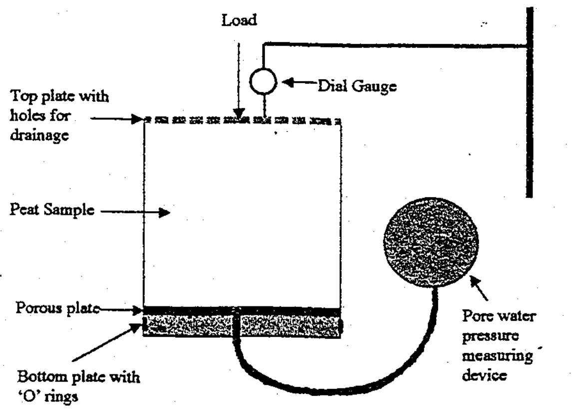

Figure 6 - Drainage Conditions in the Soil Sample

The singly drained condition was created in the sample in this manner with the view of measuring the pore water pressures at the bottom. The peat sample was loaded using the frame of the direct shear test. The complete experimental setup is shown in Figure 7.

The resulting settlement and pore water pressure variation with time is presented in Figure 8. From the shape of the settlement curve in Figure 2, and the settlement curves observed with other conventional tests it is evident that the coefficient of consolidation could not be estimated using the Casagrade (log time method). However, considering the patterns of pore water pressure dissipation the coefficient of consolidation could be estimated to be 1.66m^2/year, using the isocrone derived from Terzghi theory, corresponding to 50% consolidation.

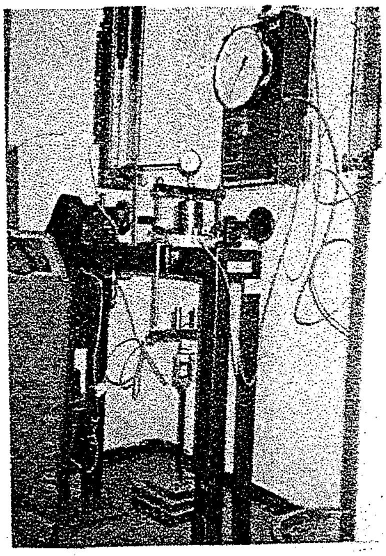

Figure 7 - Complete Loading Setup

5. CONCLUSION

Presence of peat in the sub soil creates immense construction problems due to their excessive initial, primary and secondary consolidation settlements and low shear strength.

Invariably, the heavy structures done in these areas will have to be supported on piled foundations. However, for moderately loaded structures and for infrastructure facilities such as service lines and roads it would not be an economical option. Preloading is one simple technique that can be used to improve the strength and stiffness of such Peaty Soils to bring the settlement down to acceptable limit. Nevertheless, preloading has a major disadvantage due to the required long waiting periods. As such, the effectiveness of deep mixing of peat with lime was studied in this project.

Lime mixing is seemed to cause an improvement of consolidation characteristics of peat within a shorter hardening period (2 week). The order of improvement achieved is comparable with that achieved by preloading.

The results also indicated that by applying both preloading and lime mixing together, large improvement of properties of the peat can be achived. However, it may not be practically possible to provide both types improvements due to the cost factor. However, this can be used in extreme conditions with very weak peats or soft clays.

The simultaneous measurement of settlements and pore water pressure is essential in getting an accurate picture on the progression of consolidation. An experimental setup was developed in this research making use of some of the existing laboratory facilities to measure both the settlement and pore water pressure dissipation simultaneously. This will be specially useful with peaty soils.

6. ACKNOWLEDGEMENT

We would like to make use of this opportunity to forward our sincere thanks to Dr. S.A.S. Kulathilaka – out project supervisor, for help and guidance received in the project work and during the preparation of the paper. We are extremely thankful to R.D.A., who allowed us to use their laboratory facilities to conduct the long term consolidation tests on peat. Also the cooperation extended by N.B.R.O., by allowing us to conduct the consolidation test with pore water pressure measurements at their laboratory is greatefully acknowledged.

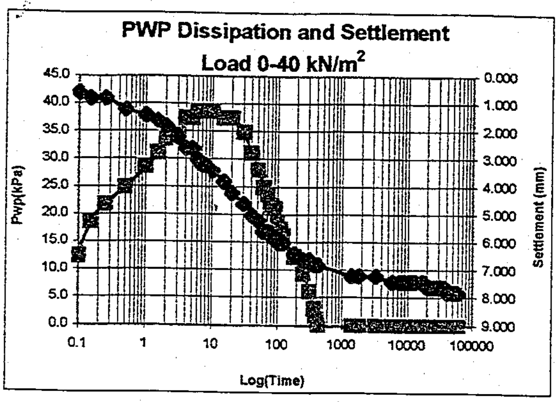

Figure 8 - Pore Water Dissipation and settlement with Time

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Some Matric Suction Characteristics of Partially Saturated Residual Soils of Sri Lanka

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Introduction.

Residual soils constitute a significant proportion of the soil cover of Sri Lanka. This is a result of the tropical weathering environment of the country which turns the exposed rock outcrops to residual soils, mainly via chemical rock weathering processes. Often these soils remain in a partially saturated state in nature. Partial saturation of a soil leads to the development of negative pore water pressures due to the menisci formed in pore water (Fredlund and Rahardjo, 1993). An important parameter defined in the mechanics of unsaturated soils is the matric suction, which is the difference between the pore air and pore water pressure. Matric suction gives rise to an apparent cohesive or adhesive strength to the soil which disappears on saturation. This paper discusses an investigation into the matric suction characteristics of a typical Sri Lankan residual soil, by using triaxial testing and centrifugal testing technique.

Laboratory Tests

A typical Sri Lankan residual soil was selected and the basic soil classification tests were conducted. Thereafter a series of undrained unconsolidated triaxial tests were conducted to study the apparent variation of shear strength parameters c and ϕ with the moisture content. Samples of the selected soil were prepared with moisture contents of 17%, 20%, 25%, 30%, 35%, and 37%. In order to obtain soil samples with moisture contents of 17% to 35%, the required amount of water was added to a dry soil sample each of a pre-determined, identical weight. In order to maintain the same soil structure for all soil samples of the testing programme, attempts were made to use an identical dry-weight of the soil for the preparation of each triaxial test sample (which had a moisture content different from the others as listed above). The moisture content was checked at the end of each triaxial test, and no significant differences were found between the final and initial moisture contents.

The last moisture content mentioned (37%) was the saturated moisture content of the soil sample. In order to saturate a sample, it was first set up on a triaxial apparatus with porous discs. A suction of 15 kPa was applied from the top of the sample, while connecting a water supply from the bottom of the sample. The water bubbles coming out of the outlet valve of the sample were noticed. It was assumed that saturation was complete in one hour (the air bubbles appeared much quicker than one hour).

Tri-axial tests were conducted on the prepared soil samples at cell pressures of 100, 150 and 200 kPa. For each of the moisture contents listed earlier, three triaxial samples were tested at the three cell pressures. Mohr circles were drawn for tests at each moisture content to determine c and φ values.

The results of the tests carried out to measure matric suction were communicated to the authors by Puswewala (2000). These matric suctions had been evaluated by carrying out centrifuge tests on wet soil samples. The procedure had been as follows. There were sixteen boxes to contain samples around the inside wall of the cylindrical head of the centrifuge. Each box had a wire mesh on the side facing outwards, which would allow water to migrate out of the sample during the rotation of the centrifuge. Eight of these boxes were filled to a depth of 75% of the full depth, with soil of 40% moisture content. A filter paper was placed inside each box at the porous side of the box, to prevent the movement of soil particles through the mesh while rotating. The remaining eight boxes were filled in an identical way with soil having 50% moisture content. The boxes were placed around the cylindrical drum so that every other box contained soil of similar moisture contents.

The cylindrical head was rotated at a speed of 2440 revolutions per minute and four boxes were removed after two hours, in such a way that two of the boxes contained soil of 40% initial moisture content and the other two contained soil of 50% initial moisture content. While boxes were removed, boxes that were at diametrically opposite locations were selected to prevent imbalance during subsequent rotation. Soil samples from the removed boxes were placed in the oven to evaluate the moisture content that the soil had retained at that particular angular speed. The empty boxes were replaced in the centrifuge head at their original positions, and rotation of the centrifuge was resumed. After two more house of rotation, four more soil boxes were taken out as described above (while preserving the balance of the cylindrical head). Soil samples from those boxes also were oven dried to find moisture content. In this manner rotation of the head was continued for six hours. Later, based on the moisture contents that the soil had retained after being rotated in the centrifuge for different periods, it was found that the moisture content retained by the soil remained constant after rotating for approximately two hours. A constant moisture content with time indicates that *the matric suction of soil can retain that much of moisture under surface tension forces*, as the soil sample is subjected to a centrifugal force which induces migration of water out of the sample.

The centrifuge test was repeated at increased angular speeds, i.e. at 3660 rpm and 4880 rpm, and the residual moisture content that the soil could retain after rotating until such time that the moisture content did not change with the time, had been measured as described above. The principle of determining matric suction could be illustrated as follows (after Khanzode et al, private communication).

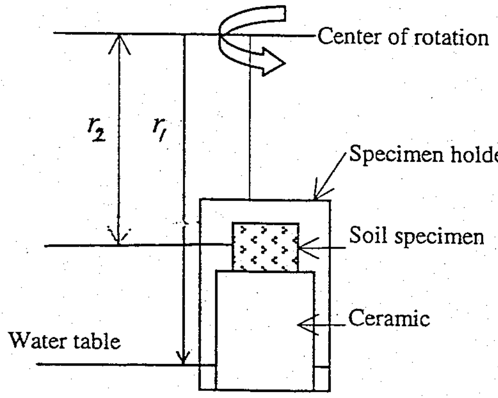

Figure 1. Suction Measurement Principle of the Centrifuge

The suction in the soil specimen in a centrifuge can be calculated using Eqn. (1):

$$\psi = \frac{\rho\omega^2}{2g}\left(r_2^2 - r_1^2\right) \qquad (1)$$

ψ = suction in the soil specimen
r_1 = radial distance to the free water surface
r_2 = radial distance to the midpoint of the soil specimen
ω = angular velocity
ρ = density of pore fluid

Results

The classification test results for the selected soil are given in the Appendix.

The variation of c, and φ values with the moisture content as per tri-axial test results could be illustrated as follows.

Table 1

Moisture Cont	'c' value (kPa)	φ value (degrees)
17%	32	25
20%	89	17.3
25%	39.3	15.1
30%	18	12.7
35%	8	5.39
37%	7.2	4.76

The variation of the cohesion with moisture content is shown in Figure 2, and the variation of friction angle with moisture content is shown in Figure 3.

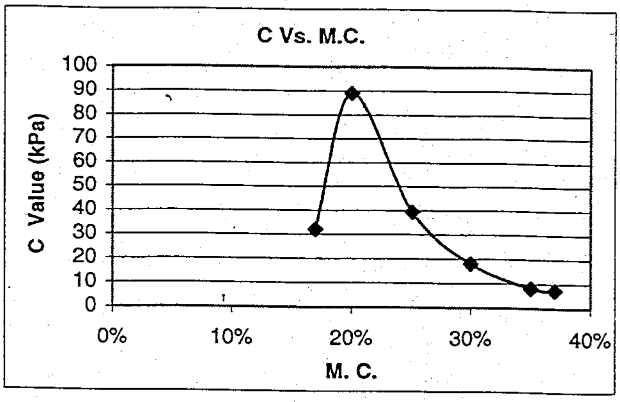

Figure 2

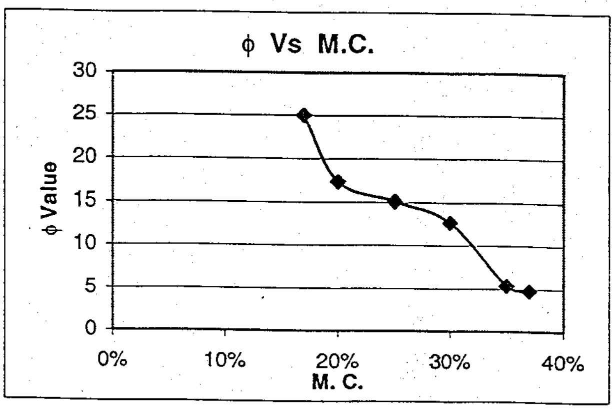

Figure 3

The variation of matric suction value with the moisture content is shown in Table 2 and Figure 4.

Table 2

Moisture Cont.	Suction (kPa)
17%	457.542
20%	257.638
25%	114.385

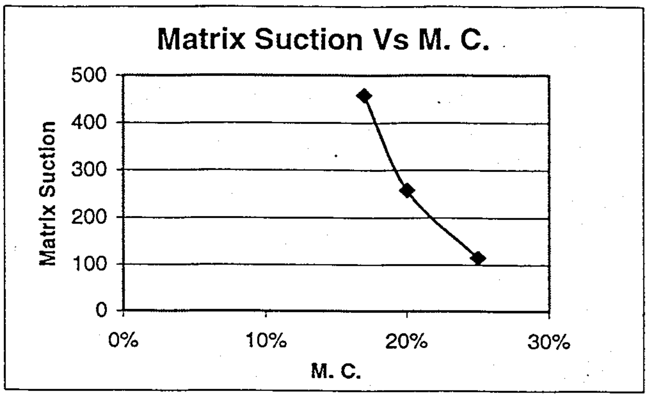

Figure 4

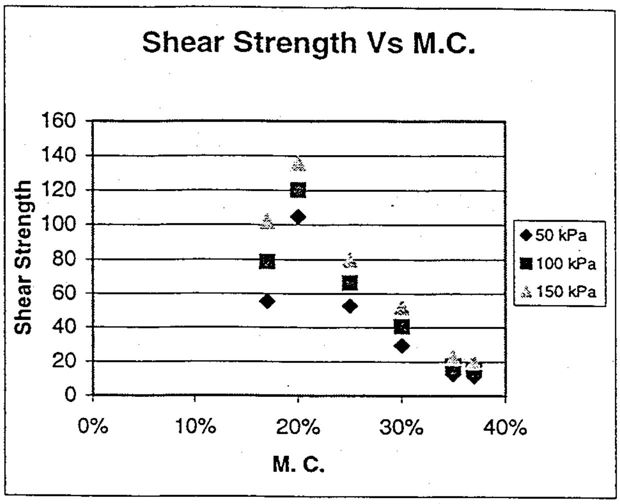

Figure 5

Discussion of Results

According to Table 1, with the increase of the moisture content, *'c'* value reaches a maximum and thereafter it reduces. The reason for this is the variation of the moisture content. When the moisture content is increased the radius of the pore water menisci between solid soil particles become large; as a result, the negative pore water pressure, and hence the matric suction value, decreases, and thus the apparent cohesion decreases. Table 1 also shows that for a smaller moisture content of 17%, *c* value is less than for some subsequent moisture content (e.g., 20%). One reason for this is that there will not be sufficient moisture to form enough menisci at 17% moisture content. Table 1 shows that the φ value is monotonically reduced with the increase of the moisture content.

Shear strength is calculated using Mohr Coulomb criterian of $\tau = c + \sigma \tan \varphi$, for three different values of σ (50, 100, 150), at the different moisture contents at which triaxial tests were conducted. The shear strength vs moisture content relationship is shown in Table 3 and Figure 5.

Table 3

M.C.	Shear Strength kN/m^2 $\sigma = 50$	$\sigma = 100$	$\sigma = 150$
17%	55.32	78.63	101.95
20%	104.57	120.15	135.72
25%	52.79	66.28	79.77
30%	29.27	40.54	51.80
35%	12.72	17.44	22.15
37%	11.36	15.53	19.69

Here as a the shape of the graph is very similar to the behaviour of 'c' with moisture content (Figure 2), it could be said that the 'c' value is dominant in this case. According to Table 2, there is a downward trend in the matric suction values with the increase of the moisture content. A reason for this behaviour is the larger radii of pore water menisci that will be formed at high moisture contents.

Concluding Remarks

Following concluding remarks could be made, based on this study:

(1). The matric suction vs moisture content curve is developed for a selected soil over a limited range of moisture content.

(2). Apparent cohesion and friction angle of the selected soil varies with the moisture content.

(3). Shear strength varies with moisture content, and follows the behaviour of the apparent cohesion.

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Appendix

According to Atterberg Limits test results, the moisture content corresponding to 25 blows in the plot is 40%. Thus the Liquid Limit could be taken as 40%. The moisture content relating to Plastic Limit test data is 26%. Thus the Plastic Index is 14%.

According to the Specific Gravity test, specific gravity obtained was around 2.00. (However, this value was later found to be erroneous due to a defect in the apparatus used).

The grading curve of the soil used for the study is as shown in Figure A-1.

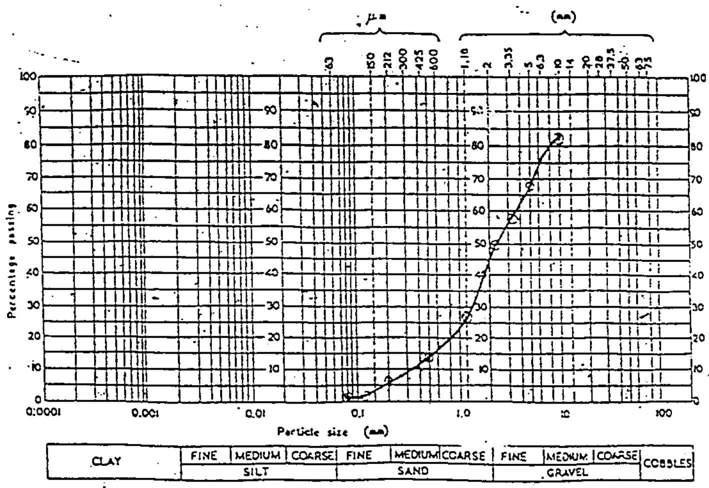

Fig A-1.

DEVELOPMENT OF A GEOTECHNICAL DATABASE FOR SRI LANKA

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ABSTRACT:
Various organizations and laboratories carry out a large number of geotechnical tests throughout Sri Lanka. It is imperative that such data obtained from various field and laboratory investigations of various parts of Sri Lanka are stored as a geotechnical database in a systematic manner so that these can be retrieved and referenced when needed. Such a database helps to carry out preliminary surveys to get an overall idea of the soil conditions of a site, to do research works and to use the data gathered from past projects for future projects in various ways. This paper describes the creation of a geotechnical database for Sri Lanka which comprises geotechnical data from variety of sources. At present, test results of hundred projects, mostly from central province have been used to develop the database. The MS Access 2000 software is used to develop the database and the geographical representation is achieved by Arcview GIS software. Menu driven user-friendly interface makes the usage of this database much easier.

INTRODUCTION

Site investigation is a major component of any civil Engineering construction project. Depending on the extent of the project it varies and cost component of this may be a significant factor. Basic information in any geotechnical investigation is the stratiography and it is most commonly determined by making bore holes, test pits, etc, and collecting soil samples and carrying out necessary tests on these samples. The characteristics of soils are generally variable and may change sharply within limited distances. Degree of thoroughness and completeness required of an investigation is linked with job requirements and availability of time and funds. For small-scale construction projects, for example, buildings, bridges, roads etc., usually routine insitu tests and laboratory tests are performed to determine necessary design parameters. However the routine tests performed are vane shear, grain size analysis, SPT, direct shear, triaxial and oedometer tests etc. If the test data obtained by such projects can be made available in a common platform it may be an important reference for future use.

Organizations such as Road Development Authority, Irrigation Department, National Building Research Organization, some private firms and laboratories carry out a large number of geotechnical tests all over Sri Lanka. The test results obtained by these organizations are kept within their organization and usually are not available to outside needy personnel. Therefore it is imperative that such data obtained from various field and laboratory investigations of various parts of Sri Lanka are stored as a geotechnical database in a systematic manner so that these can be retrieved and referenced when needed.

Therefore an attempt has been made to establish a geotechnical database for Sri Lanka, which comprises geotechnical data from variety of sources. At present, test results of hundred projects mostly from central province have been used to develop the database. The Microsoft Access 2000 software package is used to develop the database. The geographical representation is achieved by Arcview software.

SOFTWARE

MS Access: MS Access 2000 is an easy to use but full-featured database development tool. Access can be used for everything from maintaining a simple list to implementing a full-featured accounting tool. Access excels at being able to collect information through the use of either a datasheet view or a custom form.

Access is a relational database tool. A relational database is a database that allows grouping its data into one or more distinct tables that can be related to one another by using fields common to each related table. Relational databases are one of the most versatile types of databases ever developed.

Components of an Access database are as follows:

1. Tables: A table is a collection of records that can be divided into fields. This is where the actual data being stored is kept.
2. Queries: A query is used to search, view, and modify the data that exists in the tables. Queries can also be used to modify the structure of the tables or to access data that is external to the Access database.
3. Forms: Form looks and operates like a windows application. Forms can be used to enter, edit, and search data.
4. Reports: Reports enable to output data to any number of destinations such as printer or email message in an easy to read format.
5. Data access Pages: These are web pages that can be created and linked to an Access database. These pages can query or update the data contained within the database and are very similar to Access forms.
6. Macros and Modules: Macros are simply a set of actions that each performs a specific task within the access 2000 project. Modules are collections of visual basic for Applications (VBA) procedures. They provide a means of acting upon and utilizing the tables, queries, forms, and reports that exists within a database.

Geographical Information System: A Geographical Information System is an immensely powerful computer mapping system. It links geographic location with information about them so that maps can be created and information can be analyzed in new ways.

There are many ways to organize information – maps do it according to location. By organizing information this way, maps represent where objects are in the real world in relation to each other.

Geographical Information System helps to visualize and analyze information according to location. It reveals relationship, patterns and trends. It helps to work with lots of different kinds of information at the same time to solve a problem.

ArcView: Arcview is a powerful desktop Geographic Information System. With ArcView we can visualize information, update information, analyze information and create quality presentations. In ArcView, work is organized by 'Project'. A project is a file that contains all the documents used to carry out a task or manage a process. There are five different kinds of documents in ArcView: Views, Tables, Charts, Layouts and Scripts. Each does a different job and has its own set of menus, buttons and tools.

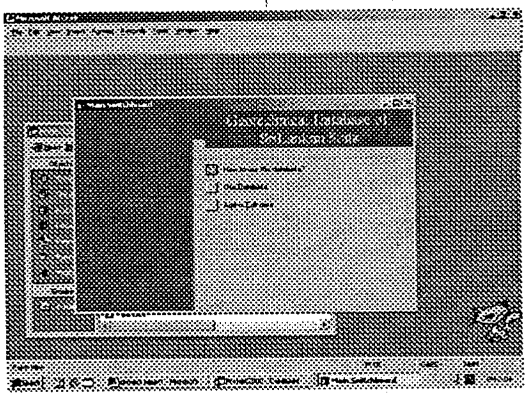
THE DATABASE

The data in the existing database is taken from manually written test results of various projects. Each project is given a serial number and each borehole is given a code number and each test performed in a borehole is given a search number. Then using the MS Access software, new data was added. The database is developed in a user-friendly format with forms. A documentation is included which describes how to use the database, so that any one can handle this database. A user-friendly search facility is introduced from which we can search using any keyword related to the name, client, site and location of the project. Using the MS Access software, required tables are created, so new data can be entered. The tables are linked with each other, so that the relationship between tables may be produced using the table linking facilities. Also data is stored and formulated such that it could be retrieved by user select search criteria.

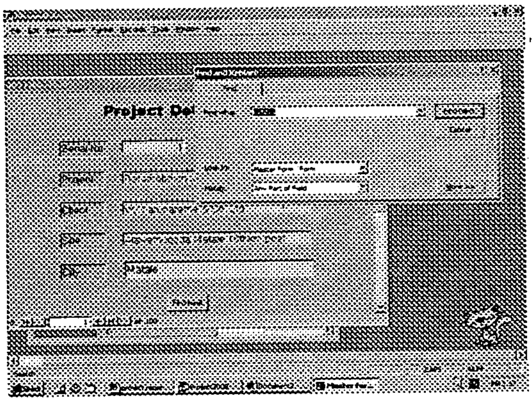
For the geographical representation, digitized maps are used.

PROGRAM OPERATION

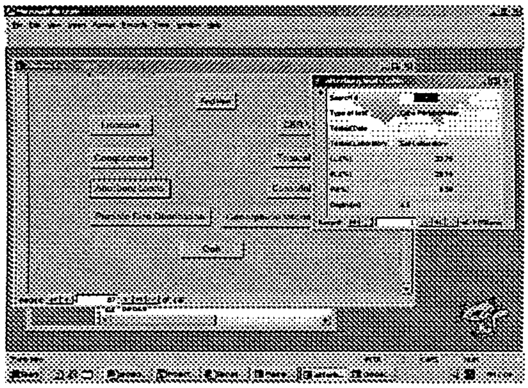
When the program is opened, a welcome screen will appear. Clicking the OK button, the switchboard appears. In the switchboard, tasks such as help, using the database, or Add or edit database can be selected, as shown in the figure.



To perform the search function, click the Find Next button in the form and the search window will appear. Using any keyword related to the project, client or location, search can be performed.



To add or edit data, select relevant button in the switchboard and then select the corresponding buttons in the the switchboards. The table will appear so that data can be added or edited.



In the geological representation of central province, any part of the map can be selected and when the mouse is pointed in a location and clicked, the data of the corresponding bore hole is retrieved.

CONCLUDING REMARKS

The existing database is limited only to the soil data from central province. Since the available data were project specific, it was very much difficult to structure and retrieve data in a usable global format even to similar conditions. This was due to the fact that data were obtained not mere purpose of creating a soil database. The structuring of the available data improves the database in following aspects:

1. Data is added, edited, or retrieved in user-friendly menu driven software format.
2. Search facility is available with respect to location, project number, data type etc.
3. Geographical representation of data. However, new locations have to be added to a new digitized map.
4. Entering new data into the database is regularized so that even a new user can handle the task quite easily.

SUGGESTIONS

1. The existing database can be integrated with the web page developed for the Geotechnkical laboratory, faculty of Engineering.
2. Other databases such as locations of available construction materials can be created and linked with the existing database.
3. It would be better if the data of soil properties presented in a graphical representation rather than in the raw data format.

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COMPUTER SOFTWARE FOR SLOPE STABILITY ANALYSIS

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ABSRACT: This paper describes computer software for a comprehensive teaching tool and to analyze the stability of a given slope. This software can mainly be divided in to two main categories as Demonstration and Analysis. The demonstration part gives the general background on remarkable incidences of landslides in Sri Lanka and other countries. It describes the causative and remedial measures and precautions for slope problems. It explains different methods of analysis and their derivation. The understanding of modeling the actual situation in to mathematical simulations is also described in the demonstration part. The analytical part is to analyze a given slope problem and to obtain optimum factor of safety and possible slip surface. This part deals with different methods of analysis such as Fellenious, Bishop, Janbu and Spencer' method and compares the results.

INTRODUCTION

In the case populating and developing the earth, man continuously encounters less favorable arrears of ecosphere; some are undesirable because of unstable soil and rock. Several parts of the Central Highlands of Sri Lanka frequently suffer from landslides, earth slips, and other types of mass movement of earth and rock. Although the areas so affected are relatively small, these earth slips cause a great deal of damages such as destroying dwellings and public buildings and disrupting transportation etc., inconvenience and killing people. Some of the areas worst affected by landslides in the last years have been Kadugannawa, Kurunagala, Kotmale, Hunasgriya, Teldeniya, Agalawatte where 38 persons lost their lives in June 1984, Beragala, Helauda, Naketiya, Nawalapitiya Wewelwatte, Yapmma and Wattawala. The problems arising from them have to be solved by geologists and engineers, working in conjunction, in a relatively short space of time.

It is therefore the fundamental understanding on slope stability, causative factors, method of analysis, preventive and corrective measures and case studies of landslides and landslides prone-areas are of much more importance for civil engineers. The engineers should be aware of the recent development in Engineering applications and should always use innovative, cost and time reduction methods.

The slope stability problems are applied for more complicated geometry, non-homogeneous soil conditions, seepage and for circular or non-circular failure surfaces. With the advent of computer their use has become routine.

SCOPE OF THE STUDY

Different methods based on different assumptions have been proposed by scientists to solve the problem. But one can see that these methods of analysis give considerable deviations in the results. Our scope is to focus only on the following methods of analysis. They are Fellenious, Bishop, Janbu Simplified and Spencer' method.

The results of slope stability analysis are usually expressed by a factor of safety, which is applied to the shear strength of the soils. Alternatively the analysis could be adapted to give the slope angle at which the failure would occur or the highest ground water level or the ultimate surface loading. In general different failure surfaces are examined and the one yielding the small factor of safety found. This is then used as the factor of safety of the slope

SLOPE CHARACTERIZATION

At the start of the slope stability analysis, the slope geometry, loadings, soil and ground water conditions must be defined. A good appreciation of the geology and hydrology is obviously essential, and often it is useful to classify the instability mechanism. There are three major classes of slope movement: falls, slides and flows

In general a two-dimensional analysis will be made, and the geometry must be simplified so that representative cross sections may be drawn. The loadings, soil and ground water conditions can be shown on each cross section, which can be then used as the basis for slope stability analysis. The principal loading on a slope is usually the self-weight of the soil, but surface loadings such as those from buildings and prestressed anchors can be included. Where a slope is partially submerged, the water pressure normal to the slope should be included.

An early decision must be made whether a total or effective stress analysis is to be made. Then representative shear strength parameters must be selected from each soil type, usually on the basis of laboratory test (e.g. Triaxial, Direct Shear) on representative samples. Sometimes the strength may be determined in the field by insitu tests.
Tension cracks may be formed at the crest of a slope, particularly in cohesive or partially saturated soils. The possibilities the tension cracks could fill with water in periods of heavy rain should be considered very carefully.

The distribution of pore pressure within the slope is required if an effective stress analysis is being carried out. Where possible this is obtained directly from instrumentation but often a model of groundwater is needed as a formwork for interpreting observations and for interpolation. In homogeneous ground conditions in the steady state it is generally conservative to consider that the pore pressure distributions are effectively hydrostatic below the water table. A more accurate pore pressure distribution may be obtained from a flow net. Alternatively the pore pressure may be expressed implicitly by the pore pressure ratio γ_u given by: $\gamma_u = u / \gamma z$ where u is the pore pressure at a point being considered and γz is the weight of soil above. This is often useful when the precise distribution of pore pressure in unknown.

DEMONSTRATION

Introduction, Methods of Analysis, Images, Causative and Preventive Measures and Remedies are Composed of this main division, which gives the fundamental ideas on slope stability.

Introduction

This element consists of two main categories; one is slope characterization and the different type of slips. The important part of slope stability analysis is the simulation of actual slope failure to a most sophisticated and understandable mathematical model. Slope characterization tells how to simulate the actual problem to a 2-D model and consideration about loadings ground water etc. The understanding of slip surface is also very important for engineers/geologists to have an idea of different types of failure surface and the possible types of soil where such types may takes place.

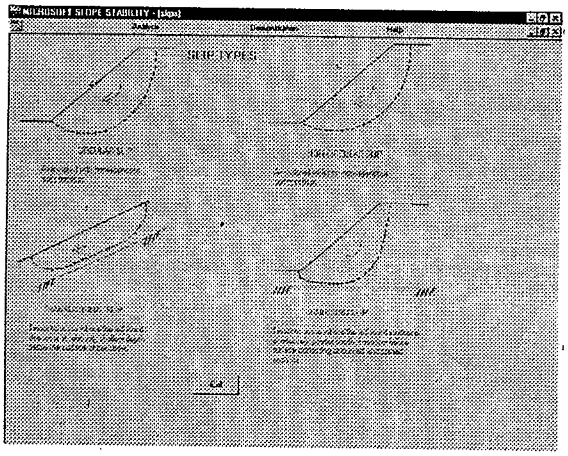

Fig: 1 Slip Types

Methods of Analysis

As far as slope stability analysis is concerned there are different suggestions have been proposed for non-linear method of analysis which are statically indeterminate problems.

The equations of equilibrium are formulated quite generally and non-linear equations are obtained for the factor of safety. The solution necessitates an iterative procedure based on necessary assumptions. They are about

- The distribution of normal stress around the slip surface,
- The position of the line thrust of the interslice force and
- The inclination of the interslice force.

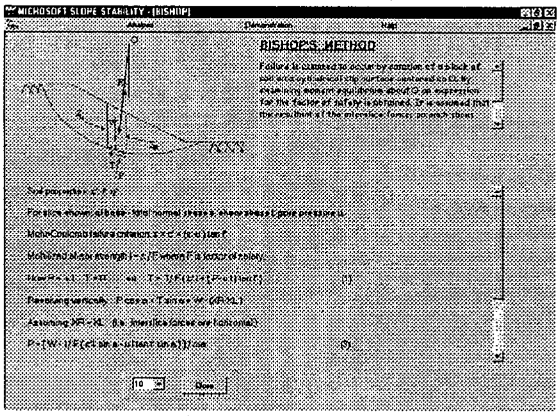

Fig: 2 Bishop Method of Analysis

In this section the user can distinguish the different types of assumptions made and the derivation of the safety factor for Fellenious, Bishop, Janbu Simplified, Janbu Rigorous and Spencer's method.

Images

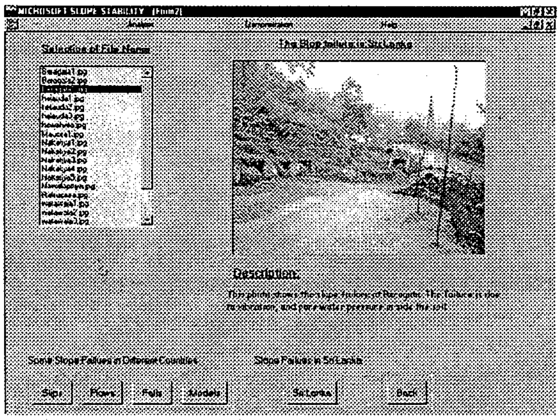

Fig: 3 Images

This part consists a lot of images for different modes of failures as fall, slips and flows occurred in worldwide and specially the very recent incidence in Sri Lanka. When a command for example "*Slip*" is clicked it will display the images of which name is highlighted under the list '*File name to select*'. When the image is on the screen user can be able to read the most possible causes of that failure. If the name of the image is changed the image and their descriptions also changes automatically.

The files containing images are saved in a folder called '*Photos*', which has to be installed separately. The program will assist the user if the folder is in unknown location in the computer.

Causative and Preventive Measures

Slope failures are like heart-attacked patients, which have to be treated so carefully.

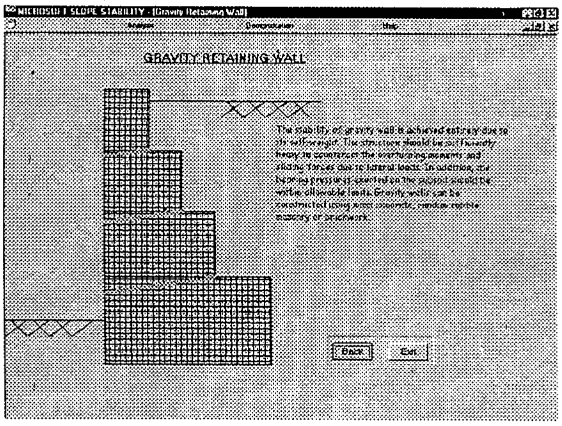

Fig: 4 Gravity- Retaining Wall

This part describes some ways of preventing slope failures in details. This part describes the in detail on different types of retaining wall and stabilizing the slopes.

Remedies

Engineers can prevent and cure shallow slides but with deep slides the load exceeds the strength of the remedies. This part explains some remedial measures for slope failures.

Data Input:

Data inputs to simulate the ground profiles are of two kinds one as the slope angle & the slope height and the second is by giving coordinates system. The first method is much more easy when analysing a man made slope especially in highway engineering problems and places where new slope construction is to take place. But here it is limited for only homogeneous and isotropic soil condition.

Advantage: We can calculate the minimum safety factor at an assumed centre of rotation considering different radius value. The location of centre is changed automatically and the least factor of safety is ultimately obtained. When the curser is pointing out the data for height and the slope there is a facility to blink the specific notations as "H" and "Deta" respectively to avoid confusion of the user.

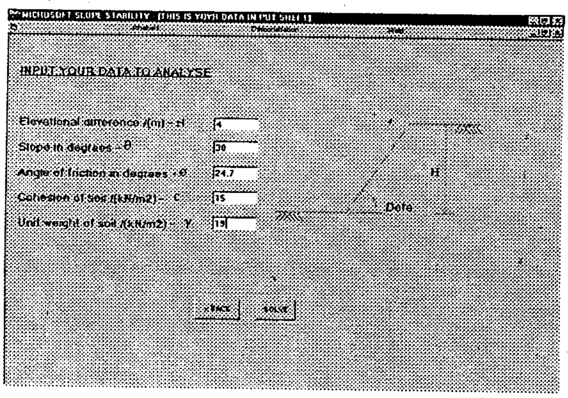

Fig: 5 Data Input-Type1

In the later method user can define many coordinates for profiles and different soil layers, water table as well as hard layer.

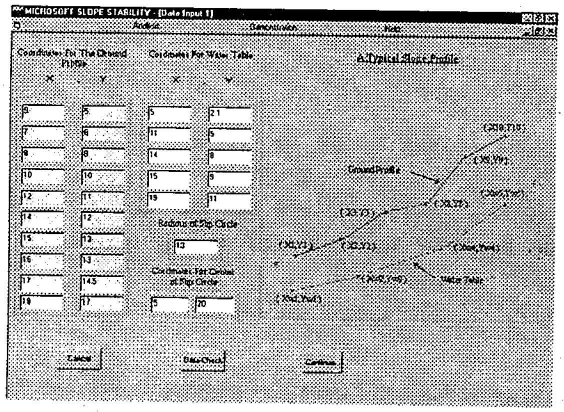

Fig: 6 Data Input-Type2

Advantage: Here the slip surface may not be circular we can calculate the safety factor for combination of circle and lines, which is due to the bedrock.

Data Check

This facilitates the user to see the data inputted graphically and can modify the data. If the user does not want to check the data specially the coordinates of the profile and slip circle assumed user can activate the batten named *Analysis* and can continue working.

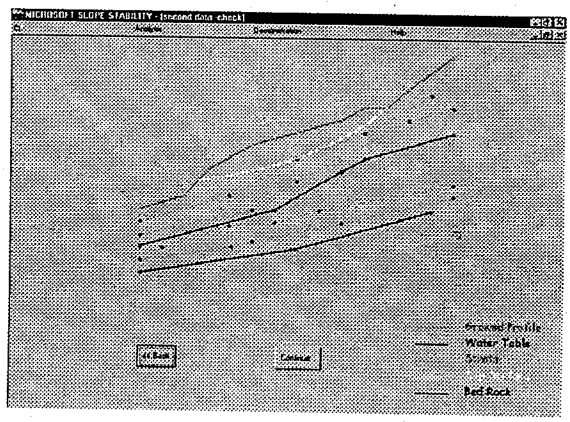

Fig: 7 Data Check

Method of Analysis & Results

In this section the user is able to analyze at the different methods such as Fellenious, Bishop and Janbu simplified and also he can look at the optimum safety factor and the slip surface for each methods of analysis. It is the choice of the user whether to select all the methods or the method(s) he/she wants. User can also see the deviation of the optimum factor of safety for those methods. It will give the factor of safety for the selected methods on the same screen and the graphical view can be observed for each selected methods and also for the minimum factor of safety.

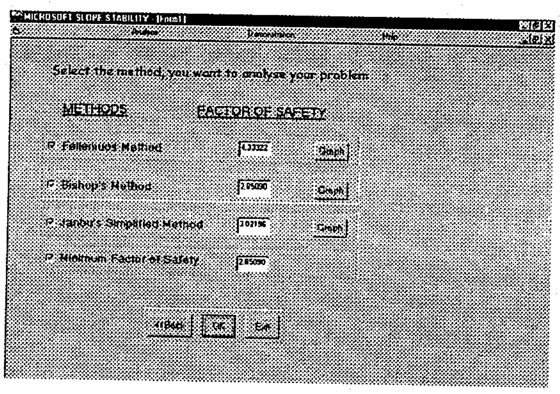

Fig: 8 Method of Analysis & Results

HELP

This software provides some guidelines for its new users by directing them to their requirements. This part outlines the contents of the program and the path for each of the components.

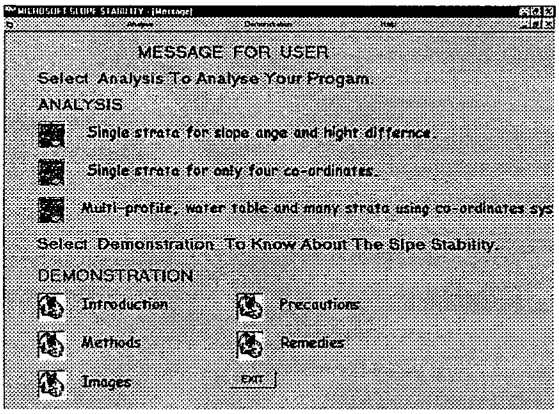

Fig: 8 Help Menu

CONCLUSION AND RECOMMENDATIONS

This computer program is written in such a way that the user can operate without much detail guidance about how to get into the program. Programs are written separately are linked in the Main Menu, So that a user can select the required option as Demonstration, Help, or Analysis individually according to his willingness. The Back and Continue command boxes are provided to help the user to continue the process whereas the Cancel command is to return to the Main Menu. This was exercised with several undergraduates who were does not acquired any information about this program and we could correct the problem encountered by themselves.

Civil engineers should learn to use the computer more efficiently. The commercially available software should be used only when necessary and only by experienced and knowledgeable engineers. A proven ability to carry out engineering task without the use of modern day packages can be considered as the minimum level of competence for computer usage. When the packages are used the user should be able to carry out a rough calculation in order to enhance the confidence on the computer output. If the slope problem is complicated the user at least can check for simple problem. It is important to realize that no good program can make a competent civil engineer.

ACKNOWLEDGEMENT

The presenters wish to express sincere gratitude to the officials of the Department of Civil Engineering, University of Peradeniya, for offering this enormous opportunity to carry out project and especially to the project co-coordinator Dr. JJ. Wijetunge. The support and assistances of the officials of Computing Center and CAD Lab are greatly acknowledgeable.

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Soil Stabilization With Lime And Paddy Husk Ash

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ABSTRACTS: Fly ash lime stabilization to improve rural roads is effectively used in many countries with controlled burnt paddy husk ash. This method will need high initial capital for the production of controlled burnt paddy husk ash. Therefore, a study has been undertaken to find the possibility of using uncontrolled burnt paddy husk ash. A series of laboratory experiments have been carried out to study the effect of lime-paddy husk ash mixture ratio and curing time on the strength development of the clayey soils in Uduthumbara, Kandy. This was done for mixtures with various proportions of lime, paddy-husk-ash and soil by varying the lime percentage from 4% to 7% and keeping the lime: paddy-husk-ash ratio as 1:2. From the results it was found that 6 % Lime and 12 % Paddy Husk Ash mixture gives the optimum results; showed a maximum CBR value of 57. The CBR values obtained are well above the required strength.

INTRODUCTION

Soil stabilization is an effective method of improving the sub-base of a road. Among many stabilization techniques fly ash with lime is used to improve rural roads in many countries, particularly in India. Lime paddy husk ash mixture will give significant amount of increase in the strength of soil. In the past many researches have been carried out and demonstrated that controlled burnt paddy husk ash will give significant amount of strength increment (e.g. Aluthgedara Sirisena-1997, M.Subentheran, Y.Thayaparan-1999). Even though, paddy husk ash is available in abundance in rural areas of Sri Lanka controlled burning is rarely practiced. However, this method will need high initial capital for the production of controlled-burnt paddy-husk-ash in a mass-scale. Therefore, it was proposed to use the paddy husk ash that was burnt in the field itself.

The problem here is that un-controlled burning may produce crystalline Silica due to over heating which will reduce the effect of stabilization and also on the other hand if it is under heated the amorphous silica will not be formed which is necessary for pozzolanic reaction with lime. Therefore, a study has been undertaken to find whether it is possible to use paddy husk ash available from uncontrolled burning for stabilization of subgrade of rural roads. The objective of this project is to find the effective ratio of lime and paddy husk ash to improve the subbase of a rural road.

SCOPE OF STUDY

The project is intended to find the optimum ratio of lime and paddy-husk-ash; here the paddy-husk-ash is to be obtained from the field in its normal form. In addition it is also intended to study the time variation of the strength of the mixture. This is done by analyzing mixture with different amount of lime ranging from 4% to 7% and ash from 8% to 14%. Optimum ratio can be obtained at the maximum CBR value, which should be greater than 20% for the soil to be used in rural road construction.

LIME AND PADDY-HUSK-ASH STABILIZATION

According to many researches done in the past it was suggested to use the lime–paddy husk ash as an economical and effective method to stabilize the clayey soils.Amorphous silica is produced from burning the paddy-husk. The resulting reaction forms calcium silicates and calcium aluminates. They will improve the durability and lifetime of pavements due to cementitious properties of paddy-husk-ash.

CHARACTERISTICS OF STABILIZABLE SOIL

Cohesive clayey soils are the most suitable soil for lime paddy-husk-ash stabilization. The general requirement for a satisfactory stabilization is the presence of cohesive clay about 10% to 35% by weight in the soil. The Atterberg Limits of untreated soil should have a liquid limit about 50% and plasticity index of between 20% and 30% for satisfactory stabilization.

UNSUITABLE SOIL FOR STABILIZATION

The following type of material is not suitable for road construction.

1. Top soil and soils containing considerable roots and other organic matter.
2. Lumpy clays, which cannot be reduced to crumbs, by the action of the rollers.
3. Peat and swampy soil.

EFFECTIVE MIXTURE RATIOS

It was found that the effective ratio of lime and fly ash is 1:2, and the favorable results may fall for the combination of lime ranging from 4% to 7%.

ACCEPTABLE CBR VALUE

The acceptable CBR value for Sri Lankan rural sub grade is around 20 therefore, a mixture which has a CBR more than 20, can be considered favorable.

POZZOLANIC ACTIVITY IN FLY ASHES

Fly ashes (Paddy husk ash) possess various physical and chemical properties characteristic of pozzolans. Pozzolans are artificial and natural minerals which by themselves are not cementitious but which react with hydrated lime and water to form cementitious compounds, namely calcium silicate and aluminates hydrates of low solubility.

Pozzolanic reactions are shown below :

$$Ca(OH)_2 \longrightarrow Ca^{++} + 2(OH)^-$$

$$Ca^{++} + 2(OH)^- + SiO_2 \longrightarrow CaO.SiO_2.H_2O$$

(Calcium silicate CSH)

$$Ca^{++} + 2(OH)^- + Al_2O_3 \longrightarrow CaO.Al_2O_3.H_2O$$

(Calcium Aluminate CAH)

CURING THE STABILIZED SOIL

The extent to which the soil–lime–ash reaction proceeds is mainly influenced by the curing time and temperature. The chemical process occur in the mixture can be compared with that of a cementation process and it has been observed that the strength of the mixture increases with the soaking time.

METHODOLOGY

The soil sample was taken at about 0.25 meter depth from the top layer near a paddy field in Uduthumbara .

To find the properties of the sample following tests were carried out;

1. Mechanical analysis and Hydrometer analysis

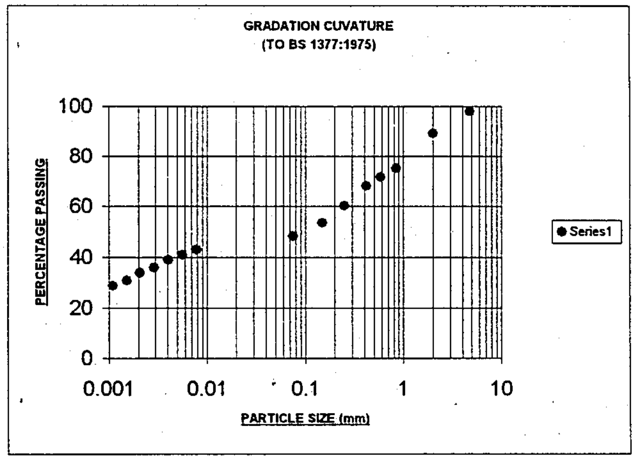

Fig 01

SAMPLE	CLAY PERCENTAGE BY WEIGHT
Uduthumbara	29

Table 01

2. Atterberg Limits tests

SAMPLE	LIQUID LIMIT /(%)	PLASTIC LIMIT/ (%)
Uduthumbara	47.7	25.1

Table 02

Based on the British Soil Classification system the soil Falls into the category of Gravely CLAY of Intermediate plasticity (CIG) .

COMPACTION TEST RESULTS

Compaction tests were done for each batch of mixtures to find the optimum moisture content. These mixtures have been prepared with various proportions of lime, paddy-husk-ash and soil by varying the lime percentage from 4% to 7% and keeping the lime: paddy- husk-ash ratio as 1:2.

Ratio of mix Lime:Ash:Soil	*Optimum Moisture content*	*Maximum Dry density/ (Kg/m^3)*
0:00:100	*17.95*	*1680*
4:08:88	*25.6*	*1510*
5:10:85	*24.8*	*1484*
6:12:82	*27.8*	*1467*
7:14:79	*31.5*	*1372*

Table 03

CBR TEST

This was done for mixtures with various proportions of lime, paddy- husk-ash and soil by varying the lime percentage from 4% to 7% and keeping the lime: paddy- husk-ash ratio as 1:2. The curing time was varied from no curing, one day, 7 days and 14 days. Two samples were tested at each curing time and the average value of CBR taken.

Special procedure was followed to prepare the sample for the CBR tests.

1. First each batch of soil was hand mixed with half of the required moulding water and then allowed for 24 hours in a humid chamber.
2. Then lime and the balance water were added.
3. After that specimens were moulded by two-end static compaction.
4. The specimen was allowed 24 hours in the atmosphere for preliminary curing.
5. For the un-soaked case CBR test was done immediately, and for the soaked cases the moulded sample was put in the 100% humid environment for the soaking period and then the CBR test was done. For the soaked case CBR values were obtained after 1 day, 7days and 14days.

Soaked days / Mix Ratio	*Unsoaked Case*	*One day Soaked*	*Seven days Soaked*	*Fourteen Days Soaked*
Soil only	*12*	-	-	-
4:08:88	*17*	*42*	*48*	-
5:10:85	*19*	*45*	*55*	-
6:12:82	*33*	*48*	*57*	*47*
7:14:79	*22*	*46*	*56.5*	-

Table 04

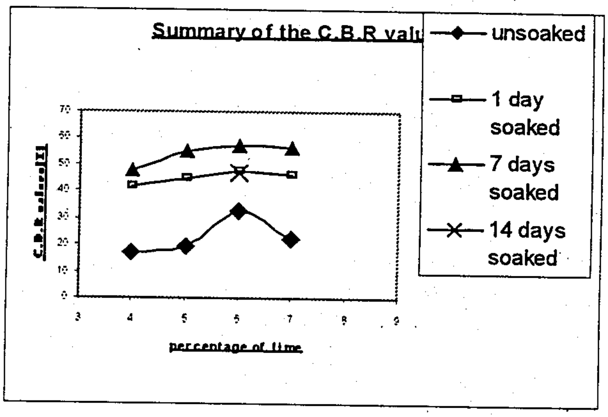

Fig 02

CONCLUSIONS

According to the results following conclusion can be made,

1. There is a considerable strength increase when the soil was stabilized with insitu-burned- lime and fly ash.

2. 6 % Lime and 12 % Ash is the optimum mix ratio for Uduthumbara soil.

3. CBR value increase with soaking. However, after 14 days CBR value tends to reduce (to 48) though still this value is well above the required strength (CBR of 20). This reduction is based only on two samples and therefore, need to be verified by further testing. Since CBR value of treated soil without soaking is also above 20 stabilized will road will be durable even in case of a short-term flood.

SUGGESTIONS & RECOMMENDATIONS

The results obtained are favorable to the objective but further analysis with increased soaking periods and soil samples taken from different sites have to be done in order to recommend this method as a stabilization technique to improve the sub-base of roads in Sri Lanka.

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DEVELOPMENT OF TEACHING GUIDE FOR RETAINING WALL DESIGN USING VISUAL BASIC-06

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ABSTRACT:

With the evolution of information technology, it is a common practice these days to use computers as a teaching guide. This enables students to learn the subject effectively. Many user-friendly languages have been developed for this purpose. This paper describes the development of such a teaching guide in design of retaining wall using Visual Basic version 6. It mainly targets the demonstration about the retaining wall and a part of Geotechnical design for Final part III students in the Faculty of Engineering, University of Peradeniya.

INTRODUCTION:

Synchronizing the teaching practice with the development of information technology is a must for educationist. Professionals use different kind of software for data interpretation teaching assistance and presentation. This reduces the time of processing, minimize the possibility of making errors and make the field more effective, spreading in the trail and error processes.

Visual Basic is one such scientific language that is being used for above purposes. The user friendliness of this language has made it famous all over the world among scientists. Specially, like JAVA language, Visual Basic version 6 can be linked with Internet browser.

OBJECTIVE:

The objective of the program development is to assist the final year Geotehinical design students who have the background knowledge in Geotehinical design aspects, through some demonstration and explanations have been added to assist slow learning students. The authors want to emphasize that it is not a commercial package.

BACKGROUND TO RETAINING WALL DESIGN:

The conventional design method of retaining walls considers it as plane strain problems based on assumed failure plane. Design engineers are adopting two basic methods. The Rankine method and Coulomb method. They differ by the assumed geometry of the failure plane. Earth pressure analysis at active state requires large wall movement. Considering the serviceability of the wall, greater factor of safety is needed for angle of friction (ϕ) for calculation.

METHODOLOGY:

User Friendly machine interface is the main feature of Visual Basic program and it has been created for inputting data such as bulk density (γ), friction angle (ϕ) and cohesion (c) along with water table depth, number of layers and thickness of layers. Once data have been given, user can execute the program

Bottom of the screen. User can select the type of retaining wall to be designed as well.

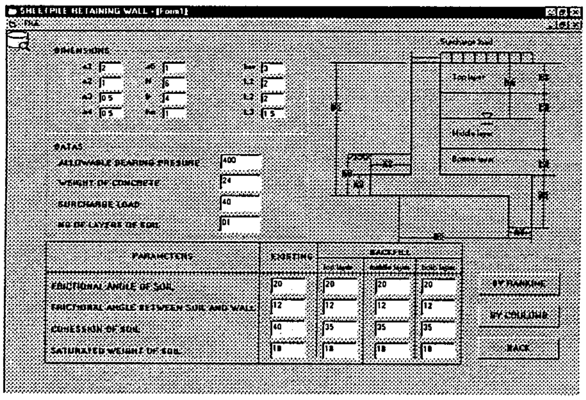

Fig.(1) input screen

The above fig shows the input screen in this screen the user has to input the dimension of the retaining wall according to the figure. If click the cursor in the text box automatically the corresponding dimension will blink which is very help full for users.

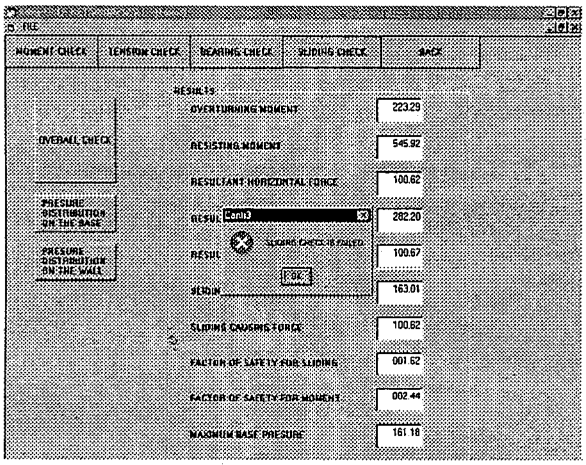

Fig.02 Output screen

The above fig shows the Output screen, in this screen all the intermediate results are given, and the user can check all the necessary checks such as factor of safety and tension in the base. If the design is fail a message box will appear. This facility is very important for the student purpose.

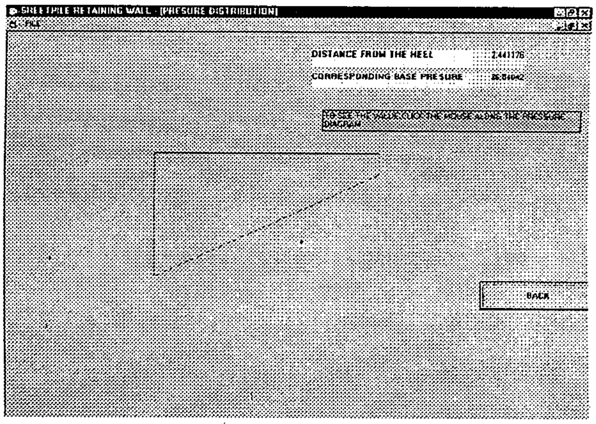

Fig.03 Pressure distribution along the base

The above fig shows the pressure distribution along the wall, by clicking the cursor on the pressure diagram can see the value at the point.

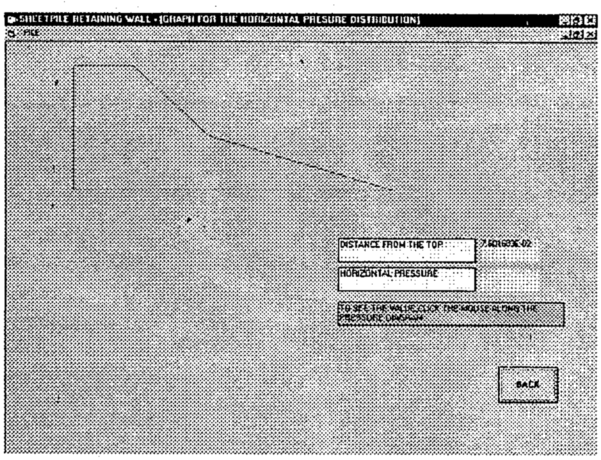

Fig. 04 Pressure distribution along the wall

The fig.04 shows the pressure distribution along the wall, the graph is discontinuous due to the water table.

The central hub of the program development is coding the program in VB language. As the design procedure requires repetitive checks for safety factors 'for 'loop have been used to do the analysis .As the development focuses on guiding the students rather than giving the end result to designers, the program has been developed such that to give the possible failure mode for given base width. In addition, it has been developed to give remedial measures to overcome that failure mechanism. This will illustrate the detail of retaining walls intensively to students.

Our programmed having the intension of a Student guide, a demonstration part have been developed in the program. It gives the background knowledge of Retaining walls, Design aspects and Conventional design procedure (Rankine method and coulomb method) it also gives an extensive explanation of types of retaining walls, its usages, material used and limitation in designing. Some photographs have been attached for illustration.

Stress in the retaining wall is calculated assuming it to be a plane strain problem it has been developed for the multi layer back fill. The design procedure has been developed for Cantilever retaining wall, Gravity retaining wall and for sheet pile retaining wall. Rankine analysis can be executed for smooth surface and horizontal back fill but it can modify to inclined back fill. Coulomb analysis eliminates the above limitations in its wedge analysis.

It gives output result such as total vertical force, total horizontal force, Sliding causing force, sliding resisting force, Overturning moment, restoring moment, factor of safety for overturning, sliding and check for tension. User can see the graphical out put as well. It gives Horizontal pressure distribution and vertical pressure distribution along the wall.

CONCLUSION:

The final year project gave to us was a great opportunity to get the experience. During this project period we studied how to handle the problem, which were encountered by us.

This software will help who is interested in retaining walls and their applications. Whenever the user faces a problem regarding the design, he could refer the demonstration. Even if the user does not have any theoretical knowledge of the retaining wall he/she can get advantage of this one. The user can choose the theory either Coulomb or Rankine method to design the geotechnical part of the retaining wall.

ACKNOWLEDGEMENT:

First, We express our thanks to all the staff members of the Department of civil engineering, University of Peradeniya, for offering us this great opportunity to do some project work under the final year project program.

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EFFECT OF CEMENT STABILIZATION ON A GRANULAR SOIL

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ABSTRACT

A project has been undertaken to find the effect of cement stabilization on a granular soil. The variation of uniaxial compressive strength with cement content, moisture content, and curing time and the variation of optimum moisture content and maximum dry density with cement content and compaction effort for a particular type of soil was studied. The soil samples which were collected from Welioya in Kalthota area which contains 75.3% sand and 24.7 % gravel and it is free from organic content. Standard and Modified Proctor Compaction tests and uniaxial compressive strength test were carried out on the sample according to BS 1377. The following conclusions were made from the studies. Maximum dry density increases with the increase of cement content and also with the increase of compaction effort. The uniaxial compressive strength of cement stabilized soil increases with the increase of cement content and also with the increase of curing time. For the soil sample at a given cement content and under the same compaction effort, maximum uniaxial compressive strength was obtained at a moisture content 2% less than optimum. Variation of uniaxial compressive strength at 28 days with water/cement ratio agrees with Duff Abrams Law. It can be concluded from this study that cement acts as a binding agent not as a stabilizer in this case of granular soil.

BACKGROUND AND OBJECTIVES

Soil as a construction material can be used for different types of construction work such as dam construction, road construction etc. depending on its physical properties such as permeability, shear strength etc. For an economical construction the suitable material should be locally available. If the locally available soil is not suitable for construction, it can be made suitable by soil improvement such as cement stabilization.

In construction of bases for highway and airfield, bearing capacity is the main criteria to be considered. In the case of construction of embankments, dams etc. the permeability of a soil is also important.

The aim of the project is to find the effect of cement stabilization on a granular soil, such as variation of uniaxial compressive strength with cement content, moisture content, and curing time and also the variation of optimum moisture content and maximum dry density with cement content and compaction effort for a particular type of soil.

METHODOLOGY

The soil sample was collected from Welioya in Kalthota area. In order to classify the soil, mechanical analysis was performed according to BS 1377 Part II. From the test it was found that the soil sample contains 75.3% sand and 24.7 % gravel. (Fig.01) So the soil is sand without any plastic clay.

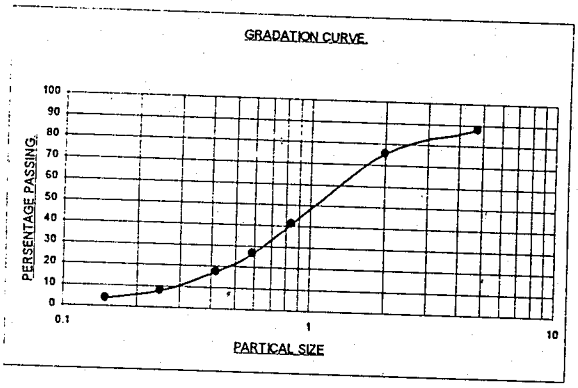

Fig.01

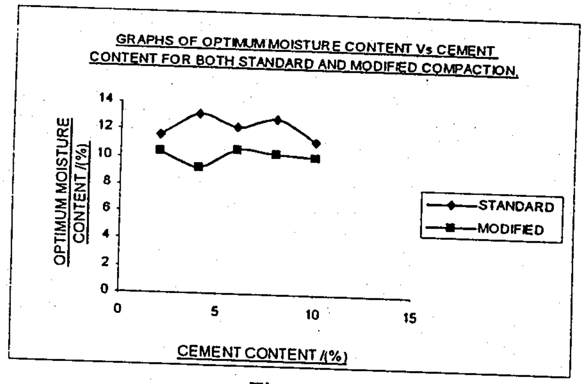

Fig 02

Then organic content and specific gravity for natural soil was found according to BS 1377 Part II and Part III respectively. From these tests it was found that the soil is free from organic content and has a specific gravity of 2.73.

Standard and Modified Proctor Compaction tests were carried out according to BS 1377 Part IV. The natural soil was added with 2% to 10% Ordinary Portland cement in 2% increment and tested to find out the optimum moisture content and maximum dry density. Two samples here tested at each cement and water content and the average results were taken. These results are shown in Fig.02and Fig.03.

In order to find the variation of uniaxial compressive strength with cement content, uniaxial compressive strength tests were carried out according to BS 1377 Part VIII, for samples of 4%, 6% and 8% of cement content. The samples were prepared at optimum moisture content and 2% less than optimum moisture content and tested after 1 day, 7 days and 28 days curing. These results are shown in Fig.04and Fig.05.

RESULTS

1. At a particular cement content, the optimum moisture content for maximum dry density for Modified compaction test is lesser than that of Standard compaction test. (The variation of optimum moisture content with cement content is shown in Fig.2)

2. Maximum dry density increases with cement content for both Standard and Modified compaction tests. Values obtained for Modified compaction tests are nearly 7% higher than that of Standard compaction tests. (The variation of maximum dry density with cement content is shown in Fig.03)

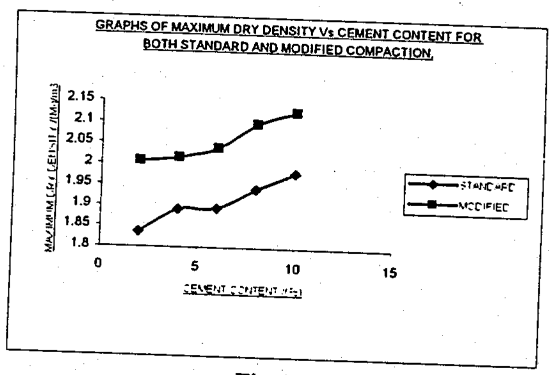

Fig 03

3. Uniaxial compressive strength increases with the increment of cement content. Variation of uniaxial compressive strength is linear for 28 days strength. Increase of 7 days uniaxial compressive strength with cement content is insignificant for 6% to 8% of cement content. Variation of 1-day uniaxial compressive strength with cement content is insignificant. (Fig.04)

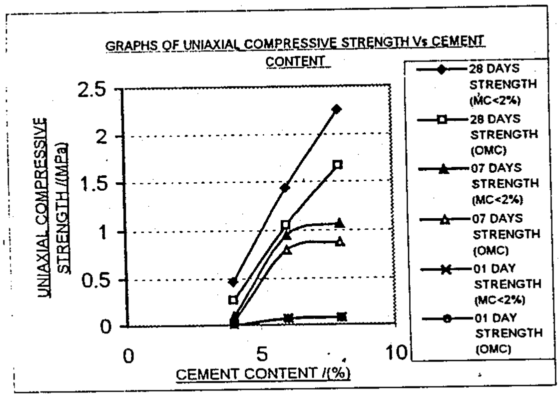

Fig 04

4 Uniaxial compressive strength increases with curing time. The variation for 4% cement content is linear. Higher values of uniaxial compressive strength were obtained at the moisture content of 2% less than the optimum moisture content compared to that obtained at optimum moisture content. (Fig.05)

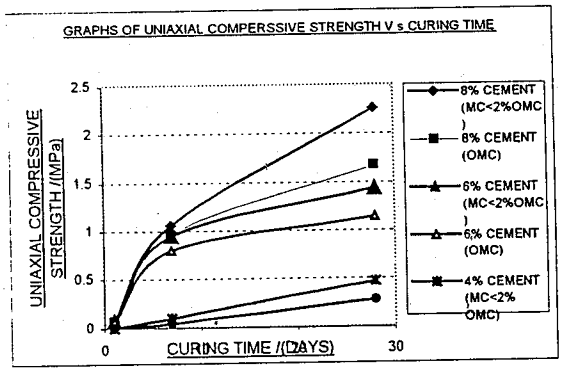

Fig 05

CONCLUSIONS

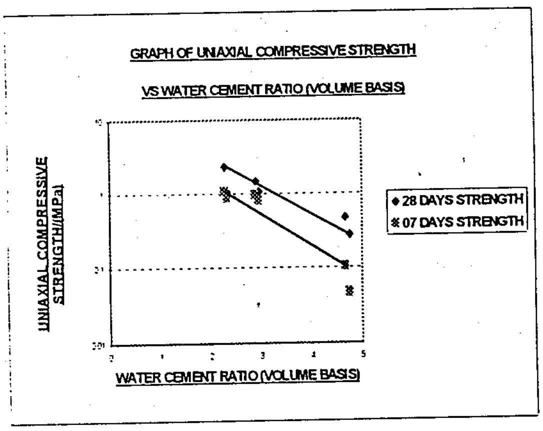

Fig 06

Variation of uniaxial compressive strength with water/cement ratio shows almost linear variation for 28 days uniaxial compressive strength in semi log plot. This agrees with Duff Abrams Law which says $f_c=K_1/K_2^{(w/c)}$ where K_1,K_2 are empirical constants,fc is compressive strength and w/c is water/ cement ratio. Therefore it can be concluded that cement acts as binding agent rather than acts as stabilizer.

SUGGESTIONS FOR FURTHER STUDIES

The soil sample tested does not contain any clay or silt. Practically when sand or gravel deposits are considered such layers may have been covered or mixed with clay or silt. When such material is excavated it will contain Gravel or sand in high percentage and silt or clay in low percentage.

It is necessary to extend the test performed to study the behavior of the above soil with cement stabilization.

Mostly for dam construction, main objective is to improve the permeability. Therefore in addition to the above tests, the permeability test should be carried out.

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