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Compressible Clay Soil As Backfill Material : Problems And Remedial Measures

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Abstract :-Soil is the most abundantly available construction material on the earth. At places it is found to be the only locally available construction material. Backfilling of utility trenches is done with the soli available from the excavation of the trenches. Properties of this backfill soil vary from site to site depending upon the material available from excavation. Many times due to use of poor soils or due to improper compaction, settlement of the backfill material due to the loss of strength in the backfill soil results in the hindrance to the traffic crossing the utility trenches and may also cause damage to the utility. Sometimes it becomes difficult to compact the back fill properly in the confined areas due to various site constraints such as backfilling around or beneath the concrete or steel structures or in the narrow trenches of the underground utilities. To avoid inconvenience to the road users and damage to the under laid pipes etc. proper care should be taken during the backfilling operations. For this in addition to imparting the required compaction to the backfill, the properties of soil available should also be improved by using various techniques of soil stabilization. The modified material should then be used in the backfilling operations.

Stabilization of yellow clays obtained from the excavation of the trench, having high to moderate compressibility, can be done with locally available sand. This may be one of the cost effective and quick methods of improving the properties of such soils.

Keyword:-

Excavated Soil, Utility duct, Backfill, clay soil, sand, compaction, settlement and trench falling.

INTRODUCTION

India has become one of the fastest growing economies in the world. With rapid privatization, investment climate of the country has been improved considerably. Mega projects for infrastructure development are being planned and new technologies are being used. For these projects new underground utilities are being laid or the existing utilities are being replaced at many places to keep pace with the rapid growth.

Laying of underground utilities for water line, sewer line, storm water line, power cable, telephone cable, gas lines, signal cables etc. requires excavation of the trenches. At the bottom of the trenches suitable bedding material is placed over which these utilities are laid. After laying and testing the utilities the trenches are filled up with the excavated soil. This method of reinstatement of the trench by the excavated soil is known as back filling.

The benefits of using soil as a construction material to perform various important functions in civil construction was realized by the earlier civilization. Low cost ease of construction, local availability, durability are some of the important aspects encouraging use of soil in the construction. For use as construction material selection of proper type of soil processing the required properties is of utmost importance.

In India various infrastructural development projects are being implemented at a very fast speed. New townships and industries are being setup, various national & state highways, flyovers, subways, mall of international standards are being constructed, rural roads are being made, capacities of existing airports are being increased and new ports are being planned. At many places the overhead power lines and telephone lines are being replaced with underground lines. In many cities houses are being supplied cooking gas by providing underground gas line. New waterlines, sewer lines are being laid or the storm water drainage system of the cities is being modified and the traffic control signals are being provided at the junctions.

All such underground utilities are usually laid within a depth of about 2.0 M from the earth surface. For lying of these utilities trenches are excavated and after laying and testing of the lines the trenches are backfilled with the excavated soil. As such the backfilling can be defined as the refilling of previously excavated space with properly compacted material.

The area for backfilling may be quite large, in which the backfilling operation will be similar to embankment construction. On the other hand the area may be quite limited due to space constraints or the location of the utilities, which may fall just adjacent to another utility or any other structure making it difficult to properly compact the backfill. In confined area problems may arise during compaction as only small equipment producing a low comp active effect can be used or because of the restricted nature of the backfill zone even small compaction equipment cannot be used effectively.

In such cases higher densities under the given comp active effects can be achieved by processing the available backfill soil before it is placed in the excavation .such processing of soil may also result in improved strength properties of the backfill soil.

At different times various measures and methods have been employed to improve upon the properties of clay soils. Stabilizing the soil is one such method being used for modifying the properties of the soil. In soil stabilization the properties of the soil can be altered by adding another material (e.g. another soil or a chemical) and compacting it to obtain improved properties for a specified purpose .

The united nation center for human settlement (UN 1992) defines the stabilization as the “modification of the properties of a soil–water –air system in order to obtain lasting properties that are compatible with a particular application “.

The main objectives of soil stabilization are to achieve improved mechanical characteristics of the soil (increase compressive and shear strength) to reduce porosity and to improve resistance to rain and wind erosion (waterproofing and reduction of surface abrasion) (wintnkorn, 1975:UN 1992 : Symons 1999).

Stabilization techniques can be categorized into three main groups:

- Compaction or densification
- Granular stabilization
- Chemical stabilization

Compaction involves compacting the soil manually or mechanically to increase its density and strength. Granular stabilization is the mechanical stabilization of two or more materials (soils) possessing complimentary physical characteristics (e.g. particle size distribution) in order to produce a material that is more favorable for construction.

Chemical stabilization is the addition of a chemical such as lime to a soil in small quantity so that the resulting chemical reaction produces a material with increased strength and decreased plasticity and shrinkage (Croft, 1968.)

Generally in backfilling operation small amount of soil is required to be backfilled as the utilities are laid at shallow depth. Due to the reasons mentioned above, it is difficult to compact the backfill materials, particularly clays, properly, resulting in poor fill which settles under working conditions. In such cases it is desirable to have easy and quick solutions to improve the compatibility and strength properties of backfill of material. With this in view in the present work an attempt is made to investigate the stabilization / improvement of clay soil with easily and locally available material.

LITERATURE REVIEW

Problem due to improper backfilling

Although the cost of backfilling is not much in comparison to the cost of utility but if the soil used in backfilling does not possess the required strength it may result in settlement of the backfilled soil with the passage of time. Consequently this may cause damage to the underground utility or in the road stretches it may become an accident spot by causing hindrance to the traffic plying over it. The cost of reopening the trench for replacing the damaged utility, stopping the traffic for this replacement and the cost involved in backfilling would thus be much higher than the cost that would have been incurred if the proper good soil had been used in the backfilled with proper compaction.

Reasons of improper backfilling

- The stenches where the utilities are laid mostly fall within right of way of road or within an open land belonging to Government agencies. These areas are maintained by Govt. agencies. The permission to lay utilities is given by the department on the conditions that the utility agency will completely reinstate the trench after laying the utility.

However since the govt. departments maintain that particular areas hence many times the agency overlook this condition due to loose control of the regulating body. The agency concerns only with safety of their utility by encasing it with pipes or concrete and does not bother about the reinstatement of the trench portion.

- Since backfilling involves spending of money and time, often agency simply fill the trench with whatever excavated soil is available without looking into the type of soil or compaction requirement for the backfill.

- Sometimes if the utility provider is sincere and wants to carry out the backfilling properly even then due to many practical site specific problems he is unable to do it. Few of such reason are :

i. The stretch may be required to be opened for traffic urgently as per the need of traffic Police authorities, particularly in urban areas. To open for traffic backfilling may be required to be carried out immediately with whatever material available at the site.

ii. Suitable soil is not available in the vicinity for backfilling.

iii. Even when suitable soil is not available at particular site there is another option of choosing some other site for the utility, but this option is not practicable as utilities runs longitudinally and sometimes at a particular slope so realignment of it is not possible in most of the cases.

iv. Due to confined nature of utility trench or overlapping of many utilities in the same trench it may not be possible to give the required compaction to the backfill material.

METHODOLOGY :

The problems associated with poor backfill material are seldom attended by the civil engineers. Based on the experience and the literature the various aspects of backfilling operations have been highlighted.

The backfill may be any type of soil it may be course grained soil or fine grained soil. In places where the backfill material is course grained or is clay of low compressibility, it can be compacted effectively and as such the associated problems are negligible. However in clays of medium to high compressibility the backfilled trench may show settlement and the associated problems may arise. Therefore in the present work yellow clay of medium plasticity and compressibility has been selected. The clay was obtained from the excavated telephone cable trench in the Char Imli Area of Bhopal.

The Narmada sand which is locally available was blended with it in different proportions varying from 5% to 25% by weight of the soil. Laboratory tests are carried to find the following index and strength properties of the raw soil (unmixed with sand) and the soil mixed with sand in different proportions.

1. Liquid Limit
2. Plastic Limit
3. Unsoaked & soaked CBR values
4. Shear strength parameters by triaxial method.
5. Differential free Swell Test
6. Permeability Test

The effect of mixing sand on the above properties of the soil selected (i.e.; yellow clay) has been studied with a view to comment on the suitability of mix soil as a backfill material.

The cost effectiveness of the clay soil stabilized with sand as against the other method of improvement namely:-

i. Soil stabilized with Lime
ii. Soil stabilized with cement
iii. Replacing soil with the murrum has been evaluated by the comparing the cost associated with three methods.

METHODS OF SOIL STABILIZATION

1. Mechanical stabilization
2. Physical stabilization
3. Chemical stabilization
4. Thermal Stabilization
5. Electrical Stabilization
6. Stabilization by grouting

EXPERIMENTAL PROGRAMME AND RESULTS

General

Sometimes the soil available at the site may not be suitable from the view point of backfilling. The more feasible approach is to improve the soil by soil stabilization .The properties of backfill material which are of interest are stated below:

1. The Atterberg limits are often used directly in specifications for controlling soil for use in fill and in semi empirical methods of design (Lambe and Whitman, 1973). The plasticity index is particularly useful in assessing the behavior of the soil.

   Soils are normally classified on the basis of grain size analysis and consistency limits. In this work the limit of soil is determined using casagranade apparatus. The plastic limit is determined using standard test procedure.

2. Soil compaction is an important requirement of the backfilling operations. Maximum dry density (MDD) and optimum moisture content (OMC) are determined using standard compaction equipment.
3. CBR value is also an essential requirement of backfill material used for reinstatement of trenches excavated under the roads. Unsoaked and soaked (96 hrs) CBR values of the samples prepared at OMC are determined using CBR apparatus.
4. Shear strength parameters C and ϕ are important for determining bearing capacity of the soil. These were determined using triaxial test machine on the soil samples prepared at OMC and MDD under unconsolidated untrained (UU) condition.
5. Differential free swell test is a simple test which indicates the swelling potential of the soil. It was conducted by comparing the volume of soil in water and kerosene as per standard practice.
6. Permeability is worked out using the permea meter to know the effects of mixing of sand on the drainage capability of the soil.

MATERIAL USED

Soil blended with sand has been taken as the prime sample material for the present investigation in order to predict it's behavior when mixed with the sand. Sample of yellow clay was taken from the excavation of telephone cable trench in the Char Imli areas of Bhopal and locally available Narmada sand was used for the stabilization process. The particle size distribution of sand is given in the below table.

Table : Particle size distribution of sand

Sieve size mm	**4.75**	**2.3**	**1.2**	**0.6**	**0.425**
% finer	100	93.36	79.46	25.92	10.52
Sieve size mm	**0.3**	**0.15**	**0.075**		
% finer	2.84	0.14	0.08		

Index and engineering properties of raw clay as well as clay mixed with sand was determined in the soil mechanics laboratory of MANIT Bhopal.

The yellow clay sample obtained from the field was made to dry in the laboratory and then pulverized and mixed with sand in different proportions as per requirement of the experiments.

Table : Shows the name of tests and number of tests conducted No. of tests carried out

Sr. No.	Test description	No. of test Tests carried out				
		On Clay	On Clay Mixed with 5% Sand	On Clay Mixed with 15% Sand	On Clay with 25% Sand	Total
1.	Liquid and Plastic Limit	1	1	1	1	4
2.	OMC & MDD	1	1	1	1	4
3.	CBR (un soaked and soaked)	1	1	1	1	4
4.	Triaxial test	1	1	1	1	4
5.	DFS	1	1	1	1	4

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6.	Permeability	1	1	1	1	4
Total						**24 No.**

Test carried out

i. Liquid Limit and Plastic Limit

ii. Determination of Maximum dry density and optimum Moisture Content

iii. California Bearing Ratio (CBR) test

iv. Triaxial Compression Test

v. Differential free swell test

vi. Determination of Permeability

vii. Results

Results obtained from laboratory testing are shown in the Table.

Table : Results of Experimental investigations

Sr. No.	Tests Conducted	Raw Clay	Clay + 5% sand	Clay + 1 5% sand	Clay+ 25% sand
1	Liquid Limit %	43.80	40.60	36.10	32.60
2	Plastic Limit %	21.00	20.36	20.05	19.00
3	Plasticity index	22.80	20.24	16.05	13.60
4	Optimum moisture content %	19.30	19.10	16.50	14.00
5	Maximum dry density gm./cc	1.738	1.793	1.825	1.887
6	Cohesion kg./ cm^2	1.10	0.80	0.50	0.30
7	Angle of internal friction, degrees	2	6	12	16
8	CBR (un soaked)	10.88	12.04	16.06	18.23
9	CBR soaked	2.36	5.89	7.05	8.63
10	Differential free swell %	40	30	25	20
11	Permeability cm/sec.	5.31×10^{-8}	8.43×10^{-8}	1.59×10^{-7}	3.2×10^{-7}

CONCLUSION

Backfilling is an important activity in the process of lying of different underground utilities. Many times proper attention is not given to it by the agency laying the utility. The backfill material is just dumped into the trench without compacting it adequately. With passage of time the loosely filled material settles and may act like a speed breaker if the traffic passes over it. It not only increases wear and tear of the vehicles but also may cause accidents during the night hours. The impact of traffic passing over the depressed portion damages the adjoining pavements and the underlying utilities. The various reasons of not carrying out the backfill activity properly can be unavailability of proper backfill material in the vicinity, compaction in small area, urgency of completing the work in short duration and lack of authoritative control over the agency carrying out the work.

Sometimes if the utility provider is sincere and wants to carry out the backfilling properly even then due to may practical site specific problems such as inferior material obtained from the trench excavation it becomes difficult to compact it properly without processing it and improving it's quality. Clays of high to medium compressibility are more phones to give effects of poor backfilling. In such situations the remedial measures may be:

i. To replace the entire excavated clay with good soil like Murrum brought from outside.

ii. The second approach is to improve the excavated clay by the process of soil stabilization.

The option or replacing the poor soil by good material may not be economical. However the second option of stabilizing the soil by lime or cement may be attempted. It is noted from the literature that the inclusion of coarse grained soil like sand improves the properties of clays. With this in view in the present work yellow clay (classified as CI) obtained from the excavated trenches of telephone line from Char Imli area of Bhopal was selected for the study. It was mixed with sand in different proportions of 5%, 15% & 25% by weight of raw soil and a number of relevant soil properties were determined in the laboratory. The details of which has already been mentioned in previous chapters.

The broad conclusions that are drawn from the results of experimental works are as follows:

i. The sand mixed clay soil has reduced liquid limit and decreased plasticity index. Thus the compressibility of the mixed soil is reduced as compared to original clay.

ii. The maximum dry density of the sand mixed oil increases, it becomes more compactable and denser than the original soil, which is an essential requirement for backfilling of trenches in confined areas.

iii. Shear strength parameter ϕ has been found to be increased and the bearing capacity of the clay improves substantially.

iv. CBR values are of the sand mixed soil have been found increased. Thus road going over the backfill mixed with sand will have more strength as compared to that of unmixed soil.

v. Differential free sell also reduces considerably. The index of differential free sell has come down from the range of high to a range of moderate hence the ill effects due to the volume change of the backfill clay will be less when sand is mixed with it.

LIMITATION AND SCOPE FOR FUTURE WORKS

Following are the limitations and scope for future study:

1. Stabilization with sand may not be economical as compared to other methods at the places where the sand is not

available locally or it has to be hauled from a long distance thus costing more.

2. Due to time constrain in present study sand was mixed maximum up to 25% only and large data sets could not be gathered, there is further scope to increase the sand content beyond 25% and to work out the optimum percentage of sand beyond which further increase in sand do not cause any improvement is soil properties.

3. The tests are carried out on yellow clay, however in nature the clay also occurs in the form of black cotton soil, red soil etc. Similar studies can be made for these clays also.

4. Amount and type of compaction, equipments suitable for a particular site and back fill clay can be studied separately.

5. Field performance study of the stabilized clay may be carried out to substantiate the test results.

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