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A CASE STUDY OF GEOTECHNICAL SOLUTION FOR FOUNDATION OF A MULTISTORIED RESIDENCIAL BUILDING

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ABSTRACT

In order to construct a good multi-storey building, the basic need is to have the strong base or fundamentals, or in the other words, the foundation needs to be strong which can withstand the load coming on it. Normally the engineer has to place his structure on soil and to some extent in the soil. Safety and durability of structure largely depend upon the design of the foundation preferred for the structure considering all the engineering characteristics of soil and other parameters. There are several options are available before the designer for decision making of foundation type, depending upon the ground conditions. Definately each type of foundation has its own merits and demerits. Looking to this variation, in my proposed work I am trying to find out which type of foundation is best suitable for different soil condition of the area Jabalpur for the construction of multistoried building with technical as well as economical parameters.

INTRODUCTION

Expansive Soils are those soils which have the tendency to increase in volume when in contact with water and decrease in volume when they are dewatered this phenomenon is called swelling. This cycle change of volume in swelling or expansive soils causes problems whenever civil engineering structures are planed and constructed on them. The type of area where a G+5 storied structure is being proposed to be built up near Jabalpur (M.P.) has a thick soil cover consisting of black cotton soil. The terrain is nearly plane and the position of water table is at a depth of 6.0 m below the ground level now the problem is to be decide about –

- The type of foundation to be provided for the proposed structure.
- Depth of foundation to be determined to make the structure stress free and safe.

Black cotton soil as is understood to be is considered as a treacherous soil as for as founding big and sensitive structure is concern because it has following characteristics –

- Cohesive in nature.
- It has moderately plastic characteristics.
- It has high specific gravity.
- It swells and reduces in volume, whenever change in moisture content observed.
- It contains a few expandable clay minerals like montmorillonite and halloysite and these clay minerals actually control the entire engineering behavior soil at different soil water conditions.

Thus Stabilization of Black Cotton Soil is studied by using Lime. Lime stabilization is not difficult to carry out. After proper mix design and testing is performed, in-place mixing is usually used to add the appropriate amount of lime to soil, mixed to an appropriate depth. Pulverization and mixing is used to thoroughly combine the lime and soil.

The moisture change in BC soils, compressibility and plasticity nature can be greatly improved with the addition of Lime. This paper includes the evaluation of soil properties like Optimum moisture content, dry density, and strength parameter with different quantities of Lime added to the BC soil and the experiments conducted on these soil mixes.

Foundation problem in expansive soil

The traditional solution of providing stable foundation to structure built on black cotton soils was in the form of the introduction of Raft foundation. The undreamed friction piles are also suggested by taking advantage of the property of cohesion of soils. Expansive (BC) soils are highly plastic in nature and the concept of undreamed pile foundation or raft foundation has been evolved and developed to counter the bad effect of expansive soil on the foundation in the cycle of watering and dewatering in course of time.

Volumetric changes of underlying and surrounding soils for a building foundation resting on moderate to highly expansive clay soil results potential detrimental effects to structure or its elements of the foundation. In simple terms, expansive clay soils swell and can cause heave with increase soil moisture, or can dry out and cause subsidence with decreasing soil moisture. This volumetric change effect the stability of structure rest over it.

Movement of expansive soil is caused by fluctuation in the moisture content of soil particles. Because homogeneous expansive clayey soils have very low permeability, fluctuation in the moisture content of the soils might normally be expected to occur over a very long period. However permeability is increased with other geotechnical phenomena such as ground faults, surface fractures due to desiccation of clays and decomposition of tree routes which causes fissures and cracks that become widely disseminated over time.

Due to repeated wetting, swelling, drying and shrinkage of the clay as it weathers, fissures often filled with silt and sand and create pathways for water that can be exacerbate the infiltration process .Water can also easily move through naturally occurring sand strata, seems and micro cracks in clay soil caused by previous shrinkage high negative pressure, also known as suction, in clay soils with low water content Also increase the tendency for water to be absorbed in to the clay. Environmental Factor other than climatic conditions can also effect expansive soils water extraction by trees and other vegetation, a process known as transpiration can cause soil shrinkage, swelling can be result of water infiltration into the soil from lawn irrigation system.

Based on above narrated fact in this study we have tried to find out the technical solution of selection of foundation for multistoried building have situated 10 km away from each other. Based on technical solution we also conduct the study of economy parameters also.

METHODOLOGY

Now in the wake of high rise structures being planned and built on BC soil and developing a concept of zero risk factor lot Of researches are being conducted on improving the property of BC soil and reducing the negative property in the connection of present work has been undertaken.

A study has been conducted on BC soil samples taken from two different localities.

- First phase determining the all the index properties from laboratory test according to IS codes.
- These index properties again tested by adding 4% and 6% lime and standard proportion were studied.

Properties of soil samples

The selected site is uniform for all the two soil samples collected from different locations of that area. Samples were collected by trial pit method at a depth of 2m. The samples on which test

performed are undisturbed soil samples of that area. The results obtained for all the fore samples are having very less variation therefore results of these two samples mentioned in this paper.

The table below shows index properties of samples.

Table 1: SAMPLE–A was taken from "Bilhari" which is considering as 10 km away from city Jabalpur and located as 23°09'40.66"N 79°56'58.38"E at elevation 417.7 m to MSL

PERTICULARS OF TEST	BC Soil	Soil + 4% Lime	Soil + 6% Lime
Liquid limit (%)	54.62	48.23	42
Plastic Limit (%)	21.64	19	18
Plastic Index (%)	32.98	29.23	24
D.F.S.	27	21.72	19
Swelling Pressure (kg/cm^2)	0.98	0.42	0.26
Shrinkage limit (%)	9.89	11.67	13.29
O.M.C.	15.6	23.3	29.7
M.D.D.	1.80	1.778	1.779
Specific Gravity	1.74	1.97	2.02
Cohesion (C)	5.2	4.3	3.89
Angle of internal friction (ϕ)	18.5	21.8	23.6
Soil Classification	**MH** - Inorganic silt of high compressibility (more than 50% passed to 0.075mm)		

Table 2: SAMPLE–B was taken from "JNKVV" of Jabalpur located as 23.10'07.72"N 79.56'20.13"E elevation of 402.43 m from MSL.

PERTICULARS OF TEST	BC Soil	With 10% Lime	With 20% Lime
Liquid limit (%)	56.89	50.72	43.98
Plastic Limit (%)	22.09	19.8	17.89
Plastic Index (%)	34.8	30.92	26.09
D.F.S.	28.5	25	22.72
Swelling Pressure (kg/cm^2)	1.06	0.51	0.29
Shrinkage limit (%)	8.78	10.56	12.34
O.M.C.	17.02	26.42	31.34
M.D.D.	1.854	1.797	1.772
Specific Gravity	1.96	2.34	2.56
Cohesion (c)	5.37	4.52	4.94
Angle of internal friction (ϕ)	17.3	22.8	24.6
Soil Classification	**MH** - Inorganic silt of high compressibility (more than 50% passed to 0.075mm)		

Based on the index properties of sample soil are modified by taking different proportion of lime and further study of properties is confined to only two samples which results are tabloid above.

As per the index properties it is decided that to go for deeper soil investigation (up to 8 m) for achieving the better degree of understanding. For this purpose manual auger boring is done at only one location. The bore log at this location is given below in fig. –

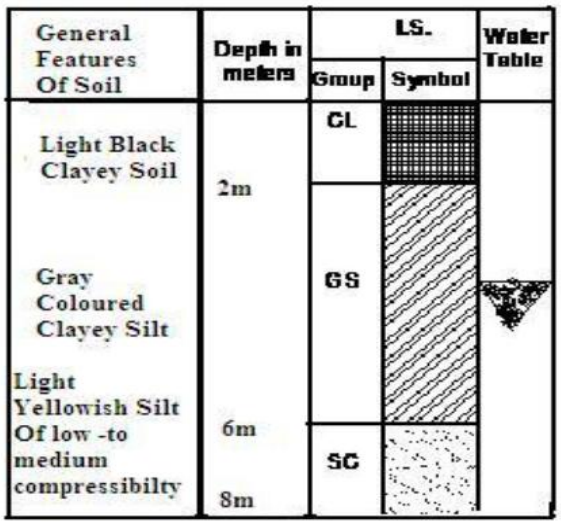

Figure - 2

DISCUSSIONS

By going through the literature it is found that lime can be used to treat soil in order to improve its workability and load bearing characteristics in number of situations lime can substantially increased the stability impermeability and load caring capacity of soil. Lime is an excellent choice for modification of soil properties and some following change has been noticed after testing the samples.

1) There is a progressive decrease in liquid limit but almost no change in plastic limit; however the plasticity index shows considerable variation decreasing with the increase in lime content.
2) Mixing of lime also has an effect on the D.F.S. values moves southward due to increase of lime content of sample in decreasing direction.
3) A progressive decrease in swelling pressure is also recorded.
4) There is almost nil or a very little variation in specific gravity and M.D.D. values.
5) There is a marginal increase in shrinkage factor.
6) The value of cohesion (c) varies and drops down with the increase of percentage of "lime" but the variation is within range.
7) The shear parameters show improvement with the increase in the values of ϕ with increase in lime content.

As far as the question of options of foundation is concern for heavy structure, the multistoried building proposed on this type of soil the following foundation can be recommend –

- Double undreamed pile foundation with embedded length of the stem and dia suitable for the load shearing of structure with proper nos of piles in a group provided with caps.
- The Raft Foundation.

Plan and structural details

Out of these two locations this paper covers only a single location. The proposed structure is residential type having Ground + 5 floors of super built up area of 322.00 sq m. of each floor and according to Jabalpur Municipal Corporation by laws the permitted built up area is 1610 sq m. According to architectural planning the ground floor is exclusively reserved for parking and other floors are proposed for residential purpose. According to the planning each floor comprises four units of 2BHK flats of super built up area 72.12 sq m. of each flat. Looking to this and other architectural constrains the building has total 45 columns. The maximum distance between two columns is observed 3.49 m. the size of column is also varies from 300X450 mm to 300X600 mm. Out of these, 4 columns are found to be worst loaded column also shown in plan and details are in table below. It is required to design the foundation by taking these worst loaded columns.

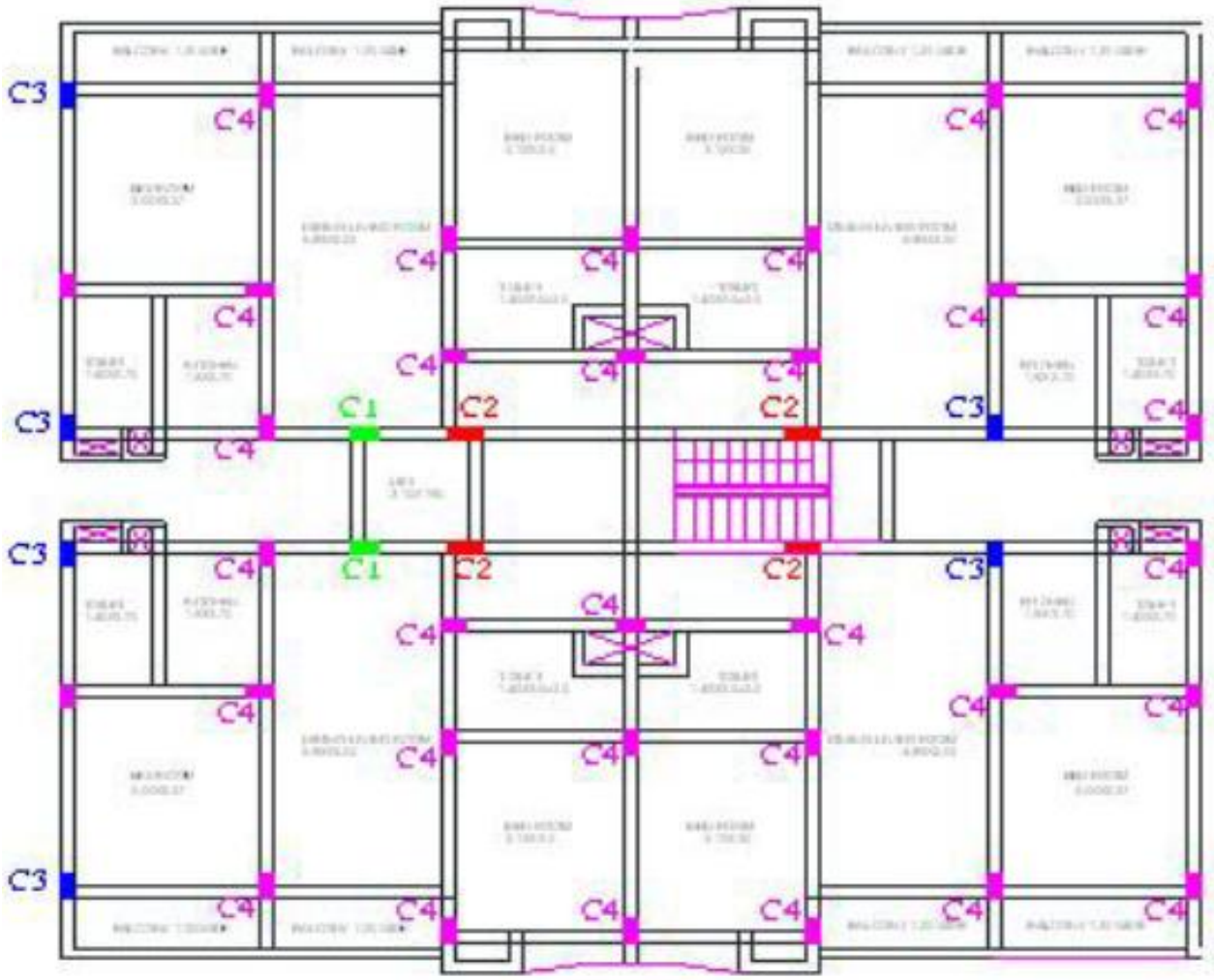

Figure - 3

Now a days various tools in the form of software is available in the market firm for structural design of buildings namely, Stadd pro, Struds, E-Tab etc. and in my opinion out of these software "Struds" is very common software so for the purpose of designing I have preferred this. In following table the detailed design of loadings and columns have shown as per analysis.

Table – 3

Column No.	Section type	Column size (mm) (parking to slab level)	Column size(mm) (First floor to top)	Axial load (kN)	Ast Provided (parking to slab level)	Ast Provided (First floor to top level)
C1	Rectangle	300 X 450	230 X 450	558.00	6 – 16 ϕ	6 – 16 ϕ
C2	Rectangle	300 X 600	230 X 600	833.11	8 – 16 ϕ	8 – 16 ϕ
C3	Rectangle	300 X 450	230 X 450	1330.19	4– 20 ϕ + 4 -16 ϕ	4– 16 ϕ +2 -12ϕ
C4	Rectangle	300 X 450	230 X 450	1330.19	4– 20 ϕ + 4 - 16 ϕ	6 – 16 ϕ

For foundation of this structure normally double bulbed undreamed piles in groups should provide with caps depends upon the distribution of load of the structure. But in this particular case the geotechnical investigation and as per soil test report it was found that the position of water table is at a depth of 4.5m below the existing ground level in several previous works it is suggested to place the foundation above the water table to overcome the bad effect of presence of water i.e. in proposed study we decided the foundation level at 2.75 m below the existing water table in the month of November-2013. In this study I assume that in rainy seasons rising of water table may be observed and it may rise up to certain level but it never be over topped the foundation level. Other important parameters of soil according to test report are as shown in table A and table B.

CONCLUSION

For safe construction of structure in expansive soil proper ground investigation must be carried out and then accordingly foundation be designed. Other field data and ground water table and its seasonal variations are some important parameters for foundation design. In this case safety of structure is of prime importance and economy is not much more concern so I suggested to go for raft foundation for this type of soil condition. Other points for not going to pile foundation are elaborated separately in following text. The other available option for such a very heavy and tall structures is ground improvement but economy is to be checked among available options of going deep foundation or ground improvement or raft foundation.

The lime contains improves the Bearing capacity of ground as per the results although water table matters for deciding the type of foundation and as per the geotechnical, field and structural (load on columns) data the Raft foundation will be better suited for the structure defined.

Why Raft is better suited for foundation under such conditions:

1) The engineering Geotechnical characteristics of soil are such that friction piles with zero value of cohesion and moderate value of ϕ would require greater nos of piles in a group and large stemmed dia to meet the load requirement of structure.
2) Because of proximity of water table closed to the ground surface the piles will always remain submerged in water and soil at different levels in fully saturated condition will provide lower value of S.B.C.

These two conditions indicates the raft foundation will be better suited for the structure for making the structure distressed, free from failure conditions arising out of settlement failure, shear failure and possible soil liquefaction during seismic activity.

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Figure – 1