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Digital Topographical Depiction of SBC and Settlement Prediction of Soil Structures using GIS Software

Sooriya Narayanan Perumal[1]*, Varatharajaperumal Thangavel[1], R.Vignesh[2], A. Jaiprasanth[2] and Balamuralidharan R.R.[2]

Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu,

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ABSTRACT

The Coimbatore region has been shifted to Zone III as per IS 1893-2016(Part 1) due to its Expansive soil conditions, therefore chances for an earthquake are high in these regions. The impact of the earthquake can be reduced and mitigated by designing suitable foundation types. The design and choice of foundations are generally based on settlement and SBC of soils. In this study, soil samples have been collected from 20 different sites in Coimbatore to determine the safe bearing capacity and settlement of the soil samples. The data so obtained were used to create the digital SBC and Settlement prediction maps using the software GIS. These maps are then used to identify the settlement and safe bearing capacity of soils in various places. With the help of the settlement values obtained, a suitable type of footing can be suggested.

Key words: *Safe bearing capacity, Consolidation, Liquid limit and Spatial analysis*

Introduction

In 2011 at Coimbatore district, there was a failure in Building Structures at Ammankulam and Ukkadam sank into the ground because of poor soil conditions and inappropriate foundations, resulting in demolitions of constructed buildings, reductions in the numbers of planned units, and the selection of new sites for tenements. Two apartments had sunk at the site.

In 2019, there was a huge failure in the compound wall at Mettupalayam, Coimbatore district and 17 people were killed in a compound wall collapse. Due to excessive rainfall of 90mm was recorded on that day. Hence, the effective pressure in the soil has reduced and the active case of the wall has failure occurred. No proper foundation Was adopted at that site.

In the future, there is a chance of getting primary disasters like Liquefaction, Landslides and foundations failure, etc. due to its poor soil conditions. From 1960 to till date, foundations and other structures have been failed in and around Coimbatore. Hence it is decided to strengthen the foundation structures based on soil conditions and structural integrity.

In this approach, soil samples have been collected from 20 different places in Coimbatore. Conventional soil sampling and required laboratory tests were done. The data were input into GIS to provide interactive maps that show the level of predictions. These maps are then used to identify the values at various locations, by denoting it in various colors.

The main objectives of the study are:

- To predict the settlement of clayey soils in Coimbatore district

([1]Assistant Professor, [2]III Year B.E-Civil Engg. Student)

- To provide useful information for land use planning
- To provide information on site effects to be accounted for, in design of a new structure.

Materials and Methods

Materials

The soil samples have been collected from 20 selected sites in Coimbatore district. The sites for investigation have been selected based on the demographics and their location. The sites that have already been studied in previous works have been excluded so as to cover different areas in this study. The sites were also selected based on the demographic properties of the region. The sites were selected so as to cover the areas of the district without omitting a region.

The SPT N- Values for the selected sites were sourced from VKP Geo tech, Coimbatore. From the SPT values Shear wave velocity has been found, which is used to create Map.

The N value is 50 for all the above locations at the depth of 0-5m

GIS

GIS is a geographic information system (GIS) for working with maps and geographic information. The city of Coimbatore located between 10°10′ and 11°30′ of the northern latitude and 76°40′and 77°30′ of eastern longitude in the extreme west of Tamil

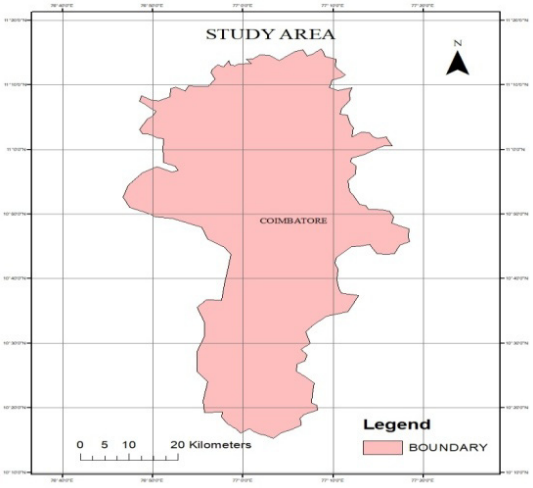

Fig. 1. Study area- Coimbatore

Table 1. SPT Values of selected sites in Coimbatore

Location	Soil type	Latitude	Longitude	SPT values (0-5m depth)
K.K.Pudhur	Loose fine sand,silt,clay	11.0308pN	76.9427pE	9
Selvapuram	Loose silty fine to coarse sand	10.9919pN	76.9369pE	8
Gandhipuram	Silty clay	11.0210pN	76.9663pE	23
Kalapatti	Silty sand and wet loose sand	11.00pN	77.02pE	5
Irugur	Silt and fine sand (sand stones)	11.004pN	76.961pE	35
Singanallur	Silty stiff clay	10.9987pN	77.0320pE	9
Pollachi	Red loam and black soil	10.659pN	77.008pE	32
Saibaba colony	Red loam, black soil	11.21pN	76.95pE	56
Valparai	Black soil and red loam	10.37pN	76.97pE	16
Ondipudhur	Silty stiff clay	10.9pN	76.97pE	22
Ganapathy	silty clay	11.3pN	77.1pE	42
Madukarai	Red loam, black soil, sandy coastal alluvium	10.913pN	76.952pE	10
Annur	Red loam, black soil, red sandy soil, calcareous soil	11.23pN	77.10pE	8
Sungam	Silty stiff clay, black soil	10.59pN	76.59pE	26
Mettupalayam	Sandy coastal, alluvium	11.3pN	76.95pE	17
Marudhamalai	Red soil, sandy loam	11.0pN	76.51pE	27
Siruvani	Red loamy, red soil	10.58pN	76.38pE	23
Thudiyalur	Black soil, red loamy soil, sandy coastal alluvium	11.0812pN	76.9416pE	28
Nallampalaym	Black soil, red loamy soil, sandy coastal alluvium	11.0494pN	76.955pE	32
Periyanaikenpalayam	Black soil, red loamy soil, sandy coastal alluvium	11.1510pN	76.9355pE	27

Nadu near Kerala state at an elevation of 432 m from the sea level. Its geographic location is mean valued to 11°01′N 76°96′ E. The city has an area of 105.5 km and a population of about more than one million. The city is surrounded by mountains on west and northern side with reserve forests and river basin (Nilgiris Biosphere Reserve), the eastern side of the district starting from the city is predominantly dry. The entire western and northern part of the district borders with Western Ghats with Nilgiris biosphere, Annamalai, and Munnar range with a western pass to Kerala popularly referred to as the Palghat Gap providing its boundary. So we decide to select the zones in Coimbatore district for determining the safe bearing capacity and predict the settlement.

Laboratory Investigation

The soil samples are cleaned, air dried/oven dried, pulverized and analyzed in laboratory for its Moisture content, Specific Gravity, and Liquid limit determination. The results are reported in a summary Table 2.

Results and Discussion

SBC map and Settlement prediction map using GIS

The value of safe bearing capacity of the soil was determined based on shear strength and settlement criterion as per IS 4603:1981 and IS 2270:1981.SBC of soil was arrived by laboratory analysis using shear strength parameters. For the given N values the SBC of soil was calculated based on settlement criterion for 25 mm settlement. The formula is,

$$q_{net} = 34.3\ (N-3)\ ((B+0.3/2B)^2 * Rw_2 * R_d$$

where

N = Corrected N value

B =Width of soil

R_d =Reduction factor

Rw_2 =Water reduction factor.

The determined safe bearing capacity values for different locations are depicted on the map using ARC. Compression index has been calculated from liquid limit of the soil at various locations at Coimbatore city. Consolidation settlement has cal-

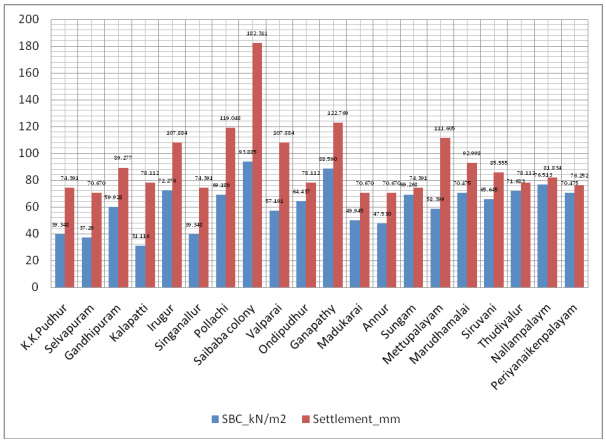

Fig. 2. Settlement and SBC chart of different regions

Table 2. Summary of soil properties

S.No.	LOCATION	Moisture Content %	G	liquid limit %
1	K.K.PUDHUR	14.2	2.66	22
2	SELVAPURAM	11.1	2.8	20
3	GANDHIPURAM	6.66	2.65	30
4	KALAPATTI	10	2.7	24
5	IRUGUR	3.33	2.55	40
6	SINGANALLUR	10	2.66	22
7	POLLACHI	5	2.6	46
8	SAIBABA COLONY	10	2.84	80
9	VALPARAI	10	2.6	40
10	ONDIPUDHUR	5	2.6	24
11	GANAPATHY	10	2.55	48
12	MADHUKARAI	8	2.7	20
13	ANNUR	4	2.66	20
14	SUNGAM	4	2.72	22
15	METTUPALAYAM	5	2.69	42
16	MARUDHAMALAI	4	2.84	32
17	SIRUVANI	5	2.65	28
18	THUDIYALUR	6.66	2.6	24
19	NALLAMPALAYAM	5	2.75	26
20	PERIYANAICKENPALAYAM	6.66	2.82	23

culated for the various sites. Figure 2 has illustrated about the SBC and settlement determination of various sites. Figure 3 and 4 represents the GIS Modeling map of SBC and Settlement of various sites.

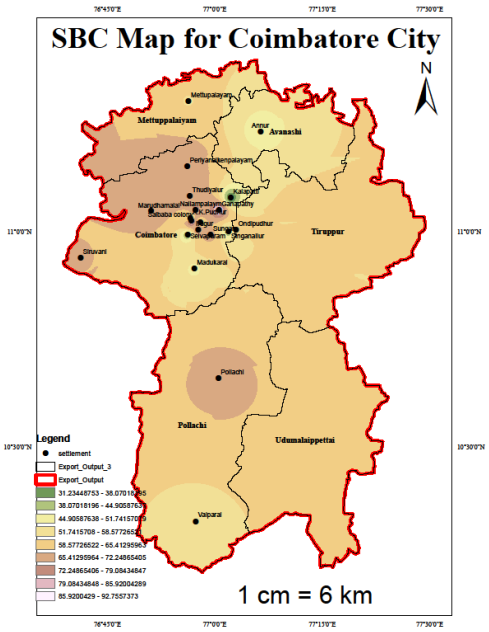

Fig. 3. Safe bearing capacity map

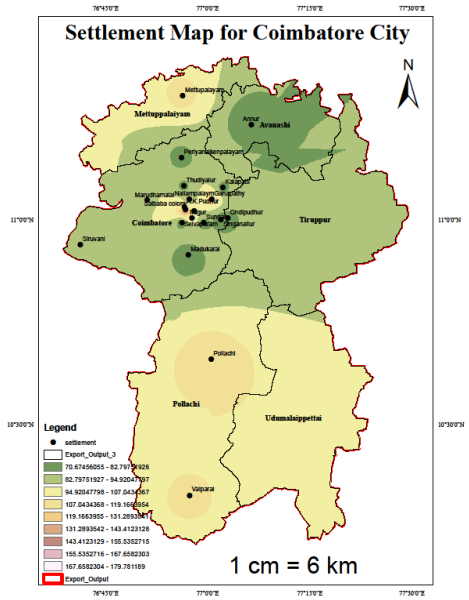

Fig. 4. Settlement prediction map

Discussion

Foundation suitability map for 20 locations was created from the values of safe bearing of soil, their inference was analyzed and remedial measures were also given suggested.

- In K.K.Pudhur site, the safe bearing of clay was calculated as 39.348 KN/m^2 and the settlement value as 74.391 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Selvapuram site, the safe bearing of clay was calculated as 37.29 KN/m^2 and the settlement value as 70.670 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Gandhipuram site, the safe bearing of clay was calculated as 59.928 KN/m^2 and the settlement value as 89.277 mm. The inference of that location is silt medium plasticity G+3 is preferred with combined rectangular footing.
- In Kalapatti site, the safe bearing of clay was calculated as 31.116KN/m^2 and the settlement value as 78.112 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing
- In Irugur site, the safe bearing of clay was calculated as 72.276KN/m^2 and the settlement value as 107.884 mm. The inference of that location is medium expansive in nature and the required deep dynamic consolidation to be done in the field before construction with pile foundation
- In Singanallur site, the safe bearing of clay was calculated as 39.348KN/m^2 and the settlement value as 74.391mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Pollachi site, the safe bearing of clay was calculated as 69.189KN/m^2 and the settlement value as 119.048 mm. The inference of that location is medium expansive in nature and the required deep dynamic consolidation to be done in the field before construction with pile foundation
- In Saibaba Colony site, the safe bearing of clay was calculated as 93.885KN/m^2 and the settlement value as 182.311 mm. The inference of that location is medium expansive in nature and the required ground improvement techniques to be done in the field before construction with pile foundation
- In Valparai site, the safe bearing of clay was calculated as 57.191KN/m^2 and the settlement

value as 107.884 mm. The inference of that location is medium expansive in nature and the required deep dynamic consolidation to be done in the field before construction with pile foundation

- In ondipudhur site, the safe bearing of clay was calculated as 64.437KN/m^2 and the settlement value as 78.112 mm. The inference of that location is is silt medium plasticity G+5 is preferred with strap footing.
- In Ganapathy site, the safe bearing of clay was calculated as 88.590KN/m^2 and the settlement value as 122.769 mm. The inference of that location is medium expansive in nature and the required deep dynamic consolidation to be done in the field before construction with pile foundation
- In Madhukarai site, the safe bearing of clay was calculated as 49.945KN/m^2 and the settlement value as 70.670 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Annur site,the safe bearing of clay was calculated as 47.530KN/m^2 and the settlement value as 70.670 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Sungam site, the safe bearing of clay was calculated as 69.268KN/m^2 and the settlement value as 74.391 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Mettupalayam site, the safe bearing of clay was calculated as 58.399KN/m^2 and the settlement value as 111.605 mm. The inference of that location is medium expansive in nature and the required ground improvement techniques to be done in the field before construction with pile foundation
- In Marudhamalai site, the safe bearing of clay was calculated as 70.475KN/m^2 and the settlement value as 92.998 mm. The inference of that location is silt medium plasticity and G+3 is preferred with combined trapezoidal footing.
- In Siruvani site, the safe bearing of clay was calculated as 65.645KN/m^2 and the settlement value as 85.555 mm The inference of that location is silt medium plasticity and the required remedial measures suggested was G+3 is preferred with combined trapezoidal footing.
- In Thudiyalur site, the safe bearing of clay was calculated as 71.683KN/m^2 and the settlement value as 78.112 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Nallampalayam site, the safe bearing of clay was calculated as 76.513KN/m^2 and the settlement value as 81.834 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.
- In Periyanaickenpalayam site, the safe bearing of clay was calculated as 70.475KN/m^2 and the settlement value as 76.252 mm. The inference of that location is silt medium plasticity and G+5 is preferred with strap footing.

Conclusion

Based on the experimental study with analytical calculations and GIS software simulations, the following conclusions were drawn.

- Among the 20 sites considered, Saibaba Colony is found to have high settlement of about 182.311 mm with its SBC value of 93.885KN/m^2. Thus, the soil is medium expansive in nature and the required ground improvement techniques to be done in the field before construction with pile foundation
- Among the 20 sites considered, Selvapuram, Madukarai and Annur is found to have low settlement of about 70.670 mm with the SBC value of 37.29KN/m^2, 49.945 KN/m^2, 47.530 KN/m^2 respectively. Thus, the soil is medium expansive in nature and the required ground improvement techniques to be done in the field before construction with pile foundation

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