Case Study And Design of Foundation of Railway Overbridge

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Abstract- *The roadway passing over a railway forming a bridge like structure is known as railway over bridge. The construction of a railway over bridge is going on at Ghatkesar, Hyderabad. The Secunderabad to Vijayawada railway line is passing through Ghatkesar Town. The railway crossing is situated at Ghatkesar-Bogaram highway. Due to heavy traffic on this route there often traffic jams near the railway crossing. To resolve this problem, the R & B Department of Telangana had decided to build an over bridge on Ghatkesar-Bogaram road over the railway crossing. The R & B Department handed over the project of construction of the over bridge to the "Mycon Infrastructures". The proposal was to construct an over bridge from Bogaram side flying over the railway track towards the Ghatkesar Town. The construction of the span over the railway track is completed. The construction work for the rest of the bridge is going on. They are planning to first complete the foundation work on the Bogaram side. In this major project we are going to study and design the foundation of this railway over bridge.*

To perform the project, a case study will be performed on the construction of the foundation of the over bridge. Also a design of the foundation of the over bridge will be prepared. For that soil analysis needs to be done on the soil of the construction site. The tests like sieve analysis, specific gravity, LL, PL, CBR etc. will be performed. Soil stabilization techniques will be applied if found any drawback on the properties of the soil as the result of soil analysis. The prepared design of the foundation will be analyzed and compared with the existing design of the foundation.

Keywords- foundation, railway over bridge, loads, bearing capacity, strength.

I. INTRODUCTION

FOUNDATION A foundation is the element of an architectural structure which connects it to the ground, and transfers loads from the structure to the ground. It is a structural part of a building on which a building stands. The foundation transmits and distributes its own load and imposed loads to the soil in such a way that the load-bearing capacity of the foundation bed is not exceeded. The solid ground on which the foundation rests is called foundation bed.

Foundations are generally considered either shallow or deep. Foundation engineering is the application of soil mechanics and rock mechanics (geotechnical engineering) in the design of foundation elements of structures. There are various types of foundation. They can be categorized into following types.

II. TYPES OF FOUNDATION

The different types of foundations used in construction are:

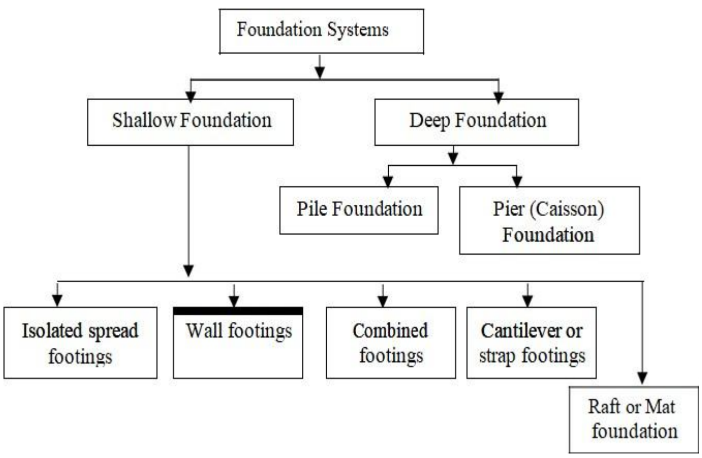

Table-1

<u>Shallow Foundation:</u>

A shallow foundation is a type of foundation that transfers loads to the very near the surface. Shallow foundations typically have a depth to width ratio of less than 1. These are usually located no more than 6 ft. below the lowestfinished floor. A shallow foundation system generally used when the soil close to the ground surface has sufficient bearing capacity and the underlying weaker strata do not result in undue settlement. The shallow foundations are commonly used most economical foundation systems.

The different types of shallow foundations are :

(A) Isolated Spread Footing:Isolated spread footing or individual footing is the most common type of foundation used for building construction. This foundation is constructed for single column and also called as pad foundation. The shape of individual footing is square or rectangle and is used when loads from structure is carried by the columns. Size is calculated based on the load on the column and safe bearing capacity of soil. Rectangular isolated footing is selected when the foundation experiences moments due to eccentricity of loads or due to horizontal forces.

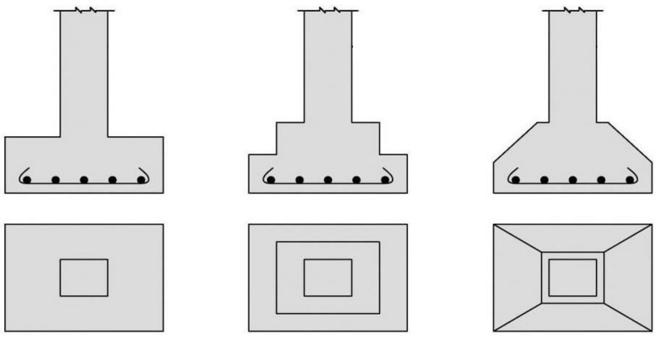

Fig-1: Isolated spread footing

(B) Wall Footing: A wall footing or strip footing or spread footing is a continuous strip of concrete that serves to spread the weight of a load-bearing wall across an area of soil. These footings are those whose base is wider than a typical load bearing wall foundations. The wider base of this footing type spreads the weight from the building structure over more area and provides better stability.

Spread footings are used for individual columns, walls and bridge piers where the bearing soil layer is within 3m from the ground surface. Soil bearing capacity must be sufficient to support the weight of the structure over the base area of the structure. These should not be used on soils where there is any possibility of ground flow of water above bearing layer of soil which may result in scour or liquefaction.

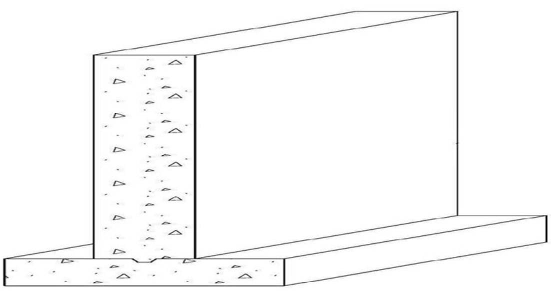

Fig-2: Wall Footing

(C) Combined Footing: Combined footing is constructed when two or more columns are close enough and their isolated footings overlap each other. It supports two or more columns. It is a combination of isolated footings, but their structural design differs.These can be of rectangular or trapezoidal shape.

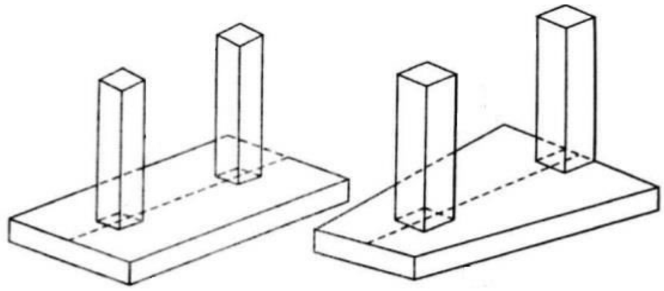

Fig-3: Combined Footing

(D) Strap Footing: A strap footing is a component of a building's foundation. It consists of two or more column footings connected by a concrete beam. This type of beam is called a strap beam. It is used to help distribute the weight of either heavily or eccentrically loaded column footings to adjacent footings

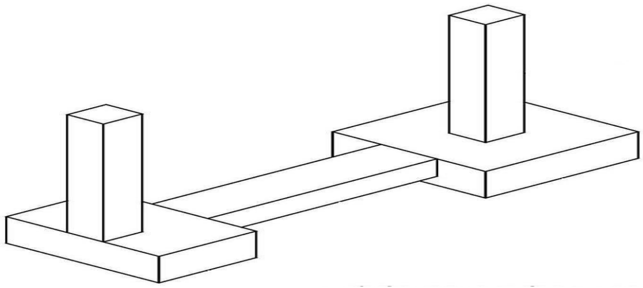

Fig-4: Strap Footing

(E) Raft Foundation: Raft or mat foundations are the types of foundation which are spread across the entire area of the building to support heavy structural loads from columns and walls. The use of mat foundation is for columns and walls foundations where the loads from structure on columns and walls are very high. This is used to prevent differential settlement of individual footings, thus designed as a single mat of the entire load bearing elements of the structure.

It is suitable for expansive soils whose bearing capacity is less for suitability of spread footings and wall footings. Raft foundation is economical when one-half area of the structure is covered with individual footings and wall footings are provided.

These foundations should not be used where the groundwater table is above the bearing surface of the soil. Use of foundation in such conditions may lead to scour and liquefaction.

Fig-5: Raft Foundation

Deep Foundation:

The shallow foundations may not be economical or even possible when the soil bearing capacity near the surface is too low. In those cases deep foundations are used to transfer loads to a stronger layer, which may be located at a significant depth below the ground surface.

Deep foundations are those founding too deeply below the finished ground surface for their base bearing capacity to be affected by surface conditions, this is usually at depths of 3 meter below finished ground-level. Deep foundations can be used to transfer the load to deeper, more competent strata at depth if unsuitable soils are present near the surface.

The different types of deep foundations are –

(A) Pile Foundation:Pile foundation is a type of deep foundation which is used to transfer heavy loads from the structure to hard rock strata much deep below the ground level. Pile foundations are used to transfer heavy loads of structures through columns to hard soil strata which are much below ground level where shallow foundations such as spread footings and mat footings cannot be used. This is also used to prevent uplift of structure due to lateral loads such as earthquake and wind forces.

Pile foundations are generally used for soils where soil conditions near the ground surface is not suitable for heavy loads. The depth of hard rock strata may be 5m to 50m deep from the ground surface. Pile foundation resists the loads from structure by skin friction and by end bearing. Use of pile foundations also prevents differential settlement of foundations.

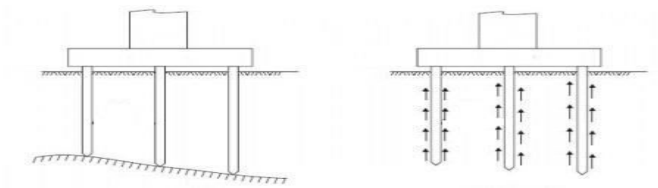

Fig-6: Pile Foundation

(B) Caisson Foundation:Caisson foundation also called as drilled shaft is a type of deep foundation and has action similar to pile foundations discussed above, but are high capacity cast-in-situ foundations. It resists loads from structure through shaft resistance, toe resistance or combination of both of these. The construction of drilled shaft or caisson foundation is done using an auger.

Drilled shafts can transfer column loads larger than pile foundations. It is used where depth of hard strata below ground level is location within 10m to 100m.

Drilled shafts or caisson foundation is not suitable when deep deposit of soft clays and loose, water-bearing granular soils exists. It is also not suitable for soils where caving formations are difficult to stabilize, soils made up of boulders or artesian aquifer exists.

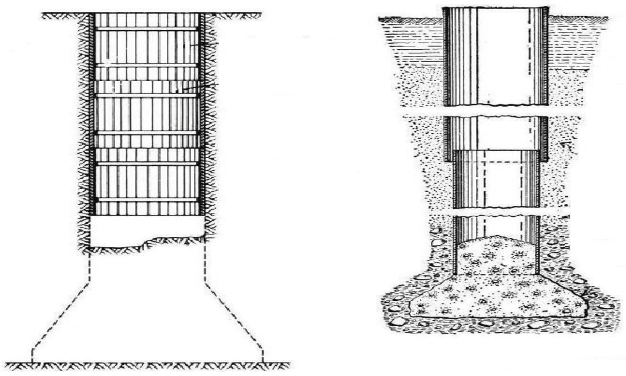

Fig-7: Caisson Foundation

III. LITERATURE REVIEW

Alex B. McBratney, Budiman Minasny and **Raphael Viscarra Rossel** say thatdiffuse reflectance spectroscopy (DRS) is attracting much interest in the soil science community because it has a number of advantages over conventional methods of soil analyses. The techniques are more rapid, timely, cheaper and hence more efficient at obtaining the data when a large number of samples and analysis are required. Moreover, a single spectrum may be used to assess various physical, chemical and biological soil properties. Until now, research in soil spectroscopy has focused on spectral calibration and prediction of soil properties using multivariate statistics. In this paper we show how these predictions may be used in an inference system to predict other important and functional soil properties using pedotransfer functions (PTFs). Thus we propose the use of soil spectral calibration and its predictions as input and as a complement to a soil inference system (SPEC-SINFERS). We demonstrate the implementation of SPECSINFERS with two examples. As a first step, soil mid-infrared (MIR) spectra and partial least squares (PLS) regression are used to estimate soil pH, clay, silt, sand, organic carbon content and cation exchange capacity. A bootstrap method is used to determine the uncertainties of these predictions. These predictions and their uncertainties are then used as input into the inference system, where established PTFs are used to infer (i) soil water content and (ii) soil pH buffering capacity together with their uncertainties. An important feature of SPEC-SINFERS is the propagation of both input and model uncertainties.

P.Bhargavi and**Dr.S.Jyothi** presented a paper which details the application of a genetic programming framework for classification of decision tree of Soil data to classify soil texture. The database contains measurements of soil profile data. They have applied GATree for generating classification decision tree. GATree is a decision tree builder that is based on Genetic Algorithms (GAs). The idea behind it is rather simple but powerful. Instead of using statistic metrics that are biased towards specific trees they use a more flexible, global metric of tree quality that try to optimize accuracy and size. GATree offers some unique features not to be found in any other tree inducers while at the same time it can produce better results for many difficult problems. Experimental results are presented which illustrate the performance of generating best decision tree for classifying soil texture for soil data set.

IV. CASE STUDY

A case study was performed on the construction of the foundation of the railway over bridge which is situated at Ghatkesar. The different pieces of works those are done to complete the construction of the foundation is given below-

Fig-8 Placing of reinforcement bars

Fig-9 : Concrete mixing machine

Fig-10 (a): Placing of concrete

Fig-11 : Hardening of concrete

Fig-12 : Filling of soil

V. SOIL ANALYSIS

Soil analysis is a very important aspect in the planning and execution of civil engineering projects and operations. It helps to classify the soil and to determine the properties like specific gravity, optimum moisture content, bearing capacity etc. of the soil. To analyze the soil a series of tests are performed on the soil. Based on the result of these tests the soil can be classified and the properties of the soil can be determined.

The tests performed on the soil of the construction site of the railway over bridge are-

- **Sieve Analysis**
- **Specific Gravity Test**
- **Standard Proctor Test**
- **CBR Test**

SIEVE ANALYSIS

Soil gradation or sieve analysis is the distribution of particle sizes expressed as a percent of the total dry weight. Gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve.

The sieve analysis is a practice or procedure used in civil engineering to assess the particle size distribution of a granular material. The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common.

NEED AND SCOPE: The results of testing will reflect the condition and characteristics of the aggregate from which the sample is obtained. Therefore, when sampling, it is important to obtain a disturbed representative sample that is representative of the source being tested because the distribution of different grain sizes affects the engineering properties of soil.

APPARATUS REQUIRED:

1. A series of sieve sets ranging from 4.75mm to 75µm (4.75mm, 2.36mm, 1.18mm, 600µm,300µm, 150µm, 75µm)
2.Balance sensitive to ± 0.01g

PROCEDURE Soil passing 4.75mm I.S. Sieve and retained on 75micron I.S. Sieve contains no fines. Those soils can be directly dry sieved rather than wet sieving

Take 500gm of the soil sample after taking representative sample by quartering

1. Conduct sieve analysis using a set of standard sieves as given in the data sheet.
2. The sieving may be done either by hand or by mechanical sieve shaker for 10 minutes.
3. Weigh the material retained on each sieve.
4. The percentage retained on each sieve is calculated on the basis of the total weight of the soil sample taken.
5. From these results the percentage passing through each of the sieves is calculated.
6. Draw the grain size curve for the soil in the semi-logarithmic graph provided.

Wet Sieving: If the soil contains a substantial quantity (say more than 5%) of fine particles, a wet sieve analysis is required. All lumps are broken into individual particles.

1. Take 200gm of oven dried soil sample and soaked with water.
2. If deflocculating is required, 2% calgon solution is used instead of water.
3. The sample is stirred and left for soaking period of at least 1 hour.
4. The slurry is then sieved through 4.75 mm sieve and washed with a jet of water
5. The material retained on the sieve is the gravel fraction, which should be dried in oven and weighed.
6. The material passing through 4.75 mm sieve is sieved through 75 micron sieve.
7. The material is washed until the water filtered becomes clear.
8. The soil retained on 75 micron sieve is collected and dried in oven.
9. It is then sieved through the sieve shaker for ten minutes and retained material on each sieve is collected and weighed.

PERFORMING THE TEST

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Fig-13: Sieve analysis

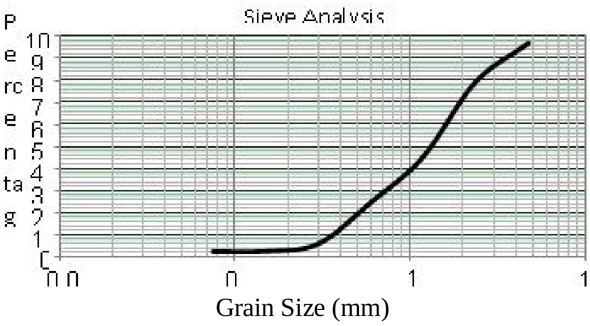
PRESENTATION OF DATA:

SIEVE ANALYSIS

Weight of Sample taken for Sieve Analysis = 500gms.

Sieve Size (mm)	Mass of soil retained (g)	Percentage of mass retained	Cumulative percent retained	Percent finer
4.75	15.7	3.14	3.14	96.86
2.36	88.4	17.68	20.82	79.18
1.18	170.8	34.16	54.98	45.02
0.6	101.3	20.26	75.24	24.76
0.3	94.6	18.92	94.16	5.84
0.15	17.2	3.44	97.6	2.4
0.075	0.38	0.076	97.676	2.32
Pan	11.36	2.272	99.948	0.05

Table-2: Sieve analysis



Graph-1: Sieve analysis

CLASSIFICATION OF SOIL:

Coarse soils	Gravel (G)	80mm-4.75mm
	Sand (S)	4.75mm-0.075mm
Fine soils	Silt (M)	0.075mm-0.002mm
	Clay (C)	<0.002mm

Table-2

Soil passing 0.075mm Sieve	Soil Type
< 5%	GW, GP, SW, SP
5%-12%	GW-GM, SP-SC
>12%	GM, GC, SM, SC

From the graph: $D_{10} = 0.39$, D_{30} $D_{60} = 1.7$

Coefficient of uniformity, $C_u = D_{60}/D_{10}$

$= 4.35$

Coefficient of curvature, $C_c = (D_{30})^2/D_{10}xD_{60}$

$= 0.69$

- Since most of the soil particles are in the range of 4.75mm to 0.075mm, it is clearly sandy soil.
- Soil passing 0.075mm sieve is 2.324% which is less than 5%. So it is GW, GP, SW or SP.

Hence the soil is '**Poorly graded sandy type soil**'

SPECIFIC GRAVITY TEST Specific gravity is the ratio of the mass of a given volume of solid or liquid to the mass of an equal volume of water at a specified temperature, commonly 4°C (39°F).

The specific gravity of a soil is the ratio of the mass of a given volume of the material at a stated temperature to the mass of an equal volume of de-aired or gas-free distilled water at a stated temperature. The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil.

NEED AND SCOPE: The specific gravity of a soil is used in relating a weight of soil to its volume and in calculation of phase relationship, i.e. the relative volume of solids to water and air in a given volume soil. The specific gravity is used in the computations of most of the laboratory tests, and is needed in nearly all pressure, settlement, and stability problems in soil engineering.

APPARATUS REQUIRED:

Specific gravity- glass bottle of 50 ml capacity with a fitted glass stopper
Stopper - glass with small hole through center to permit emission of air and water
Balance - 0.001 g sensitivity
Oven - capable of 1100C
Thermometer
Funnel
Sand bath for heating

PROCEDURE:

First weigh 'W1' the specific gravity bottle.

Transfer the oven dried soil sample to the specific gravity bottle (about 50gm when the 250ml volumetric flask is used, about10-20gm when 50cc stoppered bottle is used or 100gm when 500ml pyconometer is used).

Weigh the bottle 'W2' again with the soil.

Add distilled water to fill the bottle to fill about three fourths. Remove the entrapped air either by subjecting the contents to a partial vacuum or by boiling gently in a sand-bath till the air bubbles cease to appear while occasionally rolling the bottle to assist in removal of air.

Then cool to room temperature and fill the bottle with distilled water up to the mark and clean and dry the outside surface with a clean, dry cloth and note down the temperature.

Determine the weight of the bottle with water and soil, 'W3'. Then remove the soil and water from the bottle and clean it. Again weigh 'W4' after filling with distilled water up to the mark and drying outside.

From data obtained determine specific gravity of the soil.

PERFORMING THE TEST:

Fig-14: Specific gravity test

VI. TABULATION AND RESULTS:

SL. No	Data	Weight (kg)
1	Empty bottle (W_1)	0.65
2	Bottle + soil (W_2)	1.15
3	Bottle + soil +water (W_3)	1.85
4	Bottle + water (W_4)	1.55

Table-3: Specific gravity test

Specific gravity, G = $(W_2-W_1) / (W_2-W_1)-(W_3-W_4)$
= (1.15-0.65) / (1.15-0.65)-(1.85-1.55)
= 2.5

RESULT:

The specific gravity of the soil is 2.5

ANALYSIS

TYPE-I FOUNDATION

i) Check for bending:

Mu lim = 0.138fcklD2
$= 0.138 \times 25 \times 7500 \times (2000)^2$
$= 10.35 \times 10^{10}$ N-mm
$M_u = q_u l(l-d)^2/8$

= 0.906 x 7500 x (7500 – 2000)^2/8
= 6795 x (5500)^2/8
= 2.56 x 10^{10} N-mm

Here, $M_{u\ lim} > M_u$

Hence, provided depth is sufficient.

ii) Check for shear: As per IS code, perimeter of critical section,

= 4 (d + D)
= 4(2000 + 2000)
= 16000 mm

Area of critical section = perimeter x depth
= 16000 x 2000

Shear stress = Upward pressure/Area of critical section
= 0.906x{(7500x7500)-(3000x3000)}/16000x2000
= 1.23 N/mm^2

According to IS code maximum permitted shear stress
= $0.25\sqrt{fck}$
= 0.25x√25
= 1.25 N/mm^2

So, Shear stress < maximum permitted shear stress,
Hence provided depth of footing is sufficient.

6.2 TYPE-II FOUNDATION

i) Check for bending:

Mu lim = 0.138fcklD2
= 0.138 x 25 x 6500 x (2000)^2
= 8.97 x 10^{10} N-mm

$M_u = q_u l(l-d)^2/8$
= 0.887 x 6500 x (6500 – 2000)^2/8
= 5765.5 x (4500)^2/8
= 1.45 x 10^{10} N-mm

Here, $M_{u\ lim} > M_u$

Hence, provided depth is sufficient.

ii) Check for shear: As per IS code, perimeter of critical section,

= 4 (d + D)
= 4(2000 + 2000)
= 16000 mm

Area of critical section = perimeter x depth
= 16000 x 2000

Shear stress = Upward pressure/Area of critical section
= 0.887x{(6500x6500)-(3000x3000)}/16000x2000
= 0.92 N/mm^2

According to IS code maximum permitted shear stress
= $0.25\sqrt{fck}$
= 0.25x√25
= 1.25 N/mm^2

= 1.25 N/mm^2

So, Shear stress < maximum permitted shear stress

Hence, provided depth of footing is sufficient.

VII. CONCLUSION

The following conclusions are drawn from the test results, design and analysis of this project work:

- The soil of the construction site is a “Poorly graded sandy type soil”.
- The specific gravity of the soil is 2.5.
- The optimum moisture content of the soil for maximum dry density of 1.89g/cc is 8.3%.
- CBR value of the soil for un-soaked condition is 11.92 % and after 3 days of soaking is 9.56 %.
- The foundation constructed for the over bridge is a shallow type foundation. A raft foundation is used due to heavy load.
- There two types of foundations are constructed due to variance of load. The type-I foundation has a size of 7.5m x 7.5m. The type-II foundation has a size of 6.5m x 6.5m. Both the foundations have depth of 2m.

REFERENCE

[1] “Soil Sampling and Method of Analysis” by **M. R. Carter** and **E. G. Gregorich.**

[2] “Spectral soil analysis and inference systems: A powerful combination for solving the soil data crisis” by **Alex B. McBratney, Budiman Minasny, Raphael Viscarra Rossel**.

[3] “Analysis and Design of Railway Over Bridge at Kumaranellur” by **Prof. Ancy Joseph, Elsa Babu, Karthika Babu, Lakshmi G** and **Meera R Krishna.**

[4] “DESIGN AND CONSTRUCTION OF MAT FOUNDATIONS” by **Lawrence D. Johnson** and **Geotechnical Laboratory.**

[5] Indian standard code 800, for steel structures.

[6] Indian standard code of practise for plain and reinforced concrete, IS 456:2000, bureau of Indian standards, New Delhi.