iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** II **Month of publication:** February 2020

DOI: http://doi.org/10.22214/ijraset.2020.2065

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

Comparison of Substructure's Seismic Stability with the Change in Underlying Soil Parameters

Dr. A. R. Gupta[1], Ms. Poonam V. Sarode[2]
[1, 2]*Department of Civil Engineering M.E Struct. Engg., COET, Akola.*

Abstract: There are different types of soil are found on the earth (i.e. Sand, Silt, Clay, Loamy). In Civil Engineering aspects, each type of soil have some trouble due to which the foundation may get failed or damaged. The possibility of good construction sites to build structures on different types of soils are difficult due to their poor strength, deformation characteristics and water holding capacity. The footing having some external loading is analyzed and designed for various soil types (Sand, Silt, Clay, Loamy). Then the changes in the pressure for various soils are determined and studied. This study discussed the properties of various soils (Sand, Silt, Clay), effect of these soils on structures and covers the guidelines to construct the structure in these types of soils.

Keywords: Various Soils, Properties, Foundation, Suitability.

I. INTRODUCTION

A. Aim

To study about Substructure's Seismic Stability With the Change in Underlying Soil Parameters.

B. Objective

The study aims at removing the possibility of failure of foundation by tilting, overturning and sliding due to pressure imposed on soil by foundation being in excess of the ultimate capacity of the soil. The purpose to carry the above mentioned project is:

1) To study the soil construction property.
2) To study the types and function of footing.
3) To study seismic analysis methods.
4) To study effect of seismic forces on footing with change in underlying soil.

C. Need

Superstructure loads are transmitted to the underlying soil strata through a suitably designed foundation. Therefore, the foundation of a structure is considered the most crucial structural element in a building. Each type of soil such as silt, sand, clay, loamy, black cotton having the effects on foundation like porosity, swell and shrink, lack of drainage, water holding capacity, etc. Thus because of these effects, foundation may get fail or having some major or minor defects. Hence, to overcome or to reduced these effects, it is very necessary to analyze the safety and stability of the foundation.

II. LITERATURE REVIEW

B. Ravi Sankar, et. al (1) Design the isolated footing for cohesive & non-cohesive types of soil for same type of building and try to find which soil is economical & reduced the cost of construction of building by using standard penetration test and finally concluded that, size of isolated footing in cohesive soil is nearly two times more than in non-cohesive soil. Also in cohesive soil the isolated footing is not advisable & more costlier than that of non-cohesive soil. So in cohesive soil pile grouping, well foundation are more suitable than other types of foundation.

Tarun Tiwari, (2) Studied on the effect of soil type for evaluating the seismic performance of footing. By using software STAAD PRO, finding the better technique to make the sensitivity of footing rested on different soil type and finally stated that, soil type which are available at foundation site effects the stability of foundation when subjected to earthquake waves.

Prof. A. R. Gupta, et. al (3) Stated that, it is difficult to construct the structure in black cotton soil because of their poor strength and deformation characteristics. Thus, after discussing on the properties and effect of black cotton soil it is concluded that, under-reamed pile foundation & mat foundation is the safest and economical option to construct the foundation in black cotton soil.

Samridhi Singh, et. al (4) Studied the effect of earthquake on different types of foundation such as shallow, mat/raft, pile & structure like gravity dam, arch dam, etc. and provide few ways to overcome the losses during earthquake. The main aim is that, to protect the life of common man from dangerous effect of earthquake.

Komal Bedi, et. al (5) Studied on bearing capacity & settlement of isolated footing for various shape(i.e. square, rectangular, triangular, circular, octagonal, hexagonal, etc.) and stated that, square footing shows the better load settlement behavior for a given settlement indicating higher load carrying capacity.

III. DETAILED STUDY

A. *What is soil?*

Soil can be defined as the organic and inorganic materials on the surface of the earth that provide the medium for plant growth. For the formation of soil, it takes around hundreds to thousands of years. The soil is usually generated when rocks break up into their constituent parts. When a range of different forces acts on the rocks, they break into smaller parts to form the soil. These forces also include the impact of wind, water and the reaction from salts. Soil develops slowly over the time. It varies due to its structure and composition.

1) *Classification of Soils*
a) Organic Soil: Come from living material such as plant and animal remains.
b) Mineral Soil: Come from rocks and other non-living materials.
2) *Functions of Soils*
a) Soils serve as media for growth of all kinds of plants.
b) Soils modify the atmosphere by absorbing gases (carbon dioxide, methane, water vapor, and the like) and dust.
c) Soils absorb, hold, release, alter, and purify most of the water in terrestrial systems.
d) Soils serve as engineering media for construction of foundations, roadways, dams and buildings, and preserve or destroy artifacts of human endeavors.
e) Soils act as a living filter to clean water before it moves into an aquifer.

B. *Properties of Soils*

All soils contain mineral particles, organic matter, water and air. The combinations of these determine the soil's properties such are:

Type of soil	Sand	Silt	Clay
Properties			
1. Color	Light Brown	Beige to Black	White to dull grey
2. Size	0.05-2.0 mm	0.002- 0.05 mm	Less than 0.002 mm
3. Specific Gravity	2.65-2.67	2.67-2.70	2.70-2.80
4. Cohesive Strength	0.5-2 Kpa	75 Kpa	10-100Kpa
5. Angle of internal Friction	30-40	26-35	20
6. Density	1800 kg/m^3	2100 kg/m^3	1900 kg/m^3
7. Porosity	20-35 %	35-50 %	33-60 %
8. Permeability	5.0 cm/hr	0.25 cm/hr	0.8 cm/hr
9. Unit Weight	16 kN/m^3	20 kN/m^3	18 kN/m^3
10. Bearing Capacity	100-300 Kpa	Less than 75 Kpa	75-180 Kpa

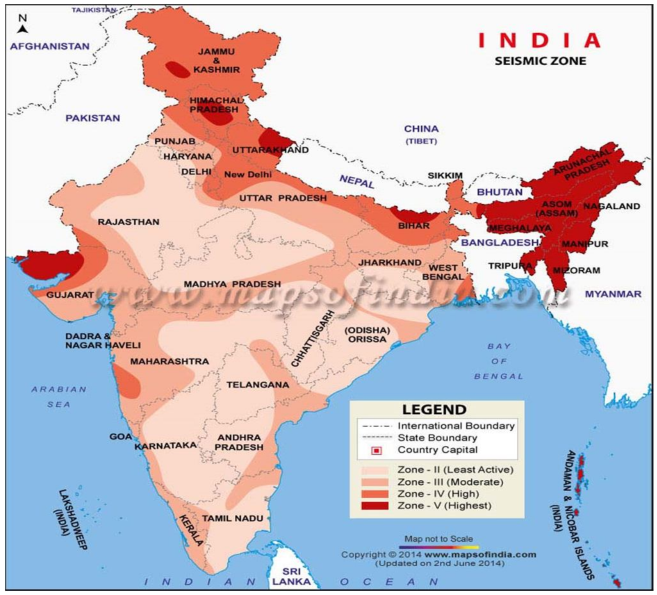
C. *Soil Texture Classification According To Their Size*

Soil Type	Diameter of Soil(mm)
Gravel	> 2 mm
Sand	0.05-2 mm
➢ Very coarse	1-2 mm
➢ Coarse	0.5-1 mm
➢ Medium	0.25-0.5 mm
➢ Fine	0.1-0.25 mm
➢ Very fine	0.05-0.1 mm
Silt	0.002-0.05 mm
Clay	< 0.002 mm(< 2 micrometer)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

D. Seismology of India

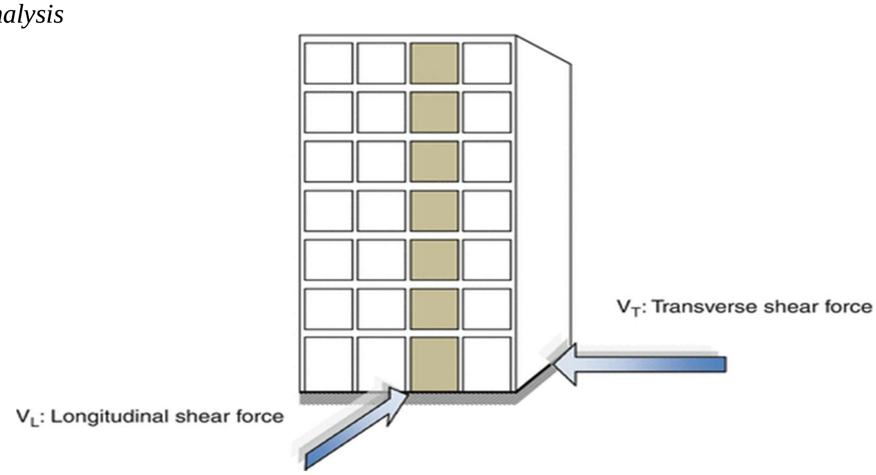
In India, the country has been divided into 4 zones. Earlier there were 5 zones however after Bhuj Earthquake of 2001, the zone I have been eliminated. Each country in the world has such zoning for all such natural disasters. India is divided into 4 seismic zones i.e. Zones II, III, IV and V. These zones are divided on the basis of Maximum Considered Earthquake and service life of structure in each seismic zone.



Sr. No.	Zone Type	Zone Factor	Name of Zone	Effect by an Earthquake	Come Under Regions
1.	Zone V	0.36	Very High Damage Risk Zone	Highest Risk	Rann of Kutch, Eastern Regions
2.	Zone IV	0.24	High Damage Risk Zone	Lesser Risk	Northern Regions, North Eastern Regions, Delhi
3.	Zone III	0.16	Moderate Damage Risk Zone	Lesser Risk	Some part of Gujrat, Maharashtra
4.	Zone II	0.10	Low Damage Risk Zone	Least Risk	Larger Part of India

E. Structural Analysis Method

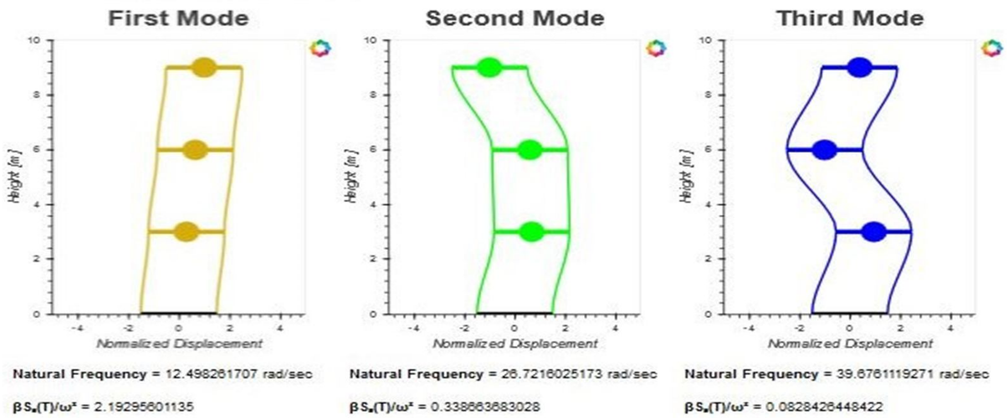
1) Equivalent Static Analysis



The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes.

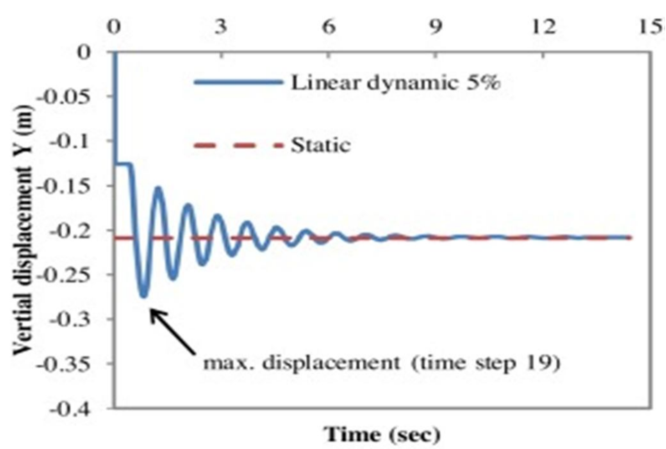
This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. The total applied seismic force *V* is generally evaluated in two horizontal directions parallel to the main axes of the building as shown in fig. It assumes that the building responds in its fundamental lateral mode. For this to be true, the building must be low rise and must not twist significantly when the ground moves. The structure must be able to resist effects caused by seismic forces in either direction, but not in both directions simultaneously.

2) Response Spectrum Analysis



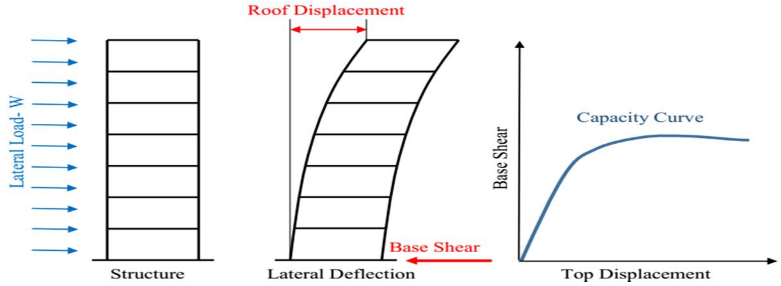
This approach permits the multiple modes of response of a building to be taken into account. This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building.

3) Linear Dynamic Analysis



Static procedures are appropriate when higher mode effects are not significant. This is generally true for short, regular buildings. Therefore, for tall buildings, buildings with torsional irregularities, or non-orthogonal systems, a dynamic procedure is required. In the linear dynamic procedure, the building is modeled as a multi-degree-of-freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix. The advantage of these linear dynamic procedures with respect to linear static procedures is that higher modes can be considered. However, they are based on linear elastic response and hence the applicability decreases with increasing nonlinear behavior. In linear dynamic analysis, the response of the structure to ground motion is calculated in the time domain, and all phase information is therefore maintained. Only linear properties are assumed.

4) Non linear Static Analysis



This approach is also known as "pushover" analysis. A pattern of forces is applied to a structural model that includes non-linear properties (such as steel yield), and the total force is plotted against a reference displacement to define a capacity curve. This can then be combined with a demand curve (typically in the form of an acceleration-displacement response spectrum (ADRS)). This essentially reduces the problem to a single degree of freedom (SDOF) system. Nonlinear static procedures use equivalent SDOF structural models and represent seismic ground motion with response spectra. Story drifts and component actions are related subsequently to the global demand parameter by the pushover or capacity curves that are the basis of the non-linear static procedures.

5) Non linear Dynamic Analysis: In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous, and is required by some building codes for buildings of unusual configuration or of special importance. However, the calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input; therefore, several analyses are required using different ground motion records to achieve a reliable estimation of the probabilistic distribution of structural response. Since the properties of the seismic response depend on the intensity, or severity, of the seismic shaking, a comprehensive assessment calls for numerous nonlinear dynamic analyses at various levels of intensity to represent different possible earthquake scenarios.

F. Various Loads Acting On Structure Under Seismology And Their Combinations

In general the loads and forces that may act upon foundation directly or by the superstructures are going to be discussed below:

1) Dead Load
2) Live Load
3) Seismic Load
4) Wind Load
5) Snow Load

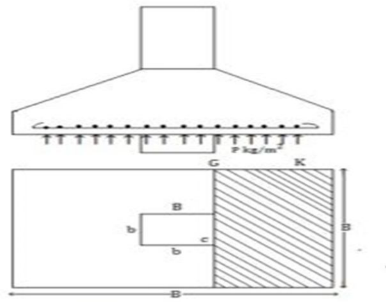
It's our duty to design a safe and serviceable structure and in order to do so we must predict the magnitudes of various loads that are likely to be applied to the substructure or superstructure over its lifetime. Hence to account for the probability of the simultaneous application of various load types, several load combinations are applied on the structure. These load combinations can be created by selecting the Indian code and also with the help of auto load combinations where they are generated by the software.

Load combinations provide the basic set of building load conditions that should be considered by the designer.

a) 1.5(DL+LL)
b) 1.2(DL+LL+EQX)
c) 1.2(DL+LL+EQZ)
d) 1.5(DL+EQX)
e) 1.5(DL+EQZ)
f) 1.5(DL + WLX)
g) 1.5(DL + WL Z)
h) 0.9DL+1.5EQX
i) 0.9DL+1.5EQZ
j) 0.8DL +0.9 SL
k) DL + 1.2 LL+1.2 SL
l) 1.2 DL + 1.2 LL +1.2 WL
m) XIII1.2 DL + 1.2 LL +1.2 WL+ 1.2 SL

G. Seismic Consideration for Footing

Footings are an important part of foundation construction. They are typically made of concrete with rebar reinforcement that has been poured into an excavated trench. The purpose of footings is to support the foundation and prevent settling. Footings are especially important in areas with troublesome soils. The dimensions of footings are depend on the size and type of structure that will be built. Concrete footings may also be needed for projects such as a deck, pergola, retaining wall or other types of construction. The choice of suitable type of footing for a structure depends on the depth at which the bearing strata lies, the soil condition, and the type of superstructure.



Isolated Column Footing

Lateral loads or overturning moments result in a non-uniform soil bearing pressure under the footing, where the soil bearing pressure is larger on one side of the footing than the other. If the lateral loads and overturning moments are small in proportion to the vertical loads, then the entire bottom of the footing is in compression and a P/A ± M/S type of analysis is appropriate for calculating the soil bearing pressures. Due to earthquake or wind loading, the line of action of total load from the superstructure does not pass through the centre of gravity of the footing resulting in eccentric loading.

So that, when only vertical load is their on footing i.e. when axial load is acted, the forces only in y direction is to be noticed but when their is lateral load and overturning moment along with vertical load acted at a time, the forces Fx, Fy, Fz and moments Mx, My, Mz is their on footing.

H. Steps for RC Structure Design

There are various steps to design the RC structure to make it durable and providing the safety against different failure.

1) Determining size of footing
2) Two way shear
3) Design of flexure
4) Check for one way shear
5) Check for development length

I. Manual Design of Isolated FOOTING

Design an isolated footing for an R.C. column of size 450 mm x 450 mm which carries a vertical load of 1000 kN together with an uniaxial moment of 100 kN-m. The safe bearing capacity of soil is 300 KN/ m^2. Use M30 concrete and Fe 415 steel.

Solution

1) Step 1: Determining size of footing

Loads on footing consists of load from column, self weight of footing and weight of soil above footing. For simplicity, self weight of footing and weight of soil on footing is considered as 10 to 15% of the vertical load.

Load on column = 1000 kN

Extra load at 10% of load due to self weight of soil = 1000 x 10% = 100kN

Therefore, total load(P) = 1000+100 = 1100 kN.

Size of footing to be designed can be square, rectangular or circular in plan. Here we will consider square isolated footing.

Therefore, length of footing (L) = Width of footing (B)

Therefore area of footing required = $\frac{P}{SBC}$ = 1100/300 = 3.67 m^2

Provide Length and width of footing = 2m

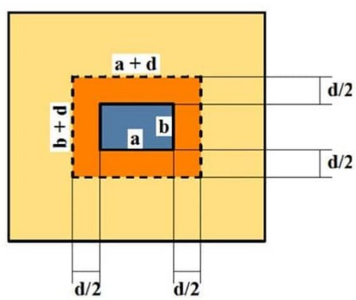
Area of footing = 2 x 2 = $4m^2$

Now the pressure on isolated footing is calculated as:

$$\frac{P}{A} \pm \frac{M_y}{Z_y} \pm \frac{M_z}{Z_z}$$

When calculated, Pmax = 325 kN/m^2
Pmin = 175 kN/m^2
But Pmax is greater than SBC of soil, so we need to revise the size of footing so that Pmax is below 300 kN/m^2.
Consider width and length of footing = L =B =2.25m
Now, Pmax = 250.21 kN/ m^2 (<300 kN/m2 -> OK)
and Pmin = 144.86 kN/m^2 > 0 (OK)
Hence, factored upward pressure of soil = Pumax = 250.21 x 1.5=375.315kN/m^2
Pumin = 250.21 x 1.5= 217.29 kN/m^2
Further, average pressure at the center of the footing is given by
Pu,avg= 296.3 kN/m^2
and, factored load, Pu= 1500 kN, factored uniaxial moment, Mu= 150 kN-m.

2) Step 2: Two way shear
Assume an uniform overall thickness of footing, D =500 mm
Assuming 16 mm diameter bars for main steel, effective depth of footing 'd' is
d = 500 – 50 – 8 = 452 mm
The critical section for the two way shear or punching shear occurs at a distance of d/2 from the face of the column (Fig.5.5), where a and b are the dimensions of the column



Hence, punching area of footing = (a + d)^2 = (0.45 + 0.442)^2 = 0.796 m^2
Where, a = b = side of column
Punching shear force = Factored load – (Factored average pressure x punching area of footing)
= 1500 – (296.3 x 0.0.796)
= 1264.245 kN
Perimeter along the critical section = 4 (a+d) = 4 (450+ 442) = 3568 mm

Therefore, nominal shear stress in punching or punching shear stress ζ_V is calculated as below:

ζ_V = Punching shear force/ perimeter x effective thickness
= 1264.245 x 1000/(3568×442) = 0.802 N/mm^2

Allowable shear stress = $k_S \cdot \zeta_C$

where $\zeta_C = 0.25\sqrt{f_{ck}}$ = 1.369 N/mm^2

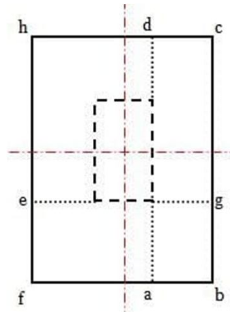
$k_s = (0.5 + \beta_C)_= 0.5 + \frac{0.45}{0.45}$ =1

therefore, allowable shear stress = 1×1.369 = 1.369 N/mm^2
Since, the punching shear stress (0.802 N/mm2) is less than the allowable shear stress (1.369 N/m m^2), the assumed thickness is sufficient to resist the punching shear force. Hence, the assumed thickness of footing D = 500 mm is sufficient. So, we will continue to use D = 500mm.

3) Step 3: Design for flexure

The critical section for flexure occurs at the face of the column.

The projection of footing beyond the column face is treated as a cantilever slab subjected to factored upward pressure of soil.



Factored maximum upward pressure of soil, Pumax= 375.315 kN/m2

Factored upward pressure of soil at critical section, Pu= 312.1 kN/m2

Projection of footing beyond the column face, l = (2250 – 450)/2 = 900 mm

Bending moment at the critical section in the footing is given by:

Mu = Total force X Distance from the critical section

Considering uniform soil pressure of 375.315, Mu = 180 kN/m^2

$$\frac{M_u}{bd^2} = 0.92$$

from SP 16, percentage of reinforcement can be found for M30 concrete, fe415 steel for above $\frac{M_u}{bd^2} =$ pt = 0.265%

Ast = pt x bxd

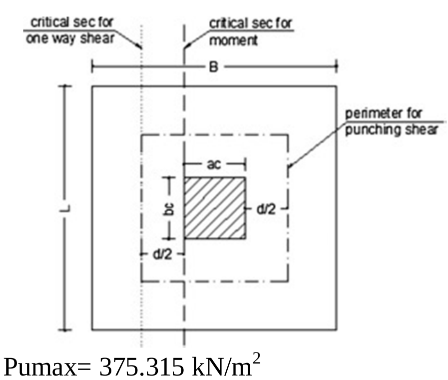
considering 1m wide footing, Ast required = 1171.1 mm^2/ m width

Provide 16 dia bar @ 140mm c/c

Repeat this exercise for other direction as well. Since, uniform base pressure is assumed, and it is a square footing, Mu and Ast for other direction will be same.

4) Step 4: Check for One-Way Shear

The critical section for one way shear occurs at a distance of 'd' from the face of the column.



Factored maximum upward pressure of soil, Pumax= 375.315 kN/m^2

Factored upward pressure of soil at critical section, Pu= 375.315 kN/m^2

For the cantilever slab, total Shear Force along critical section considering the entire width B is

Vu = Total Force X (l – d) X B

= 375.315 X (0.9 – 0.442) X 2 = 343.8 kN

Nominal shear stress = Vu/(Bxd) = 0.346 N/mm^2

For, pt = 0.265, and M30, allowable shear force from Table – 19, IS 456:2000, is greater than 0.346 N/mm^2

Therefore, the foundation is safe in one-way shear.

5) *Step 5:* Check for development length

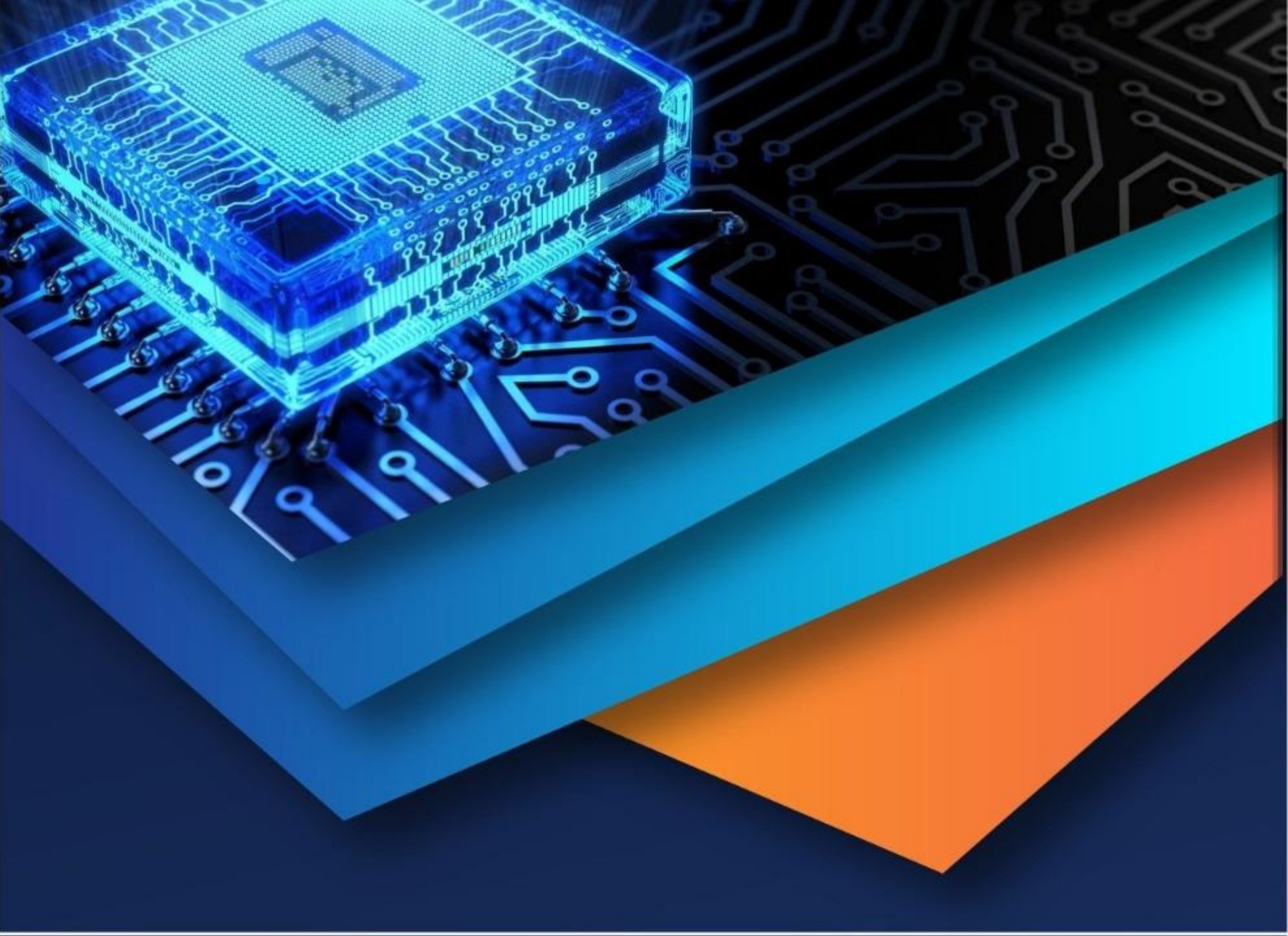
Sufficient development length should be available for the reinforcement from the critical section.
Here, the critical section considered for Ld is that of flexure.
The development length for 16 mm diameter bars is given by
Ld= 47 x diameter of bar = 47 x 16 = 752 mm.
Providing 60 mm side cover, the total length available from the critical section is
0.5x(L – a) – 60 = 0.5x(2250 – 450) – 60 = 840 > Ld, Hence O.K.

IV. CONCLUSION

From the study done in the seminar and literature review it can be seen that, the various points are shown to reduced the bad effects on footing for different soils. Behavior of footing during seismicity are also studied in this seminar. Also the study of various codes are carried out for design of footing in different types of soil and for changes in parameter of various soils. Finally, it can be concluded that, the behavior of structure subjected to static or dynamic forces change rapidly with the change in soil properties and thus it is necessary to find out the response of building with the change in soil properties.

REFERENCE

[1] B. Ravi Sankar, Dr. D. S. V. Prasad, Dr. GVR Prasada Raju “Designing an Isolated Footing in Cohesive and Non-cohesive Soils” IOSR Journal of Mechanical and Civil Engineering(IOSR-JMCE), ISSN: 2278-1684, Vol-13, Issue-01, Pp. 68-71, Jan-Feb 2016.
[2] Tarun Tiwari “The Effect of Soil Type on Isolated Footing During Earthquake” IJNRD, ISSN: 2456-4184, Vol-02, Issue-06, June 2017.
[3] Prof. A. R. Gupta, Ms. Roochira R. Bobde “Study of Suitable Foundations for Black Cotton Soil” International Journal for Research in Applied Science and Engineering Technology, ISSN: 2321-9653, Vol-07, Issue-05, May 2019.
[4] Samridhi Singh, Faizan Ahmad, Bandita Paikaray “Effects of Earthquake on Foundation” International Journal of Research in Engineering and Technology, Vol-04, Issue-13, Dec 2015.
[5] Shaik Muneer Hussain, Dr. Sunil Kumar Tengli “Study of Tortional Effects of Irregular Buildings under seismic loads” International Journal of Applied Engineering Research, ISSN: 0973-4562, Vol-13, No.7, Pp. 55-60, 2018.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY