RECOMMENDED FIELD INVESTIGATIONS FOR EARTHQUAKE SAFTEY OF LOW, MEDIUM AND HIGH-RISE BUILDINGS IN DIFFERENT SOIL CONDITIONS

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1. INTRODUCTION

Structures are supported by soil or rock at its base, and before construction of any proposed project it is necessary to understand the behavior of its base medium. Stability and strength provided by the soil or rock depends on the load applied by the type of structure at its base. Engineering properties and index properties of the soil are obtained from different soil tests and similarly properties of rocks obtained from rock tests. Depending on the site suitability respective field tests need to be adopted. Overall organization of activities to find the site conditions based on the physical properties of soil or rock together called as geotechnical investigations.

Soil plays one of the important roles during seismic events because of cyclic loading experienced by soil with different frequencies. From some of the past seismic events it is observed that failure of super structure was also due to failure of sub-structure, for not considering the soil at the foundation level as shown in figures 1, 2 & 3. For example, Niigata 1964 earthquake, in which one of the major causes of damage was failure of foundation caused by loss of bearing capacity due to liquefaction of sand or by ground movement where structures were supported by different soil strata [1]. The study of geophysical aspects of the soil at the site are not only useful for the safety of super structure against gravity, but also against the dynamic loading conditions at its base.

Figure 1: Niigata Earthquake 1964

Geotechnical investigations are economical when compared to the additional expenditure required for any unfavorable ground conditions previously undiscovered and found during or after the construction. The cost of site investigation is relatively small, usually less than

Figure 2: Mexico City Earthquake 1985

Figure 3: Kocaeli Earthquake 1999

0.5% of the total cost of the project [2]. Geotechnical investigations are necessary to provide information for structural engineers in design and construction to make a project most cost effective. These site investigations are not economical but also provide safety which is more important aspect of any project.

2. SOIL EXPLORATION TESTS BASED ON STANDARD CODES

IS1892:1979 is the Indian standard code of practice for subsurface investigations for foundations. This code mainly deals with subsurface investigations for foundations of multistoried buildings to determine sequence, extent, nature and engineering properties of each soil stratum for site affected by proposed project [3]. In this code, current methods of subsoil exploration methods are classified based on type of soil formation.

Table 1

S.No	Method	Type of formation
	Reconnaissance Methods	
	i) Geophysical	
1	Electrical resistivity method	Alluvial deposits weathered and fissured rock, buried channels and ground water
2	Seismic refraction method	Do
	ii) Sounding	
3	Standard penetration test	Non – cohesive soils without boulders
	Static cone penetrometer test	Primarily used in cohesive soils
	Dynamic cone penetrometer test	Primarily used in cohesive soils
	Exploratory Methods	
4	Shell and Auger	All types of soils specially soil of mixed type
5	Hand Auger	All soils except sands and gravels above water table
6	Simplified mud boring	Silts and sands or mixed soils especially below water table
7	Wash Boring	Soft to stiff cohesive soils and fine sand except gravel and boulders
8	Percussion drilling	Rocks and soils with boulders, except clay or loose sand
9	Rotary drilling	Rocks, fissured rock and all soils except cobbles and boulders
	i) Explanatory sampling	
10	Open tube sampler and split tube sampler	Cohesive soils and silts
11	Double tube core barrel	Coarse sand and gravels; most suitable for soft rocks like shale and any weathered rock formation.
	Detailed Investigations	
	i) Undisturbed sampling	
12	Thin walled tubes 50 to 125 mm	Soils of medium strength
13	Piston type sampler	Clays and silts
14	Samplers with special core retainers	Do
15	Sand sampler	Sand without boulders
16	Solidification methods	Do
17	Open cuts and trenches	All types of formations
	ii)Bearing capacity tests	
18	Plate load test	Clay and sandy formations
19	Load tests	Rocks
20	Vane shear test	Soft and sensitive clays

Engineering properties of soils are obtained from the field tests mentioned by the code. The capacity of the soil not only depends on type of formation but also depends on proposed project and type of structure. Eurocode 7 [4] also suggests these field tests based on the site requirements.

3. CONCLUSIONS

From past literature study on geotechnical investigations states mainly, the field tests based on type of soils. The ability of the soil to resist loads depends on the type of soil and also on type of structure. Under dynamic loading conditions soil shows the complex behavior [5] so it is very important to consider type of soil while designing structures in seismic zones. Structural design has to consider possible real site conditions, even under dynamic loading conditions. Soil behavior under different loading conditions are given by the field tests proposed by standard codes. All the field tests given in standard codes may not be required for the given site conditions, only specified field tests need to be performed based on proposed project and soil conditions. This paper is mainly on the field tests required for the different height of buildings founded on different type of soils. In this paper, type of soils is considered according to IS 1893 (Part 1):2016. In this code soil has been divided into three types as hard, medium and soft soil mainly based on standard penetration number (N) [6].

Table 2

S. No	Soil Type	Remarks
1	Rock or Hard Soils	N >30
2	Medium or Stiff Soils	10 <N<30
3	Soft Soils	N<10

Mainly three types of buildings are considered in this paper, they are low (5-storey), medium (10-storey) and high-rise (20-storey) buildings. This paper suggests the structural and geotechnical engineers with field tests necessary for low, medium and high-rise buildings founded on hard, medium and soft soils respectively.

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