

Analysis of Foundation Failure in Concrete Structure

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Abstract - Foundations are key element in construction projects. Identification of foundation failures and providing necessary treatment is very important. Many foundation failures are due to inadequate protection to foundation soils, improper geotechnical investigation and design error, improper sequence of construction and water level fluctuation. This paper reviews different causes for distress of foundation and also discusses their solutions to overcome and prevent these failures in consideration with cost. The questionnaire survey was conducted to rate the factors that contribute to the problem/defects of foundation construction and cost effective remedial approach for foundation failure. The questionnaire survey was evaluated by Relative importance index method and analysed by Microsoft Excel.

Key Words: Foundation failure, Distress factor, Cost effective remedial, Relative importance index method.

1. INTRODUCTION

The main function of foundation is to transfer the loads from superstructure to, the underlying soil or rock over a large area at reduced pressure. It serves as an interface between superstructure and substructure. Generally foundations are classified as shallow foundation and deep foundation. A proper design of foundation system requires the following (i) purpose of engineering structures, possible service life loadings, various forms of framing, soil profile, construction approaches, construction costs, and clients/owner's needs (ii) design without affecting environment and enough margin of safety with respect to unexpected events and uncertainty in determination of engineering properties of soil and satisfactory tolerable risk level to all the parties, i.e., public at large, the landlord, and the engineer.

Additional contemplations that should be taken into account vary as per particular requirements and purposes, such as, foundation in extreme climate conditions, foundation on loose soils, foundations for different loading conditions like overturning, sliding or uplift, consideration for future expansion, protection against corrosion or other injurious material present in soil, suitability with respect to local environment standards etc. It is well understood that engineering structures even though being constructed with suitable health and safety measures do fail or collapse.

The failure of a structure may be due to poor design, faulty construction, overloads and foundation failure. The failure of foundation tends to the failure of entire structure, loss of life as well as economical problem. There are several factors contributing to the failure of the foundation, if overlooked or addressed unsuitably, such as, design error, improper soil investigation, fluctuation of ground water table, seismic loads, etc.

2. OBJECTIVE

The main Objective of the study is

- ❖ To identify the factor that contributes to the problems/defects of foundation construction field operation.
- ❖ The aim of this research, investigate cost effective remedial approaches for different failure conditions of foundation.
- ❖ The study of safety aspects related to foundation in construction.

3. METHODOLOGY

The Main Objective of the study is

- ❖ Literature study
- ❖ Field investigation
- ❖ Preparation of Questionnaire
- ❖ Questionnaire distribution and collection
- ❖ Data Analysis
- ❖ Results and discussion

The general procedure of this study depends largely on the survey questionnaire which will be collected from the various local building contractors of different places by mail or by online filling Google form. A thorough literature review was initially conducted to identify the factors that contribute to the problem/defects of foundation construction and cost effective remedial approach for different factors.

Questionnaire survey – the data was collected through questionnaire survey delegated to contractors, consultants and clients that involve in management of construction project.

E-mail Survey – the questionnaire will also be sent through email to respective respondents namely contractors, consultants and clients.

3.1 Factor Contributes Problem/Defects Of Foundation

The following factors are the impacts that contribute to the problems/defects of foundation construction in field operation.

- ❖ Load transfer failure
- ❖ Lateral loads
- ❖ Construction error
- ❖ Unequal support
- ❖ Water level Fluctuation
- ❖ Vibration effects
- ❖ Soil condition
- ❖ Inadequate geotechnical investigation and design error
- ❖ Foundation failure due to slope instability
- ❖ Other consideration like atmospheric action and weathering of subsoil due to trees.

3.2 Cost Effective Remedial Approaches For Different Factors

The following factors are the cost effective remedial approach for different failure conditions of foundation construction.

3.2.1 Load Transfer Failure

- ❖ Underpinning using steel piers
- ❖ Underpinning using helical anchors
- ❖ Underpinning using micro piles

3.2.2 Unequal Support

- ❖ Resting the foundation on rigid strata such as rock or hard moorum
- ❖ Proper design of the base footing
- ❖ Limiting the pressure in the soil

3.2.3 Water Level Fluctuation

- ❖ Compaction of wet side of optimum moisture content

- ❖ Control of soil moisture using plastic fabric underneath the foundation
- ❖ Installation of drain layer
- ❖ Installation of footing drainage, sumps & surface drainage work

3.2.4 Soil Condition

- ❖ Transferring the structural loads by designing and constructing deep foundation system
- ❖ Soil stabilization with lime, lime fly ash, Portland cement & bituminous material
- ❖ Pressure grouting
- ❖ Mud jacking
- ❖ Underpinning

3.2.5 Foundation Failure Due To Slope Instability

- ❖ Modifying the geometry of slope
- ❖ Provision of retaining wall
- ❖ Constructing tie backs.

3.3 Safety Measures

- ❖ Proper planning and subsurface investigation
- ❖ Strengthening and stabilizing the foundation of an existing building or other structure
- ❖ Proper analysis and design
- ❖ Construction control and supervision
- ❖ High quality construction
- ❖ Quality control and quality assurance measure instituted by field engineers
- ❖ Monitor – sinkhole formation
- ❖ Control on dewatering and ground water level
- ❖ Providing proper drainage system
- ❖ Modifying the geometry of slope
- ❖ Monitor and control the ground and structural vibration.

4. FIELD INVESTIGATION

The investigation of site is an essential prerequisite to the construction of all civil engineering works with a view to assess the general suitability of the site for the proposed new works and to enable in preparing an adequate economic design. This includes, (i) To know the present construction practice of foundation construction and (ii) To identify the problem with construction.

The factors to be considered in onsite investigation

- ❖ Ground/soil condition
- ❖ Presence of tree roots
- ❖ Ground water level
- ❖ Underground water courses, old drains, pits, wells, old foundation etc.
- ❖ Presence of excessive sulphate or other injurious compound in the ground water and soil.
- ❖ Rainfall Data
- ❖ Seepage



Fig -4.4: Presence of tree roots

4.1 Observations From Field Investigations.

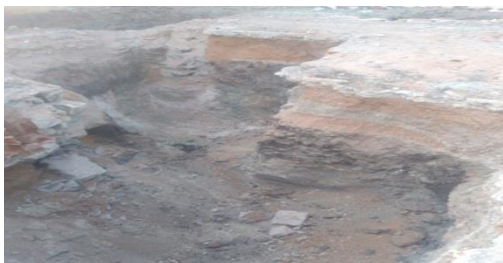


Fig -4.1: Foundation on Rock Stratum



Fig -4.2: Foundation on poor soil (silt/clay)



Fig -4.3: Water logging during excavation

5. ANALYSIS AND EVALUATION

This evaluation of the questionnaire was performed by Excel spreadsheets and Relative importance index method.

5.1 Relative Importance Index Method

The questionnaire survey form was designed to verify the existing methods and process which are related to the project progress monitoring. It is important at an early stage to decide for analyzing method before developing any system of data collection. The collected survey data is analysed using Statistical method. The data were collected by using measurement or Likert scale method. Five scale ranking was used to conclude the severity of influence on project progress monitoring techniques by client, consultant and contractor. This study also uses Relative Importance Index Method to analysis data of survey and explained as follows:

$$\text{Relative Importance Index} = \frac{\sum w}{A \times N}$$

Where,

- W is the weightage given to the factors by respondents. Weightage is given as 1,2,3,4 and 5 for very low, low, medium, high and very high.
- A is the highest weight in the scale and it is given as 5
- N is the total number of respondents

Table-4.2: Ranking for factors about cost effective remedial approach

S.No	Factors	RII	Rank
I	Load Transfer Failure		
1	Underpinning using steel piers	90.37	1
2	Underpinning using helical anchors	59.26	2
3	Underpinning using micro piles	51.85	3
II	Unequal support		

4	Resting the foundation on rigid strata such as rock or hard moorum	84.44	1
5	Proper design of the base footing	67.04	3
6	Limiting the pressure in the soil (loads from the superstructure should be within limits of safe bearing capacity of soil)	78.89	2
III	Water Level Fluctuation		
7	Compaction of wet side of optimum moisture content	88.15	1
8	Control of soil moisture using plastic fabric underneath the foundation	64.81	2
9	Installation of drain layer	53.70	4
10	Installation of footing drainage, sumps & surface drainage work	61.85	3
IV	Soil condition		
11	Transferring the structural loads by designing and constructing deep foundation system	86.30	1
12	Soil stabilization with lime, lime fly ash, Portland cement & bituminous material	82.59	2
13	Pressure Grouting	65.93	4
14	Mud Jacking	60.00	5
15	Underpinning	80.74	3
V	Foundation failure due to slope instability		
16	Modifying the geometry of slope	64.44	1
17	Provision of retaining wall	57.41	2
18	Constructing tie backs	47.04	3

6. CONCLUSIONS

The paper reviewed, the investigation of the present conditions for construction and to identify problems with foundation that occurs at construction field operations. The study of safety aspects related to foundation in construction. The Questionnaire survey was conducted to identify the factors that contribute to the problem/defects of foundation construction and also to find cost effective remedial approach for different failure condition. The questionnaire survey data were evaluated by Relative importance index and analysed by excel spreadsheets.

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