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Need of Safe Zone Mapping in Building Planning and Construction

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Abstract

Earth formation is heterogeneous in nature which changes its lithology, structure and type with special variations. The change may occur even at a very small spatial distance. Thorough scanning of soil layers below proposed foundation of structures is very difficult due to affordability and availability of equipment's/trained manpower. Therefore, uncertainties of soil behaviour cannot be ruled out. These uncertainties sometimes are responsible for part or full failure of building and other structures. Most important part before planning and construction of buildings /structureson any land is to identify the venerability challenging which may affect the long term or short term stability of structures. Such venerable areas should be avoided or proper protective measures should be incorporated during planning stage. The venerable areas may beland slide prone areas, geological fault area, construction site on chemically contaminated soil, filled up soil like construction on municipal dumps or debris,areas prone to flood or Tsunami, expensive soils and marshy lands etc. However, various technologicalreclamation, strengthening and modifying solutions are available but the main issue is to identifythe area specific problemsthrough available, past records and data, site investigation and strategic planning. Underground service lines detection for extension of buildings is also a great task. If, above issues are ignored structures are liable to damage or failure.

Failure of structure may also take place if, the loose fill soil is below the foundation and is not properly stabilized, as during earth quake loose soil may become denser and reduces its volume which create gap below foundation of structures. It may lead to building structure settlement partially of fully. Due to partial settlement tilting or overturning may give rise to fatal accidents. So, it is most essential to find out the safe zone for building construction through various data mining and investigation of the site and nearby vicinity to safeguard the structural stability.

Before planning any heavy structure or high-rise buildings soil behaviour beneath the foundation should be thoroughly studied and investigated, so that building could be designed by addressing the possible challenges. If the soil conditions are not favourable necessary soil improvement techniques should be adopted to stabilize soil and improve its bearing capacity. This paper will highlight the probable problems associated to hazardous aspects to be considered before and during planning the building in any area. Safe zone mappingneed is continuously increasing, because increasing trend of construction of high-rise buildings. High rise structures exert high pressure on the soil which leads to higher risk of failure of structure, if proper protective measures not adopted.

1. Introduction

Buildings are essential part of human settlements like housing, education, health, commercial, sports and industrial etc. Requirement of each building is different from each other and lot of variations are according to purpose, category, affordability, location,

earthquake zones, and climatic regions such as snow bound and cold, temperate, hot and dry, hot and humid.The available site locations could be in landslide prone areas, marshy land, filled up lands. The construction planning and feasibility studies need through investigation of location. The specifications also vary according to budget availability, availability of local materials and trained tradesmen in the region. Though the basic requirements of every structure are entirely different but structural stability, integrity and durability of all type of buildings is of paramount importance, as any failure of structure may lead to many tangible and intangible losses. On the other hand building construction or purchase is a lifetime dream for a common man. To make the dream true, it is most essential to invest in the safest construction projects. Identification and selection of safe and stable site through various technological solutions is much needed for proper planning and design. A few important aspects need to be considered forselections of safe zone for building construction are being discussed in this article.

2. Venerable Areas for Building Projects

1. Areas Subjected to Global Failure

When the steep sloped bed rock is beneath the soil mass and soil mass balance is due to frictional resistance, in such cases if the frictional resistance between bedrock and overlaid soil is reduced due to any reason the soil stability is endangered. It may lead to entire slope failure (global failure). This type of soil failure may be due to the following reasons:

- Due to excessive rainfall and percolation of water up to bed rock which will reduce the frictional resistance between soil and bed rock and frictional balance is disturbed and whole soil mass will slide over the bed rock.
- When the soil mass above steep slope bed rock is fully saturated and structural load is applied or exist over it the liquefaction may take place, which will lead to failure of entire soil mass.
- If the soil mass is partially or fully submerged in water then also there is a risk of entire slope failure.

This type of situation is normally encountered in hilly regions. Such areas are most venerable for construction of any large project. Hence, after proper verification and identification area should be declared unsafe zone for any large construction, asthe structural stability of the heavy structures is questionable. Alternatively, safe zone should be selected for such projects, in order to saveloss of structural damage and fatal cases.

2. Areas of Frequent Avalanche

Some hilly areas are snow bound throughout the year and identification of safe zone is more difficult. In these areas apart from soil stability the stability of snow is a matter of concern. In avalanche snow mass flows down on slope. It compress the air below and produce powerful wind which can blow a house apart, break doors and windows, tears off the roofs etc.. Avalanches strike instantaneously without any warning which can be fatal also. The areas should be identified where frequent avalanche takes place. Before any road and building construction these areas should be avoided. If not possible, the appropriate protective measures should be adopted prior to road and building construction. However, it is still a challenging task and new technologies should be invented to deal with the situation.

3. Areas with High Water Table

The low water table is not much problematic for most of the structures, but high water table could affect the foundation stability of the structures provided appropriate corrective measures are not adopted. Depending on the soil types, depth of water table and seasonal variation in it leads to the following type of problems:

- Construction and waterproofing of basements are difficult, time taking and resources consuming due to difficult construction in water flooded area as the presence of water exists in foundation base. Very skilled, specialised and expert labour / supervisors are needed to accomplish the task. The cost of the project is enhanced tremendously in such areas.
- If, water table rises upto the ground surface, the hydrostatic pressure will additionally exert on foundation, which makes it uneconomical due to large dimensions.
- It leads to humidity concerns, resulting rusting of reinforcement, growth of bacteria and molds,decay of wooden members and saltpetre in structures.
- The construction cost is increased for providing grading, drains and installation of pumps to move water away from the structures. Special paints and sealants could also be used to protect the foundation from the moisture.

4. Areas of Water Resources Scarcity

In dry geographic regions water scarcity is a challenging task to maintain regular supply for different purposes including house hold water uses. A lot of expenditure is involved in developing a systemfor pumping from streams, rivers, canals, open water bodies and recycling of water.Efficient distribution system and rainwater harvesting is also an essential part to reduce loss of surface runoff and increase water availability. Construction water transportation is also costly process in these regions. For saving the curing water chemical curing may be needed, which may not be cost effective. As far as possible, such areas should be avoided during project planning stage, as the cost of construction and living is very high. Project feasibility, need, scope and cost benefit analysis should be properly studied before taking final decision for implementation of any project.

5. Zones with Geological fault

These Zones are most venerable for commissioning any project due to volcanic or seismic activities near the fault line. No design code permits building construction in the fault lines vicinity. Even safely designed buildings as per normal codal provisions may fail under a fault rupture incidence. Construction sites in such areas are unacceptable as it may lead to catastrophic damages. Hence, it is better to avoid these areas for heavy construction projects.

6. High Seismic Tremor Zones

Seismic hazard is one of the most deadly natural hazards on earth. Areas with frequent tremors are considered as significantly threatened areas. The threat from strong shaking may lead to catastrophic damages. To make the structure safe appropriate protective measures are needed. The problem is further enhanced if, it is unstable hilly region. However, various structural design codes to mitigate risk have been developed and are easily available.There remain many factors of concern, such as maintaining quality of material, construction works, and adoption of necessary provisions given in the code. On the other hand extra cost for protective measures is quite high.In case of any lapse unexpected structural damage can take place. Still there is need for finding new, improved materials which can provide cost-effective design and construction solutions. Such areas of for large projects should be selected after careful study by considering all the possible aspects.

7. Landslide Prone Areas

A landslide is the movement of earth, rock mass and debris downwards to a slope. Landslide consists five modes of slope failure: falls, slides ,topples, spreads, and flows. Every landslide has different causes. Landslides can be caused in unstable slopes due to rainfall, snowmelt, water stream erosion, changes in ground water level, earthquakes, volcanic activity, disturbance by human activities, or a combination of the above factors. The stability of slopes should be ascertained during selection of project sites. The cost of works needed for taking slope stability measures is generally very high. As the works related to area protection such as construction of retaining or gabion walls, developing terraces, protecting rain water from entering the soil through networking of properly designed drainage and filling the cracks with suitable grouts. Selection of such areas should be minimized.

8. Areas of High Soil Erosion

The areas where the soil erosion is high (sheet, gully, water or glacial erosion) reduce the depth of foundation slowly-slowly. It weakens the foundation and unequal load distribution may take place. The structures with weak foundations may not be stable. On the other hand water pollution and environmental pollution is also a threat. Project works in such areas needs many protective measures like; soil stabilization, protection of slopes, runoff control etc. As far as possible these areas should be avoided for major projects. However, ground stabilization and other protection techniques are available but the cost of preventive measures is very high. The need of deeper foundation will also enhance the construction cost.

9. Hilly SlopesObstructing Winter Sun toBuildings

Hilly areas are generally very cold in winter season. In order to minimize the cold effect in building structures winter sun plays a vital role. The locations, where the visibility of winter sun is low due to orientations of hilly slopes should be avoided and alternate site should be selected.

10. Areas of Heavy Vibrations

There are many areas where continuously heavy vibrations are observed, these may be due to Some Military Exercise (blasting and bombing), heavy industries, railway lines etc. in the vicinity. These vibrations are harmful for structural stability and health of peoples. In these areas extra precautions in design and execution of the projects is need. Poor workmanship if any may cause heavy damage to structures. Such zones should not be preferred for residential/ commercial building construction projects.

11. Areas of Marshy Land.

Marshy lands are swampy, wet, waterlogged, spongy and muddy. Without strengthening and stabilizing it any building construction is very difficult. The building construction on marsh lands is more costly alsoas compared to normal land areas. The main reason behind it is the huge cost of reclamation and strengthening the area. On the other hand, wellexperienced building construction companies are required for planning and execution of projects in these areas.Due to presence of moisture in soil(even after strengthening the marshy land)option of providing basement has to be surrendered. These areas are not considered safe for any residential project provided all necessary development measures are adopted.

12. Flood Prone Areas

In the flood prone areas thereare always risk of structure damage by tilting, collapse andsubsidence. Lot of measures are needed to make the structure safe. Flood affects different

building parts depending upon flood depth, duration. Uplift force takes place because of soil saturation and additional horizontal force act on the structure created by flood current. In flood prone areas secondary hazards are alsoassociated such as high winds or storms, ground settlement, lightning, slope instability etc. Flood water normallysubmerges buildings and causes various types of damage depending on flood depth, duration and building types. During flood living conditions are disturbed, travelling, getting potable water, transport, maintaining food supply chain, health care etc. are very difficult. The selection of such venerable areas for residential projects should be avoided.

13. **Areas with Limitations**

There are many areas, where many restrictions are applicable as per bye laws of local authorities, government or military installations. Various types of limitations may be like restrictions on height of building,forest reserve areas, areas with restricted entry, not allow the ground water for construction uses. All these restrictions does not allow free hand to designers and construction agencies to work. If possible, some alternative areas for project planning and implementations should be considered.

14. **Unstable Roads(passing through snow avalanche prone areas)**

Topography, hydrology characteristics of soil, erosion, landslides,snow avalanche,wet unstable terrain, and sensitive environments are some reasons for instability of roads.Routing of road should be planned after careful weightage to full range environmental aspects before construction.

3. Technological Options Available for Evaluating Safe Zones

a) Geological Maps

With the advancement of technology and advanced surveying systems many types of geological maps are easily available for example: landslide susceptibility mapping on macro scale 1:50,000, site-specific Landslide Mapping on Micro scale (>1:2000), threshold modelling and landslide early warning system etc. These maps and data associated with them helps in selection of appropriate safe area for project planning and implementation.

b) **Seismic Micro Zone Maps**

Many countries have their own standards for seismic zones and their venerability level generally in form of data and maps. According to seismic zoning map assists one to identify the lowest, moderate and highest hazardous or earthquake prone areas, which makes selection of safe site and planning easier.

c) Metrological maps

Metrological department of each country has long range and short range meteorological data and maps of surface runoff, infiltration, catchment areas, snow and rainfall including intensities and durations, daily and seasonal changes in temperature (minimum and maximum), day light hours etc. Past records of discharge and highest flood level are also provided. So, before planning of any projects these data may help in decision making and determining the various structural safety aspects of structures.

d) Litho-logical Maps

Litho -logy is a science that describes the geochemical, mineralogical, and physical properties of rocks. Rocks play an important role in many processes at the earth surface, especially the fluxes of matter to soils, ecosystems, rivers, and oceans etc. Now a days, litho-logical maps, state wise, country wise and internationally for all areas are available. These maps can help in site selection

and project planning and implementation in any areas. The fault zones and venerability of the area may be easily assessed so that appropriate safety measures may be adopted.

e) Soil Cover Maps

These maps are easily available in each country, which generally denotes the type of soil in different zones. These maps provide different type of soils, such as laterite, mountain, black, red, alluvial, desert, peat, saline and alkaline soils. However, these maps are mostly used in agriculture purpose but helps in site selection for civil engineering works also.

f) Earthquake Zone Maps

These maps provide different seismic zones based on past history of earthquake intensity and duration. These zones are modified with the latest records available and extrapolating the data. After Latur and Usmanabad earth quakes in Maharastra (India) zone I was abolished and merged in zone II. These zones provide helps in site selection for many the projects and necessary protective measures needed in different zones.

g) Aired Area Maps

These maps help in selecting project sites considering, low, medium and high wind areas. Where high wind blows, the chances of erosion and deposition in different areas are enhanced. If there is no option available to choose alternate project site, then appropriate precautions are needed to be adopted.

h) Arial Mapping of Terrain

Areal maps may be created by drone camera or any flying objects locally for detail information of the vicinity. Different type of sensors may be used for mapping different types of information through Arial survey. These maps provide local geotechnical information of the project site, which helps in selection of specifications, procedures and technology to be used.

i) Scanning Soil by Geo-radar or Geophones

These techniques are mostly used to ascertain soil type and variation in soil depth and bed rock layers thickness etc., up to certain depths depending upon the equipment workable range. It can identify the water bearing strata, cavity or cracks also beneath the soil cover.However, scanning entire area is difficult but susceptible areas may be scanned. Buried objects if any, may also be identified. It provides data to help in taking site specific decision.

j) Land Reclamation Techniques

In case, the project site compulsions are to plan and execute project in hazardous areas then appropriate strengthening measured are necessarily should be adoptedlike; Soil Stabilization, Land Slide Control , flood control and protection, drainage improvement, rainwater harvesting, tunnelling, wind breakers, providing earth quake resistant bands etc.

5. Conclusion

Unstable zones are venerable for structural stability of the structures which may lead to fatal accidents. Different type of losses may be avoided by construction of projects in safe zones. It will provide cost effective solutions for long term safety of structures. Inconvenience caused by various damages may be saved. Displacement and reconstruction chances are reduced. Tangible and intangibles losses are minimised. In case, project construction is essential in unsafe zones, the appropriate protective measures should be adopted using appropriate technologies and feasible innovative methods.

6. References

planning, design, construction and maintenance

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