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Decoding the Causes and Probability of Failure In Structures Effect of Seismic Pressure.

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ABSTRACT

Soil liquefaction is a common phenomenon during earthquakes. Its effects on structures are devastating and it occurs in many forms. The mechanism of soil liquefaction is very complicated due to the nature of soil, which renders it difficult to fully understand. Because of the consequences it can bring to structures, soil liquefaction should be an important factor considered in earthquake design, especially for important structures. The present state of liquefaction research indicates that fortunately the above foundation failure can be reduces by adopting some precautions in construction, which should be within the economic means of people in most countries. Liquefaction is major part earthquake which causes foundation failure and lots of life. It is fairly well accepted that earthquakes will continue to occur and cause disasters if wearer not prepared. Assessing earthquake risk and improving engineering strategies to mitigate damages are the only options before us. "Enologists, seismologists and engineers are continuing their efforts to meet the requirements of improved owning map., reliable databases of earthquake processes and their effects better understanding of liquefaction characteristics and construction of foundation

Keywords: Soil Liquefaction, Earthquake, Seismic Effects.

INTRODUCTION (*HEADING 1*)

Foundation failure refers to the structural instability or damage that occurs in the foundation of a building or structure. The foundation is a critical component of any construction, as it provides the necessary support and stability to ensure the integrity and safety of the entire structure. When a foundation fails, it can lead to a range of problems, including structural damage, safety hazards, and costly repairs.

FOUNDATION TYPES

A. *Historic foundation types*

These foundations can be classified as Pad stones, Stone Foundations, Earth fast or Post in Ground Constructions, Rubble Trench foundations.

B. *Modern foundation types*

Nowadays, these foundation types are generally used for construction purposes. These can be classified as Shallow Foundations and Deep foundations.

The objectives and purposes of a foundation are as follows:- A foundation is a structure constructed below the groundlevel to support the load of the weight of the structure aboveit. It gives lateral stability to the structure by providing arigid and even surface for transferring the load. Thefoundation rests on a solid ground, foundation bed. The purposes of the foundation is first, to make the load ofthe structure within the safe bearing capacity by disbursing the load over a large bearing area. Also, preventing lateralmovement of the supporting material, increasing stability of the structure as a whole, and securing firm bed forbuilding operations

WHAT IS FOUNDATION FAILURE?

Foundation failure refers to the condition in which the structural foundation of a building or structure becomes compromised or unable to adequately support the load it was designed for. The foundation of any structure is crucial because it provides stability and distributes the weight of the building evenly to the ground. When a foundation fails, it can result in various structural problems and safety concerns.

Foundation failure can manifest in several ways, including:
1. Settlement: The foundation sinks or settles unevenly into the ground, causing the structure to become uneven or sloped.
2. Heaving: The foundation may heave or rise unevenly due to factors such as soil expansion or frost action, causing structural damage.
3. Cracking: Cracks may appear in the foundation walls or in the building itself. These cracks can widen over time, affecting the structural integrity.
4. Shifting: The foundation may shift horizontally, leading to misalignment of walls, floors, and other structural components.
5. Bowing: Foundation walls may bow inward or outward, often due to pressure from expansive soil or water-related issues.

The Soil Structure Interaction

It is conventionally considered to be beneficial for the seismic response of a structure. The soft soil debris could remarkably extend the occurrence of seismic waves and that increment in natural period of architecture might result to resonance with extended surface vibration period. The perpetual deformity and degradation of soil may further exasperate architectural seismic reaction. When Earthquake excitation happens in a structure, it connects with the foundation and the soil and thus leads to a change in the movement of the ground surface. Soil-Structure Interaction generally can be distinguished into two phenomena: inertial and kinematic interaction. The ground movement due to earthquake results in soil rearrangement which is called as free-field motion. Nevertheless, the foundation fixed into the soil does not ensue the free surface motion. This inefficiency of the foundation in matching the free surface motion causes the kinematic interaction. Contrarily, Inertial interaction is defined as the mass of the superstructure which imparts the mechanical force to the soil leading to the further deformity in the soil. Kinematic effect being more dominant at low level of ground shaking results in the extension of period and increment in the emission damping. Nevertheless, inertial interaction becomes predominant with the commencement of stronger vibration, soil modulus deterioration and soil- pile gaping limit radiation damping causing bending strains and enormous movement fixed near the ground level which results in pile damage earthquake effects on deep and shallow foundations are accounted for by designing them structurally to ensure serviceability and provide necessary strength. Strength considerations primarily involves ensuring that the loads on foundation remain well below the allowable bearing capacity specified under seismic conditions and the serviceability of foundation is ensured by designing the substructure as per the estimated permanent ground deformation. The responses of structures during an earthquake are usually analyzed assuming that the foundations are rigidly fixed at their base. Such analyzation generally anticipates overturning moment at the base that transcends the maximum allowable overturning resistance because gravity force, meaning that a part of mat foundation would occasionally exhilarate during an earthquake. The nonlinear behavior of shallow foundations during excessive amplitude earthquake-induced loading can disperse the seismic energy by the soil yielding mechanism underneath the foundation . The upliftment along with the yielding causes extreme fugitive and enduring deformities such as sliding, rocking and settlement .

Structures that are sufficiently designed opposing thedynamic loads amid an earthquake will have momentous prospect of seismic failure because of enormous perpetual ground movements due to surface fault wreckage. Subsidiaryfractures also adds significantly to the comprehensive devastation due to enormous ground movements, and these are placed at comparatively large distances from the positionof the central element of the fault fracture.

Fig 1 (*Foundation failure caused the collapse of this building in Chautara Sindhupalchowk*)

Foundation failure can occur for various reasons, including:

a. **Soil Conditions:** Inadequate soil compaction, poor drainage, expansive clay soils, or soil erosion can all contribute to foundation problems.
b. **Design or Construction Deficiencies:** Errors or shortcuts in the design and construction of the foundation can lead to structural weaknesses.
c. **Water Issues:** Water infiltration, poor drainage, plumbing leaks, or flooding can damage the foundation.
d. **Environmental Factors:** Natural disasters like earthquakes, floods, or excessive frost can stress and damage foundations.

Foundation failure can have serious consequences, such as structural damage, safety hazards, and reduced property value. Addressing foundation issues often requires the expertise of structural engineers or foundation specialists. Depending on the severity and cause of the failure, repairs may involve foundation underpinning, reinforcement, waterproofing, or even a complete foundation replacement.

Early detection and timely remediation of foundation problems are crucial to prevent further damage and maintain the structural integrity and safety of the building. Regular inspections and maintenance are essential for ensuring the longevity of a building's foundation.

WHAT IS THE WAY OF FOUNDATION FAILURE

Foundation failures can occur for various reasons, and they can manifest in different ways. Here are some common causes and signs of foundation failure:

Causes of Foundation Failures:-

- **Poor Soil Conditions:** The type and condition of the soil upon which a building's foundation is constructed play a significant role in its stability. Issues like expansive clay soils that shrink and swell with moisture changes, loose or poorly compacted soils, or soil erosion can contribute to foundation problems.

Poor soil conditions can indeed be a significant factor contributing to foundation failures. The type and quality of the soil beneath a building's foundation can play a crucial role in its stability and long-term performance. Here are some ways in which poor soil conditions can lead to foundation failures:

1. Expansive Soils: Expansive soils, such as clay soils, have the property of swelling when they absorb moisture and shrinking when they dry out. This cycle of swelling and shrinking can exert tremendous pressure on a foundation, leading to foundation movement and cracking. The uneven movement of the soil can cause differential settlement, where one part of the foundation settles more than another, resulting in an uneven and unstable structure.

2. Poorly Compacted or Loose Soils: Soil that has not been properly compacted during construction or is naturally loose can lead to foundation settlement. These soils lack the necessary density and stability to support the weight of the building, causing it to sink or settle over time.

3. Soil Erosion: Soil erosion, which can occur due to factors like heavy rainfall or inadequate drainage, can undermine the foundation's support. As the soil erodes from beneath the foundation, it can lead to settling or shifting, causing structural issues.

4. High Water Table: A high water table, where the groundwater level is close to the surface, can saturate the soil around the foundation. This can lead to buoyancy forces that push the foundation upward, causing heaving or instability.

5. Poor Drainage: Inadequate drainage systems around a building can result in water accumulating near the foundation. Excess moisture can weaken the soil and lead to foundation damage.

6. Frost Heave: In cold climates, freezing and thawing of the soil can cause frost heave. This process can push the foundation upward, leading to uneven settlement and structural problems.

To address foundation failures caused by poor soil conditions, various solutions may be employed, depending on the specific issues:

1. Foundation Underpinning: Underpinning involves reinforcing the foundation or extending it deeper into stable soil or bedrock to provide additional support.

2. Drainage Improvements: Installing proper drainage systems, such as French drains or sump pumps, can help redirect water away from the foundation.

3. Soil Stabilization: Techniques like soil compaction or the injection of grout or stabilizing materials can improve the load-bearing capacity of unstable soils.

4. Foundation Repair or Replacement: In some cases, damaged foundations may need to be repaired or replaced to restore the structural integrity of the building.

A thorough assessment by a structural engineer or foundation specialist is crucial to identify the specific soil-related issues causing foundation failures and determine the most appropriate remediation measures. Early detection and addressing soil-related problems are essential to prevent further damage to the foundation and the overall structure.

❖ ***Inadequate Design or Construction:***

Mistakes made during the design or construction of the foundation can lead to structural weaknesses. This includes using improper materials, insufficient reinforcement, or not accounting for the building's load-bearing requirements. Inadequate design or construction practices can be a significant factor contributing to foundation failure. When the foundation of a building is not properly designed or constructed, it can lead to structural weaknesses and instability over time. Here are some ways in which inadequate design or construction can result in foundation failures:

1. Improper Material Selection: Using subpar or unsuitable construction materials for the foundation can weaken its structural integrity. For example, using low-quality concrete or insufficient reinforcement can lead to cracks and deterioration.

2. Inadequate Load-Bearing Capacity: If the foundation is not designed to bear the weight of the building adequately, it can result in settlement or sinking, causing structural issues.

3. Insufficient Footings: The size and depth of the footings (the part of the foundation that spreads the building's load to the soil) are critical. Inadequate footing design can lead to uneven settling or heaving.

4. Lack of Proper Reinforcement: Reinforcement, such as rebar or steel mesh, is essential for providing strength and stability to the foundation. Inadequate or improperly installed reinforcement can compromise the foundation's durability.

5. Design Errors: Mistakes or oversights in the architectural and engineering plans for the foundation can lead to structural weaknesses. These errors might include incorrect calculations, poor design choices, or failure to consider soil conditions.

6. Construction Deficiencies: Errors during the construction phase, such as poor workmanship, insufficient compaction of soil, or inadequate curing of concrete, can result in a weak foundation.

7. Failure to Account for Environmental Factors: Foundations must be designed and constructed to withstand the environmental factors of the specific location. Failure to consider factors like earthquakes, frost, or high water tables can lead to foundation problems.

To address foundation failures caused by inadequate design or construction, the following steps may be necessary:

1. Structural Assessment: A thorough structural assessment by a qualified engineer or foundation specialist is essential to identify the specific design or construction deficiencies.

2. Reinforcement or Retrofitting: Depending on the extent of the issues, reinforcement or retrofitting measures may be implemented to strengthen the foundation and address structural weaknesses.

3. Foundation Repair or Replacement: In severe cases, damaged foundations may need to be repaired or replaced to ensure the stability and safety of the building.

4. Preventative Measures: Going forward, it's essential to implement proper design and construction practices when building new structures to prevent future foundation failures.

In summary, inadequate design or construction practices can lead to foundation failures, compromising the stability and safety of a building. Timely intervention, often guided by a structural engineer, is necessary to assess the extent of the problem and determine the appropriate remediation measures. Proper design and construction practices are crucial for ensuring the longevity and integrity of a building's foundation.

WATER AND MOISTURE

Water-related issues can be a major factor in foundation failures. Excessive moisture from heavy rainfall, poor drainage systems, plumbing leaks, or poor waterproofing can weaken the foundation.

Water and moisture-related issues are significant factors that can contribute to foundation failures. Excess moisture can weaken the foundation, compromise its structural integrity, and lead to various problems. Here are some ways in which water and moisture can lead to foundation failures:

1. Poor Drainage: Inadequate drainage systems around a building can allow water to accumulate near the foundation. This excess moisture can saturate the soil and lead to settlement or shifting of the foundation.

2. Plumbing Leaks: Water leaks from plumbing systems, such as pipes or sewer lines, can introduce moisture into the soil beneath the foundation. Over time, this can weaken the soil and cause foundation problems.

3. High Water Table: A high water table, where the groundwater level is close to the surface, can saturate the soil around the foundation. This can create buoyancy forces that push the foundation upward, causing heaving or instability.

4. Surface Water Infiltration: Heavy rainfall or inadequate grading around the building can lead to surface water infiltrating the soil near the foundation. When the soil becomes saturated, it can lose its load-bearing capacity, leading to settlement.

5. Erosion: Soil erosion caused by heavy rain or improper grading can wash away soil from around the foundation, exposing it to additional moisture and undermining its support.

6. Freeze-Thaw Cycles: In cold climates, freeze-thaw cycles can cause moisture in the soil to expand and contract, leading to frost heave, which can push the foundation upward and create structural issues.

7. Hydrostatic Pressure: Excessive moisture in the soil can create hydrostatic pressure against the foundation walls. This pressure can cause cracks, bowing, or inward movement of the foundation walls.

Fig 2 (*Foundation damage due to Surface Water Infiltration*)

POOR MAINTENANCE

Neglecting regular maintenance and repairs can allow minor foundation issues to worsen over time. Cracks in the foundation or walls, for example, can expand and compromise the structural integrity if not addressed promptly.

Poor maintenance is a common cause of foundation failure and can exacerbate other underlying issues. Neglecting routine maintenance and repairs can allow minor foundation problems to escalate into major structural issues. Here's how poor maintenance can lead to foundation failure:

1. Neglected Cracks: Cracks in the foundation, whether due to settling, soil movement, or other factors, can start as small and relatively harmless. However, if left untreated, these cracks can widen over time, compromising the foundation's integrity and potentially leading to structural instability.

2. Blocked Drainage: Gutters, downspouts, and drainage systems around the property are critical for directing water away from the foundation. When these systems become clogged with debris or are not properly maintained, water can accumulate near the foundation, leading to soil saturation, erosion, and potential foundation issues.

3.Failure to Address Plumbing Leaks: Plumbing leaks beneath or near the foundation can introduce moisture into the soil, weakening its load-bearing capacity and causing settlement. Neglecting plumbing repairs can exacerbate moisture-related foundation problems.

4. Lack of Grading and Landscaping Maintenance: Proper grading and landscaping are essential for directing surface water away from the foundation. Over time, neglecting these aspects can lead to erosion, poor drainage, and water infiltration issues that affect the foundation.

5. Vegetation Overgrowth: Trees and large shrubs planted too close to the foundation can draw moisture from the soil, causing it to shrink and potentially lead to settlement. Additionally, invasive tree roots can damage foundation walls if not managed.

6. Ignoring Warning Signs: Foundation problems often manifest through visible signs such as cracks, uneven floors, or doors and windows that no longer operate correctly. Ignoring these warning signs can allow foundation issues to progress, leading to more extensive and costly repairs.

ENVIRONMENTAL FACTORS

Natural disasters like earthquakes, floods, or nearby excavation work can exert external forces on the foundation, leading to damage or failure. Environmental factors can play a significant role in foundation failures. These factors, which are often beyond human control, can exert forces and stresses on a building's foundation, potentially leading to structural problems. Here are some common environmental factors that can contribute to foundation failure:

1. Earthquakes: Earthquakes can subject a building to lateral forces and ground shaking, resulting in foundation movement, settlement, or cracking. Areas near tectonic plate boundaries or fault lines are more susceptible to earthquake-related foundation issues.

2. Floods: Flooding can inundate the soil around a foundation, leading to soil erosion and weakening of the foundation's support. In severe cases, floodwaters can even undermine the foundation or cause buoyant forces, pushing it upward.

3. Freeze-Thaw Cycles: In cold climates, freeze-thaw cycles can cause moisture in the soil to expand and contract, leading to frost heave. This upward pressure can result in foundation movement or damage.

4. High Water Tables: Areas with a high water table, where the groundwater level is close to the surface, can subject foundations to hydrostatic pressure. This pressure can push against foundation walls, leading to cracks or bowing.

5. Soil Types: Different soil types have varying characteristics that can impact foundations differently. For example, expansive clay soils can swell when wet and shrink when dry, leading to foundation movement.

6. Volcanic Activity: In areas with volcanic activity, volcanic ash deposits and lava flows can affect the soil composition and stability, potentially impacting foundation performance.

7. Soil Erosion: Soil erosion due to heavy rainfall or improper land management can lead to the exposure of the foundation's base, making it susceptible to damage.

8. Landslides: In hilly or mountainous regions, landslides can exert extreme forces on foundations, causing settlement or even structural damage.

9. Groundwater Fluctuations: Seasonal changes in groundwater levels can affect the moisture content of the soil around the foundation. Excessive groundwater fluctuations can lead to soil instability and settlement.

10. Sinkholes: In areas prone to sinkholes, sudden collapses of underground cavities can damage foundations and structures built over them.
To mitigate the impact of these environmental factors on foundation failure, builders and engineers in susceptible regions often implement specific construction techniques and design considerations. These may include deep foundation systems, such as piles or piers, to reach stable soil or bedrock, as well as reinforcement and bracing methods to enhance structural resilience in earthquake-prone areas.

Understanding the specific environmental challenges in a region and engineering foundations accordingly is essential for minimizing the risk of foundation failure due to environmental factors. Additionally, regular inspections and maintenance can help detect and address issues before they lead to more severe problems.

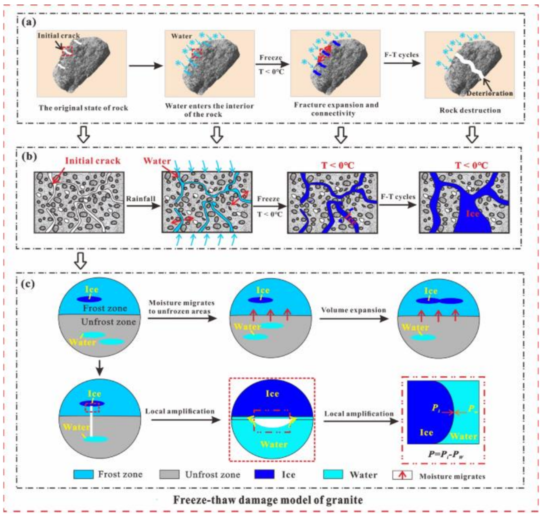

Fig 3 (*Foundation damage due to freeze-thaw cycles*)

Fig 4 (*Foundation damage due to Sinkhole*

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ACKNOWLEDGMENT

The effect of earthquakes on the foundation of different architectural structures is influenced in a number of ways by the nature and the behavior of the soils in the affected area. In spite of modern Engineering technology, the complete structure may collapse in an earthquake if the foundation of the structure lies on soft soil. However the geotechnical engineers can incredibly enhance the structure how the structure and foundation together react to the seismic waves.

The solutions to prevent the damage are :-

1)The superstructure is tied to the foundation so that the entire structure acts as a single unit.

2)The building can be floated above its foundation which is known as base isolation. Resulting to which, lateral acceleration is decreased and the structure experiences far less deformity and damage. However, the structure still can receive a fixed amount of vibration energy during seismic loading even with a base isolation system in place.

The building itself can drench this energy to some level, however, its capability to do so is proportionate with the ductile nature of the material used during construction. Presently, materials such as a combination of rubber and steel plates are invented which are used on buildings to absorb the vibration due to the Earthquake. These are a few ways by which we could prevent some losses during earthquakes in future. Earthquakes cannot be stopped, but we can learn more, in aspiration of discovering new ways to protect ourselves from their dangerous effects. Simple precautions are the most effective ways to minimize Earthquake damage.

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