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Ground Anchoring – Effective Technique Used To Secure Structure from Lateral/Vertical Forces

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Abstract- An earth anchor is a device designed to support structures, most commonly used in geotechnical applications. Also known as a ground anchor, earth anchor or mechanical anchor, it may be impact driven into the ground or run in spirally, depending on its design and force-resistance characteristics. They are used in both temporary and permanent applications. Ground anchors are effectively restraining devices used in many different types of structures including retaining walls, dams, wharves, bridge abutments and foundations for buildings. Ground anchors are stressed to prevent structural movement and they typically transfer their load over a fixed length. These are commonly referred to as tension anchors and are suited for strong rock conditions. For anchors founded in soil or weak rock, load distributive compressive and tension anchors are used as they have small successive bond lengths rather than one unique longer bond length. Ground anchors consist of a specific anchoring assembly designed to transfer home anchoring loads to the ground are are used extensively in manufactured home installations. Ground anchor movements of several inches can have significant negative impacts on long-term performance. In cohesive soils, such anchor movements in a vertical direction can approach or exceed the soil's shear strength. In such cases, the ground anchor is supported by the soil's residual shear strength, resulting in a decrease in anchor capacity.
Keywords- earth anchors, load transfer, structural movement, shear strength, impact on soil, applications.

I. INTRODUCTION

A. General Analysis

1) Working: Once installed and load-locked, an earth anchor exerts effort to the soil above it, with the soil in turn providing resistance. Upward soil compression created by the anchor is typically exerted in a frustum shaped cone reflecting:

The shear angle of the soil.
The depth at which the anchor has been installed.
The load applied to the anchor.
The size of the anchor and size and angle of its lateral surfaces.

When angled these lateral surfaces generate greater cone-shaped soil resistance than a simple cylinder created by purely perpendicular design.

2) Installation: Site analysis determining soil load resistance is often required before earth anchor installation. Included are depth that the anchor is to be driven, soil strength, moisture content and corrosivity. Appropriate test installations are also to be done to determine optimal anchor design or conformance with project specifications. Installation methods differ depending on soil composition and moisture. Earth anchors are commonly driven into the ground using a drive rod and impact hammer. Pilot holes are required denser soils. After an impact driven anchor has been installed, the drive rod is removed along with the anchor load-locked typically by rotating it ninety degrees. For lighter anchors a hand tool is often sufficient.

3) Applications: Earth anchors are typically used in civil engineering and construction projects, and have a variety of applications, including:
Retaining walls, as part of erosion control systems.
Structural support of temporary buildings and structures such as circus tents and outdoor stages.
Tethering marine structures, such as floating docks and pipelines.
Supporting guyed masts, such as radio transmission towers.
Anchoring utility poles and similar structures.

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Drainage systems, for load locking and restraining capability to happen simultaneously.

Landscape, anchoring trees, often semi-mature transplants.

General security, as in anchoring small aircraft.

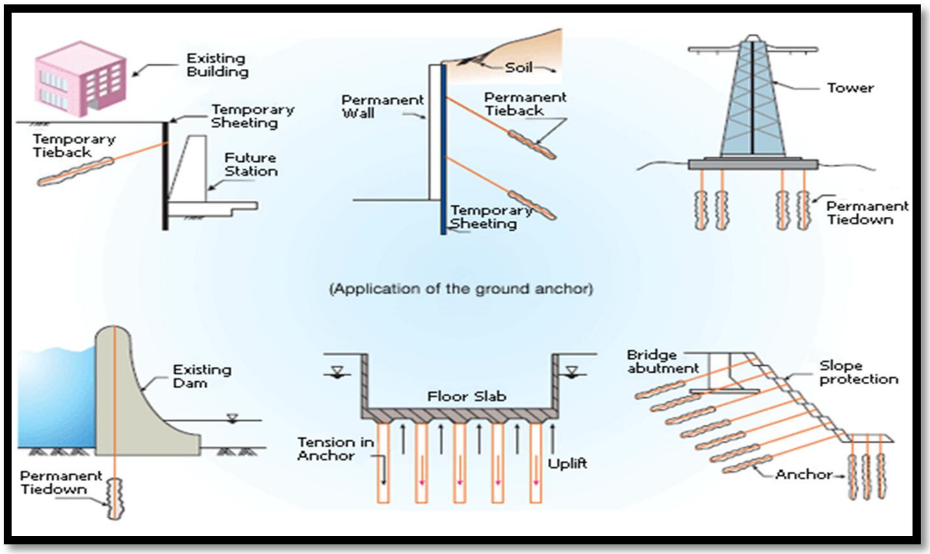

Figure 1: Applications of ground anchor

B. Classification of Ground Anchors

Ground anchors are classified according to their service life, purpose, installation procedures and method of load transfer from the anchor to the ground. An anchor with a service life greater than 24 months is generally considered permanent. Permanent anchors shall always have some type of corrosion protection system based on the service life of the structure, the known aggressivity of the environment and corrosive properties of the soil and consequences of tendon failure.

Also, anchors can be classified into frictional type anchors that are supported by the friction of the grout and the ground, ground pressure type anchors that acquire anchoring force with the passive resistance of the ground using ground pressure boards or piles, and complex type anchors that are a combination of the above two types, based on the supporting method of the fixation ground. Frictional type anchors can also be classified into tensile type anchors and compressive type anchors based on the load application method to the grout. Lastly, compressive type anchors can be classified into load concentrative type anchors and load distributive type anchors depending on the distribution of the load.

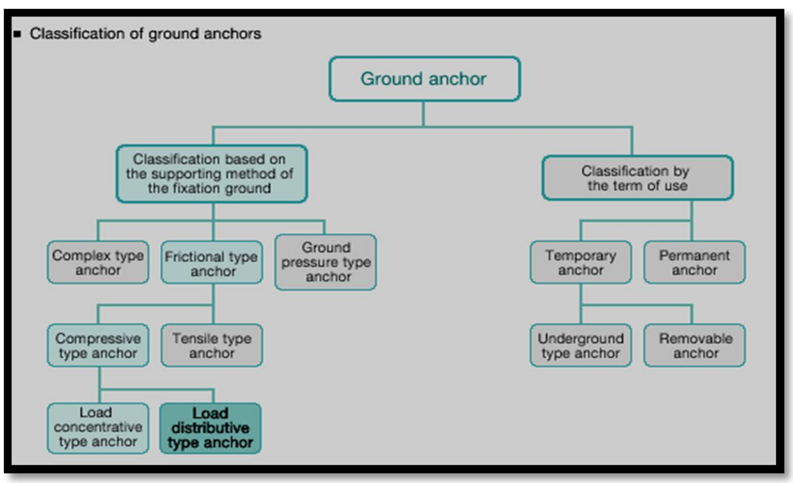

Figure 2: Classification flowchart of ground anchors

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C. Comparison by the Characteristics of Each Anchor Type

1) Load Concentrative Tension Type Anchor: When stress is applied to tension type anchor, load transfer occurs to bond length through adhesion of steel strand and grout. Due to load concentration, the parts of tension type anchor attached with steel strand and grout become unzipped and this leads to crack and load reduction. In addition, tension type anchor has the weakness of progressive debonding and time-dependent load reduction (creep) occurrence when friction of load concentration zone exceeds the extreme skin friction of the target ground. Then, as the parts attached with steel strand and grout become unzipped, it changes its state. The relatively concentrated skin friction of anchor becomes higher than the allowed value between ground and grout body to progress. Accordingly, load reduction takes place. The drawbacks of tensile type anchors are that a progressive destruction occurs due to the jacking crack in the grout and creeps due to load concentration, greatly reducing the load.

2) Load Concentrative Compression Type Anchor: Compression type anchors consist of an unbounded polyethylene (PE)-coated steel strand which transfers the jacking force / load directly to a structural element located at the distal end of the anchor. Unlike the tension type anchors, the grout body for compression type anchors is loaded in compression which is capable of securing much higher loads. However, due to the concentrative design of these anchors, the use of high-strength grout is frequently required to secure the jacking forces at the distal end. Also, it is often difficult to secure concentrative anchorage force in weak soils. Similar to the tension type anchors, compression type anchors are subject to the occurrence of progressive debonding and time-dependent load reduction (creep). In this case the friction required to secure the concentrated load exceeds that of the skin friction for that zone. This effect causes grout debonding and loss of soil confinement pressure resulting in load reduction.

3) Load Distributive Tension / Compression Type Anchor: As discussed, high stresses from tension and conventional compression type anchors transfer concentrated loads to the soil and grout body which can become overstressed resulting in failure. Therefore, load distributive compression type anchors have been developed and are being used, which uniformly distribute the anchor load to the grout body and soil along the theoretical length of the bond zone. In addition the grout strength requirements are reduced as well as applied eccentricity. As a result high loads can be achieved even in normal soil condition. Recently, load distributive tension type anchors have been developed which are capable of securing stable loads in even relatively weak soils such as clay and silts. These anchors do not require high strength grout and have low eccentricity as well. The use of load distributive anchors results in a more uniform distribution of the anchor force to the soil. Therefore, load reduction and creep are minimized, enabling the anchor to maintain initial design load. The load distributive compression and tension type removable anchors provide significant advantages to building owners as once the anchors are removed at the end of the project construction, there are no obstructions left in the ground that will conflict with any future developments. For multi-strand anchors, the strands are run through specialize greasing and sheathing machine. This machine parts the individual wires of the strands followed by immersion into a grease bath before completely encapsulating the strand in the outer sheathing to ensure no voids are present.

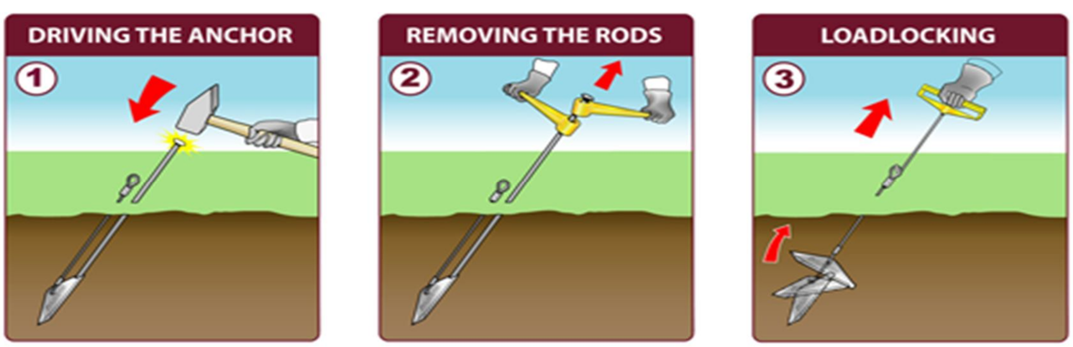

Figure 3: Process of soil anchoring

II. ANCHOR INSPECTION AND TESTING

To get the most from a ground anchor, it is important to ensure it is in good working order. There is a need to offer an independent inspection and testing service for installations.

Maintenance program can be established with asset managers and owners to ensure a testing schedule appropriate to the age of the structure, and anchor type, is maintained.

Visual inspections and testing can be undertaken on historical anchors to verify the integrity of both the exposed anchor elements, and the performance of the anchor relative to design loads. A detailed construction report is provided.

There are typically 3 classes of tests required:-

A. On-Site Proving Trial Testing

On-Site Proving Trial Testing is conducted on trial anchors which are installed prior to the main works commencing and do not form part of the production works. Proving tests are required to verify the designers assumptions made in relation to geotechnical ultimate bond rupture, and maximum acceptable rate of creep. They are also useful in evaluating the expected performance of the production anchors thereby ensuring they are fit for the site conditions found to be present.

B. On-Site Suitability Testing

On-Site Suitability Testing is conducted on either the production anchors or additional anchors identical to the production anchors. It is normal to conduct suitability tests on at least the first three anchors installed. The data obtained provides a datum point against which the performance of each production anchor can be measured.

C. On-Site Acceptance Testing

On-Site Acceptance Testing is performed on all production anchors. Testing demonstrates the anchor's ability to withstand a load up to 1.5 times greater than its working load.

Figure 4: Testing of ground anchor

III. TYPES OF ANCHORS

Several styles of anchor assemblies are available that can adequately secure a manufactured home to resist flood, wind, and seismic forces. Helical earth anchors, cast-in-place concrete footings, drilled concrete anchors, and cross drive anchors are just a few of the types available.

A. Helical Earth Anchors

Helical earth anchors are designed to be screwed into the ground and are often referred to as ground anchors. Helical earth anchors typically consist of a shaft, head, and one or more helixes. The head is used for installing and fastening the anchor to the home, and tensioning the anchor. Toward the bottom of the shaft, there is one (single) or more helical disks for the anchor to be screwed into the soil. The helix provides much of the anchor’s load capacity. The typical lengths of helical ground anchors are 30, 36, 48, and 60 inches.

Helical anchors also may be installed with stabilizer plates to increase the lateral capacity of the anchor by enlarging the surface area used to develop passive soil resistance.

B. Concrete Anchors

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Concrete anchors use dead weight of a concrete footing or a combination of concrete weight and soil uplift resistance. Uplift resistance can be increased by the use of drilled concrete piers. In both cases, the home must be securely attached to the concrete elements using anchor bolts, tie-rods, or other structural connection. Anchor attachments placed in concrete must be installed with adequate depth to develop the required strength. The load capacity of the anchors must be sufficient to resist applicable design loads.

C. Cross Drive Anchors

Like helical ground anchors, cross drive anchors are constructed with a head secured to a metal shaft. Cross drive anchors are shafts driven into competent soils to develop their resistance. As their name implies, cross drive anchors are driven in pairs that form an "X" or cross. The heads of the anchors are secured to the home with metal straps.

Figure 5: Helical, concrete and cross drive anchors

D. Anchor Design and Capacity

Steel ground anchors are the most common anchor assembly application for manufactured home installations. Ground anchors are typically constructed with a circular shaft of one or more helixes; a head connects at the opposite end of the anchor, which then connects to the home's frame and/or sidewalls with steel straps or cables. Anchor shafts are typically 5/8 inch to 3/4 inch in diameter, and helixes range from 3 inches to 8 inches in diameter. Most anchors used for manufactured home applications have one helix, although anchors with two to four helixes are available.

Most anchor heads are "U" shaped and contain predrilled bolt holes. The bolts connect the anchor to the home's frame or sidewalls with 1¼-inch anchor straps. Some anchors have heads with closed eyes for cable connections. The bolts in "U" shaped anchor heads can be used to pre-tension the anchor. Pre-tensioning an anchor with closed-eye heads requires using other devices like turnbuckles. It requires anchoring equipment and anchoring assemblies to be capable of resisting allowable minimum working loads of 3,150 pounds and ultimate loads of 4,725 pounds without failure of either the anchoring equipment or the attachment point on the manufactured home.

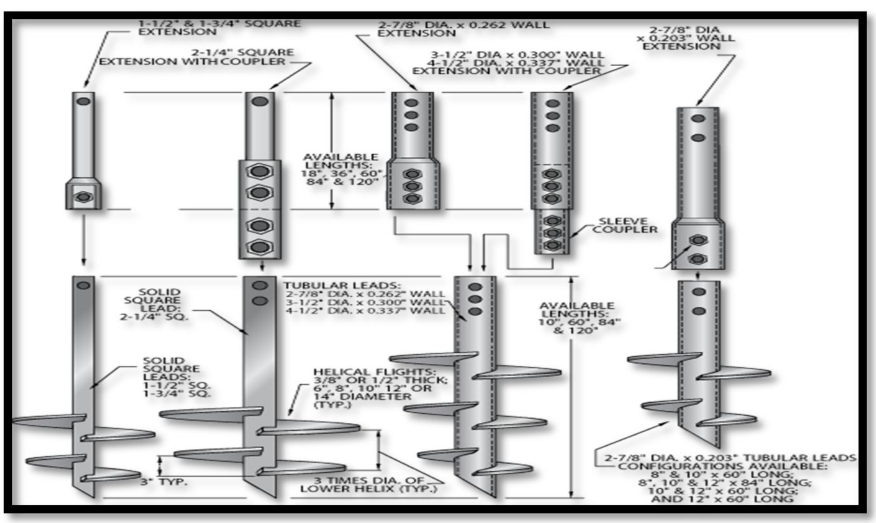

Figure 6: Typical anchor design

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E. Selection of Anchor

Ground anchors should be selected based on the specific soils conditions at the manufactured home site. Short anchors with smaller helixes may be used in firm, well compacted soils. Longer anchors or anchors with larger or multiple helixes are required in weaker soils.

Most anchors are selected based on standard torque probe tests conducted at the site. During those tests, a 5 foot long auger probe is screwed into the ground to the approximate depth of the anchor helix. A torque wrench measures the torque required to advance the probe. The resulting torque value is used to classify the soils and select an appropriate anchor.

F. Anchor Performance

The capacity of anchoring systems is a function of the soil response to loads applied to the anchor assembly. For ground anchors, important geotechnical considerations include soil type or classification, soil shear strength, load-deformation characteristics (i.e., modulus of sub grade reaction, or stiffness), and moisture condition. Research has identified additional considerations impacting the capacity and performance of ground anchors, including anchor geometry, anchor depth, anchor orientation, and direction of load relative to that orientation.

Soil response mechanisms are different for axially and non-axially loaded ground anchors. Soil response for axially loaded ground anchors is the result of shear stresses along the failure plane.

Failure occurs when the stresses exceed the soil shear strength. The geometry of the failure surface varies based on the critical depth of the anchor. Ground anchors with an embedment depth less than the critical depth to anchor base width ratio (D/B) respond as a shallow foundation. Ground anchors with a depth greater than D/B respond as a deep foundation. Non-axially loaded ground anchors resist lateral movement by mobilizing the passive resistance of the surrounding soil. As small diameter rods develop little passive soil pressure resistance, stabilizer plates are used in the contact area to increase the passive resistance and reduce movement.

Vertical, axially loaded anchors are relatively efficient. The soil shear failure is a symmetrical, roughly truncated cone extended from the anchor bearing plate to the ground surface. Non-vertical, axially loaded ground anchors are somewhat less efficient due to the asymmetrical shape of the shear failure surface. The asymmetry is the result of the shallow depth at the top side of the anchor relative to the bottom side.

Movements of axially loaded anchors are proportional to the applied loads. The load-movement is approximately linear in granular or non-cohesive soils. Cohesive soils tend to be less linear, particularly as the amount of clay in the soil increases. Soil related anchor failure in granular soils may occur rapidly and may cause ground surface movements around the anchor. Anchors in cohesive soil typically fail more slowly.

Anchor failure may also result from weld failure between the anchor shaft and the anchor head, weld failure between the shaft and the helix, collapsing of the anchor helix, or metal tearing around the anchor head strap bolts.

Anchors used with stabilizer plates respond differently than axially loaded anchors. The small diameter shaft does not create much passive resistance in the soil; therefore, small loads produce relatively large movements. After the anchor shaft contacts the stabilizer plate, lateral movement as a function of load decreases significantly as a result of a larger area of passive resistance mobilized by the stabilizer plate. As the shaft comes in contact with the stabilizer plate, stiffness increases significantly. However, the apparent stiffness remains less than axially loaded anchors.

IV. CONCLUSIONS

According to the current scenario, grouted anchors need to grout in the construction and this is a limitation in zones of cold climates. Although this system needs excavation and their speed is slow in construction due to performance of grout. Although plate anchors don't need to grout but they have much limitation such as need to excavate, low speed in construction and their applicants are few due to uplift forces. The Helical system is a good system for different parts because they don't need grouting, excavation and their speed is good in construction but their applications are limited. It is important that different researchers in the world can extent different anchors with easy condition. In order to extent new anchors, the scientists are testing new anchors in extreme geotechnical conditions for decreasing the problems of different anchors in near future, although using geo synthetics and grid-fixed reinforcement (GFR) in investigating anchors behavior has solved some lacks and problems such as uplift response and failure zones in symmetrical anchor plates.

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