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Construction and Performance of Ground Anchors in Rock

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Abstract - *In this study the performance and construction of ground anchors in rock are investigated. In current state of affairs of engineering, several structures experiences overturning moments thanks to lateral masses which ends up in a very combination of tension and compression responses at foundation level furthermore the structure needs to resist uplift forces. In these conditions, an efficient manner is that the North American natione of tension parets that are cited us ground anchors. Rock anchors are employed in structures to counteract uplift forces working on foundations and post-tension existing concrete structures. Rock anchors are manufactured from high tensile steel, and generally they're anchored. For many applications the rock anchors are tensioned to a force beyond what's necessarey to resist the muse uplift force.. Each rock anchors and rock bolts are eventually grouted on their full length. a number of the additional common uses for rock anchors and bolts are to produce tiebacks for bridges, to extend stability of walls, slopes, and dams, to secure surface in mines and tunnels or to secure structures against forces from wind or moving machinery. The paper aimed for the higher understanding of behaviour of pre-stressed ground anchors in rock.*

Key Words*: *ground anchor, overturning moments, uplift forces, rock anchors and rock bolts.

1. INTRODUCTION

Nowadays deep excavation for the basement within the structure becomes a compulsory half as the way of house exploitation for underground parking and alternative uses. The applying of anchored holding walls has been adopted in urban construction for recent many decades. an oversized variety of researchers and engineers have contributed to the event of each style and construction ways for tie-back anchored walls so as to extend anchor bearing capability within the last 3 decades.

1.1 Problems in underground construction

Dewatering operation was a difficult issue within the construction method. Although, an oversized quantity of water was pumping out and it absolutely was not still attainable to lower the water level to the excavation level. Therefore, the groundwater was still a difficult issue that had to be thought-about within the excavation method. This weakens the soil round the structure and makes the structure fail.

1.2 Ground anchors – an effective solution

To stabilize the bottom round the projected excavation zone, in rock the bar ANchor was used as an economical and economical technique. Cast-in-situ concrete piles were thought-about to support the anchors.

A Ground associatechor may be a structural component put in in soil or rock that's wont to transmit an applied tensile load into the bottom

1.3 Types of Ground anchors

Depending on their service life, rock anchors may be

- Temporary
- Permanent

Depending on the application of stress, may be

- Passive
- Active or Post-Tensioned

Depending on cement grout injection, rock anchors may be that are currently used in U.S. practice.

- Straight shaft gravity-grouted ground anchors (Type A)
- Straight shaft pressure-grouted ground anchors (Type B)
- Post-grouted ground anchors (Type C)
- Under reamed anchor. (Type D)

Table -1: Types and methods

Type	Grouting methods
A	Gravity displacement
B	low pressure (typically pi < 1000 kN/m^2)
C	high pressure (typically pi > 2000 kN/m^2)
D	Under reaming operation.

2. METHODOLOGY

The construction process was carried out by the following order under the guidance of qualified Engineers.

- ✓ Ground clearance
- ✓ Site inspection and geological studies
- ✓ Preliminary test
- ✓ Construction of cast in-situ piles (secant piles)
- ✓ Excavation done layer by layer
- ✓ Dewatering

- ✓ Drilling
- ✓ Anchor installation
- ✓ Grouting
- ✓ Stressing
- ✓ Test to check the quality (load cell)

3. MATERIALS REQUIRED FOR CONSTRUCTION OF AN ANCHOR

3.1 Grouting Materials

The materials used during grouting process are

- **Cement**

The cement shall be either ordinary Portland cement conforming to IS: 269-1976 or sulphate resistant cement conforming to IS: 6909-19737.

The use of high alumina cement complying with BS 915 should be restricted to temporary anchorages with a service life not exceeding 6 months and to anchorages used for testing ground holding capacity. As a prudent measure to minimize sulphide content, only cements complying with BS 12, BS 1370 or BS 4027 should be used for tendon bonding in permanent anchorages.

Fig.3.1 cement OPC 53 grade

- **Admixtures**

Admixtures should only be used if tests have shown that their use improves the properties of the grout,

- ✓ Improving workability or durability,
- ✓ Reducing bleed or shrinkage or
- ✓ Increasing rate of strength development.

Admixtures should be free from any product liable to damage the steel or the grout itself. For example, no admixture that contains in total more than 0.1 % (m/m) Expanding agents containing aluminium to give grout expansion of up to 5 % may be used in accordance with the manufacturer's instructions. Wherever possible, admixtures should be used and tested in accordance with BS 5075.

- **Cebex-100**

Cebex 100 is an admixture for cementitious grouts where it reduces the W/C ratio. It is a combination of plasticing agent and a gas producing expansion medium. The advantages includes

- ✓ Ensures low permeability
- ✓ Long term durability
- ✓ High fluidity with low water
- ✓ High early strength

Fig.3.2 cebex-100

3.2 FABRICATION MATERIALS

The materials used during fabrication process are

- ➢ Pre-stressing steel bar
- ➢ Centralizers
- ➢ Couplers and Hexagonal Nut

3.2.1 Pre-stressing steel bar

Single bar ar most well-liked for brief and medium capability anchor. rib bars will either partly or totally given deformations. this needs a minimum hole size, however the final word carrying capability of the bar is probably going to be larger than plain bar. Common sizes out there ar 25mm, 32 mm, 36mm, etc.

3.2.2 Centralizers

Centralizers ought to be provided on all sinews or encapsulations to confirm that the tendon or encapsulation is centred within the grout column. Centralizers ought to guarantee among the borehole a minimum grout cowl of ten millimetre to the sinew or encapsulation at the centralizer and will be provided at centres consistent with the angle of inclination of the bottom anchorage and therefore the doable sag between points of support so as to produce a minimum grout cowl of five millimetre to the sinew or encapsulation. the planning of centralizers among encapsulations ought to guarantee a minimum five millimetre grout cowl wherever such cowl is deemed to be a physical protecting barrier.

For rock reinforcement systems employing a bar spun into rosin, a centralizer, wherever needed, could also be wont to retain the bar within the centre of the opening and to retain rosin within the fastened anchor section in up hole configurations. Wherever this centralizer is additionally used as a spacer, it ought to guarantee among the borehole the minimum specified grout cowl.

3.2.3 Coupler and hexnut

Tendons factory-made from bar is also extended mistreatment applicable couplers. The strength of the coupled bars mustn't be but that of the connective tissue. Couplers ought to be designed specified grouting of the anchorage isn't seriously obstructed.

Hexnut is employed at the each finish of the mechanical device to make sure the correct association.

3.3 STRESSING MATERIALS

Typical stressing equipment includes:

(1) Hydraulic jack and pump;

(2) Load cells

(3) Jack chair

3.3.1 Hydraulic Jack and Pump

A hydraulic jack and pump area unit accustomed apply load to the connective tissue either at the anchor head or at a pull head hooked up to the prestressing steel. The hydraulic jack should be capable of applying a coaxal load to the connective tissue. The load ought to be transferred to all or any of the prestressing components of the connective tissue.

Fig 3.3 hydraulic jack and pump

3.3.2 Load cells

For extended load hold periods, load cells are used as the means to monitor a constant applied load while the pump is incrementally adjusted. Over extended periods of time, any load losses in the jack will not be reflected with sufficient accuracy using a pressure gauge. Also, temperature changes can affect the hydraulic jack and/or pressure gauge readings.

Fig 3.4 load cell

3.3.3 Jack chair

For bar anchors, a jack chair is placed over the anchor head and it rests on the bearing plate. The jack chair enables testing to be performed on bar anchors with the nut already in place and permits access to the nut during transfer of the lock-off load.

Fig 3.5 Jack chair

4. CONSTRUCTION SEQUENCE

During the construction of ground anchorages the operations may influence the capacity of the anchorage. The operations include the following sequence.

- Drilling with or without flushing,
- Tendon installation,
- Grouting system
- Stressing

The construction of ground anchorages should be carried out in such a manner that the validity of design assumptions is maintained. A method statement detailing all operations including plant information should be prepared prior to site anchorage work. The work should be under the supervision of experienced personnel.

4.1 DRILLING

Drilling methods normally involve a rotary, percussive or rotary-percussive mechanism and, occasionally, vibratory driving technique. Core drilling is rarely used for anchorage holes because of the high cost and the belief that the smoothness of the bore reduces the bond capacity. Drilling necessarily disturbs the ground. The method should be chosen relative to the ground conditions to cause either the minimum disturbance or the disturbance most beneficial to the anchorage capacity.

Care should be taken not to use high pressures with any flushing media, in order to minimize the risk of hydro fracture of the surrounding ground, particularly in built-up areas and where anchorages are installed at shallow depth. In this connection, a free passage within the borehole to the surface is desirable to prevent the build-up of excessive pressures in the surrounding strata. A free passage or open return also permits the driller to monitor major changes in ground type from the drill cuttings or flush. Drilling through rock is carried out by using either rotary method with water flush or using pneumatic percussion method with air and/or water flush.

Fig 4.1 Drilling

The presence of gas mains, electric cables, water mains and other services that may be damaged and cause injuries need to be investigated before work commences. Anchor holes should be drilled at specified locations and tolerances as shown on the approved drawings. Drilling tolerances include length, orientation, and diameter. Common practice is to drill beyond the design length to permit better drill hole cleaning.

4.2 TENDON INSTALLATION

Immediately prior to installation the tendon should be carefully inspected for damage to components and corrosion. Punctures of protective layers should be repaired. The tendon should be lowered at a steady controlled rate. For heavy tendons weighing in excess of 200 kg, approximately, mechanical handling equipment should be employed, as manual operations can be difficult and hazardous. The use of a funnelled entry pipe at the top of a cased hole is recommended to avoid damage to the tendon as it is installed past the sharp edge of the top of the casing. On occasion, particularly at the start of a contract, the tendon should be withdrawn after the installation operation, in order to judge the efficiency of the centralizer and spacer units and also to observe damage, distortion or the presence of smear, e.g. in chalk or clay. Where significant distortion or smear is observed, improvements in relation to the fixing or design of the centralizers, or the borehole flushing method may be necessary.

Fig 4.2 Anchor fabrication

4.3 GROUTING

After the anchor is lowered, the fixed length of the anchor is grouted. Grouting is carried out under pressure by fixing a packer at the top of the fixed length or as necessary in accordance with the type of anchor. Normally thickest possible grouting is adopted for primary grouting. Adequate care is required so that the free length of the anchor remains free to elongate. On the top of the borehole, the cement grout should be correctly stopped in order to allow a good installation of the anchor head. When the injection is finished, the extra length of injection pipes must be cut of and removed.

Grout is injected through a pipe that is installed all the way to the toe of the anchor. The grouting to be continued till the grout overflows from the top of the hole consistently. After completion of grouting operation, temporary casing should be removed any used. After removal of casing, the grout shall be filled for the decreased volume of grout.

4.3.1 Test carried out while grouting

Following tests are conducted on grout mix:

1. **Flowability:** This is done using a Flow Cone apparatus. The time taken for the flow of pre-measured quantity of grout is noted which shall be in the range of 10 to 18 seconds.
2. **Shrinkage and bleeding test:** Grout mix is poured into a transparent beaker. Shrinkage and bleeding are measured and records maintained.
3. **Compressive Strength:** Fifteen numbers Grout cubes of 100x100x100mm shall be taken and the compressive strength checked after 7days, 14days, 18 days, 21 days & 28 days

The test results of the grout shall be checked with the following properties.

- ✓ Compressive strength should not less than 30MPa before stressing of anchor.
- ✓ Bleeding of grout should be maximum of 2% after 24 hrs. There should not be any bleeding.
- ✓ The Temperature of the grout shall be 10 to 30 degrees centigrade.

4.4 STRESSING

Ground anchor is load tested to verify its capacity. The load test is performed at the ground surface and consists of tensioning the pre-stressing steel element (i.e., strand or bar) and measuring load and movement. This is commonly known as stressing.

Stressing is carried out after 21 days of grouting by when, it attains the required strength. Depending on the different types of anchors used, details of the stressing jack vary. The anchor is stressed for about 10 % of the load and elongation measurements taken beyond this range. This takes care of any seating errors.

Fig4.3 stressing

4.4.1 INSPECTION

Field data sheets which record the correct information regarding each particular operation are an essential part of anchorage works. Stressing records and analysis sheets should not only present the load/displacement results but also provide complete information on stressing equipment, monitoring system, tendon measurements, tendon properties, and grout strength records. The monitoring of anchor head displacement in the direction of the tendon axis due to structural movement may be difficult and require calculation or interpolation. Should anchor head displacement continue during load monitoring periods it should be recorded and due correction made for resulting load loss in the anchorage. The completion of the record sheet and graphical plot of load/displacement during a stressing operation allows on-going assessment of the anchorage performance.

5. CONCLUSIONS

From the various studies and the execution work carried out the following conclusion were arrived.

- ✓ The ground anchors are currently used in all underground works and it is the effective one.
- ✓ Ground anchors and anchored systems have become increasingly more cost-effective through improvements in design methods, construction techniques, anchor component materials, and on-site acceptance testing.
- ✓ Considering different criteria the anchor type is being selected and that should be more effective in the future

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