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PROBLEMS FACED IN TUNNELLING

Rakhi Arora
Civil Engineering Dept
Delhi Technological University
Delhi, India

Ujjwal Dagar
Civil Engineering Dept.
Delhi Technological University
Delhi, India

Abstract **- Metro projects have gained significance in the past decade, and hence a study of the EIA parameters was conducted at the Jahangirpuri-Badli extension line of the phase 3 network, with testing of noise levels, TDS, TSS and chlorides of the samples collected from the Azadpur station underground construction. This paper also focuses on the problems associated with tunnelling in difficult grounds. One such situation has arisen in Azadpur phase three extension where bed rock was found instead of the assumed soil strata. Furthermore, the same site that we visited also faced the perilous condition of quicksand. A study was carried out.**

Keywords *- Metro, tunneling, running sand, grouting, rock quality designation index*

I. STRENGTH ESTIMATION OF ROCKS AND PROBLEMS FACED IN TUNNELLING

Tunnels are dug in types of materials varying from soft clay to hard rock. The method of tunnel construction depends on such factors as the ground conditions, the ground water conditions, the length and diameter of the tunnel drive, the depth of the tunnel, the logistics of supporting the tunnel excavation, the final use and shape of the tunnel and appropriate risk management.

There are three basic types of tunnel construction in common use:

1. Cut-and-cover tunnel, constructed in a shallow trench and then covered over.
2. Bored tunnel, constructed in situ, without removing the ground above. They are usually of circular or horseshoe cross-section.
3. Immersed tube tunnel, sunk into a body of water and laid on or buried just under its bed.

In the first stage the geological investigation is done and the rock mass strength is computed which helps in the design of cutter head.

1. Practical estimation of rock mass strength
2. Generalised Hoek Brown criteria

The generalized Hoek Brown failure criteria for jointed Rock masses are defined by:

$$\sigma'_1 = \sigma'_3 + \sigma_{ci} \{m_b (\sigma'_3 / \sigma_{ci}) + s\}^a \quad (1)$$

Where σ'_1 and σ'_3 are the maximum and minimum effective stresses at failure respectively

m_b is the value of Hoek Brown constant m for the rock mass *s* and *a* are constants which depend upon the characteristics of the rock mass, and σ_{ci} is the uniaxial compressive strength of the intact rock pieces.

Geological strength index

The strength of a jointed Rock mass depends on the properties of the intact rock pieces and also upon the freedom of these pieces to slide and rotate under different stress conditions. This freedom is controlled by the geometrical shape of the intact rock pieces as well as the conditions of the surfaces separating the pieces. Angular Rock pieces with clean, rough discontinuity surfaces will result in much stronger Rock mass than one which contains rounded particles surrounded by weathered and altered material. The geological strength index (GSI), introduced by Hoek, Kaiser and Bowden provides a system for estimating the reduction in rock mass strength for different geological conditions.

Once the geological strength index has been estimated, the parameters which describe the rock mass transfer characteristics, are calculated as follows;

$$M_b = m_i \exp(GSI-100)/28 \quad (6)$$

For GSI greater than 25 that is rock masses of good to reasonable quality, the original Hoek brown criteria is applicable with

$$s = \exp[(GSI-100)/9] \quad (7)$$

$$\text{And } a = 0.5 \quad (8)$$

For GSI less than 25 that is rock masses of very poor quality the modified Hoek Brown criteria applies with

$$s = 0 \quad (9)$$

$$\text{And } a = 0.65-(GSI/200) \quad (10)$$

Rock quality designation index (RQD)

The Rock quality designation index (RQD) was developed by Deere to provide a quantitative estimate of Rock mass quality from drill core logs. - RQD is defined as the percentage of intact core pieces longer than 100 mm (4 inches) in the total length of core. RQD is directly dependent parameter and its value may change significantly, depending upon the bore hole orientation. RQD is intended to represent the rock mass quality in situ.

RQD= [(∑Length of Core Pieces>10 cm)/Total Length of Core] *100

6.3 Rock tunnelling quality index, Q

On the basis of an evaluation of a large number of case histories of underground excavations, Bartan et al.(1974), of the Norweigian Geotechnical Institute proposed a Tunnelling Quality Index (Q) for the determination of rock mass characteristics and tunnel Support requirements. The numerical value of the index Q varies on a logarithmic scale from 0.001 to a maximum of 1000 and is defined by

$$Q=(RQD/j_n)*(j_r/j_a)(j_w/SRF)$$

Where
RQD is the rock quality designation
j_n is the joint set number
j_r is the joint roughness number
j_a is the joint alteration number
j_w is the joint water reduction factor
SRF is the stress reduction factor

However, the factors that make tunnelling difficult are generally related to:

- Instability
- Heavy loading from ground
- Natural and man-made obstacles and constraints
- Physical conditions

Instability:

It prevents timely placement and maintenance of adequate support at and behind the working face. It arises from the lack of standard time as in non-cohesive sands and gravels or due to adverse orientation of joint and fracture plane. The problem encountered with running sand is settlement and cratering at the surface with damage to utilities in the area. If the ground is permeable consolidation grouting of entire sensitive area can be undertaken to stabilize the soil before tunnelling. If dewatering is successful in depressing the water table below the tunnel invert, the compressed air is attractive provided the working pressure is very carefully controlled. The slurry shield can be best adopted for controlling variable conditions were running sand are present.

Heavy loading:

It creates problems of design as well as installation and maintenance of a suitable support system. When a tunnel is driven at depth in relatively weak rock a range of effect may be encountered from squeezing through popping to explosive failure of rock mass. It may also result from effect of tunnelling in swelling clay or chemically active materials.

Obstacles and constraints:

Boulder beds in association with running silt and caverns in limestone are examples of natural obstacles. In urban areas, abandoned foundations and piles present man- made obstructions.

II. A CASE STUDY

At Azadpur ,Delhi ,during the third phase metro construction , a slurry shield was to be used for a tunnel originally expected to be in soil but later on boulders and a bed of hard rocks was encountered in a span of 10 meters stretch, tested by conducting the Standard penetration test (SPT) by the involved personnel and authorities. The data for the strength characteristics of the rock collected from the concerned authorities is as follows:

Intact rock strength = 110 mpa
Hoek- Brown constant = 17.7
Geological strength index = 75
Friction angle = 43o
Cohesive strength = 9.4 mpa
Rock mass compressive strength = 43 mpa
Rock mass tensile strength = -0.94 mpa
Deformation modulus = 42000 mpa

Due to the above cause the machine got stuck and the project is stopped from April 24, 2015 till date. The cutter head was originally designed for strength of about 20 mpa having shield diameter of 6450 mm and the cutter roller were added to the head in the hope of solving the unexpected problem but failed to deal successfully.

III. RESULTS AND CONCLUSION

The various problems faced in tunnelling were enlisted, delineated by a case study of the Azadpur metro station where bed rock was encountered. The solutions proposed were dissolving of rock in highly saline water, which had to be dismissed due to the time constraints and the amount of slurry that would be produced. Addition of cutter rollers was suggested but couldn't prove to be of much use. Ultimately, demolition and due compensation to the residential building above seems like the only option.

IV. REFERENCES

[1]Tunnel Engineering Handbook, JOHN O. BICKEL THOMAS R. KUESEL ELWYN H. KING