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Application of Porous Concrete for Tunnel Lining

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Abstract :- **The maintenance and life of tunnel is a vital aspect of a HighwayTransportation Engineering System. The tunnel installation, execution and maintenance play an important role in healthy traffic movement all over the year. An innovative modification in the process of lining of tunnels can assist help an efficient draining system by usingporous concrete before the lining layer of concrete. This study focuses on the application and utilization of porous concrete to drain off the water from the tunnel site.**

Keywords: **- Tunnel, porous concrete, draining system, lining, Highway Transportation**

I. INTRODUCTION

Water is the tunneller's enemy, it causes problems during excavation; it introduces additional expense into the tunnel lining and ground support; it frequently causes ongoing problems during the working life of the tunnel, sometimes affecting not only the tunnel lining but also the structures and fittings within the tunnel. Lining of tunnels is very important to stop seepage of water through the pores and fractures present in the rocks of roof and walls of tunnel. This can prove fatal to life and property as well as longer halting of vehicles in case of roadway and railway tunnels.

A) Effects of Lining on natural Flow of Water

Modern grouting techniques, and especially modern grouts, enable us to seal even considerable water inflows, although the unit cost of hydrophilic and latex grouts is high. Small leaks are often difficult to seal by grouting alone.It must be remembered that sealing of leaks does not remove water and harmful chemicals that may have permeated the lining,or chemicals deposits that may have been left after evaporation of water. These leaks will continue to affect the lining unless other remedial measures are taken.

Due to provision of lining, the pores and fractures are blocked which were the natural flow paths forthe seepage of water. The water gets collected within them and forcing them to widen/open up. This loosens the rocks leading to separation of boulders from the parentrock which again exerts extra pressure on lining causing it to fail.

B) Damaging effects of water on tunnels during their working life:

Segmental concrete tunnels are generally reinforced with steel bars, which are subject to corrosion if adequate concrete cover or positive corrosion protection is not provided. Corrosion may lead to spallingof the concrete and loss of structural capacity. Lack of watertightness in segmental concrete lined tunnels may occur where inadequate provision is made for sealing the joints between segments or whereprovisions have become defective. Moisture, particularly in cases involving dissolved salts, may cause corrosion of reinforcing steel.

Infiltration of ground water containing chlorides has caused electrolytic action with the steel reinforcement, causing corrosion and consequent cracking of the surrounding concrete. Corrosion of metallic fixing within the tunnel is also noted. Rising groundwater table are apparent in many of the industrialized capitals. Where tunnels were constructed above the water table and no formal provision was made for waterproofing joints between the precast concrete segments, a rising groundwater may enter the tunnel quite freely.

In permeable soils, typically of silts and sands, loss of fines from the surrounding ground into the tunnel may result from high groundwater inflows. The inflow of fines into the tunnel has led to settlement and ovalisation of the tunnel.

In rail tunnels, where stray currents from the traction supply may occur, the electrolytic action of the moisture may be particularly severe, with the rapid migration of the chloride ions to the steelwork attracting the current. In this respect it may be noted

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that under wet conditions, the insulation of rails used for current return may be severely reduced, increasing the likelihood of stray currents.

The accumulated water exerts pressure on lining of the tunnel. It is impossible to construct segmental cast iron tunnel with large amount of water seeping into the tunnel. The power supply made within the tunnel can be short circuited and is prone to accidents.

II(a). CASE STUDY 1

Darekasa Railway Tunnel

This tunnel is situated on the Howrah-Bombay railway line in India. Tunnel is easily accessible from the Darekasa railway station. The tunnel has a total length of 223.41Mts. The height of the DRT is 16.15 Mts. The DRT was completed in 1962. Frequency of train movement through DRT is 23 regular scheduled trains and 30-35 goods trains per day on an average. During the study of the DRT and the site around tunnel, it was found that the roof of DRT had developed 2 cracks extending up to a level of 22 Mts. or so. In addition, there were small clay pockets observed in roof towards Salekasa end of tunnel. To know the nature and the danger potential of the cracks a close study of the site was made and the following conclusion was drawn. The tunnel rock consists of Quartzite, Quartzite-Breccia with minor intrusion of Pegmatite. Two types of joints are parallel to strike and other is trending in South-East direction. Minor intrusions of pegmatite were along strike direction of Quartzite. The Quartzite is pink in color and offer resistance to weathering because of their hard and compact nature. The Pegmatite is coarse grained and also pink in color. The microcline feldspar in pegmatite is prone to weathering and gives rise to Kaolin clay. The same phenomenon has been noticed in tunnel roof while exposures of hard and compact Pegmatite were seen above the tunnel. The presence of clay pockets is indicative of weathering due to Water and weathering Damage (WWD).

II(b). CASE STUDY 2

Use of High Density Polyethylene Drainboards in Gothard,Switzerland:

An attempt has been made earlier to drain excess water from tunnel site by use of High Density Polyethylene drainboards (HDPE). It proved to be efficient to drain water from site as well as have resistance to acidic and alkaline medium. The main disadvantage lies in the manufacturing of such polymer sheets and its local availability.

III. METHODOLOGY

The methodology elaborates the application of porous concrete layer, so as to drain off the water from tunnel site.

Methodofdrainingwater

This is achieved by providing porous concrete above the tunnel lining.As explained in Fig.No.1, in this method Porous concrete is provided in place of grouting. A thick layer of this concrete sufficient to drain the seeping water through the adjoining rock is layed first. Then the water proofing material is placed. Finally regular lining(as per the structural suitability) is placed. Chamber/drains leading out of tunnel are built at the bottom of tunnel.

As the compressive strength of the porous concrete is very less (maximum compressive strength obtained in laboratory test is 25 MPa and may differ according to use of cement, aggregates and methods of making concrete)it cannot be provided for the lining of tunnel directly. But the porous concrete can be supported by the original lining as shown in the above figure. Due to placing of porous concrete the natural flow of the water will not be blocked and the water can be led easily out of the tunnel. The water draining capacity of porous is as high as 200 lts/ hr as observed by some laboratory test (the draining capacity may vary with thick of concrete and density). The Single Infilltrometer is being used to test the draining capacity of porous concrete efficiently.

This can also help to keep the ground water table below the tunnel lining which can help to reduce the hydrostatic pressure on lining.

A water insulating material can be provided in between the original lining and porous concrete layer. Which can be assured of not getting damaged due to any cause such as weathering (as it is being sandwiched between two concrete layers) The original lining is to be designed well in advance to carry the load of porous concrete. The grade of concrete may vary with soil conditions on tunnel site and other parameters.

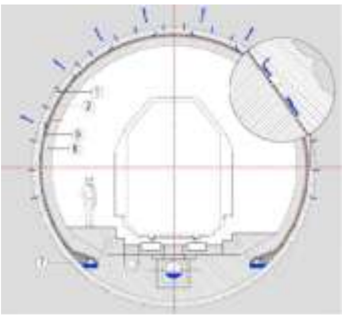

Fig.No.1: Detail of tunnel wall showing rock (1), porous concrete (2), waterproofing (5), concrete liner (6), Drainage pipes leading water out of tunnel(7).

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Permeability Test of Concrete

The permeability test of concrete is conducted by using Single Infiltrometer. As explained in Fig.No.2, Single infiltrometer is a simple device used to determine the amount of water seeping through the concrete per unit time. It consist of hallow rectangular box which is open at top and bottom and is placed just over the concrete block prepared beforehand. All the edges and corners are made watertight by lime so that no water can spill out. While performing the test a measured quantity of water is poured from top in the hollow box and stopwatch is started. The time required to drain off the whole quantity of water is measured and from this data the draining capacity/permeability of porous concrete is calculated. This test can also be performed at constant head.

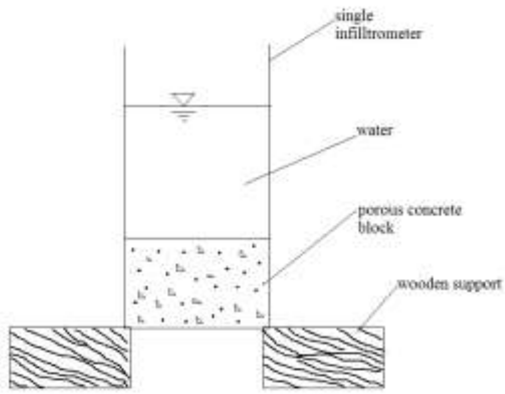

Fig.No.2 Single Infiltromete

Fig.No.3 Free Draining of porous concrete.

IV. CONCLUSIONS

It is obvious that remedial work operation must not be allowed to cause damage to sound linings. Without causing any changes to original structure of tunnel and its stability, the use of porous concrete has following advantages

1. Life of The tunnel lining is increased
2. The originalstructure of rockand soil adjoining tunnel remains undisturbed.
3. The natural flow of water is retained.
4. Safety of life and property against sudden failure.
5. Suitable for all types of rock and soil conditions.
6. The tunnel is dry and free from moisture for most of the year.

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