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Case Study

MAINTENANCE AND REPAIRS OF TRAFFIC TUNNELS- A CASE STUDY OF DAREKASA, GONDIA DISTRICT, MAHARASHTRA, INDIA

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Recent maintenance techniques and distinctive deformation case study of Indian railway tunnel is presented in this paper. Inspection of tunnel lining is divided into primary inspection and secondary inspection. Under the study, non-destructive inspection method is used in the process of practicable inspection to make this routine introduced. Repair and reinforcement methods of deformation tunnel is divided into countermeasures against earth pressure, countermeasures for deteriorated lining, countermeasures against leakage of water and weathering damage, and countermeasures against spalling. Moreover, the present case study is concerning recent typical deformation of Darekasa railway tunnel pertaining to countermeasures against leakage of water and weathering damage and spalling of tunnel lining.

Keywords: Indian Railways (IR), Darekasa Railway Tunnel (DRT), Water & Weathering Damage (WWD)

INTRODUCTION

Indian railways (IR) started its 53 km journey between Mumbai and Thane on April 16, 1853 and is today one of the largest railways in the world. The railway network, invariably referred to as 'the lifeline of the Indian economy' is spread over 109,221 km (Government of India, 2009). IR is one of the premier infrastructural wings of the economy combining all major functions of a conventional railway system. It builds and maintains infrastructure assets like tracks, tunnels, bridges, electric traction, signaling systems, telecom network, stations/terminals, etc. Apart from operating goods and passenger trains, operates suburban trains in various metros.

In developing nations like India the cleaning and minor repairs in tunnel are ignored. This is due to the reason of considerable disruption in traffic and possible higher overall cost. Apart from good housekeeping, tunnel cleaning is mainly required to maintain good illumination level in heavily trafficked tunnel, by removing light absorbing dust from the respective lining

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and from the luminaries. Other consideration is the possible corrosive effects of dirt and in effects on ventilation and fire resistance. The factors like past atmosphere corrosion, accidental damages due to collision and fire caused repair requirements. Following parameters are considered for tunnel maintenance: Ground conditions including degree of jointing, joint conditions, ground water, fault zones, mixed face situation and Rock parameters are compressive and tensile strength of rock, existence mechanical properties of mineral components and elastic behavior of rock material, unconfined compressive strength of rock (Jeur *et al.*, 2008). To ensure the long-term serviceability of any infrastructure, it is important to use the most advanced techniques available, both in the investigation phase and in maintenance. This maximizes the likelihood of early detection of defects and may even reduce the remedial work needed. Further an improved understanding of the progress of deterioration and its mechanism allows appropriate maintenance strategies to be determined and preventive measures to be implemented (Marosszeky *et al.*, 2002).

CLEANING

These include manual cleaning from hydraulic access platforms, otherwise used for road lighting maintenance or probable mobile pressure washers for walls. Where tunnels are too long special cleaning vehicles have been developed with brushes and sprays to cover walls and luminaries. These are carried on vehicle used for road washing. A vehicle fitted with static brushes to fit the tunnel profile, developed several years ago, and has been proven to be not as effective as high pressure detergent application traffic grime. It is however, necessary to close the traffic lane dressing the process when using a long lance to reach crew and shoulders of the tunnel.

ACCESS

Quick access is essential for short-term maintenance task. The contraction of scaffolding or even erecting of readymade access is impracticable in most cases. In adequately ventilated tunnels any access equipment will perform well. In unventilated tunnels, while on task of short duration, such as laminar replacement, use of a self propelled hydraulic platform of vehicle mounted platform would be an advantage.

REPAIRS

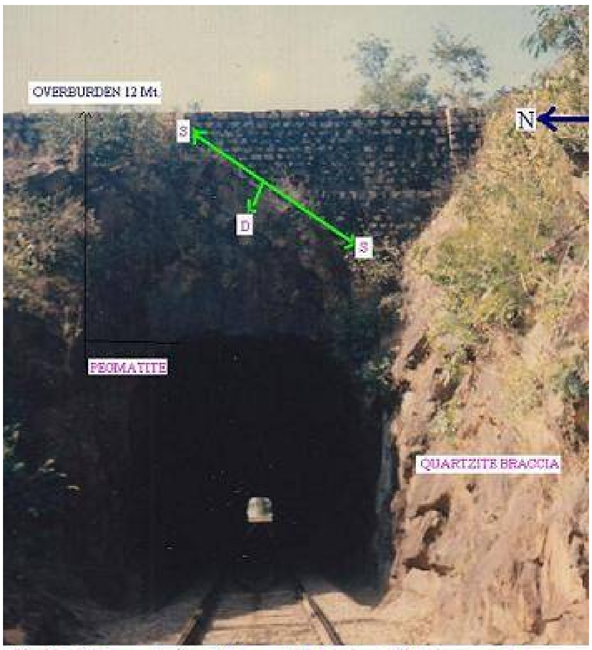
There are several materials for lining repair, such as hand applied mortars, compounds for injection into cracks, mortars applied by shotcrete etc. (Burrows, 1997). The new range of repair compounds includes cementitious mortars, polyester resin mortars and epoxy resin mortar. Nitometer HB is a high build epoxy mortar for vertical and overhead work, producing strong repair in spelled concrete. Render is intended for larger area of repair and is a cementitious pre-pack requiring only mixing with water on site reebafill is polyester resin mortar, made by the addition of resin and hardener, to produce a quick setting repair with good adhesion and high chemical and oil resistance.

Shotcreting is also an acceptable method of rapid renovation. Although often associated with rebound problems, with skilled operators and proper material mix, it is usable in temporarily-closed road tunnel. Portable plant which can be rapidly setup and removed has been developed and used to repair post damaged spelling in Penine, U.K. rail tunnel after cleaning down by pressure jetting.

CASE STUDY

This tunnel is situated on the Howrah-Bombay Railway line in India. Tunnel is easily accessible from the Darekasa railway station. The tunnel is at an elevation of 399.00 MSL. DRT has a total length of 223.41Mts. The height of the DRT is 16.15 Mts. The DRT was computed in 1962 and sleepers were laid down in the same year. The rails were laid in March 1966. As on today 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

Figure 1: Shows Jointed Pegnalite Rocks at Salekase End



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 as shown in Figure 1. To know the nature and the danger potential of the cracks a close study of the site was made and the following conclusions were drawn. The tunnel rocks consist of Quartzite, Quartzite-Breccias 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 as shown in Figure 1. 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).

The Quartzite is hard to excavate but the presence of joints would facilitate excavation by chisels and hammer but not by blasting. Medium sized blocks of Quartzite can be easily removed by taking advantage of joints.

Numerous joints combining in one alignment have given rise to cracks in tunnel roof. It has been noticed that the cracks diverge from ventilation shafts. The removal of overburden as well as adjoining rocks seem to have resulted into diminishing of pressure, which otherwise was equally distributed in the rocks body. The cracks do not seem to pose any immediate danger to the tunnel roof, but in near future proper treatment of cracks have to be taken care of.

It was reported that there is heavy percolation of water through cracks during the rainy season. The water sometimes gets mixed with soil and rocks debris forming thick mud. The presence of copious quantities of water noticed in some weep holes giving cause of concern. The water penetrating through the joints in Quartzite in rainy season must be finding its way in the tunnel.

It was noticed that all the joints in the rocks are not open, but some joints have not opened to give rise to cracks few millimeters to few centimeters in width. The widening of cracks is attributed to the abrasive action of water. The cement seems to have applied to fill in the cracks in the roof but this measure was not found to be effective. The enormous pressure exerted by water through interconnecting joints, has loosen the cement and in some places it has been completely washed away. It is thus, obvious that the entry of water through joints and their subsequent widening cannot be prevented by ordinary method of applying cement or by lining of tunnel walls. These will prove preventive measures against collapse only.

In order to achieve everlasting results, the joints in the quartzite should be filled by pressure grouting. The entry of rain water is neither from far away spot on the surface, nor through any master joint, as none was noticed. The joints in the quartzite were so spaced that the pressure grouting is feasible proportion without much loss of cement slurry. Taking advantage of the open joints, on ground surface of tunnel, the slurry can be pushed through by trial and error method.

In order to avoid loss of time, in location of suitable spots for pressure grouting, water may first be injected and its behavior noted underground. Furthermore, since the thickness of the overburden is only 12 to 16 m the injection of water and its appearance in tunnel, should not suffer from much time lag.

The pockets of clay need different treatment. The clay has a property of absorbing water but not of transmission. The clay pockets even though extending inside the tunnel roof, more than a few meters, do not themselves act as a conductor of water. The clay can however, swell and dislodge from main body by sheer weight. The clay pockets are not weal zones but have potential to pose danger. In order to avoid large quantity of clay as far as possible, and filling the gap by pre-molded cement blocks. Alternatively any suitable material not affected by water can be used.

CONCLUSION

Cracks in DRT structure mostly occurred *in situ*. Most cracks have to be repaired using a cementitious material with crack sealing properties derived through crystallization reactions. Moisture penetrations at the repairing locations have to be substantially stopped. However, there will be relatively higher weathering risk at some cracks, despite the fact that they have been fully sealed. In order to suppress the weathering of the rocks in crack zones an injection of super-fine cement grout is proposed. Theoretically, cement grouts are ideal for sealing cracks in concrete. They should suppress corrosion activity by reinstating a high pH environment and by chemical binding free chloride ions. In practice the coarse grain size (up to 100 μm) of normal Portland cement limits its application for crack grouting. However, the development of micro-cement products with a maximum grain size smaller than 12 μm or even 6 μm has created new possibilities to repair such cracks.

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