The DFCCIL JOURNAL

ISSUE VIII, SEPTEMBER 2020

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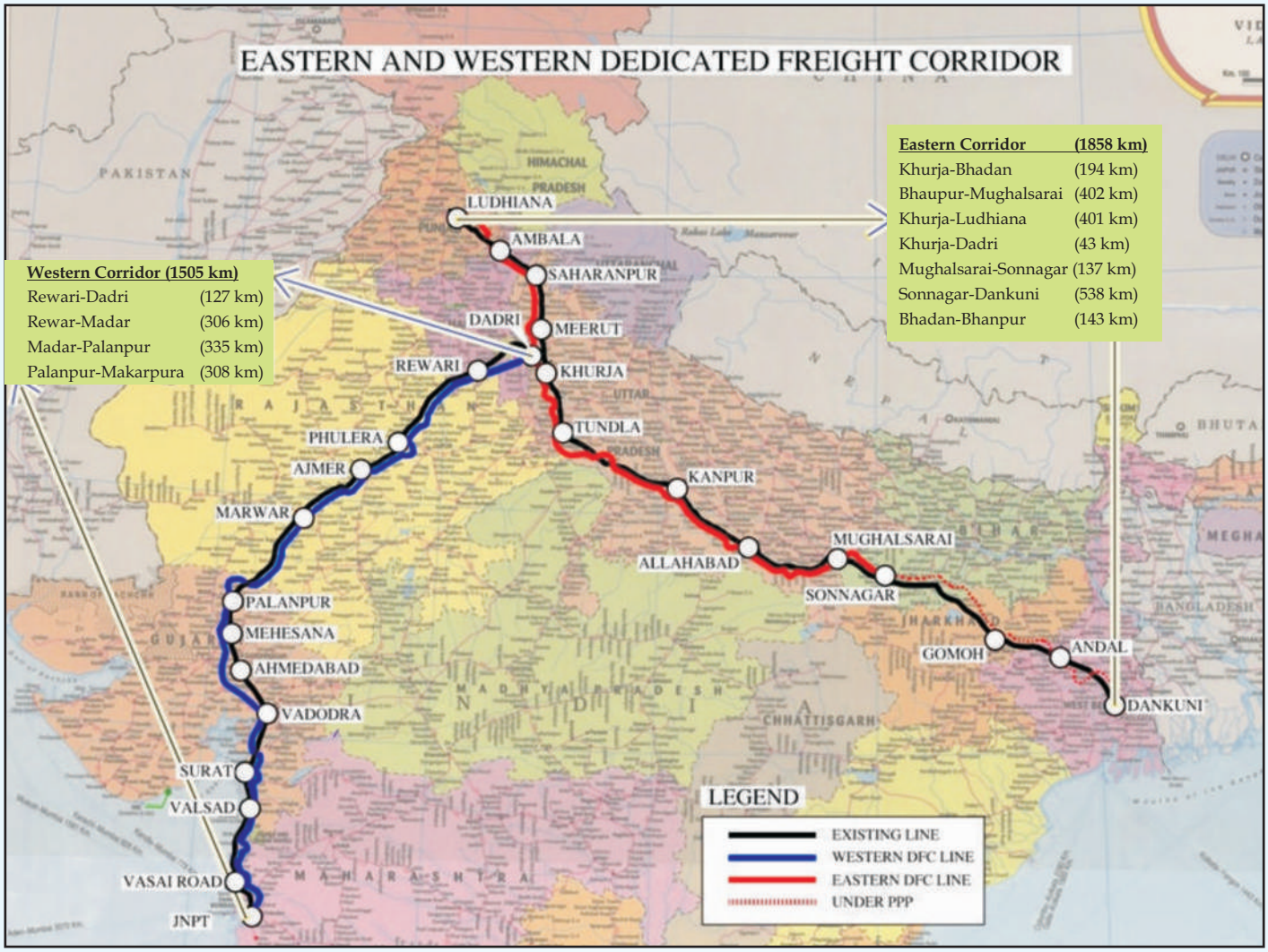

Targets

Western Corridor

SN	Sections	Targets
1	Dadri - Rewari (127 Km)	March 2022
2	Rewari - Madar (306 Km)	Completed in December 2019
3	Madar - Palanpur (335 Km)	March 2021
4	Palanpur – Makarpura (308 Km)	March 2022
5	Makarpura – JNPT (430 Km)	June 2022

Eastern Corridor

SN	Sections	Targets
1	Ludhiana – Khurja (401 Km)	June 2022
2	Khurja – Bhadan (194 Km)	Completed in October 2019
3	Khurja – Dadri (46 Km)	June 2021
4	Bhadan – Bhaupur (157 Km)	October 2020
5	Bhaupur – Pt. Deen Dayal Upadhyaya Nagar (402 km)	June 2022
6	Pt. Deen Dayal Upadhyaya Nagar – Sonnagar (137 Km)	December 2021
7	Sonnagar – Dankuni (538 Km)	Proposed to be done through PPP

FROM THE *Editor's Desk*

R. N. Singh
Managing Director, DFCCIL

Dear Readers,

It gives me immense pleasure to write this message to release the 8th issue of DFCCIL Journal. In a short span of about 2 years, DFCCIL Journal has grown significantly in stature and quality of content. Beginning in December 2018,it has maintained significantly regularity and published bouquet of scholarly Articles on variety of Multidisciplinary Technical or Non-Technical topics.

It is satisfying to note that in the second quarter of this year despite set back due to Covid-19 pandemic, the DFCCIL Project witnessed major developments and achievements, some of which are mentioned below;

1. Trial run of Loco was carried out successfully in New Palanpur -Durai (342 Km) section of WDFC on 30-31.07.2020 after completion of track laying works. Now, the "Team DFCCIL" is working tirelessly to commission the full Rewari-Madar-Palanpur section (650 Km) by Feb'21 for commercial runs which will connect the NCR region with the ports of Gujarat via DFC.
2. A tunnel-breaking ceremony was held on 24-07-2020 on completion of caving work for the one-kilometre long tunnel of Western Dedicated Freight Corridor (WDFC) through Aravalli mountain range, near Sohna in Haryana. This will be the world's first electrified rail tunnel fit for double-stack containers.
3. The section Khurja-Bhadan , on Eastern Dedicated Freight Corridor, has already been commissioned and the section Bhadan to Bhaupur is likely to be commissioned shortly. Thus, the train movement in 350 KM stretch of Eastern Dedicated Freight Corridor (DFC) from Kanpur to Khurja will be fully commissioned by Dec'20 and and the entire traffic of the goods train of this section will shift, making existing railway lines of Indian Railway fully available for passenger trains.
4. Due to support of the Hon'ble Railway Minister of Railways, lot of critical land and other issues pending with State Government were resolved during the quarter, which would definitely help in meeting timelines for the Project.
5. In this Journal, we bring to our readers well researched, & suitably illustrated (with quality Pictures & Diagrams) highly, informative Articles across a wide range of interesting subjects like Digital Terrain Modelling- Role in Economic Alignment Design, Geo Technical challenges during execution in Pir-Panjal Tunnel T-80 of USBRL Project (A case study), Determining height of noise barriers for DFC project, Effective management of COVID-19, support to migrant workers, Innovative model for sustainable development in DFCCIL- Lessons from MGNREGA etc. For successful commissioning & operation of Freight Corridors, creating the knowledge repository is the need of the hour and by publishing such Articles and Case Studies, DFCCIL is contributing towards the same, which would greatly benefit the organisation in future. I, believe that readers would find the DFCCIL Journal- Issue VIII intellectually stimulating enriching and useful in the project work.

I take this opportunity to appeal the DFCCIL team to continue the current momentum of project and share and enrich all readers with knowledge and experiences gained.

Enjoy reading and working.

R. N. Singh
Managing Director, DFCCIL

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Front cover picture

Tunnel Breakthrough Milestone in Aravali Range between Rewari-Dadri Section

Back cover picture

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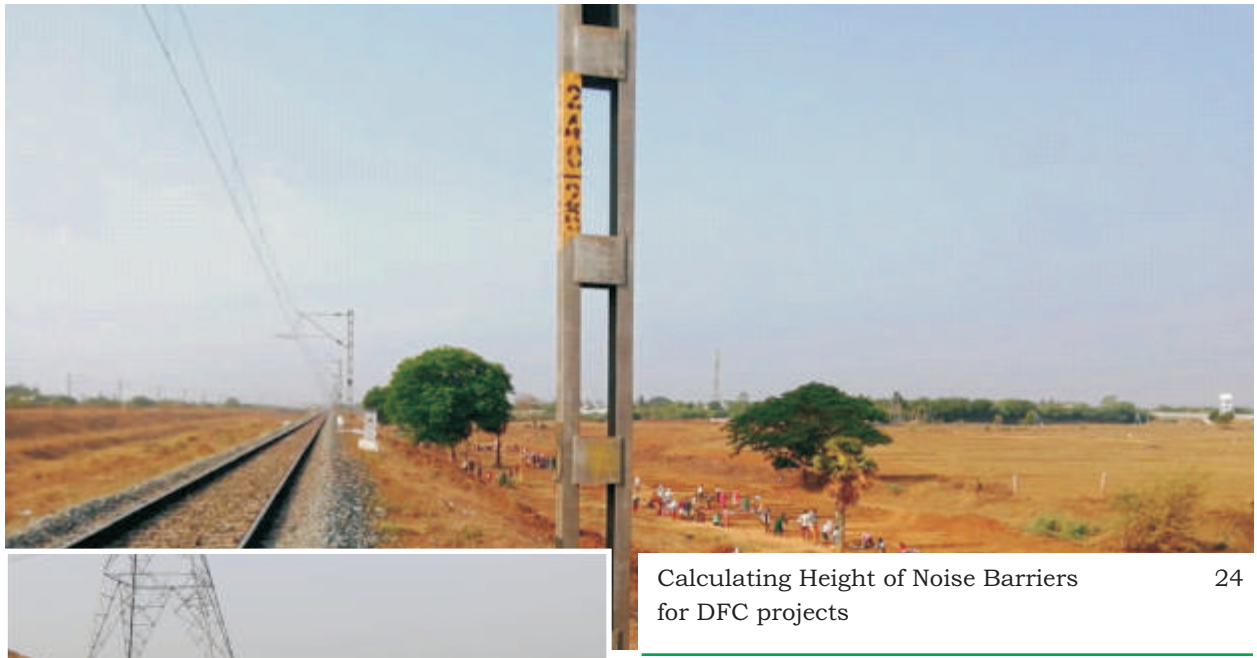

PHOTO

CTP-15B - Sinking work for Pier no. 13 in progress

EMP – 16 Foundation work of TSS (220 KV) at Kharbao

CTP – 12 -Track Linking with NTC @ Ch. 73.530

CTP- 14 - D-shaped Tunnel after completion of Blast work

CTP – 15B - Girder Launched at P3-P4, P4-P5, P5-P6

GALLERY

Final Torqueing of Bolts at Important Bridge No.55(Markanda)

CP-301 - Sub-Structure Completion status at RFO 165

CP-301- PSC Slab launching at RFO 164

Preparation of Pile Cap for Pier P-3
at Important Bridge No. 13 over River Yamuna

Return Wall lift and approach work in progress @ Minor RUB 164A

डेडीकेटेड फ्रेट कोरीडोर

Innovative Model for Sustainable Development in DFCCIL-Lessons from MGNREGA

Sachinder Mohan Sharma,
GGM/Mechanical/DFCCIL/Co.

Pratham Agrawal,
XEN, Ahmednagar, CR.

ABSTRACT

The Dedicated Freight Corridors are coming up at a fast pace and will be game changers as far as rail transport is concerned. Utilizing state of the art technology in infrastructure development and rolling stock they will reduce the cost of transportation and bring about a modal shift from road to rail. This shift is expected to reduce the Green House Gas (GHG) emissions and save more than 450 million ton of CO2 in first 30 years of operation. The mission area of DFCCIL includes its commitment towards ecological sustainability(https://dfccil.com/).

Figure 1 Drone view of first Heavy Haul Train run on EDFC's 194 km Bhadan - Khurja section on 14.09.2019.

Figure 2 Double Stack Train inaugural run on Western DFC.

To fulfill its promise of a green corridor and sustainable development DFCCIL needs to look at innovative ways to meet these objectives through green growth and eco-innovation. Innovation is the act of applying knowledge, new or old, to the creation of new processes, products, and services that have value for at least one of your stakeholder groups. In today's context it is doing more with less- affordability and sustainability. As defined by Kemp and Pearson (2007) eco-innovation involves constructing, assimilating, or exploiting a product, service, process, or organizational method that brings novelty to the firm and that results in minimizing environmental risk, pollution, and other negative impacts. This helps in progressing towards the goals of sustainable development through efficient and responsible use of natural resources and at the same time creates business opportunities.

One such initiative can be the greening of the freight corridors by tree plantations along the approximately 3000 kilometers of its route length. The innovation here is that we can do this without spending any money from DFCCIL by using the provisions in the schemes of the Government of India. This initiative can also be source of non-fare revenue and can be self-sustaining as can be seen from the case study of South Central Railway and Central Railway.Thus getting railway related work through other government schemes is both a process and business model innovation. It has immense benefits for various stakeholders like the rural people who get employment, DFC, People who stay close to the alignment and may not use the employment opportunity but are benefitted by the greenery and noise reduction, local government etc. to name a few.

Nothing is more powerful than an idea whose time has come and time of Convergence with the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) has come. Railway is the 24th department to secure convergence.

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) 2005 seeks to provide at least 100 days of guaranteed wage employment in a financial year to every rural household whose adult members volunteer to do unskilled manual work. The goals of the act are socio-economic development and social inclusion through opportunities for employment for vulnerable people living in rural areas. This scheme also promotes environmental objectives by rejuvenating the natural resource base of rural areas. The economic benefits of MGNREGS cannot be disputed with lot of researchers suggesting that it has helped dent poverty, reduced distress migration and raised the bargaining power of rural labour. A study conducted by National Council of Applied Economic Research found that MGNREGS has reduced poverty by 32% and thereby enabled the upliftment of approximately 1.4 crore people (Development, 2020).

Case study of SCR

South Central Railway pioneered the implementation of this scheme with Ongole Sub-division spearheading it through the efforts of the author, Pratham, who was ADEN at that time. Railway works had never been done through this scheme but with persistent efforts, six type of works were included in the Ministry of Rural Development letter dated 06.04.2018 which also elaborated upon three essential policy aspects–

1. Six type of non-skilled railway works were identified which were to be offloaded to MGNREGS.
2. Labour and Material component of works will be met form MGNREGS.
3. Gram Panchayat will be the Principal Implementing Agency.

Figure 3 Trench cutting and cess work in progress in Ulavapadumandal of Ongole Sub-division

Figure 4 Trench cutting and cess work in progress in Ulavapadumandal of Ongole Sub-division.

The pilot project conducted in Ongole Sub-division started with 170 laborers for three weeks to check the efficacy of these six works. During the successful execution of such works, it was soon realized that some new works could be added and some existing works could be modified to better suit the railway requirement. Hence a new policy by the Government of Andhra Pradesh was launched on 24.11.2018 identifying nine types of work which could be undertaken in Railway jurisdiction. They are -

1. Desilting of water ways of bridges/RUBs/Pipe culverts/Box culverts.
2. Strengthening/widening of Railways embankment.
3. Trench cutting along Railway boundary.
4. Desilting of Open Wells.
5. Recharge structures to functioning bore wells/dried up bore wells.
6. Block plantation.
7. Village parks in Railway colonies.
8. Linear Plantation.
9. Connecting roads to level crossings up to Bitumen level (90:10).

Figure 5Trench Cutting and Cess Work in progress in Singarayakonda Mandal of Ongole Sub-division.

Figure 6 Trench Cutting and Cess Work in progress in Singarayakonda Mandal of Ongole Sub-division.

The road for getting the sanctions was not as smooth as a lot of effort was required to get the works included in the MGNREGA list. In order to win the trust of the villagers and to facilitate the labour, First Aid boxes were provided at the nearest level crossings so that these could be accessed by the MGNREGA labour in case of emergency. Further, hand pumps at the level crossings were rejuvenated so as to provide a source of drinking water. Some old FRP toilets which had been procured for an earlier event, theKrishna PushkaraluMela, and which were lying idle were installed at LC gates along with proper sump wells. These were also made available for use by the labour, especially women. All these confidence building measures ensured that willing labour was always available for doing work for Indian Railways through MGNREGA.

Figure 7 First aid kit safety boxes supplied at each LC gate.

Figure 8 Fibre Reinforced Plastic toilet (green structure) installed at each LC gate.

Figure 9 LC 148 having toilet and hand pump for water.

Currently the first five types of work are under progress. The amount sanctioned for a total of 867 works currently stands at Rs. 45.4crores and 223 works amounting to Rs. 3.87 Croresare under progress. Some other works which were undertaken as part of MGNREGA are as below:-

1. Providing toilets at all Level Crossing Gates (38 nos.) and Stations (9 nos.) in Ongole Sub-division.
2. Providing water facility at all Level Crossing Gates (38 nos.) and Stations (9 nos.) in Ongole Sub-division.
3. Providing first aid safety kit boxes along with ORS (Oral Rehydration Solution) at all Level Crossing Gates (38 nos.) and Stations (9 nos.) in Ongole Sub-division.

Following this successful implementation, an exclusive head of Railway Project has been created in the main website - http://www.nrega.ap.gov.in/Nregs/ (Official website of NREGA for the state of Andhra Pradesh).The sanctioned, in progress and completed list of works under convergence scheme can be monitored via the link given below:-

http://www.nrega.ap.gov.in/Nregs/FrontServlet?requestType=AssetregRH&actionVal=WorkCatergory&id=Railway%20Project$&type=&Atype=-1.

It is pertinent to note that monitoring system under MGNREGS is online which makes overseeing transparent and easy.

The potential of this scheme is tremendous with Rupees 600 Crores of sanctions awaited in this financial year itself. This may seem very small as the last year's budget under MGNREGS for the state of Andhra Pradesh alone was approximately Rupees 10,000 crores. All the works listed above are of maintenance nature. Once offloaded, the freed-upfunds of railways can be diverted towards other activities.

Lessons for DFCCIL

As far as the DFC is concerned, a list of possibilities can be explored based on the successes in Ongole Sub-division

1. Tree plantation along the railway boundary - The plantation policy under MGNREGS states a three year maintenance period with a mandatory clause of 80% survival rate. A watcher is also deputed for regular watering and ensuring protection against grazing. The above stated policy guidelines are pursued with all seriousness. Another important point to note here is that for MGNREGS, tree plantation is one of their core activities unlike Railways. DFC in consultation with the forest department can utilize the land along the tracks for commercial plantation. The plant species can be chosen which after maturity can be cut and can fetch non-fare revenue for the DFC. The local pulp and paper industry may be interested in this. Indian Railways has empowered the junior scale officers in the latest Schedule of Powers (2018, Part A S. No. 21 & 32) for the auction of trees. The same process had been applied in the Daund-Manmad doubling Project of Central Railwayand this has been a source of non-fare revenue.
2. Another idea which was implemented with success was the work of trench cutting along railway boundary. Numerous benefits were there beginning with mitigation of cattle run over cases in the Ongole section. Secondly, the cut trenches serve as rain water harvesting pits.Upto 18 kilometers of trench have been dug up. The excavated trenches also served as water holding structures. In times of need, the nearby farmers put in submersible pumps to extract water from these structures thereby resulting in a synergistic working. This helped Railways in building trust with the local community and pending approvals of closure of level crossings could be secured easily.Similar works can be done along the DFC and this would also help in connecting with the local communities.
3. Ongole Sub-division has also managed to secure financing for some of the construction projects partly via MGNREGS funds and partly via centrally sponsored scheme. The Construction of Cement Concrete Approach Road to Singarayakonda station was undertaken with labour cost being financed under MGNREGS and material cost being financed under SPMRM(Rurban- a centrally sponsored scheme). Similarly, Construction of public wash toilet and approach road street lighting was also undertaken in twostations falling within Ongole jurisdiction. Similar activities can be undertaken in the approach to DFC stations.

An advantage of such an engagement with the local government and community is that once the work starts, there is a dedicated labour force working near the track. For maintenance works, the contractors can draw labour from such force for conducting safety related track works.

What we at DFCCIL can do?

The field managers at DFCCIL need to conduct trust building exercises which begins with a courtesy meeting with Guardian Minister of the District, MP, MLA and District Collector and thereafter, regular meetings with CEO, ZilaParishad, Mandal Parishad Development Officers (MPDOs) or Block Development

Officers (BDOs), Employment Guarantee Scheme Engineers (EGS Engineers), Program Managers, Program Officers, Technical Assistants and Field Assistants. They should also attend Gram Sabha, Gram Panchayat and Zila Parishad Meetings in order to understand the problems faced by the general public at large. Once the managers get a clear understanding of the scheme modalities, they should then submit estimates to the BDOs for further processing. After the estimates get approval from Gram Panchayat, technical sanction from the MGNREGS department and Administrative approval from Collectorate office, execution of work can begin. As far as confidence building measures are concerned, our local units have a good rapport with the Civil Administration and this would be a good starting point. We could also use our CSR funds for some socio-economic initiatives at the local level.

COVID – 19 has forced us to reassess and redesign the way we work as an organization. This crisis is also an opportunity to innovate and think out of the box. Railway including DFCCIL can draw upon this scheme in order to function smoothly 24X7, reduce the cost of maintenance and to also generate non fare revenue. As far as the society is concerned it gives us an opportunity to partner and contribute to nation building by engaging with the local communities. We will indeed transform transportation by transforming the lives of the communities along our alignment. In the words of father of our nation, **"The future depends on what we do in the present"**

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Resumption of Khurja Dadri Project Site during Covid 19 pandemic - An Approach towards Safer Environment

Md. Tanveer Khan
Project Manager (Engineering),
DFCCIL, Eastern Corridor, Noida.
Email:- tkhan@dfcc.co.in

Ashish Kumar
Environment Manager,
GIL-TPL (JV)

ABSTRACT

Construction work of Double Rail Line from Khurja to Dadri -resumed in April during Covid-19 outbreak abiding all guidelines issued by Government /MHA from time to time. M/S GIL-TPL(JV) is working very hard to take all precautions like wearing mask, site sanitization, thermal screening etc. for all workforce to avoid any risk of Covid 19. Company has provided essential items to all workforce including groceries, gas, medicine etc. during lockdown so that they can be retained at site only and after permission, work can be started withthe same workforce. As per approved SOP, workers are maintaining social distance, ensuring wearing of mask, regular hand washing / sanitization etc. at site. Daily activities at each site includes thermal screening, site sanitization twice etc. that takes extra time to start work with safety.

This paper intends to summarize all efforts done by CP-302 to successfully support/ retain the workers and resume work at site.

Keywords: Covid 19, Work Resumption, Sanitization, Thermal Screening.

Introduction

The existing trunk routes of Howrah-Delhi on the Eastern Corridor and Mumbai-Delhi on the Western Corridor were highly saturated. Railways lost the share in freight traffic from 83% in 1950-51 to 35% in 2011-12. To ease the pressure on existing routes, save time and money, the EDFC & WDFC projects were conceived and construction started. This project (Khurja – Dadri section) is a part of EDFCwith a length of around 46 kms. The entire stretch of the project is located in the State of Uttar Pradesh and passes through two districts namely Bulandshahar and Gautam Budh Nagar.The project is certified with ISO 14001:2015 and OHSAS 18001:2007.

Currently, approx.450Labour and Staff/Officers are working in this project safely. Contractor has established a well-developed Safe Operating Procedure for site works so that all workforce feels safe during their working hours.

Site Management

Project site management is done as per approved Safe Operating Procedure (SOP). Implementation of activities like thermal screening, site sanitization etc. to mitigate the risk of Covid 19 pandemic. Awareness sign boards are displayedat several locations for creating awareness amongst all.

Development of SOP for work resumption and Isolation Ward

Safe Operating Procedure is developed and followed at all sites. This SOP is prepared to guide resumption of work safely at all site offices / batching plants / gantry yards / stores after the lockdown period. All precautionary measures are ensured at all sites, so that employees / contract workers feel safe and secure at work place.

Isolation ward is developed for handling any type of emergency during Covid 19 pandemic. Doctor and Male nurse are available at all time.

Yoga Camp is also organized for physical fitness of workers as depicted in the photograph below

Thermal Screening

Contactless thermal screening is mandatory for all workforce before reaching site/office. The arrangements have been made at all site locations. If the skin temperature in key areas, especially the forehead and corner of the eyes, is above normal body temperature, then that person is selected for additional screening. The person with elevated temperature is screened with virus-specific diagnostic test.The person who handles the thermal screening is not required to be physically close to the person being evaluated. However, it is mandatory to wear PPE kit while doing thermal screening to avoid any risk of infection.

A specific checklist is also maintained at site with proper record of thermal screening.

GMR

GIL-TPL (JV) LOT - 302
CONTACTLESS THERMAL SCREENING

TATA

Site Location :- Date :-

Contractor Name :-

Sr No.	Worker Name	Body Temprature (°F)			Mobile No	Remark
		Morning	Afternoon	Evening		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

First Aider/ Medical Representative Site Engineer Safety Officer

Sanitization and Hand wash Facility

Sanitization and hand wash facility is maintained at all major site location. Contactless hand sanitizer dispenser and hand wash facility is developed at site for proper sanitization of workforce. Awareness among worker is created for maximum use of hand wash rather use of sanitizer.

Cleaning staff and others is also aware to clean their hands often, including immediately after removing gloves, by washing hands with soap and water for 20 seconds. It is instructed, if soap and water are not available and hands are not visibly dirty, an alcohol-based hand sanitizer that contains at least 70% alcohol may be used. However, if hands are visibly dirty, always wash hands with soap and water.

Contactless hand wash facility at siteContactless hand sanitizer at site

Site Sanitization

Sanitization is carried out by using Sodium hypochlorite solution. Sanitization of office area is carried out twice in a day while sanitization of every site is carried out once in a day, as the chances of contamination is less in outdoor due to air currents and exposure of sunlight.

Work execution

After site sanitization and thermal screening of workforce, work is executed by maintaining social distancing. A mandatory checklist is also developed which is to be filled at every site before execution of work. During working, it is mandatory for all staffs and workforce to wear company provided mask specified for Covid 19.

TATA	**GIL-TPL JV Lot 302** **Mandatory Checklist to re-start work at site (Post COVID 19)**	GMR

Location:

S. No.	Observation	Yes	No
1	Mandatory Thermal scanning to everyone at site		
2	Mandatory use of PPEs like Face Mask, hand gloves etc.		
3	Provision for Hand wash with soap & sanitizers at every entry and exit point of site		
4	Paan chewing, Gutka, Tobacco, etc. are strictly prohibited		
5	Portable drinking water facility with sanitization		
6	Spitting at site is strictly prohibited		
7	Mandatory Social Distancing (each individual has to maintain minimum 1 m distance at site)		
8	Mandatory disinfection of site before start of work (labor camp, toilet, office, etc.)		
9	Mandatory cordoned off site area and no visitors/trespass are allowed inside area		
10	Mandatory Separate water bottle to each individual labors or use disposable glass (no sharing of glass/bottle permitted)		
11	Display Pre-caution Measures Board mentioning Do's and Do not in language known to workers at site		
12	Availability of site engineer/safety officer at site		

Remarks: No work is allowed before filling and signing of this checklist at every sites.

Site Engineer (Name & Sign)	**Safety Officer (Name & Sign)**

Summary & Conclusion

Following all MHA guidelines & preventive measures stringently, the management of CP 302 could successfully resume workin the last week of April during Covid 19 outbreak. The work is going on in full swing currently and around 16 Km track linking has been done during the period of lockdown. The feedback from workforce and staffs is good enough to continue smooth working at site. All workers and staffs are being motivated/ counselled regularly to keep their moral high and make them feel safe so that they canwork towards the progress of the project.

डेडीकेटेड फ्रेट कोरीडोर

Effective management of COVID-19, support to migrant workers and successful resumption of construction work in Khurja – Pilkhani section of EDFC

Dr. Raman Chaudhary
Sr. Dy. General Manager & Head Social,
Project Administration & Industrial Relations
Larsen & Toubro
DFCCIL -CP 303 Project

J.P Goyal
Dy. Chief Project Manager
(Civil), DFCCIL, Meerut, U.P

ABSTRACT

The outbreak of coronavirus pandemic 2019 (COVID-19) created a global health crisis that -had a deep impact on the way we perceive our world and our everyday life. Similar to others, Contract Project (CP) 303, too, is reeling under the impact of coronavirus pandemic and is uncertain of the post lockdown phase.

As per WHO Coronavirus disease (COVID-19) is an infectious disease caused by a novel type of coronavirus. The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. Symptoms typically include fever, cough, and shortness of breath. Non- respiratory symptoms like loss of smell/ taste are also being experienced. Few are asymptomatic, who pose a greater threat. The health crisis has left millions of migrant workers displaced and millions job less.

This paper intends to share the experience of Lot-303 of facing this unprecedented health emergency with a strong Standard Operating Procedure and effective Organisational Management and ultimately resuming the construction work successfully post lockdown

Keywords: Work resumption, Migrant workers, Standard Operating Procedure for COVID-19

Introduction:

On 24 March, Prime Minister Narendra Modi announced a complete 21-day – nation-widelockdown to curb the spread of the coronavirus pandemic in country. After the announcement of lockdown in our country on 24th March 2020 all work activity stopped, and migrant workers suddenly found themselves in a critical condition due to uncertainty over their livelihood. Due to imposition of section 144, no transportation modes were available for labour or materials. -

This unprecedented health emergency had put Project Management of Lot-303 in a challenging situation of adapting to a new normal. On one hand, workers had to be retained, availability of essential items as well as construction materials had to be ensured and on the other hand staffs /workers had to be guided, motivated and counselled to face the highly contagious health crisis.

Migrant workers were especially motivated and counselled to stay back during lockdown period at site to prevent COVID 19 contamination of & livelihood insecurity of workers,as well as any adverse impact on construction activities.

Project Description:

The project EDFC CP-303 involves design and construction of civil, structures and track works involving formation in embankments / cuttings, ballast on formation, track works, bridges, structures, buildings, yards, integration with Indian Railways' existing railway system and testing & commissioning on design-build lump sum basis for khurja – pilkhani section.Approximate route length is 222 km.

Site Management:

EDFC CP-303 tookextraordinary step for retention of 1800 workmen during lockdown. Supplied them with essential goods and supported them economically all throughout the lockdown period. This helped in preventing deterioration of economic condition of workers and their dependents as well as progress of the project works

Prepared and is following the standard operating procedures in line with order/ circulars issued by Government from time to time. Safe and standard operating procedures followed in post lockdown period are as follows:

a. Awareness & Counselling:

Awareness & counseling sessions were conducted continuously among the labors. Health monitoring practices like daily thermal screening, randomly B/P (Blood Pressure) Checking were adopted. Mandatory use of personal protective equipment like facemask, Face-shields, hand gloves etc. were ensured. Health officials from other government agencies conducted awareness sessions amongst workers. District administration also visited site and counselled workmen from time to time. Wages paid to workforce continued during & after COVID period that made them feel financially secured during this pandemic.

Fig 1: Continuous Health monitoring of workforce

By Male Nueaw

By EHSO

By Male Nurse

By Male Nurse

By PMC

By PMC

Fig 2: - COVID'19 awareness training was carried out to educate workforce.

b. Health monitoring & establishment of Isolation Wards

Arrangements have been made fordaily Sanitization of work site, plant, machineries and equipment, dispenser for hand sanitizer, hand washing area for workers.Hand sanitizers and Soap (bar) are also being supplied to workforce on regular basis. COVID-19 awareness posters are displayed at labour camps, offices, Plant premises, work sites etc. Eight -isolation rooms have been createdunder the supervision of doctors at labour camps and other placesin case of initial symptoms. Workmen above the age of 55 years were suggested to work from home, as well as others were also given a choice to continue their work from home as per their feasibility. Health camps were organized from time to time for workmen staying at camps and for sub-contractor workers.

c. Regular Monitoring & Emergency Response:

Regular monitoring of COVID-19 response measures includingthat of labour's physiological condition have been conducted. Counsellor/ emergency response team was on standby 24*7. It has been ensured that installation of Arogya Setu application is done by in the mobile phones of all employees. No workmen are allowed to enter the premises of EDFC CP-303 without their thermal screening & record is maintained for the same. Took permission from SDM of Bulandshahr, Hapur, Meerut & Saharanpur (U.P) respectively to provide meal, grocery & health care services retaintheworkers, staffs & their family at different locations. For emergency services permission were taken from District administration in their respective districts.

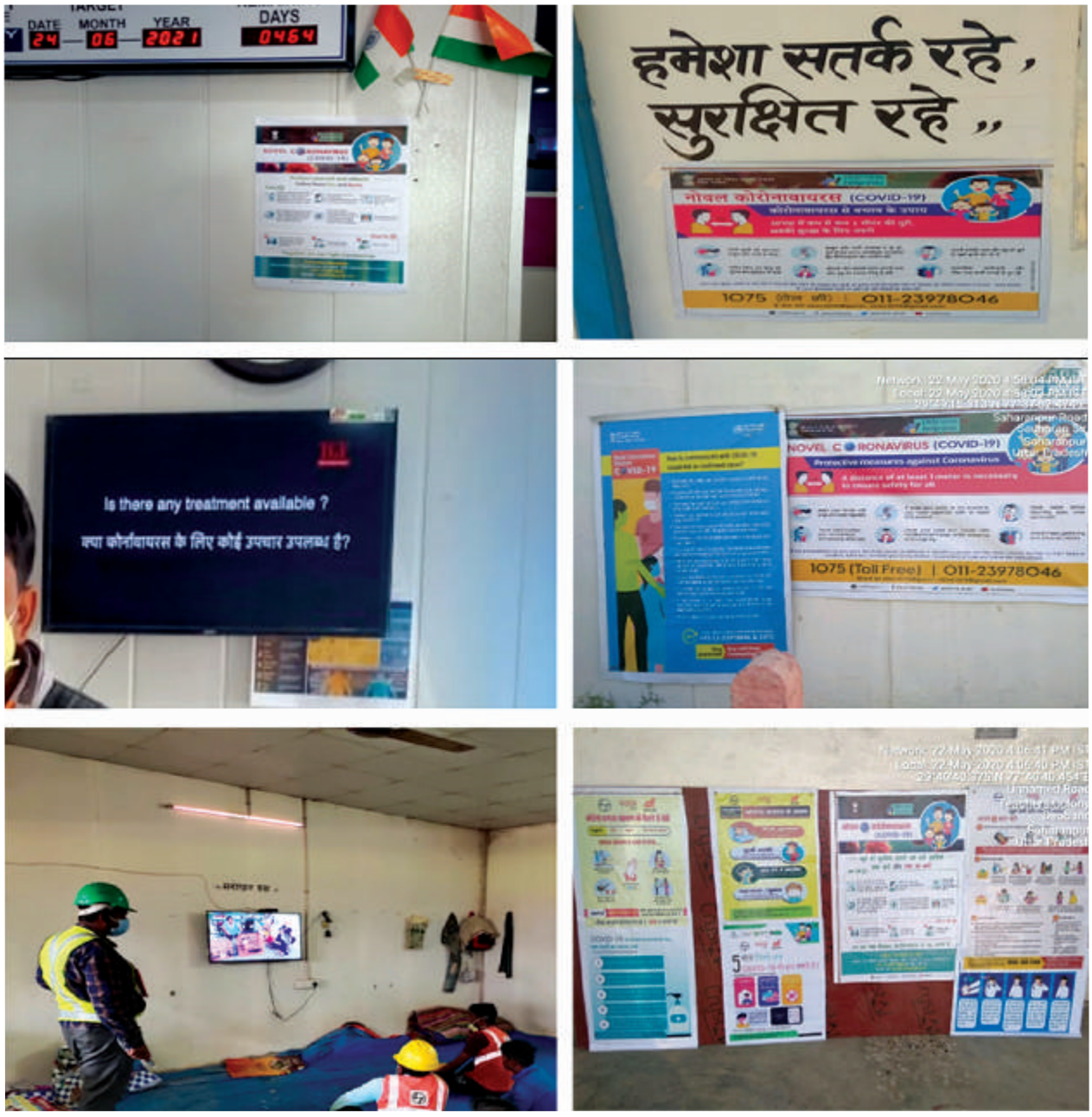

Fig 3: - COVID'19 awareness poster and promotional videos are being displayed for awareness.

d. Social Distancing:

To maintain social distancing following measures have been taken for conducting daily work: a. Work is being carried out in two shifts.

b. Fifty percent workforce in office.

c. Work from home.

To maintain the efficiency & continuity of work, workers have been hired from green zone only and keeping them safe in nearby green zone villages instead of labour camps. New Workmen engagement

procedure was prepared and strictly implemented for recruitment of new workforce. We have also increased some work fronts horizontally like commencement of RE wall, drain work etc to provide extra space and ensure that social distancing is maintained

e. Other Preventive Measures:

Proper arrangements were made for worker's basic daily needs like food, potable drinking water, entertainment & connectivity to their family members to avoid any stress & depression. During this lockdown period no workforce was affected by any health-related (COVID-19) issue and no case of mental stress was found. During this lockdown period, extraordinary permission was obtained from District Collector, Hapur

Installation of Sanitization gate

Hand Wash availability is ensured in enough Nos

Document Drop Box

Use of Hand Sanitizer is ensured

Use of Hand Sanitizer is ensured

Use of face detection for attendance

Fig 4: - Other Good Practices

and successfully unloaded approx. 11,000 Metric Ton of Rails at Gulaothi Depo by maintaining all mitigation measures suggested by government authorities.

Though the preventive measures of Ncovid-19 are simple, they need to be followed very stringently by both the administration and individual person. Ultimately, in CP-303, with a very stringent SOP & its implementation no labour is found affected directly or indirectly due to COVID-19 and departed from the project during lockdown period. It is a great achievement for CP 303 that the project management was able to successfully retain approx. 1800 workforce in the project. It was the combined efforts & support of all DFCCIL, PMC & L&T's management & volunteers to achieve this target during this pandemic situation. CP-303 is committed to crumble all unwanted

Calculating Height of Noise Barriers for DFC projects

Tamosi Bhattacharya
(Environmental Planner)
Consultant/ Environment/ SEMU

Abstract:

Determining the height of noise barriers in general is a function of diffraction angle, path length difference, frequency and speed of noise, height of locomotive, height of wagons, height of receptor, railway width and height of source. While conducting the Environment Impact Assessment (EIA) as part of Detailed Project Reports (DPR), often it is not financially or technically feasible for DPR Consultants to determine the exact length, height, material type, width of noise barriers. This results in lack of guidance and clarity regarding noise barrier construction during implementation period along with considerable difference in cost estimation as well. This calls for formulation of a detailed guideline for noise barrier designs along with warrants for selection of sensitive noise barriers[i].

This paper attempts to formulate a guideline for easy determination of noise barrier height using dimensions of acoustical shadow zones.

Keywords: Noise Barrier, Acoustical Shadow Zone, Diffraction Path

1. Introduction

Criteria for noise barrier design includes length, height, thickness, shape, gap and height-width ratio that depends on various factors like location, rail facing length, height and type of sensitive receptors[ii] etc. Some of these parameters however would differ slightly in case of Metro Rail, High Speed Rail, Indian Rail or Dedicated Freight Rail. Height is one such parameter. Determining the height of a barrier is a function of diffraction angle, path length difference, frequency and speed of noise, height of locomotive, height of train, height of receptor, railway width and height of source. This paper attempts to simplify the method of determining the height of noise barriers in case of rail/ DFCC projects using the concept of acoustical shadow zone and its dimension drawing. This method can be easily replicated for any other noise sources as well.

2. Basic method for determination of height as in practice

Noise attenuation by a barrier takes place due to absorption, transmission loss, reflection or forcing it to take a longer path i.e. diffracted path (Figure 1).

Diffraction is the ability of sound waves to bend around top or side edges of barriers. This ability of sound waves to diffract depends on frequency i.e. higher frequency waves diffracts less and vice versa. This means diffraction angle of high frequency waves are less deep and get attenuated better by barriers than that of lower frequency sound waves.

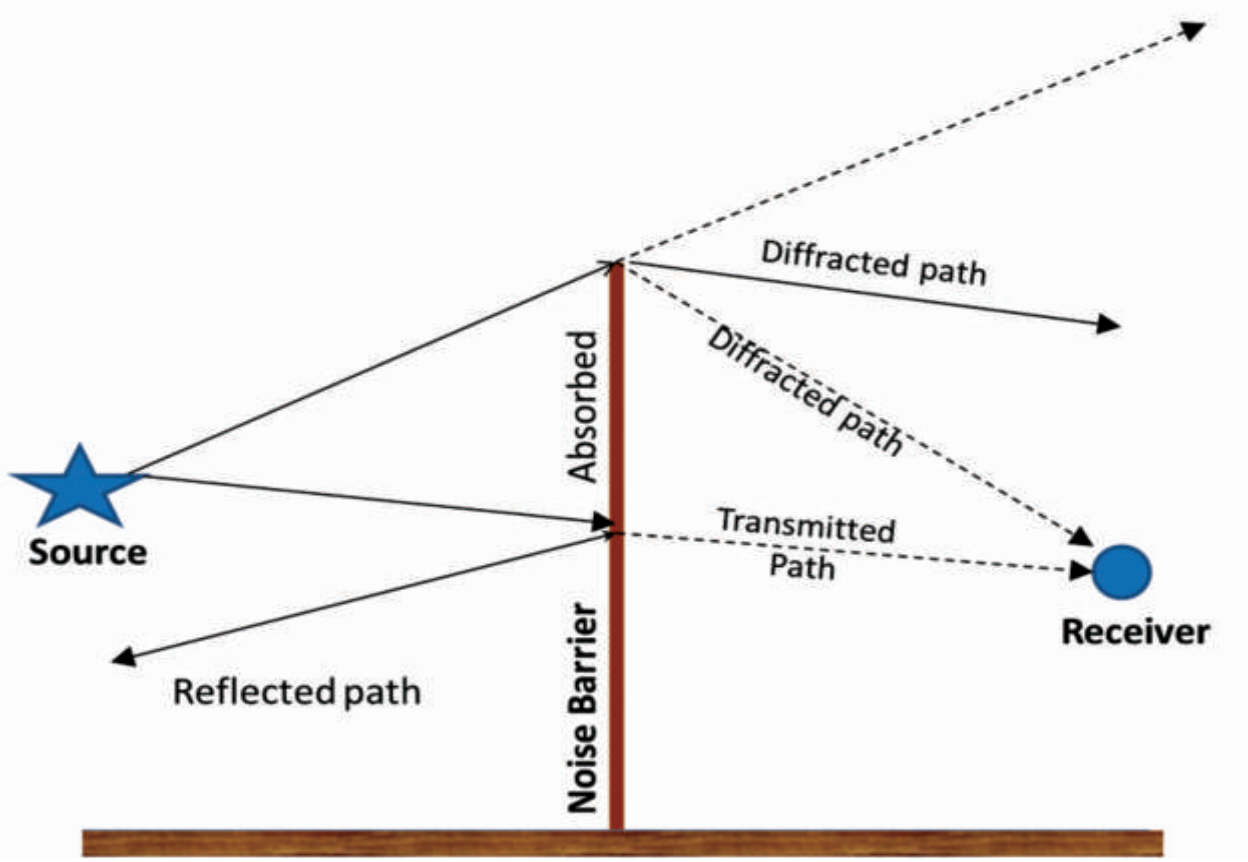

Figure 1: Barrier absorption, reflection, diffraction and transmission

An important aspect of diffraction is the path length difference (δ) between the diffracted path from source over the top of the barrier to the receiver, and the direct path from source to receiver as if the barrier were not present[iii]. Path Length Difference is calculated using formula (1)

Path Length Difference (δ)= a+b-c .....(1)

Where, 'a' is the distance from source to top of barrier; 'b' is the distance from top of barrier to receiver; c is the direct distance from source to receiver.

The path length difference is used to compute the Fresnel Number (N0), which is a dimensionless value used in predicting the attenuation provided by a noise barrier positioned between a source and a receiver. The Fresnel number is computed using formula (2).

N0 =+ 2(δ0/λ) = + 2(f δ0/c) .....(2)

Where, N0 is the Fresnel Number determined along the path defined by a particular source –barrier-receiver geometry; + is positive in the case where the line of sight between the source and receiver is lower than the diffraction point and negative when the line of sight is higher than the diffraction point; λ is the wavelength of the sound radiated by the source; f is the frequency of the sound radiated by the source; and c is the speed of sound.

The attenuation value can be calculated depending on Fresnel number (N) using Maekewa equation (3)[iv]

Sound Level Attenuation (AT) = 10 log (3+20 N) N>1 .....(3)

If the path length differences increases, the Fresnel Number and thus barrier attenuation increases. If the frequency increases, barrier attenuation increases as well. It is easy to analyse if frequency and path length difference both are either increasing or decreasing in a particular instance but in case they are indirectly related, computing the height in absence of the value of frequency (or wavelength and speed of sound waves), may not be feasible. Often it is difficult for an EIA consultant to carry out the monitoring /measurements and design of noise barrier as they involve technical and financial constraints in light of scope of contract agreement and early stage of project.

An alternative method based on empirical data has been formulated in this paper that can help easy determination of height of noise barrier at the EIA stage itself and can give a fair idea of the design and cost likely to be incurred during implementation.

3. Alternative method for calculation of height

The main criterion in this method is the Acoustical Shadow Zone (ASZ). ASZ is the zone on the opposite side of the barrier where the sound approaching from source is reduced by absorption, reflection, transmission and diffraction. The zone between the screen and the reception point is divided into an illuminated zone and a shadow zone[v] (Figure 2). All observation points in the shadow zone perceive a reduction of the sound level while those in the illuminated zone get very little advantage from the barrier. Shadow zone is separated from the illuminated zone by the line of sight. Line of sight is the straight line path between the source and the top of the noise barrier. However, due to diffraction and scattering, sound penetrates into the shadow zone causing it to decrease with distance from the barrier[iv].

To demarcate the acoustical shadow zone, site specific data is required on the height of receiver, height of source, distance from source to proposed noise barrier, distance from proposed barrier to receiver. Dimensions of these known variables need to be drawn using any drawing software to determine the unknown variable, height of noise barrier.

In case of railway projects noise is generated from the locomotive and wagons at various heights viz. rolling of wheels on track (lowest source), traction, whistling /honking and aerodynamic noise (highest source) as given in Figure 3. Aerodynamic noise is generally caused due to unsteady airflow over train at a speed >300 kmph. Hence, in case of DFCC projects, whistling /honking is the highest (in terms of height) source of noise that needs to be attenuated. However, considering noise from honking or whistling shall depend on the fact that whether whistling or honking would be required to be done in those particular locations (if DFC is parallel to IR) or in locations of same nature in that particular Railway Division as per Indian Railways. This information is likely to be available in the General and Subsidiary Rules of the concerned IR Division. The other way can be to locate existing whistle boards ("W") of IR along parallel sections or at locations of same nature in the division along detours while conducting field survey for preparation of Environment Impact Assessment.

Height of the noise barrier shall be as much as to let the line of sight from maximum source height pass above the receptor height that will ensure that the receptor falls within the acoustical shadow zone. The receptor can still receive the diffracted noise however, increasing the height of barrier will increase the distance travelled by the diffracted noise and in turn

increase attenuation. Increasing the height after a certain level may not be economically or structurally sustainable and hence top edge treatments of various shapes can be provided that can diffract the noise waves away from the receptors.

At locations, where height of receptor is more than the source height, additional attenuation can be attained by increasing the number of diffractions at the top edge of barrier and that is possible by providing top edge treatment i.e. T–top, Y-top, Cylindrical, mushroom, pear-shape, curved top etc (Figure 4, 5,6). Top edges with absorptive/ soft materials are likely to be more effective.

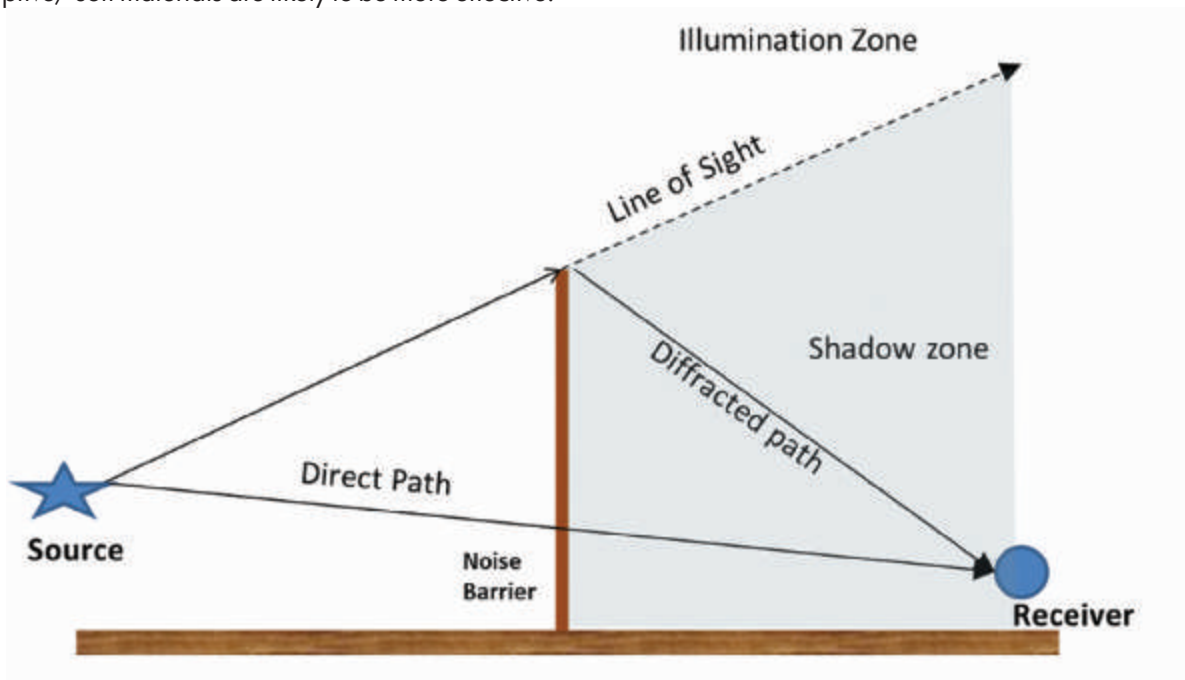

Figure 2: Shadow and Illumination Zone

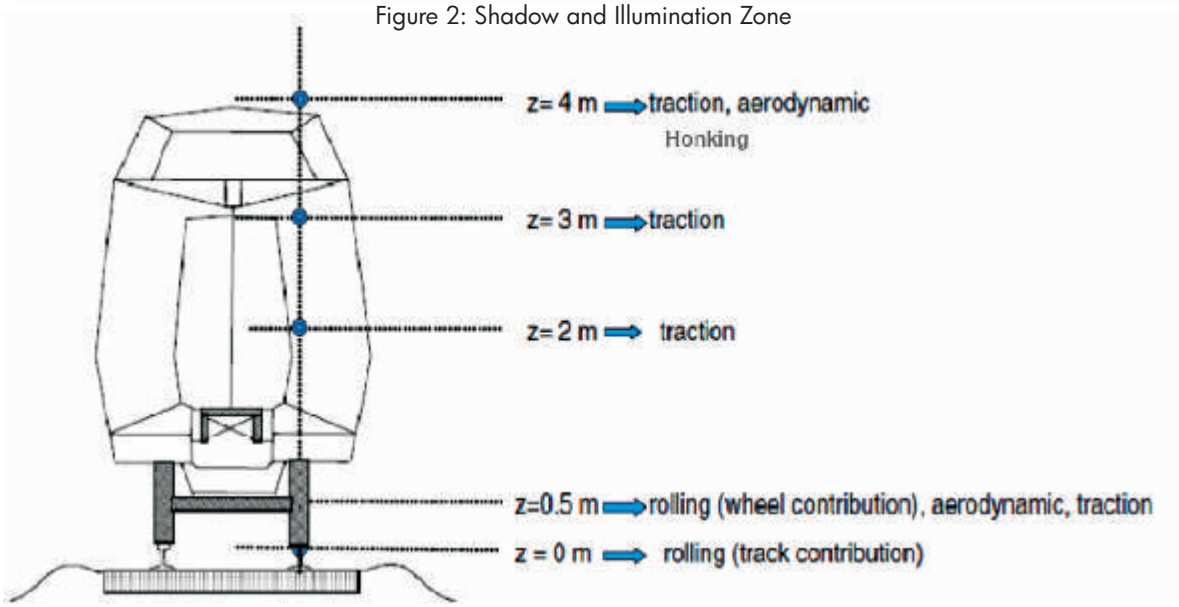

Figure 3. Sources of Noise at Various Height (approximate)[vii]

One can choose the top edge shape by comparing the height of shadow zone extended by various types of top edge shapes. To do so one can draw a straight line from the maximum source height (vertically above centre line of each track, as the farthest rail track dominates the noise at the receiver) as a tangent to the top – edge up to the receptor on both sides. The one that covers the maximum receptor height within the shadow zone shall be chosen. A schematic diagram comparing the shadow zones for plain vertical and few other top edges is given as an example in Figure 7. It is advised to map some simple information during design study of railways so as to facilitate determination of barrier height easily viz. distance of source to proposed noise barrier, maximum source height, maximum height of receptor, distance of receptor from proposed barrier.

Part of sound waves incident on the noise barrier tends to reflect back towards the train and again gets reflected back by passing trains increasing the apparent height of the source (Figure 8). This process continues until the sound reaches the top of the barrier where it is diffracted towards the receiver. These multiple reflections effectively raise the height of the noise source to near the top of the barrier and hence there is little or no path difference between the direct and the diffracted rays.

An effective way to get rid of the apparent height consideration is to use absorptive noise barriers or tilt barriers outwards so as to reflect the noise above the receiver rather than towards it.

It shall be noted that the protruding edge of top shape towards the rail shall be at a distance not less than that of the electrical poles.

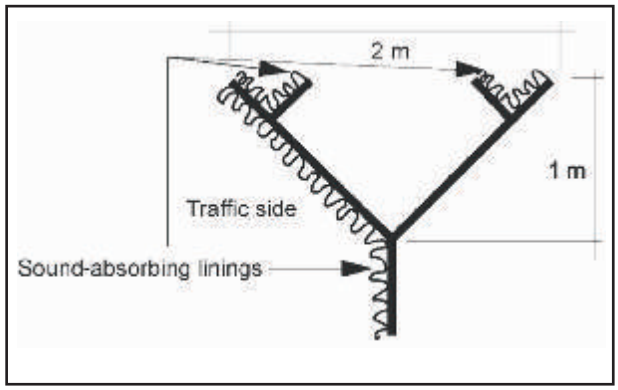

Figure 4. A multiple Y-shaped barrier[viii]

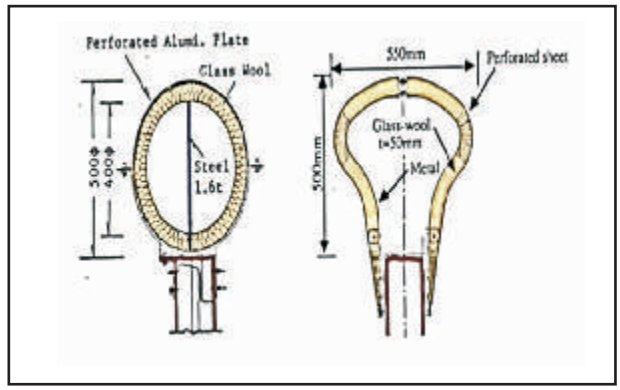

Figure 5. Cross section of cylindrical and mushroom shaped barrier[ix]

Figure 6. Tubular shaped barrier

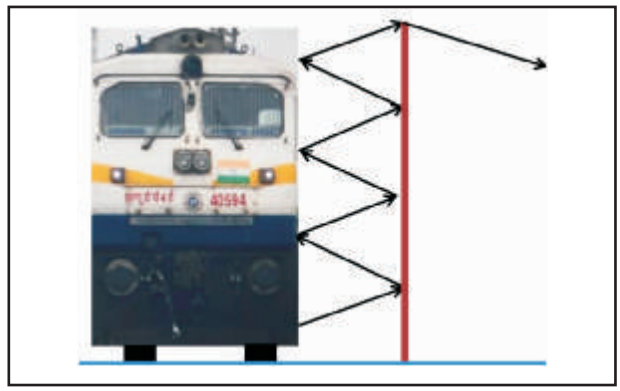

Figure 8 Multiple reflections affecting the Apparent Source height

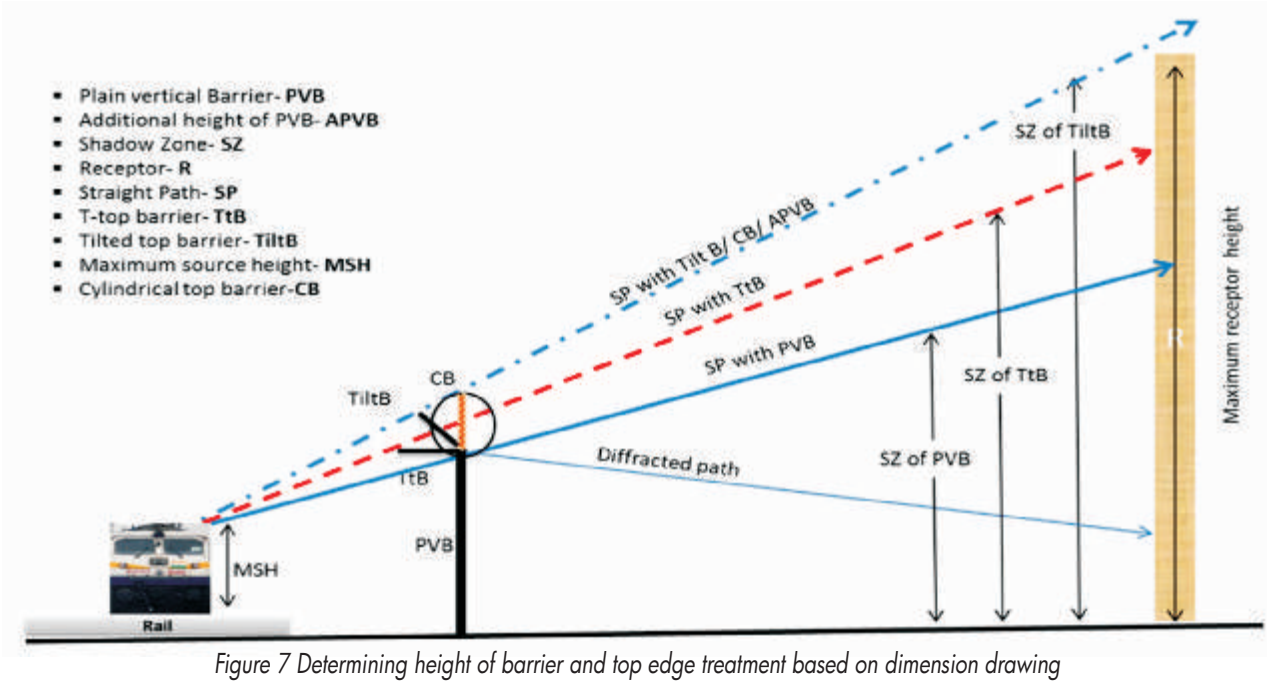

Figure 7 Determining height of barrier and top edge treatment based on dimension drawing

Case Example:

Indian Locomotive of class WAG9H is likely to be used for the Eastern Dedicated Freight Corridor with its horn at the height of 3.895 m from the track. Diameter of the horn is likely to be 0.1524 m and hence the final height of noise generating source would be 4.0474 m from above the track level. Distance from horn of loco to proposed noise barrier is 3 m. Receptor school building is 10 m in height and at a distance of 40 m from the proposed barrier locations. Given the above four dimensions, height of noise barrier has been calculated using AutoCAD drawing software. The resultant height is 4.46 m. All heights have been considered from track level (Figure 9). Height of the noise barrier will tend to increase as receptor comes closer. As depicted in Figure 10, other conditions remaining same, when distance between noise barrier and receptor decreases to 5 m the height of barrier increases to 6.28 m. To lower the height of barrier one can opt for top edge treatments. As shown in Figure 11 with a half Y tilted at 130 degrees at a height of 4.5 m vertical straight barrier, the total dimension comes down to 5.93 m. Financial and structural feasibility however shall be considered while deciding on the top edge treatment

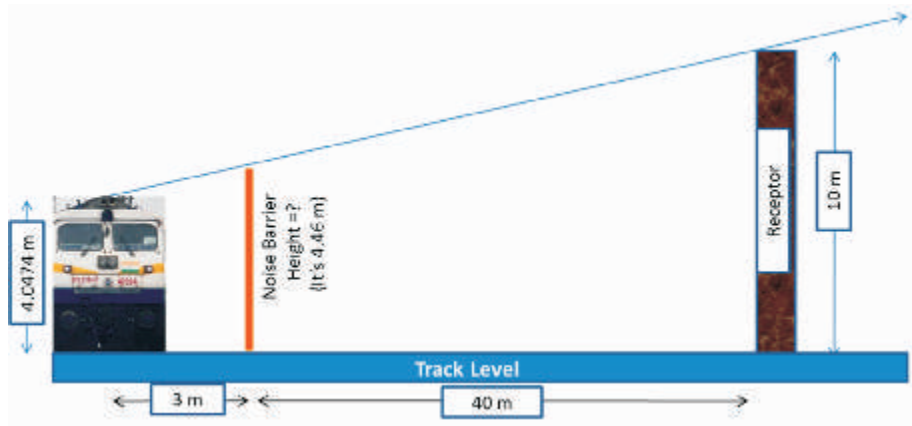

Figure 9 Case Example to calculate height of noise barrier using line of sight and shadow zone

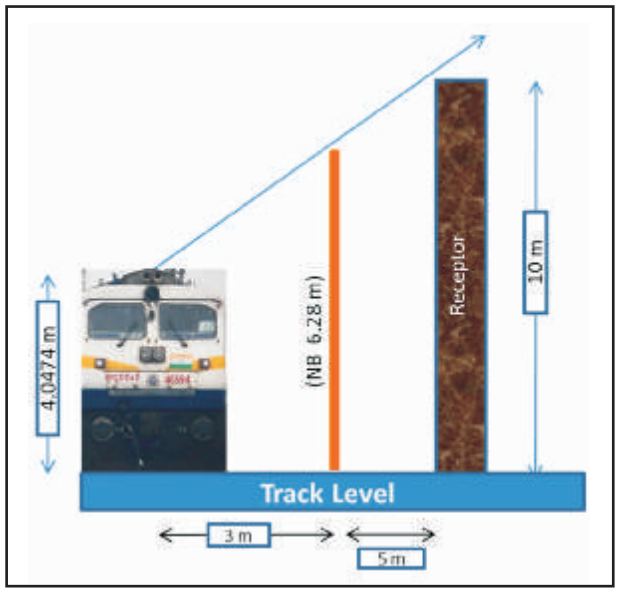

Figure 10 Increase in height of barrier when receptor is closer

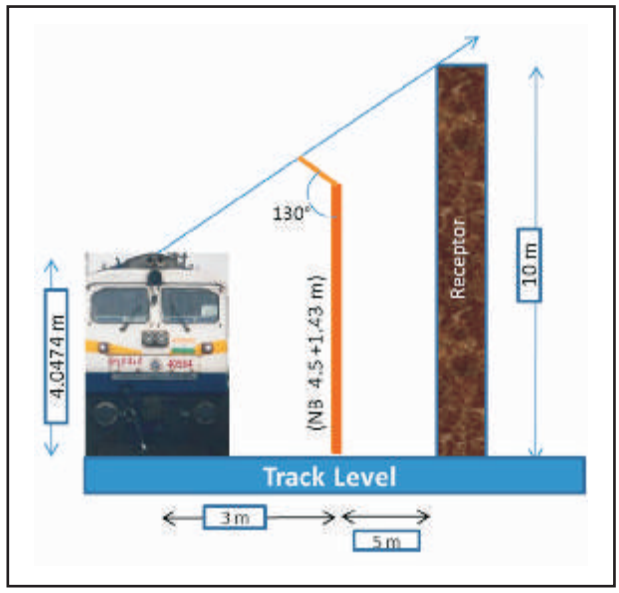

Figure 11 Noise barrier with Top edge treatment to decrease height

4. Conclusion

Though the height could be determined using the parameters of line of sight and shadow zone, it will be necessary to test the design for both acoustic and physical properties before installation to ensure magnitude of noise isolation and structural stability

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Digital Terrain Modeling – Role in Economic Alignment Design

CTP-14 case study

R.K. Rastogi
PM/Civil/Noida

Abstract:

Ministry of Railways has planned to constructthree future Dedicated Freight Corridor covering about 4000 Route Kms on three future corridors viz East Cost Corridor(1115 Km), East West Sub Corridor(1868Km), North-South sub Corridor(975Kms).

Through this write up, an attempt has been made to describe that,3D images of the terrain in real-time, based on high-resolution Digital Elevation Model (DEM) data, can provide a high-resolution and accurate DEM of targeted areas. The development of the alignment design model incorporating modern graphics capability, advanced remote sensing technologies, improved software languages, modern optimization techniques, and environmental considerations will improve the design process for future DFC corridors.

It is explained practically that how Digital Terrain Modeling helped in economical design and modification of alignment,initially proposed by M/S RITES LTD,in CGM/Noida unit, in the geographically difficult terrain of Arawali hills. How knowledge gained could be extended for economic design of alignment in some selected geographically difficult & inaccessible terrains or in some shortlisted areas having potential business opportunity to develop most beneficial alignment by adopting various permutations and combinationsfor development of Integration of Inter-Model Transport system for future corridors.

Digital Terrain Models (DTM) sometimes called Digital Elevation Models (DEM) is a topographic model of bare Earth that can be manipulated by computer programs. It is a three dimensional representation of a Terrain surface consisting of X, Y, Z co-ordinates stored in a digital form. It also includes other geographical elements and Natural features such as rivers, Ridge Lines, valleys, depressions etc.

Vegetation, buildings and other cultural features are removed digitally - leaving just the underlying terrain.DTMs are used especially in civil engineering, geodesy & surveying, geophysics, geography and remote sensing.

Fig-1 DTM/DEM

Digital Surface Model (DSM)-Digital Surface model represents the Earth Surface and includes all objects such as Tree, Buildings over it.

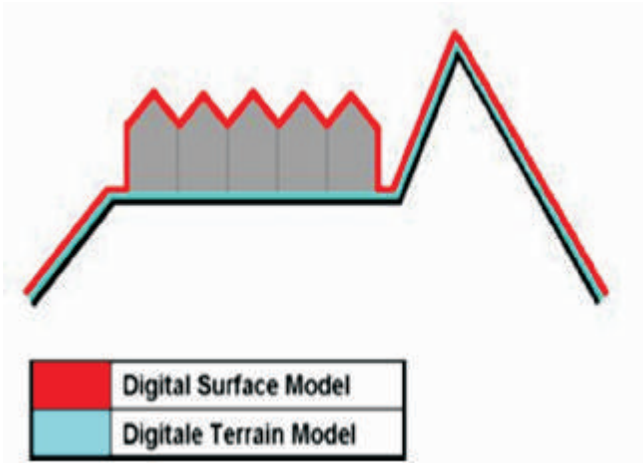

Fig-2 DSM

Following images shall clearly indicate the difference between DTM(DEM) and DSM.

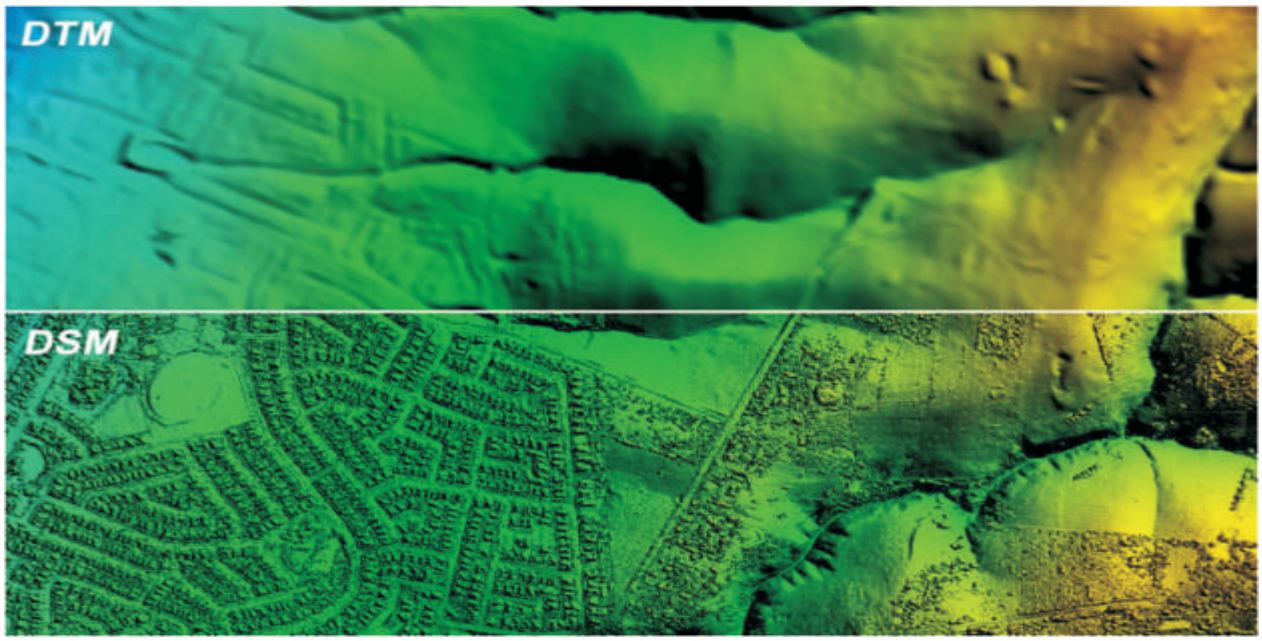

Fig-3 Indicative DTM/DSM image

Methods for obtaining elevation data used to create DTM/DEM/DSM:- Following survey technics are used for collection of raw field data for generation of DTM/DEM/DSM.

- Lidar
- Radar
- Stereo photogrammetry from aerial surveys
- Structure from motion / Multi-view stereo applied to aerial photography
- **Block adjustment from optical satellite imagery**
- Interferometry from radar data
- Real Time Kinematic GPS
- Topographic maps
- Theodolite or total station
- Doppler radar
- Focus variation
- Inertial surveys
- Surveying and mapping drones
- Range imaging

Benefits of Data Collection from Satellite Imaginary V/S Other Methods

Creating Digital Elevation Model (DEM) by digitizing contour lines from topographic maps or through stereoscopic semi-automated methods from aerial photographs are proven methods. However, DEM generation from satellite stereo image pairs of optical and microwave sensors, is still not a common practice. The DEM generated from satellite stereo pairs have some significant advantages over other sources, viz:

1. World wide availability of satellite data without any restriction (often available as archived data) as against restricted and non-availability of topographical maps and aerial photographs. In addition to above latest live satellite imaginary may be obtained through IRSC.
2. Large area coverage per scene
3. Moderately high resolution
4. Faster processing through sophisticated software and little manual effort
5. Low processing cost
6. All weather and day/night image acquisition capabilities (in case of microwave sensors)

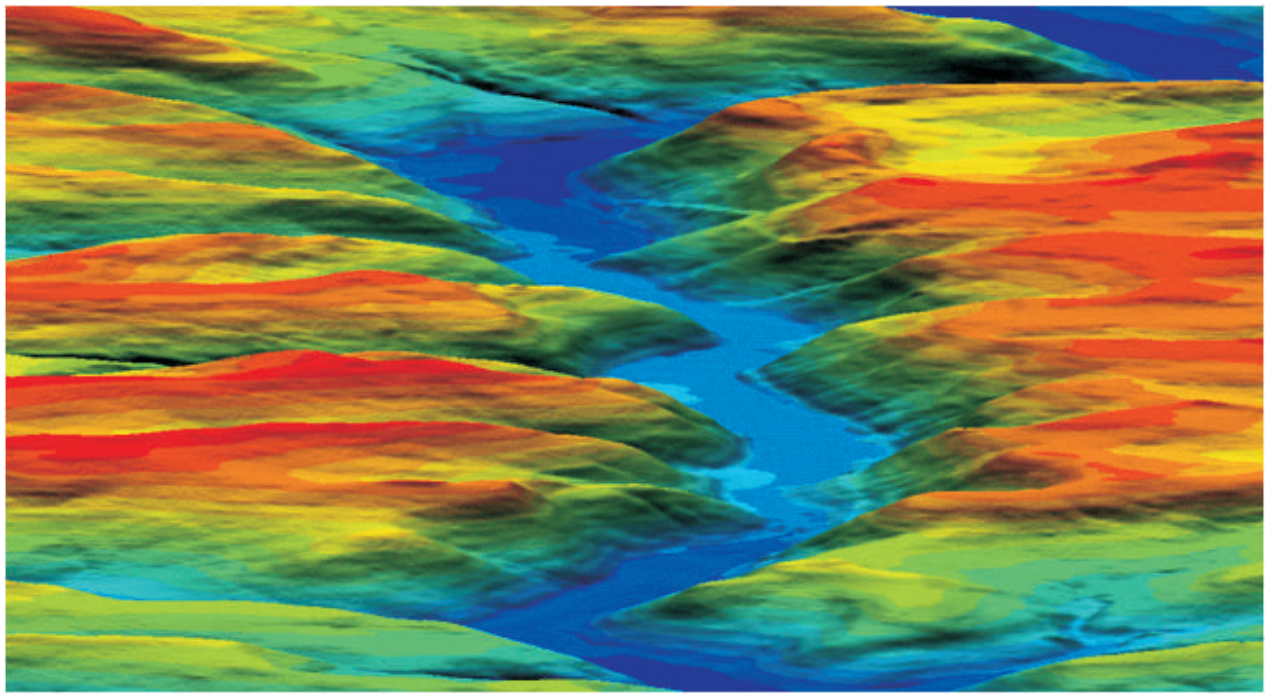

Fig-4 Digital Elevation Model

Digital Modeling and its use in Alignment Design through Arawali Hills in CTP-14 Contract:-

CTP-14 alignment in CGM/Noida unit was passing through Arawali hills in alignment length of 10-12 Km. Where the up hills ground level in Mewat is around 80 mtr height from the downhill ground Level in Sohna ,Gurgaon. Uphill and downhill area is bifurcated through Arawali hills of width around 800 mtr to 1200 mtr along the alignment and this hill is forming an impervious barrier which retains the uphill water table around 70 mtr above the downhill water table. Five villages named Dhulawat, Pipaka, Ghusbathi, Patuka & sahsola are situated at Up Hills of Arawali. These villages are having Tube-well irrigation as the only source for their Crops.

The RojkaMeo industrial area and Sohna town is situated at Downhill of Arawali.

Fig-5 RojkaMeo Industrial Area at Downhill of Arawali

Fig-6 Sohna town at downhill of Arawali

Alignment proposed earlier by M/S RITES was reviewed during Oct-2013 and does not found appropriate due to following reasons.

- Proposed RITES alignment was passing through the middle of populated area of Patuka village through a deep Cut causing huge socio political, financial & safety implications.
- Proposed RITES alignment after crossing Arawali hills was passing through the middle of RojkaMeo industrial area & bifurcate the same.
- In RITES proposal, the invert Level of proposed Tunnel through Arawali falls below the Ground water table in uphill area which would result in flow of Ground water through the Tunnel opening to the downhill side resulting in lowering of water table on the uphill side & flooding in downhill side of Arawali (There is a level difference of around 70 Mtr in Up hills and Downhill side of Arawali & Arawali acts as an impervious barrier to retain the water on uphill side& tube-well are the main source of irrigation on uphill side of Arawali). It would result in great discomfort in uphill as well as in downhill population in Sohna area of Gurgaon.
- The Proposed length of Tunnel was 2.9 Kms resulting in huge cost for a double stack electrified SOD.

Subsequent meetings with GM/RITES/Gurgaon revealed that the ground water table was not considered while proposing the alignment through the Arawali and he was also of the view that the previously proposed alignment should be suitably altered to minimize the social, environmental and financial impacts.

FiG-7 Alignment Proposed by RITES LTD through Arawali

The search for alternative alignment was started through the most difficult geographical terrain of CGM/Noida unit, which was also inaccessible and it was too difficult its survey through traditional survey equipment such as theodolite, Plane table or Total station.

The idea of getting Satellite imaginary and to create DTM from that imaginary by linking the same with ground control points was thought. **National Remote sensing Centre (NRSC),** Hyderabad was contacted to get satellite imaginary.

National Remote Sensing Centre (NRSC) at Hyderabad has been converted into full-fledged centers of ISRO since September 1, 2008. Earlier, NRSC was an autonomous body called National Remote Sensing Agency (NRSA) under Department of Space (DOS). The Centre is responsible for remote sensing satellite data acquisition and processing, data dissemination, aerial remote sensing and decision support for disaster management.

Fig -8 NRSC, Hyderabad

NRSC has outsourced theabove work to Astrium Satellites to get real time satellite imaginary. Due to rampant illegal mining in this region the real time imaginary was required to know the exact terrain at the time of planning.

Astrium Satellites -was one of the three business units of Astrium (now Airbus Defense and Space), a subsidiary of EADS (now Airbus). It is a European space manufacturer involved in the manufacturing of spacecraft used for science, Earth observation and telecommunications, as well as the equipment and subsystems used therein and related ground systems.

EADS Astrium Satellites employs around 8,348 people on nine sites in the United Kingdom, France, Germany and Spain.

NRSC has demanded the Google imaginary of the targeted area (Minimum 100 Sq Km), so that on a clear day when the European satellite passes through the targeted area, the clear imaginary could be obtained.

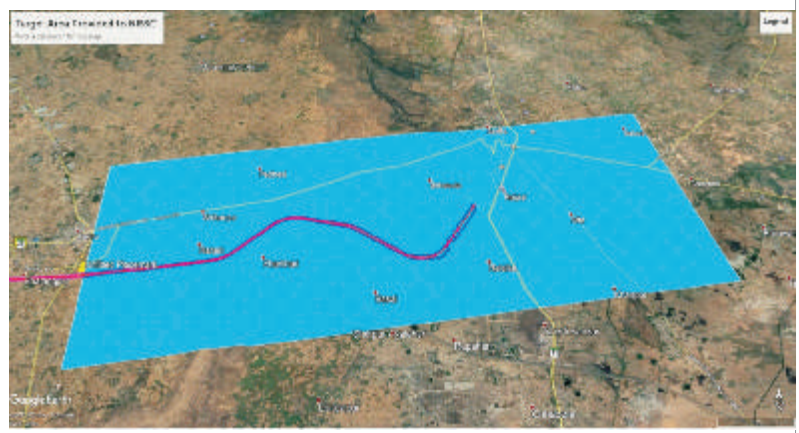

Fig-9 Targeted area image(100sqkm) provided to NRSC

Imaginary of targeted area of Size 6.67x15Km (100 Sq-Km) by marking box of light blue colour as shown in the above image was provided to NRSC.

High resolution satellite imaginary (Pleiades-0.5m stereo) with 0.5 mtrre solution was captured on a clear sunny day on17/02/2014 and was supplied to Noida Unit by NRSC in a CD along with certain secrecy terms and conditions on a payment of Rs 339300/-

Fig-10 Satellite Imaginary received from NRSC

One consultancy services M/S Introsoft Solutions was shortlisted for collection &synchronization of ground data with the satellite imaginary, to prepare DTM/DEM from the obtained data and to identify the three-four most appropriate alignment in this inaccessible area.

M/S Introsoft Solution has collectedGround Control Points (GCPs) and stereo GCPs from reference maps in order to reference the images to ground. Further, TPs (Tie points) were also collected to improve matching between the two stereo pairs and following workflow was adopted.

Workflow to create DTM/DEM:-DTM/DEM is created by the use of ArcGISapplication by adopting following workflow.

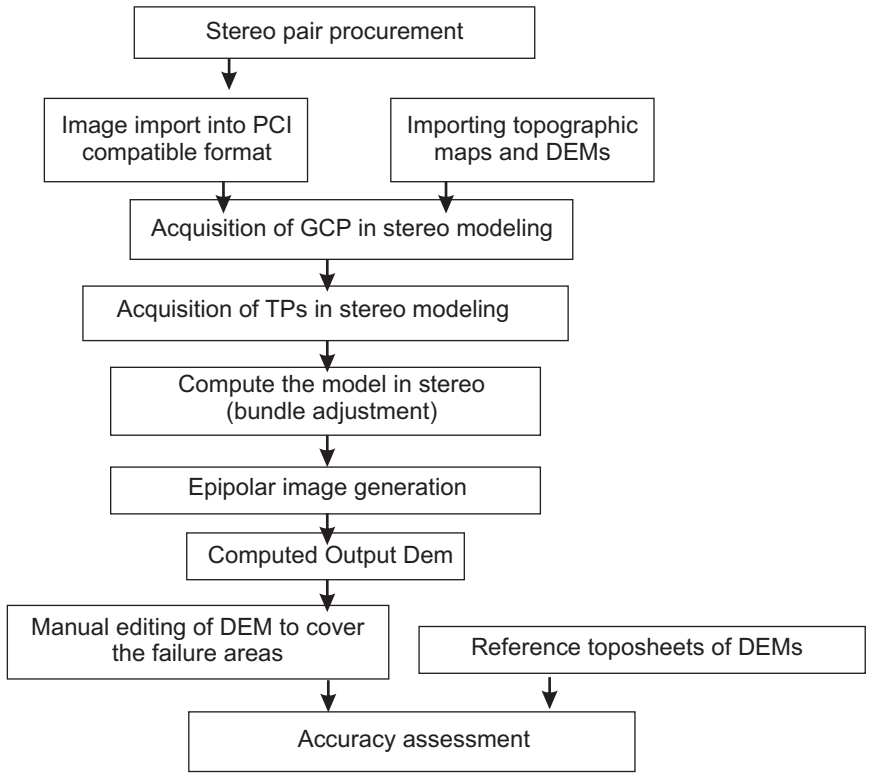

Fig-11 Flow Chart for making DTM

DTM/DEM was prepared and contours were generated at 0.5 Mtrintervals. The data so obtained was imported in Civil 3d (or MX Rail software).The Schedule of dimensions such as width of formation in Filling/Cutting, Side slopes in Filling/Earth Cutting/Rock cutting, vertical clearances on ROB, RUB,Max ruling gradient, grade compensation, degree of curve etc were also fed in the software.

Then above data was again imported to Global mapper software and a detailed presentation was made by M/S Introsoft Solutions in Noida Unit. Through this presentation we were able to reach at any inaccessible point of Arawali hills by simply moving the cursor on desktop screen and were able to know the height of that point and were able to draw the cross sections at any particular point to know the cutting/Filling at any particular cross section. Through these tools and with one-two day brain storming session we were in a position to mark six appropriate alignments in this geographically difficult terrain.

The outsource agency was asked to fix horizontal & vertical alignment and to compute quantity as well as cost on these six shortlisted alignments.

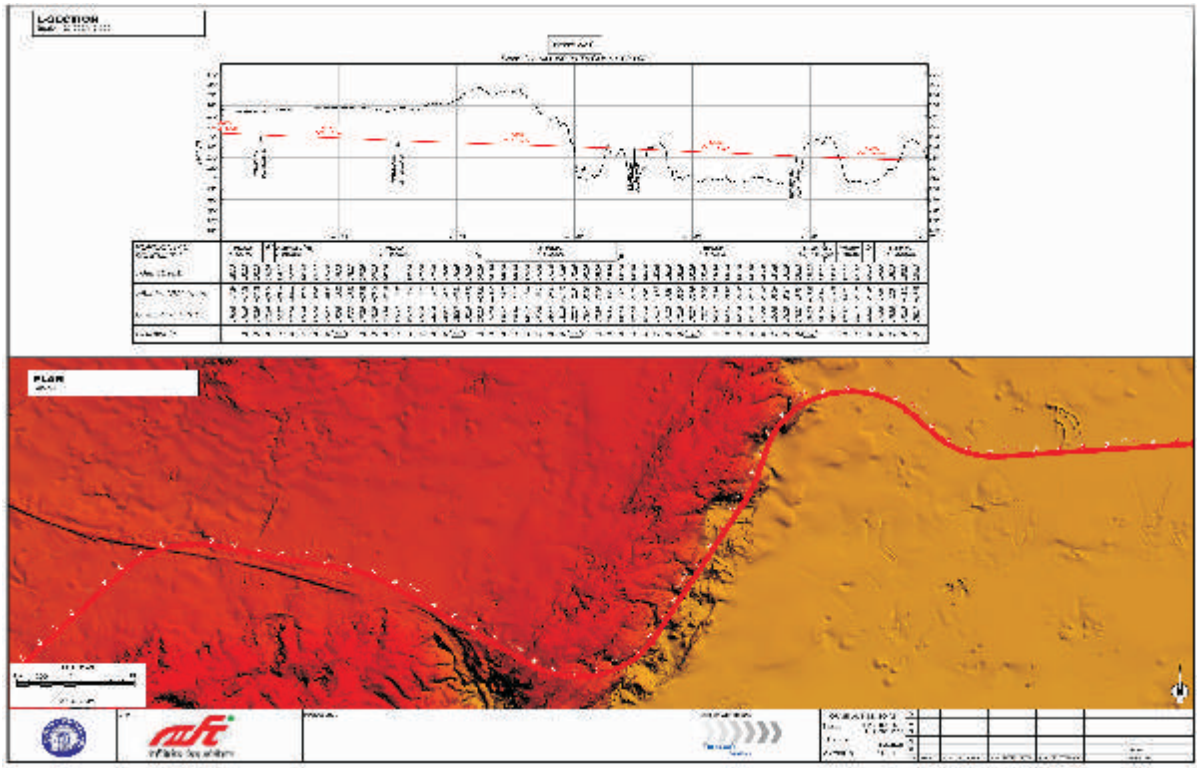

Fig-12 Option-1 Alignment-0

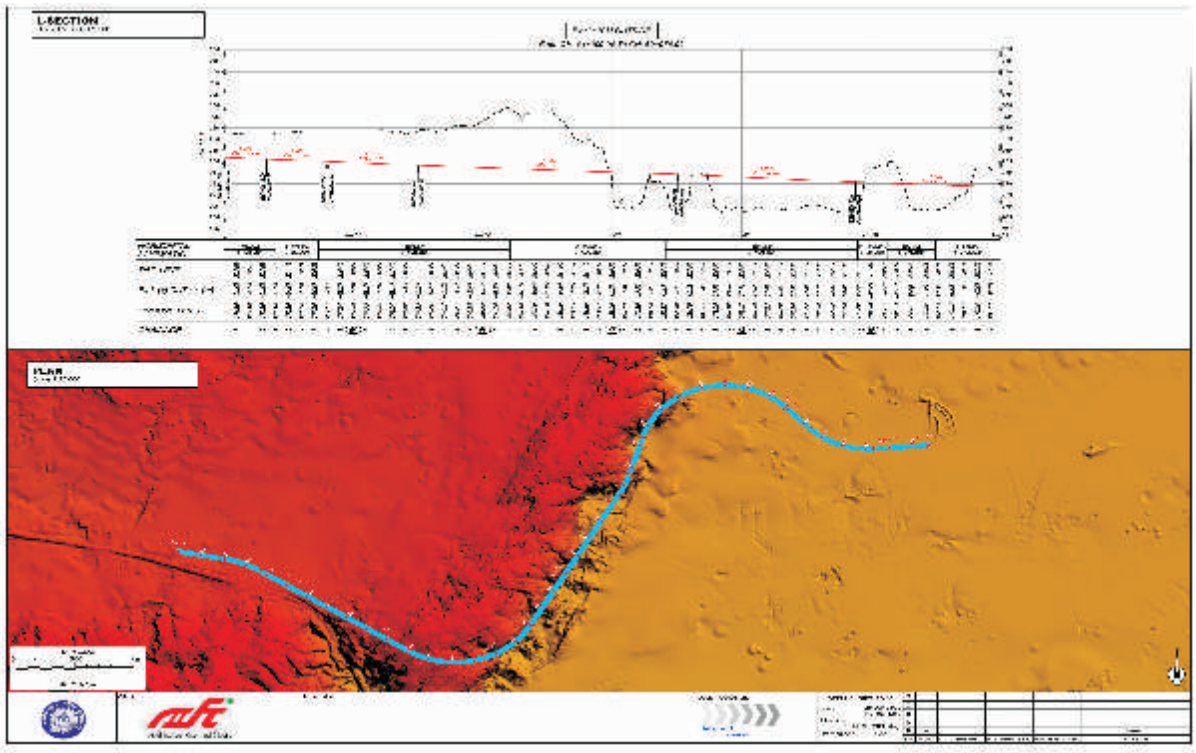

Fig-13 Option-2 Alignment-10M Outside

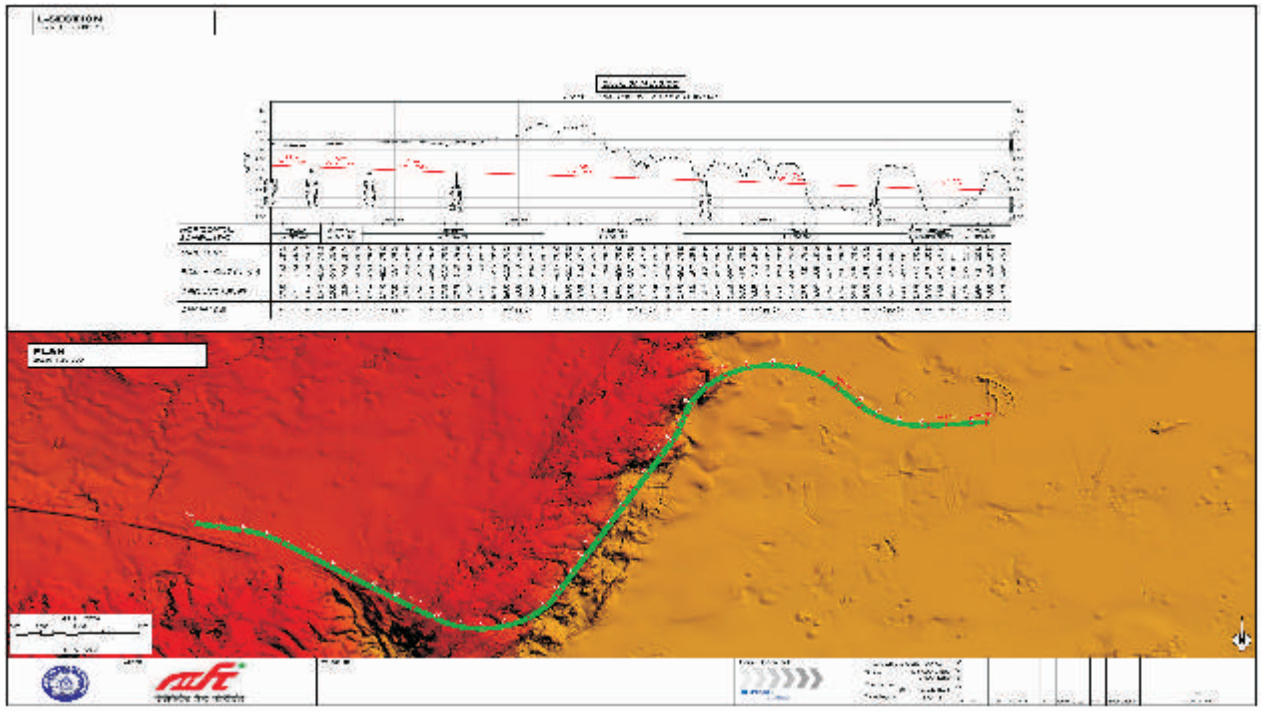

FIG-14 Option-3 Alignment-50 Inside

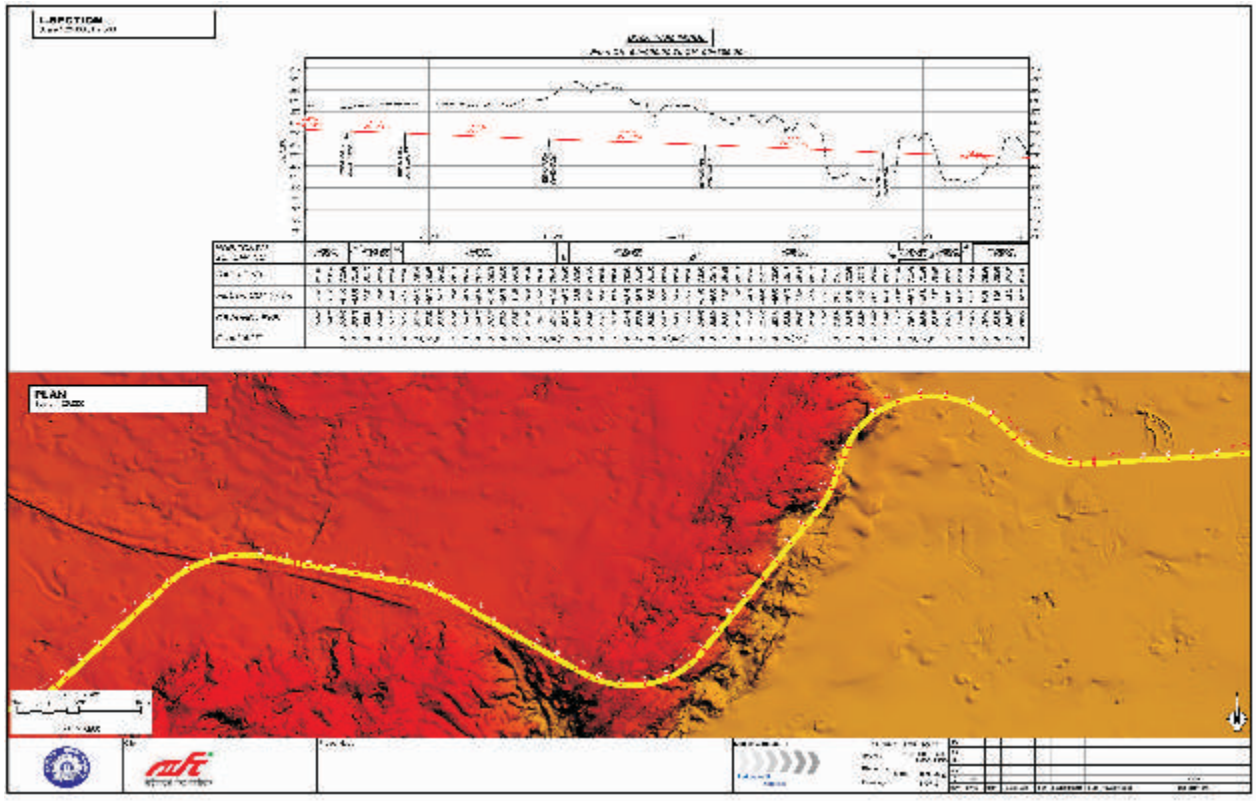

Fig-15 Option-4 Alignment100 Mtr Inside

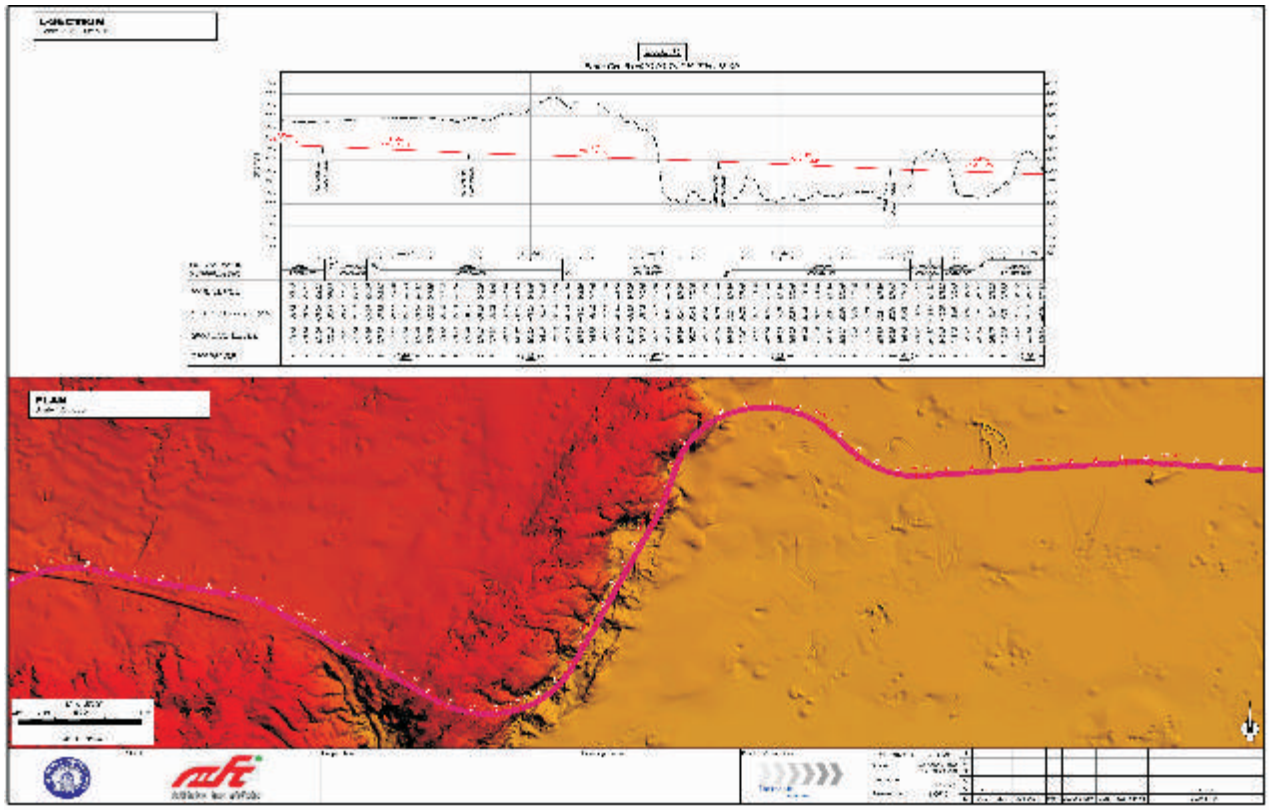

Fig-16 Option-5 Alignment-A1(Viaduct+Tunnel)

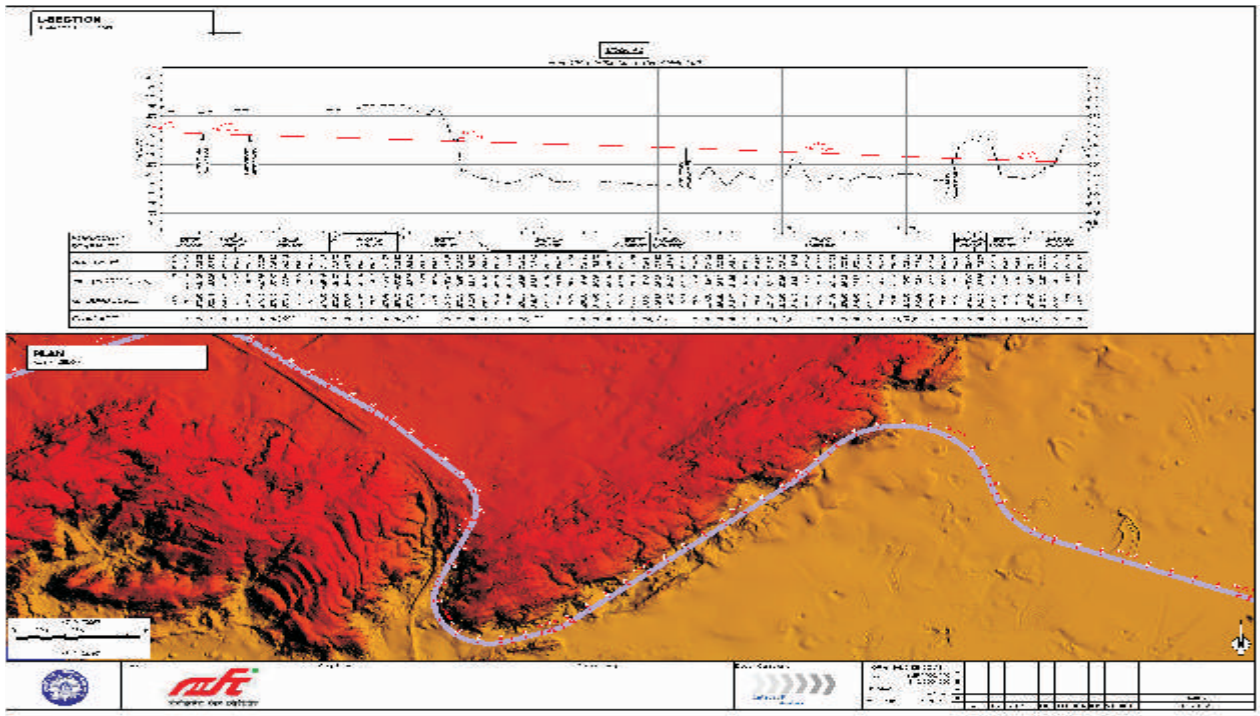

Fig-17 Option-6 Alignment-A2(Only Viaduct)

In all the above proposals the red area in the Plan shows the Hills Portion, while the yellow portion shows the ground at foothills of Arawali. There is elevation difference of 70-120 mtr between the red and yellow portion. Due to smaller scale plans of all options (1-6) looking similar, but the difference are clearly visible in the L-sections displayed just above the plans. For better understanding the various options are elaborated as under

Option-1Alignment-0- After passing through the 1 Km long Tunnels, the proposed alignment followed the ground topography as far as possible along the foot hill of Arawali in order to design a balanced section by optimization of cost of cutting & filling. The total cost was calculated as 572 Crores for 5 Km alignment length from DFC Km 65/000 to 70/000.

Option-2Alignment-10m outside-After passing through the 1 Km long Tunnels this alignment was planned 10 mtr outside (beyond the hill) the Option-1 and due to increase in fill height and height of Bridges, the The total cost was calculated as 590 Crores for 5 Km alignment length from DFC Km 65/000 to 70/000.

Option-3Alignment-50m Inside-After passing through the 1.2 Km long Tunnels, this alignment was planned 50 mtr Inside (Towards the hill) from Option-1 and fill height was drastically reduced, but due to increase in length of Tunnel and Depth of cutting the total cost was calculated as 597 Crores for 5 Km alignment length from DFC Km 65/000 to 70/000. This alignment was found unsafe due parallel fault line of the hills along the traffic directions andrampant illegal mining in this area of Mewat.

Option-4Alignment-100m Inside-After passing through the 1.5 Km long Tunnels this alignment was planned 100 mtr Inside the Option-19Towards the hill) and fill height was almost eliminated, but due to increase in Depth of cutting the total cost was calculated as 566 Crores for 5 Km alignment length from DFC Km 65/000 to 70/000. This alignment was also found unsafe due to parallel fault line of the hills along the traffic directions and rampant illegal mining in this area of Mewat.

Fig- 18 Natural fault lines in Arawaliparallel to the Direction of Traffic

Option-5Alignment-A1-(Tunnel with viaduct) After passing through the 1 Km long Tunnels this alignment was planned almost 100 mtr outside the Option-1(Beyond the hill) and completely taken out from the foothill and after exiting tunnel proposed to be passed through viaduct. The total cost was calculated as 682 Crores for 5 Km alignment length from DFC Km 65/000 to 70/000.

Option-6Alignment-A2-(Only Viaduct)-In this proposal ,tunnel was completely eliminated and the alignment was planned through the viaduct along the deep ravine stretches in Arawali. It has increased the alignment Length by almost 10% and the cost was calculated as 668 Crores+ 50Crores to protect the slopes from falling boulders. This alignment was also felt unsafe as the same was passing through the water flowing area of Arawali.

Although alignment suggested by M/S RITES LTD was the shortest and geometrically better, but the same neither was most economical nor was fit due to environmental and socio political considerations. So therefore, after considering all pros and cones, Option-1 was found safe, workable, sustainable, economical and environment friendly hence adopted for modification of earlier alignment proposed by M/S RITES LTD between DFC KM 63/000 to 70/000.

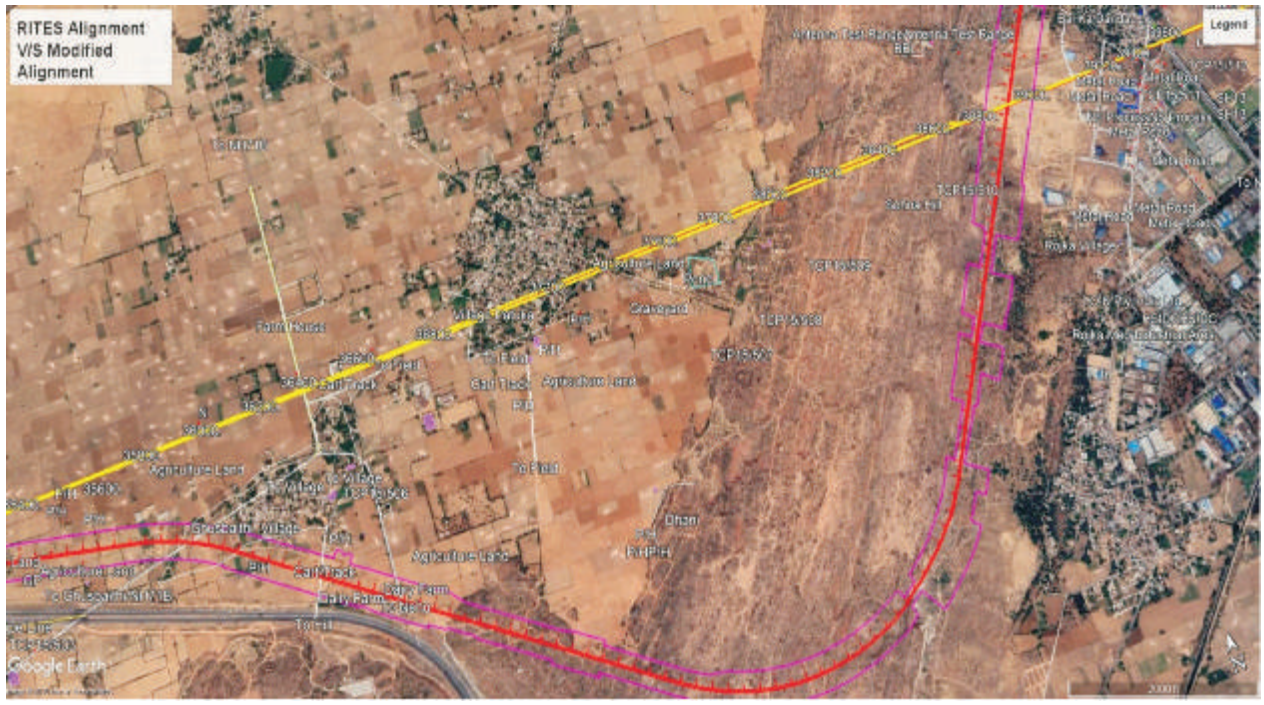

Fig-19 Rites Alignment v/s Modified Alignment

Adoption of Option -1 V/S RITES alignment: - In Fig-19 RITES alignment was shown in yellow colour, while modified alignment shown in red colour. Following benefits achieved.

- Length of Tunnel reduced from 2.9 Km to 1.0 Km leads to reduction in construction as well as in maintenance cost.
- In new proposal tunnel planned at a higher invert level, i.e above 4 mtr from the highest water table of last 20 years, so Problem of dipping in ground water table in uphill side and flooding in downhill side was completely eliminated.

- The alignment was shifted from the built up residential area and industrial area hence eliminating the dislocation of houses/Industries and thereby eliminating socio political implications also.
- Due to increase in the length of alignment along the hills the exit of alignment from hill area of Mewat to plain ground of Sohna (with continuous downgrade of 1 in 200) was maintained at a comparatively lower level(4 to 5 Mtr), resulting in lower height of viaduct and earthen embankment at the exit of hill resulted in overall cost savings.
- The newly proposed alignment after exiting tunnel is passing through the slopes of Arawali near to foothill thereby completely sealing the exposed rock through earthen embankment and slope protection measures to be adopted for protection of Railway track and thereby eliminating the possibility of illegal mining on that face of Arawali in a length of around 3 Km. Thus will also result in environmental protection. This alignment was highly appreciated by the then Deputy Commissioner/Mewat.
- The new proposal has occupied lesser irrigated fertile land and does not bifurcate the land of 05villags in another parts as the same was running parallel to KMP expressway on the uphill side.

Thus by spending less than Rs 10 Lakh and after a hard work of 3-4 months crores of Government money was saved.

Application of Digital terrain Modeling for DFC future Corridors:-

DFC has planned following future corridors of around 4000 track kms

S.N	Future Corridor	From ----- To	Length(RKM)	Package
i	East Coast Corridor	Kharagpur-Vijayawada	1115	Package-1
ii	East West Sub Corridor	Bhusawal-Nagpur-Kharagpur	1673	Package-2
	Rajkharswan-KaliPahadi-Andal	195		
iii	North-South Corridor	Vijaywada-Nagpur-Itarsi	975	Package-3
			3958	

DFC has invited consultancy tenders for preparation of DPR, traffic study, Market demand survey, Cost Calculations, Cost Benefit analysis, Inter-model transport integration etc for above future corridors.

From CTP-14 experience we have already learned that in geographically difficult terrain following may not always be true.

- Shortest &Geometrically good alignment is always the most economical alignment.
- Shortest & Geometrically good alignment shall always be the most environment friendly and shall have minimum socio political complications.
- Reputed consultant has suggested the best alignment after considering all financial, social and environmental implications & there is no scope of improvement further.

Similarly when Inter-model transportation services to be developed and integrated in potentially viable stretches situated very near to each other. Desktop Study of geographical elevation model of the targeted area is compulsory in order to try various permutation and combinations to minimize cost and to maximize the returns on investment.

A three dimensional (3D) alignment design model was developed as a decision support tool that provides an

Engineer with a quick evaluationof alternative available. In the model, initial trial routes are generated by "tracing" the possible paths using computer cursor on a 3D image of the terrain. The model integrates two optimization techniques (linear programming and a heuristic approach) for selection of a vertical alignment with the lowest total costs, while conforming to environmental requirements. Improved 3D OpenGL accelerator is used to display and render 3D images of the terrain in real-time, based on high-resolution Digital Elevation Model.

However, it may not be possible to critically examine the whole alignment of 4000 Km through desktop study of Digital Terrain Model at higher level of Management. So in order to get best return on Investment for future corridors following is recommended.

(A) Shortlisted consultant should be asked to present Digital Terrain Model along with all site data/features of the targeted area of all

1. Geographically difficult and inaccessible Terrains/Ghat section&
2. All closely situated potentially viable stretches shortlisted for integration of Inter-model transportation services in 3d software for detailed desktop study to try various permutations and combinations & to critically examine the final proposal for the most optimal solution.

By adopting this technique we can definitely bring great economy in design of alignment for future corridors with minimum land cost and with all environmental as well as socio economical & Socio political considerations.

One futuristic Planning cum innovation cell containing 1 expert from each discipline Civil, Operation, Mechanical & Electrical should be set up at Co-office Level for adoption of latest innovation in construction and maintenance of future corridors in order to reduce cost and to maximum return on invested capital.

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GEO TECHNICAL CHALLENGES DURING EXECUTION IN PIR-PANJAL TUNNEL T-80 OF USBRL PROJECT (A CASE STUDY)

(SANDESH SHRIVASTAVA)
General Manager/ Co-ord.
Dedicated Freight Corridor Corporation of India Limited
Ambala

Abstract:

The Pir-Panjal Tunnel is 11.215 Km. long railway tunnel that consist of single BG track and 3.0m wide road for maintenance, rescue and emergency. One shaft & Adit was also constructed to facilitate the constructional activities (by reducing the construction period); out of which Adit shall be used as emergency escape & access in case of fire and other accident.

Geology plays very significant role during construction stage of any tunneling project or underground project, due to the uncertainty and risk involved in the underground project; however same can be minimized by doing the best suited geological and geotechnical investigation of the area in question before the start of work and also by investigation during the execution of the mining work.

Geology along the tunnel alignment plays a important role in any of the major decisions to be taken during planning, designing and construction stage of tunnel. In this paper case study regarding geological challenges faced at different locations and their technical solution to minimize the damage and time saving by immediate action at site for tackling the issue have been discussed.

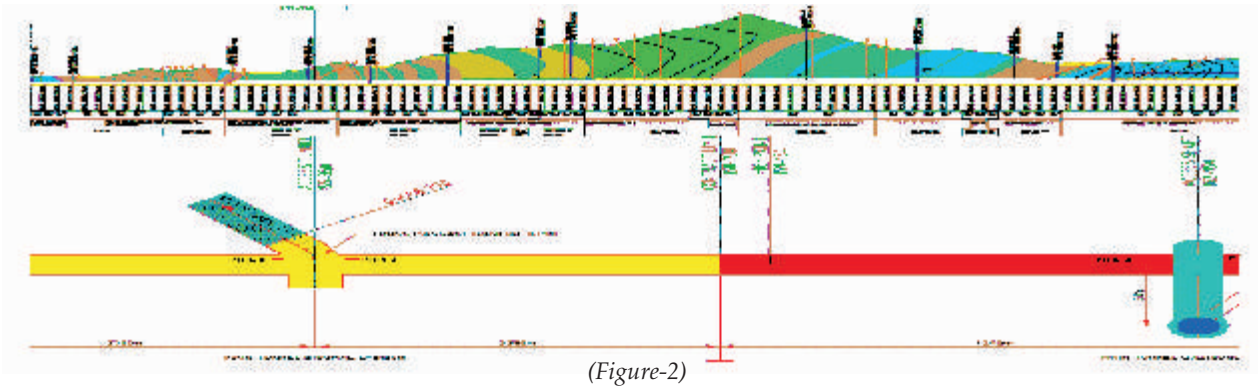
1. Introduction:

The Pir-Panjal Tunnel 11.215 Km. long straight railway tunnel having finished cross- sectional area 48.50 m^2 is the longest traffic tunnel in India & constructed with New Austrian Tunneling Method having maximum and minimum over burden as 1140m & 10m respectively, connected Jammu region with Kashmir Valley to provide all weather access. This tunnel runs 1.9° E to the true North South direction and located about 440m below the existing Jawahar Road Tunnel (Figure-1).

PIR PANJAL RAIL TUNNEL
Length: 11215 mts.

(Figure-1)

This tunnel is the key element of Udhampur-Srinagar-Baramulla rail link project (National Project). This tunnel consist of single Broad Gauge track, single tube having 3.0m wide road for maintenance emergency rescue & relief. The tunnel has an access tunnel 780 m long located at 2.85 Km. from its south portal, having a 10° down ward gradient from its portal, to be used as emergency escape & access in case of emergencies, rescue and relief operations. The tunnel has an access shaft of 55m deep & 11m dia located at 760m from its North Portal and connected with main tunnel by 36m long cross passage, (figure-2). This tunnel is having high point in mid of tunnel and down ward gradient (0.33% to 1%) towards portals for drainage of water.



(Figure-2)

2. Geology of the area in general and along the alignment of tunnel T80 in particular:

2.1 Regional Geology

The Kashmir Valley is situated between the two arms of high and rugged mountain ranges: Dhauladhar-Pir Panjal Range in the SW and Zanskar Range or Great Himalayan Range in the NE. It has a unique position in the Himalayan Geology for its complete Cambro-Trias sequence. The general trend of Pir Panjal mountain range and strike direction of bedding is NW – SE. Folding and faulting is very common in the area.

The project site is situated in Seismic Zone V as per Indian Seismic Zoning Map IS-1893 and 1984 IX. The geological sequence of the beds around the Banihal Pass is given in table 1.

Period	Name	Lithology
Quaternary		Fluvioglacial deposits, slope debris,
Trias (+Jura)	Triassic	Limestone
Middle to Upper Permian	Zewan beds	Shale, limestone, quartzite
Middle Permian	Gangamopteris beds	Sandstone, shale
Upper Carboniferous	Panjal Trap	Andesite and basalt
Upper Carboniferous	Agglomeratic Slates	Shale, tuff and conglomerates
Middle Carboniferous	Fenestella Shales	Shale, quartzite's and magmatic veins
Lower/Middle Carboniferous	Passage Beds	Shale and quartzite's
Lower Carboniferous	Syringothyris Limestone	Silicified limestone, quartzite and magmatic veins

Table 1: Stratigraphy around Banihal Pass.

2.2 Geological Setting along Tunnel Alignment

Chainage	Geological description
152+600-153+240	Clayey silt and gravel - silt intercalation.
153+240-156+400	Quartzite's and shales usually dipping to northeast with 30 to 40 degrees. Steeper l ayers near fold cores and faults. Fold axis strike sub-horizontal northwest-southeast, dipping slightly towards southeast. Faulting usually rectangular to folding and schistose (AC-faults, striking northeast-southwest), parallel to folding (BC-faults, striking northwest-southeast) and in some cases parallel to schistosity. The folding is brittle deformation. A strongly fractured zone with numerous changes of schistosity along a series of brittle folds results a repeated switching between northeast and southwest dipping between 154.250 and 154.700.
156+400-157+300	Agglomeratic slates usually dipping to northeast with 30 to 40 degrees. Steeper layers due to folding. Faults as before but with increase of structures parallel to schistosity. Repetition of tuff 9 and conglomerate layers due to folding around agglomeratic shales.
157+300-158+200	Panjal Traps, dipping steeply towards southwest. In outcrops south of Panjal Range the dip direction is northeast with 40 to 50 degrees. North of Panjal Range the dip direction is southwest again with 40 to 50 degrees. The transition zone must be the Panjal Range itself. Faulting parallel to schistosity and as before.

158+200-159+400	Quartzite's, shale's and thin limestone layers dip steeply to moderately into southwestern direction. Faulting sub-parallel and parallel to schistosity, some rectangular faults and a few westeast bearing structures.
159+400-162+500	Limestone section with a tectonic intercalation of a 500 m thick quartzite-sandstone sequence.Dipping steeply to moderately into southwestern direction. Change of dipping (usually between 35 and 65 degrees) due to large scaled folding. Predominance of parallel to schistosity and rectangular faults or fault zones.
162+500-162+900	Quartzite's with minor shale, occasionally with small limestone and volcanic intersections,dipping to southeastern direction.
162+900-163+560	Clayey silt and gravel silt intercalation.

Table 2: Geological setting along Pir Panjal tunnel

2.3 Hydro geological conditions

2.3.1 Groundwater Types

Four different groundwater types can be found in different rocks:

Type of ground water	Rock types	Estimated discharge quantities		Notes
		Short time	Long time	
Porous aquifer	Alluvial Deposits and Slope Debri	less than 2 l/s/10 m	less than 1 l/s/10 m	Due to high contents of clay and silt no high amounts of porous groundwater expected.
Joint aquifer	Quartzite, Tuff, Panjal Trap (Silicified Limestone, Shale)	less than 2 l/s/10 m	less than 1 l/s/10 m	
Karst aquifer	Limestone	occasionally up to more than 200 l/s/10 m	occasionally up to more than 200 l/s/10 m	Karst water table at about 1870 m may occur with a 12 bar water pressure in tunnel. Amount of water dependent on diameter and connection of cavities.
Water bearing fault zones	All hard rock types	up to more than 100 l/s/10 m	up to more than 25 l/s/10 m	

Table 3: Groundwater types

2.3.2 Groundwater Quantities

From an annual precipitation of approximately 1300 mm about 30 to 50 % evaporate, about 30 to 40 % will run off and only 10 to 40 % will seepage. This caused an underground discharge of 5 to 20 l/s/km² with an average about 10 l/s/km². As the catchment area of Pir Panjal Tunnel is estimated to be about 50 km², the total of available water amount is 500 l/s. Considering discharged 50 % of this amount into the tunnel, the possible maximum longtime discharge was estimated more than 250 l/s. These calculations are made without regards to underground karst connections. Therefore it was not possible to predict either a short or a long time quantity. Table 4 gives an overview about discharges at surface in the area, showing 5 karst springs at Quazigund side of the Panjal Range (No. 1 to 4 and 9) and 4 joint or fault springs at Banihal side (No. 5 to 8).

Due to draw down of the water table it was expected that some of the nearest karst springs will reduced in their discharge or even fall dry.

Number on map	Name (if known)	Description	Use	Estimated Discharge (March 2004)	Distance from Tunnel Alignm	Elevation
1	Verinag	Non periodical Karst spring atthe village Verinag with major Spring drainage role.	Water supply.	2.5 m^3/s	4.5 km	1876 m
2	Lower Mundai Spring	Non periodical Karst spring atLower Mundai	Water supply.	40-50 l/s	1.2 km	1870 m
3	Lower Mundai periodical spring	Periodical Karst spring at Lower Mundai. Running 4 to 6 months / year.	Agricultural use only.	15 l/s	1 km	1890 m
4	Spring S' Pramgam	Non periodical Karst spring	Water supply.	3-4 l/s	200 m	1870 m
5	-	Fault spring at contact quartzitetuff	-	< 1 l/s	500 m	2130 m
6	-	Joint spring in quartzite.	-	< 1 l/s	0 m	1900 m
7	-	Fault spring between quartzite and shale.	-	< 1 l/s	200 m	2000 m
8	-	Fault spring between quartzite and shale.	-	< 1 l/s	250 m	2040 m
9	Vet Vethah Spring	Karst spring.	Water	??	Approx. 3 km	Approx. 1870 m

Table 4: Springs.

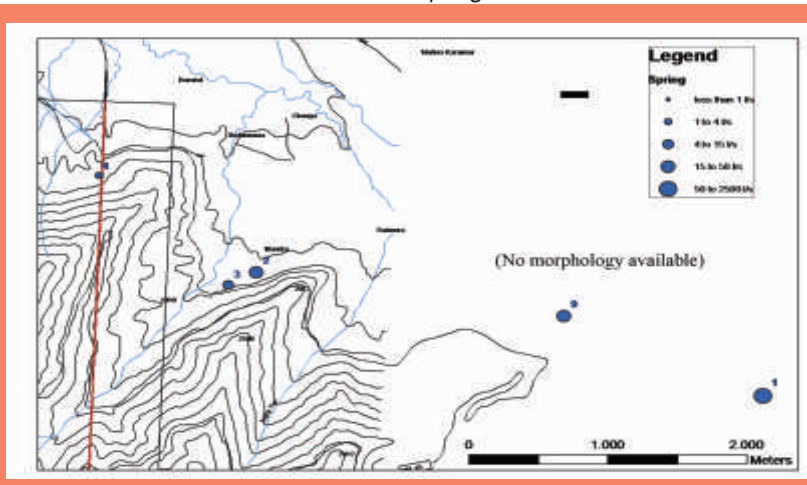


Figure 3 Springs 1-4 and 9.

3. Geological/Geotechnical Investigation done before start of construction activities and data used in the design:

3.1 Geological Mapping

Geological mapping (scale 1:25000) performed by Geological Survey of India using satellite images (scale 1:12500). Based on these images a tectonic map (scale 1:25000) showing lineaments and master joints were produced. These studies were verified by few traverses taken around the area on parts of the alignment.

3.2 Geological and Geotechnical Data from Jawahar Tunnel

The Jawahar Tunnel extends in NE - SW direction crossing the Pir Panjal range near Banihal Pass. It is a twin tube road tunnel with a length of 2560m and a cross section of approx. 30m 2 . The elevation of tunnel is 2220m and maximum overburden is approx. 600m. Striking direction of tunnel is perpendicular to striking direction of geological formations.

3.3 Core Drilling

In the wider vicinity of portal areas 6 core drillings (BH 1/80* to BH 6/80) with a length between 30.0m and 85.0m have been performed. BH 1/80 to BH 3/80 are located in the south and BH 4/80 to BH 6/80 in the north portion of Pir Panjal tunnel. This test was performed in jointed limestone. SPT tests were carried out in Borehole BH 1/80 down to a depth of approx. 16.0 m. Encountered material was clayey silt. N (SPT values) was varying from 39 to 68.

3.4 Rock Mechanic Tests

Rock Mechanic Tests were carried out on rock samples collected of boreholes BH 2/80 (km 153.259), BH 3/80 (km 153.305), BH 4/80 (km 162.571) and BH 5 (km 162.840). Tests (UCS, triaxial shear tests, points load tests etc.) were carried out on silicified limestone, basic volcanic rock and quartzite. Examples for UCS tests are listed in table 5.

Rock type	No of samples	UCS [MPa]
Volcanics*	2	20,0 – 21,9
Silicified Limestone	5	6,2 -52,8
Dolomitic Limestone	1	30,8
Quartzite	7	53,0 – 227,5

Table 5: UCS tests Pir Panjal tunnel

**small layer between other rock types of alterated sample*

3.5 Soil Mechanic Tests

Soil mechanic tests were performed on undisturbed samples. In borehole BH 1/80 (km 152.680) triaxial shear tests have been made on silty clay samples collected to a depth of approx. 12.0m. Mechanical properties and consistency limits were analyzed on samples collected to a depth of 21.0m.

Undisturbed samples were taken each 3.0m up to 24.0m depth in silty clay in borehole BH 6/80 (km 163+120). Triaxial shear tests were made in silty clay collected to a depth of approx. 15.0m. Mechanical properties and consistency limits were analyzed on samples collected to a depth of 24.0m.

3.6 Engineering Geological Mapping

Detailed engineering geological mapping was carried out on an approx. 1.0 km wide corridor along the alignment of Pir Panjal Tunnel with a mapping scale of 1:10000. Northern slopes were snow covered but complete continuous profiles were exposed. Southern slopes were completely accessible. The mapping of Access Tunnel alignment was also performed during this field mapping.

3.7 Field and Laboratory Tests

3.7.1 Field Tests

Refraction seismic profiles were performed along and across tunnel alignment in the soft ground areas. Starting from Ch.162+800 to Ch.163+650 in the north and from Ch. 152+625 to 153+300 in the south approx. every 100m a cross profile with a total length of 110m was made. Longitudinal profiles in the south were made from Ch.152+600 to Ch.153+365 with two small gaps in village of Charil (km 153+060 to km 153+120 and km 153+235 to km 153+250). Longitudinal profiles at north side were continuing from Ch. 162+800 to km 163+605). These profiles indicate the overburden of weathered rock with fluvioglacial deposits (here clayey silt) and a layer dominated by gravel with silt and sand (bouldery strata). A distinct border was shown between weathered and jointed rock mass and hard rock. Hard rock was encountered only at lowest level of profiles and was not likely to be encountered in crown level of tunnel before reaching shaft location

3.7.2 Laboratory Tests

Abrasivity tests (Cerchar Abrasivity Index; CAI), UCS and Brazilan tests (determination of tensile strength) were carried out on samples from former core drillings near portal areas (campaign BH 1/80 to BH 6/80). A summary of these investigations can be seen in table 6:

Borehole No., depth of sample [m]	Chainage [km]	Rock type	UCS [MPa] [MPa]	Tensile strength	Cerchar Abrasivity Index (CAI)
2/80 (37.5-37.6m)	153+259	Silicified limestone	68.81	4.63	0.99 (little abrasive)
2/80 (40.5-42.0m)	153+259	Panjal volcanics (Tuff)	52.23		0.49 (not abrasive)
2/80 (52.4-52.5m)	153+259	Dolom.lime-stone	67.18	6.50	0.95 (little abrasive)
3/80 (19.8-20.0m)	153+305	Silicified limestone	176.00	10.86	2.08 (abrasive)
3/80 (77.0-77.2m)	153+305	Quartzite	267.55	12.29	3.49 (highly abrasive)
4/80 (48.3-48.4m)	162+571	Limestone	*	5.54	0.62 (little abrasive)
5/80 (58.2-58.4m)	162+840	Flaggy limestone	28.26	1.44	0.98 (little abrasive)
5/80 (67.4-67.5m)	162+840 basic rock	Agglom. slate and	*	9.97	6.04 (extremely abrasive)
5/80 (81.1-81.3m)	162+840	Quartzite	232.76	13.05	4.75 (extremely abrasive)
5/80 (85.5-85.6m)	162+840	Quartzite	257.05	14.17	4.80 (extremely abrasive)

Table 6: UCS, tensile strength and Cerchar tests Pir Panjal tunnel

**sample not found suitable for testing*

3.8 Geological Model Pir Panjal Tunnel

The basic tectonic setting of Pir Panjal range in the area of tunnel alignment is dominated by a folding structure which is leading to different main dipping directions on both sides of the range. On southern parts a medium steep inclined NE dipping direction of

bedding planes is prevailing. Towards the border to Panjal Traps inclination becomes steeper. On the northern side of the range flat to medium steep dipping towards SW is dominating. This indicates that the central Panjal Traps are folded which reduces the thickness of this formation from surface towards elevation of tunnel alignment. Folding was observed also on northern parts of alignment causing a large thickness of limestone with minor shale intercalations (2m to 10 m thick only) in this area.

Based on engineering geological mapping and existing and additional site investigations geological longitudinal sections were produced for the Pir Panjal Main Tunnel. Geological mapping in combination with performed field and laboratory test provided the basis for rock mass characterization.

3.9 Rock Types

The following rock types have been determined in Pir Panjal area:

3.9.1 Quaternary Deposits

This summarized rock type consists of four different types:

- Alluvial deposits (consist mainly of silty gravel, possibly sand).
- Well sorted silt and fine grained sand.
- Slope debris including mudflows, earth slip and landslide (badly sorted sediments of every grain size).
- Lodgment till (ground moraine) has not been seen but might be expected in some portions between slope debris or alluvial cover and hard rock

3.9.2 Limestone

Limestone found in two different modifications:

3.9.2.1 Silicified limestone: This limestone located around Chareel is a yellow to brown, sometimes white limestone It is fine grained and laminated. Some parts are silicified. Breccias sealed with calcite concretions, intercalations of quartzite bands and magmatic veins are also common.

This type of limestone was found mainly at the southern part of Pir Panjal tunnel, between chainage 153+240 and 153+520 and possibly as a small band at 154+650 (total: approx. 300 m).

3.9.2.2 Mesozoic limestone: This light blue to grey, sometimes dark blue limestone dominates the area north of Panjal Range. Large scale folding multiplies the original thickness. Thin layers (< 0.2 m) of marl parts and shale are intercalated commonly, thicker layers up to more than 10 m rarely. Joints are usually filled with clay or calcite concretions but are even in many cases open. This limestone shows advanced karstification. The estimated karst water table is situated at a level of 1.870 m. In Pir Panjal tunnel Mesozoic limestone was found between chainage 158+750-158+800, 159+400160+100

and 160+730-162+500 with a total of 2.500 m.

3.9.3 Quartzite

Quartzite shows different types (all of sedimentary origin, grain size usually about 0.1 to 0.15 mm):

3.9.3.1 South of Panjal Range

- Massive Quartzite (approx. 30 %): Quartzite, massive, no bedding visible. White to greenish and grey. Clay content very low (less than 1 %).
- Banded Quartzite (approx. 30 %): Quartzite, white to yellow – grey, with brown to grey bedding in 1 to 5 cm.
- Conglomerates (approx. 30 %): Quartzite, consisting of conglomerate. (These types: UCS >> 200 MPa).
- Shaly Quartzite (approx. 10 %): Quartzite with different shale content (up to 50 %), grey to brown and red-brown, UCS < 100 MPa The quartzite south of Panjal Range was part of the "Passage Beds" and the "Fenestella Shales" in F UCHS (1971).

3.9.3.2 North of Pir Panjal Range

- Red banded Quartzite (approx. 70 %): Massive, fine grained quartzite in 0.5 to 2 m thick layers. The layers are usually separated by thin shale intercalations.

- Sandstone (approx. 30 %): Fossiliferous sandstone (grain size < 1 mm), in places fading to clayish sandstone.

Quartzite usually found intercalates with shale. The thickness of quartzite sequences without shale was beyond 150 m.

3.9.4 Shale

Shale consists of clay and quartz (to be seen with lens) with changing quartz content. Shale usually accompanies quartzite's and separates them into different layers. The major shale layer, found three times between 154+700 and 155+520, is fossiliferous. It was tectonically increased maximum thickness of more than 0.5 km. This shale's are

probably part of the Lower Carboniferous "Fenestella Shales" in FUCHS (1971).

3.9.5 Agglomeratic Shale, Tuff and Conglomerate (Agglomeratic Slates)

This approx. 900 m long sequence (from 156+400 to 157+300) was characterized by a volcano-sedimentary facies including agglomeratic shales, tuff and conglomerates. A major sequence predominated by shale was figured out in both layout plan and longitudinal section and was supposed to be a fold core as well.

Agglomeratic tuff depicts a medium grained (< 1 mm) tuff with 1 to 4 cm agglomerates. Larger, up to meter-sized grains are mentioned in literature but had not yet been observed in field. The tuff fades into both conglomeratic and shaly portions.

This sequence is summed up to the "Agglomeratic slates" (FUCHS 1971 II), which are part of the "Panjal Volcanic Series" including the "Panjal Trap" as well.

3.9.6 Andesites and Basalts (Panjal Trap)

The usually green rock depicted a fine to medium grained matrix contains mid to coarse grained (until more than 10 cm) quartz. The rock color varied from its typical green to red or blue. Panjal Traps contained mineralized joints with epidote, chlorite, quartz and pyrite.

Rock was hard to very hard and jointed, green with white porphyroblasts (quartz), but even green, massive and fine grained without porphyroblasts or grayish-green with porphyroblasts of different source rocks, red with porphyroblasts and sometimes with cleavage. Veins consist of epidote, quartz and some pyrite. Joints show variation surface have different roughness. They were undular with good interlocking and showed only surface staining.

5.1.2.2 Laboratory Tests

Laboratory tests were performed on 18 representative field samples of Pir Panjal Tunnel. The following tests have been carried out:

- Uniaxial (unconfined) compressive strength (UCS)
- Brazilian tensile strength (BTS)
- Load - deformation diagram (determination of Young`s Modulus; Secant Modulus, linear strain and demanded

fracture energy)

- Specific gravity
- Cerchar abrasivity test (CAI)

These tests were performed according to ISRM standards with exception of UCS tests. The UCS and related tests have been performed with a height / diameter ratio of 1 which allows tests also from smaller samples.

3 Construction phases of tunnel T80:

The construction of tunnel was divided in to three phases to minimize the construction time. As North end there are about 600m soft ground tunneling was done with very shallow ground cover and water body crossing the alignment at 300m from portal location. To create additional construction phases one access tunnel had been constructed at about 2.75Km from South portal. Similarly one shaft was constructed at about 600m from north end to start the critical drive from north side without waiting for completion of soft ground tunneling. The below table shows the construction phases of T80:

S. No.	Phase (Mining activity)	Start Time	Completion time
1	Access tunnel and Shaft construction	Oct 2004	Nov 2006
2	Soft ground tunneling 610m at North side	Nov. 2004	April 2007
3	Main Tunnel Construction at Both side	August 2005	April 2012

Table 7

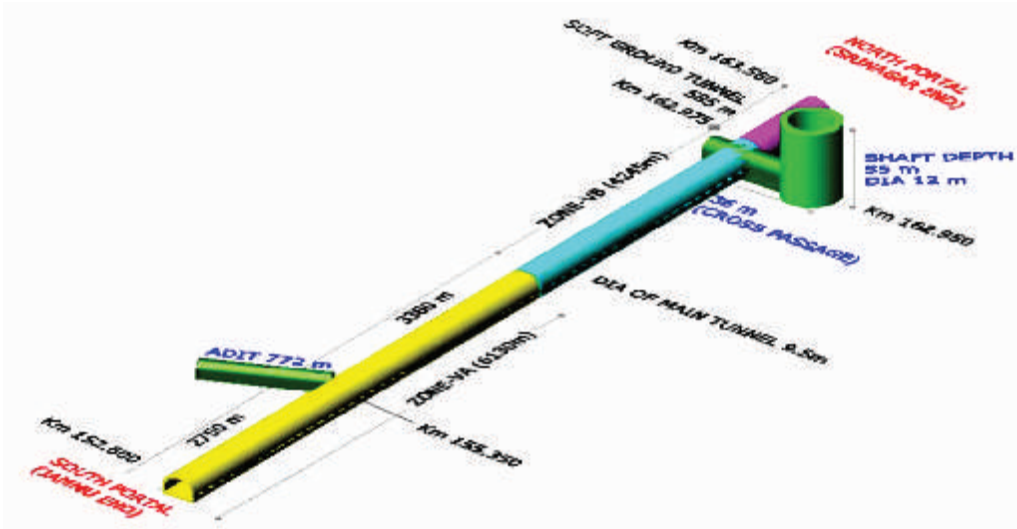


FIGURE 4 :SHCEMATIC LAYOUT OF TUNNEL T-80 SHOWING CONSTRUCTION PHASES

4.1 Soft ground tunneling 600m at North side:-

Earlier it was planned to have mined tunnel portal (at Chainage 163+300), the soil cover above tunnel crown was approx. 17 m. Although this was more than required for tunneling and even the topography and the soft ground conditions do favour that location. But at Chainage 163+300 a system of existing nallas was crossing the tunnel alignment at the proposed C&C tunnel section. The minimum overburden above tunnel crown at that location was about 12 m. The excavation for the cut & cover tunnel as well as the start of the mined tunnel at CH 163+300 could only be carried out safely after the diversion of a system of existing nallas at that location.

Later on it was decide to omit the C&C tunnel from chainage 163+300 to 163+560 and planned to go for soft ground tunnelling from chainage 163+560 to 162+950 i.e. 610m in length with the vertical shaft at 610m from proposed mined portal and X-passage for independent working for the main tunnel drive so as to ensure that the same would not be on the critical time path in case of delay in soft ground tunnelling.

The work of soft ground tunnelling was started in month of Nov 2004 and completed successfully in the month of April 2007.

5.1.2.3 Access tunnel and Shaft construction:-

To create an additional faces of mining a suitable location of Adit had been identified near Tathar village. In order to overcome the altitude difference of approx. 100 m between the portal of the Adit and the main tunnel, a total length of 772 m with a downward gradient of 9.98% was required. The Adit is joining the tunnel alignment at around CH 155+350 (i.e.approx. 2750 m from the mined tunnel portal in the South). Rock conditions appear favourable, however nothing was known regarding to hydrologic conditions, and there were major construction risk for the Adit excavation (downward heading). The work of Access tunnel was started in month of Oct 2004 and completed successfully in the month of Nov. 2006.

Similarly to avoid the critical drive from North side on critical path in case of delay in completion of soft ground tunnelling of 610m a vertical shaft of 12m dia. 56m deep and 36.50m long X-passage to connect with main tunnel was constructed for independent working for the main tunnel critical drive. The work of Access shaft and X-passage was started in month of Oct 2004 and completed successfully in the month of March. 2006.

4.3 Construction of Main Tunnel from both ends:-

Construction of Main Tunnel was divided into two package, i.e.

(A) Construction of Pir-Panjal Tunnel from KM.152+600 to KM 158+730 (Zone-VA)

The location of the tunnel south portal was at Chainage 152+600 with the maximum height of the cut at portal was 17 m. The soil cover at the tunnel portal axis was around 7 m. This is considered sufficient for tunnel excavation to start under a pipe roof. From south portal up to a distance of approximately 600m sector-wise mining with tunnel excavator/controlled blasting had been done to avoid the damage to the village chereel which is located over the tunnel alignment T-80. With an intermediate construction access for the southern section of the main tunnel, two additional tunnel faces established to enhance the progress rate of tunneling.

The mining work from south drive of tunnel stared in March-2006 completed in April 2012 with total three faces. The face at south portal was started in March 2006 and face from Access tunnel junction was started from Jan. 2007.

(B) Construction of Pir-Panjal Tunnel from KM.158.730 to KM. 163.560 (Zone-VB)

After the construction of Access shaft and X-passage in the month of March 2006 the work of critical drive (in rock strata) from North end was started in the same month of March 2006. The mining work of zone V was physically started in March 2006 and completed in the month of April 2012.

5. Geological challenges faced during construction:

Underground works are always prone to unforeseen challenges. Geological and geotechnical investigation can only provide some clue to the problem but the gravity of the problem can only be understood once it is encountered. In Pir-Panjal tunnel several problems were encountered during excavation. In which some were predicted before the design and some were faced during the construction stage. Due to the flexibility in design and availability of on site designer, impact of these problems on the project was reduced.

- Low Overburden
- Excavation under chereel village
- Difficult Geological situations

In Pir-Panjal tunnel during the excavation of soft ground on both side low overburden was encountered. This low cover was due to the nallahs flowing over the tunnel alignment. Both nallahs are perennial in nature and are situated at chainage 163+300 and chainage 153+042 in North and South respectively. Due to the low overburden and nallah flowing over the tunnel, a separate excavation plan was developed.

Village Chereel is situated on the alignment of Pir-Panjal tunnel from South portal between chainage 152+972 and chainage 153+350. The rock /Soil cover is ranging from 24m to 48m. Rock was encountered in the tunnel under the village at around chainage 153+150. Structures in the village are made mostly of bricks and clay with wooden girder. To avoid any mishap, excavation under the village was carried out very carefully. Ground movement was monitored very closely as differential settlement could generate cracks and weak village structure could be damaged. During excavation in the soft ground portion under village big boulder of more than 1m dia were encountered. These boulders were ripped off instead of breaking or blasting. This reduced the vibration/shattering around the tunnel and subsequently reduced the damage to the structure. In the transition zone between soil and rock, large amount of water in flow was observed during many probe holes drilled in that location. The inflow of water was more the 100 l/s. At the particular location, (chainage 153+153) to avoid any cavity & rapid settlement pipe roofing with 76mm SD rock bolts was carried out. This pipe roofing formed umbrella over the tunnel crown and provided path for water to flow out.

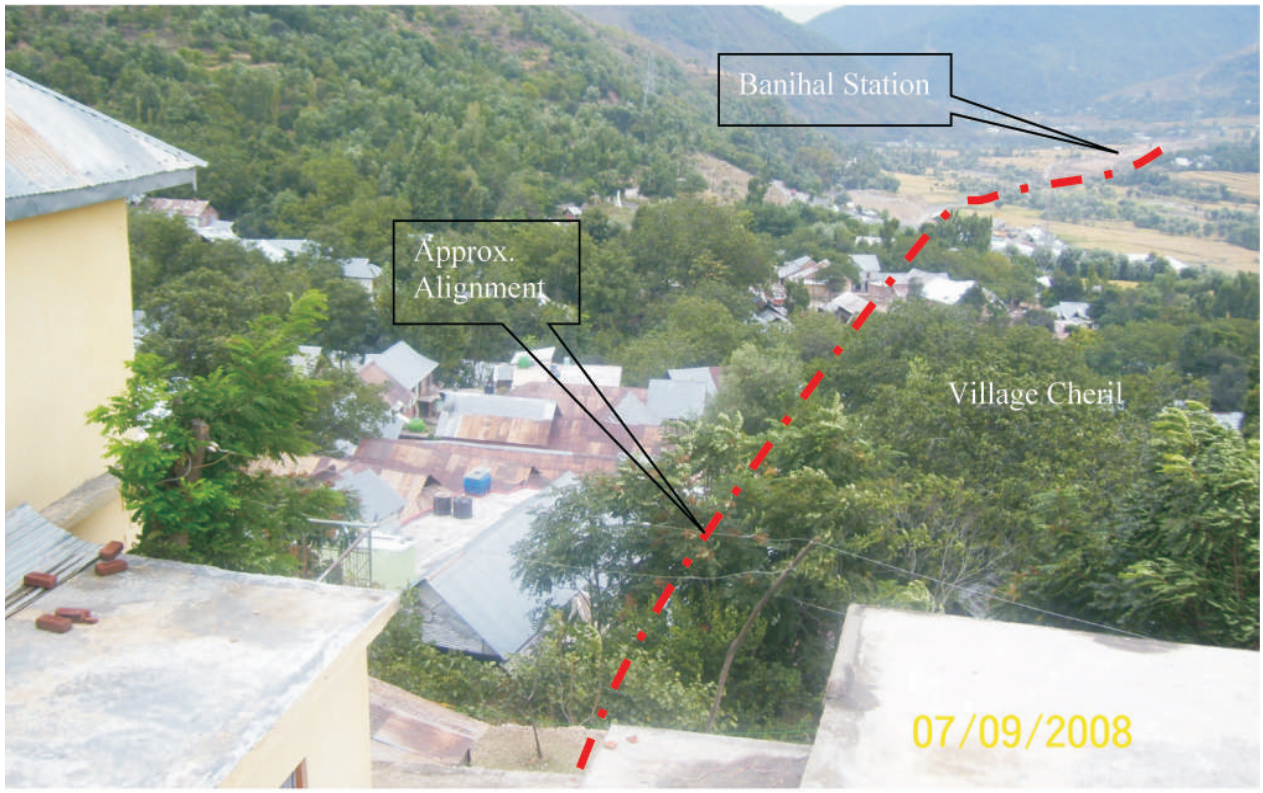


Figure 4: Alignment under village

At around chainage 153+160 strong rock was encountered, hence blasting was the only choice left. At this location strength of the rock was around 70 to 100 mpa. To reduce the vibration in the village and to minimise the damage to the structure, sector blasting was carried out and there were less chances of differential settlement. A vibration monitoring team was also engaged to monitor the vibration on the ground which helped in blast design. A trigger level of 2 – 10 mm/sec was set which specified in case of very sensitive buildings and historic structure by Director General of mine and Safety (DGMS) (India). To avoid any problem to the villagers, it was also decided that the blasting will be carried out only in the day time avoiding school time and other important village activity. Drilling pattern adopted was Burn Cut as it is believed to be best in the given conditions and generates less vibration. Number of holes per blast was reduced to 35 only. Vibration monitoring result reflected that vibration was in the range of 2.5 mm/sec in all most all cases. These precautions proved useful, as no major problem aroused during the excavation under village.

5.1 Difficult Geological situation

Tunnelling in Himalaya region is a very challenging work for the tunnelling team. During tunnelling in PirPanjal tunnel some geological challenges occurred but same had been tackled with efficient technical solution and implementation of the same to reduce the impact of damage due to geological failure/ problem. The following geological surprises faced during the construction at different locations.

- Adverse condition in access tunnel at tunnel meter 22.
- Adverse condition at the junction of Access tunnel and Main tunnel at tunnel meter 765m from Access tunnel portal.
- High water ingress & Rock fall at tunnel meter 316 in

MTS-2 (Main Tunnel South from access tunnel) at chainage 155+666

- Rock fall & cavity formation at tunnel meter 746 in MTS-1 (Main Tunnel South from access tunnel towards South) at chainage 154+604
- Poor geology in MTX-S (Main Tunnel from North towards South) (TM – 2545.0)
- Extreme geological condition in MTS–2 (Rock Bursting) (High Overburden - >800m)
- High water ingress MTX-S (TM - 2311.8; CH – 159+838.2)

Out of above mentioned geological surprises at 7 locations three most critical are being discussed in detail.

5.1.1 Adverse condition at the junction of Access tunnel and Main tunnel at tunnel meter 765m from Access tunnel portal

5.1.1.1 Introduction

The face was at approximately TM 765 on the right hand side to TM 766.5 on the middle portion where weak has caused slight over excavation of the round length, the last lattice girder installed was approximately at TM764. The rock class was RC V. Fore-poles of 6m length had been installed in previous rounds. Support measures as proposed were installed at site with a round length of maximum 1.20m, fore-poling from the 10 o'clock to 2 o'clock position, and face bolts was done as per RESS. The left hand size of the face consists of highly sheared shale, fractured into chips of maximum 15mm size. The right hand side of the face consists of fairly compact, moderately strong dark grey to black shale. Water in-flow is moderate at approximately 30 to 50 l/s over the last 20m and from the face. Water inflow has increased continuously over the last several rounds.

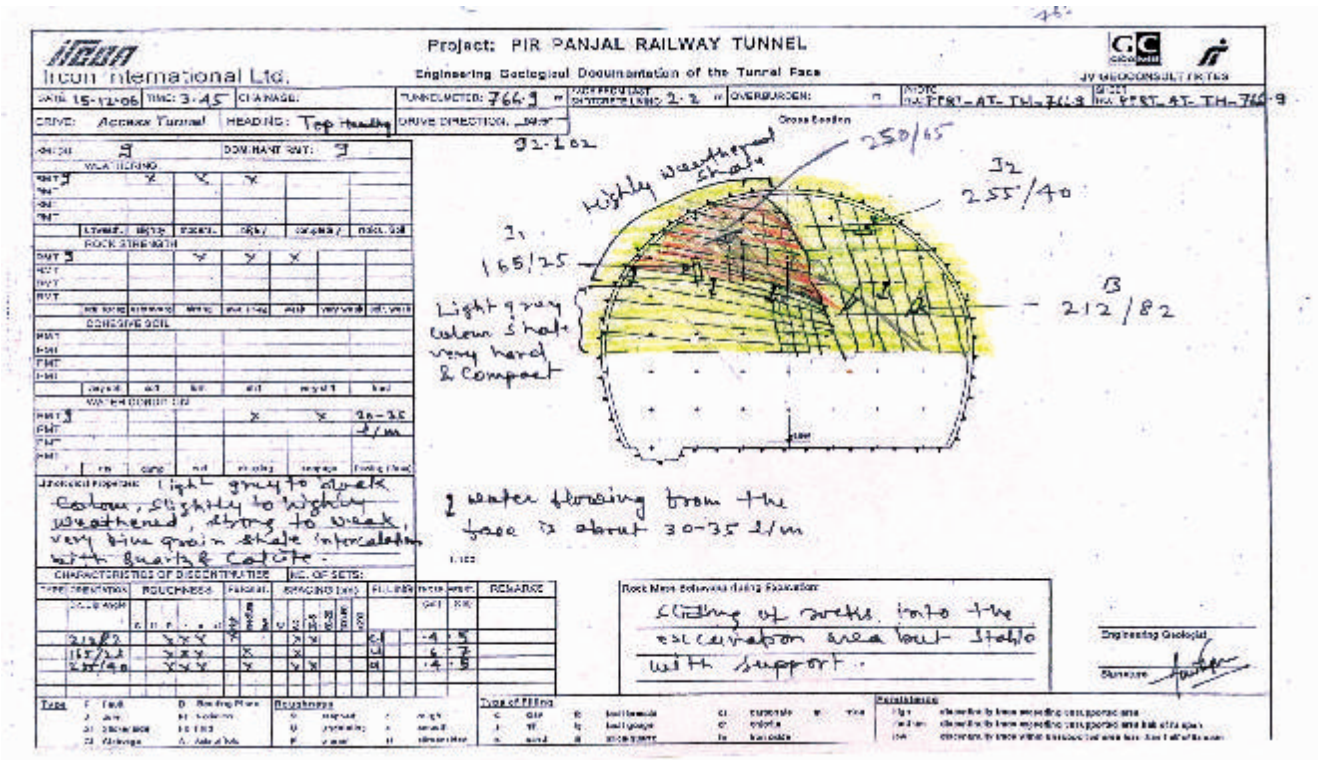
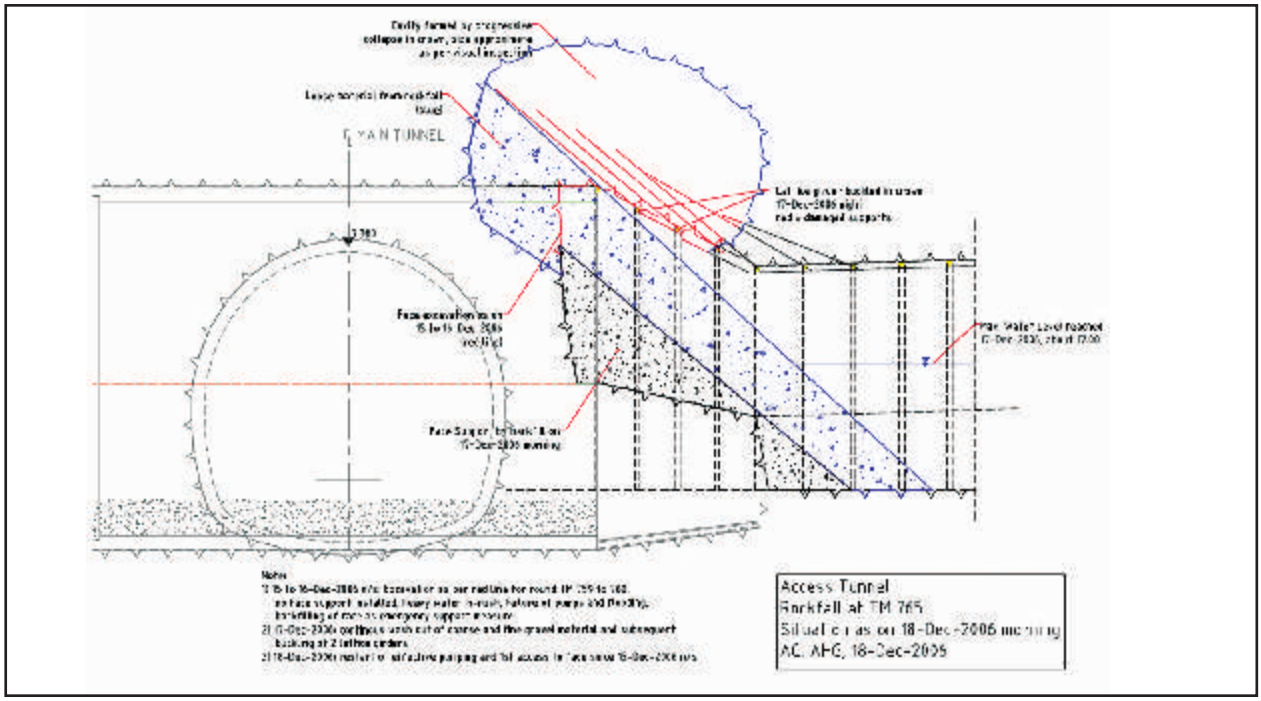


Figure 5: Face map at chainage

Figure 6: Access Tunnel TM 765.0, water pool near the junction

Figure 7: Access Tunnel TM 765.0, collapse near the junction



Sketch 1: showing Cavity formation

5.1.1.2 Causes of collapse

A) Geological

Near the junction of Access tunnel and main tunnel at tunnel meter 765 from access tunnel a cavity developed due to sudden ingress of large amount of water from the weak zone prevailing in the tunnel face. The shape of the cavity was semicircular with depth of the cavity varied from 2.5m to 6.5m and length of the collapse was around 7m.

After the blast at tunnel meter 766.5 heavy water in rush of at least additional 100 l/s follows from the area where sheared and compact shale join. The water leads to rapid wash out of material from the weak zone of the face. The crown area remains stable and the attempts were made to run the installed large capacity pumps but fails to start them.During late afternoon and early night the lattice girders and shotcrete at TM 767.3 and 766 caved in. Weak material from the crown was washed out at a considerable rate.

A very weak zone of sheared shale in connection with high pore pressure of water and an unfavourable strike of

the fault was encountered and the material washes out progressively and quickly.Due to the down- ward gradient and high water ingress from the face, water pool was developed along with the heap of crushed material.

B) Technical

As the pumps could not be started by the contractor water is pooling approximately 1.5m deep at the face. A considerable area of the face has been washed out and water in flow continues in the same intensity. Work on the pumps still continues but pumping is still not sufficient to draw down the water. The water level reaches approximately half height of the face.Water inflow continues in the same range.

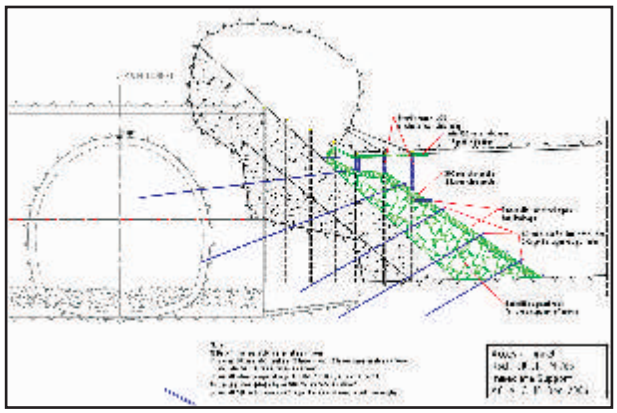
Besides the unpredicted geological conditions a number of other factors contributed to the extent of the collapse. The actual core of the fault out of which the majority of the cone of muck material visible in the pictures originated has a size of 7mX3 m.

5.1.1.3 Remedial measures

(A) Immediate measures

At first step, tunnel section near the face was back filled with strong rock up to one meter from the crown. This was

done to support the face and to prevent further wash of the material. After dewatering, back fill material are covered with 300mm of shotcrete and two layers of wire mess. Some drain holes were drilled in the loose muck and around the face to release the hydrostatic pressure built up behind the shotcrete lining



Sketch 2 :Immediate support to the face by shotcrete and rock bolts

On the loose muck some probes were erected to support the back fill material. Then some pipes were drilled in the cavity for backfilling. Once the cavity was backfilled then additional SDR bolt were drilled in and around the cavity portion for grouting. After all these treatment of the cavity, pipe roofing with 76mm SDR was drilled. This creates an umbrella above the tunnel for the start of the excavation. 9m long 6 numbers SDR bolt were also drilled in the face to consolidate the loose muck.

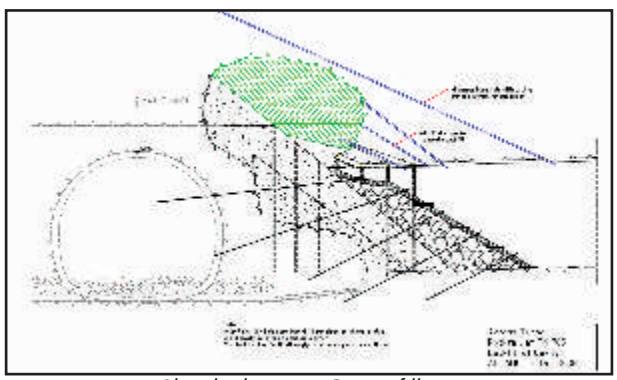
(B) Strengthening of support between TM 750 and TM 760

• Additional 150mm shotcrete and single layer of wire-mesh has been installed.

• Contact grouting between TM 740 and TM 760 was done to fill the cavities and internal voids.

• One weep hole per Sqm of shell of minimum 1.0m length be between TM 750 and TM 760 was drilled.

• Footing of shotcrete shell was strengthened by fresh shotcrete over extended wire-mesh or re-bar after removing of loose shotcrete.



Sketch showing Cavity filling

5.1.1.4 Preparation before start of Re-mining

For Consolidation grouting with cement grout of an umbrella of 32dia SDR bolts, 6m long 300mm have been drilled covering the whole area of the tunnel from spring line left to spring line right.

(A) Re-Mining

• **Excavation to TM761**

Excavation of the loose and partly grouted material that has been backfilled or piled up during the formation of the cavity has been done in 1 m rounds. After every round the existing supports have been checked and if required strengthened. Excavation was proceed to approximately TM761. At that location the face was secured by shotcrete, wire mesh, and face bolts. Existing anchors of the immediate support installed earlier have been used as face bolts.

• **Pipe Umbrella at TM761**

At approximately TM 761 a steel rib made from 150 mm H-beam has been installed on proper footing and secured by application of shotcrete.Over the installed steel rib, 76 mm SD bolts of 12 m length have been drilled at 300 mm c-c distance. The umbrella covered at least 120° of the crown area with grouting by cement grout.

• **Re-Mining TM761 to TM766**

Re-Mining has been done with a round length of not more than 1.0m. The heading rounds have been further divided in top heading and bench as per site requirement. At each round fore-poling of SD bolts dia 32 was done as per enclosed drawing.

• **Mining from TM766 to app. TM770**

Excavation has been done with a round length of not more than 1.0m The heading rounds have been further divided in top heading and bench as per site requirement. At each round fore-poling of SD bolts dia 32 was done as per enclosed drawing.

Face drainage was drilled with 12.0 m length, dia 65 mm, and minimum 4 holes. Rock anchors with 6.0m SD bolts long were installed. A temporary invert was installed of 300 mm thickness. After three (3) rounds of heading two (2) rounds of invert was installed.

• **Consolidation / Contact Grouting**

After reaching two rounds into an area of rock not disturbed by the earlier rock fall the face was supported

as per design. For the whole length of tunnel from TM760 onward to the current face contact grouting was done to fill any voids in and behind the shotcrete shell. After grouting and setting of grout drainage and weep holes were drilled again to prevent water pressure build up.

5.1.2 High water ingress & Rock fall at tunnel meter 316 in MTS-2 (Main Tunnel South from access tunnel) at Ch. 155+666

5.1.2.1 Introduction

On 28-Jul-2007 a fault gauge was encountered in MTS2 at Ch. 155+666 and on the next day a partial collapse of four lattice girders up to Ch. 155+661 occurred.

Excavation of the rounds up to Ch. 155+661 progressed through tectonically crushed shale and quartzite. Fore-poling was used to reduce over break and protect the labour from dislocating blocks during erection of mesh and lattice girder (LG). Heavy seepage was encountered at app. Ch. 155+662.5 to Ch. 155+663.5 but disappeared almost entirely after Ch. 155+664.5.

Figure 8 MTS2, Seepage Ch. 155+662.5 to Ch. 155+663.5

During excavation of the round from Ch. 155+664 to Ch. 155+665.8, highly crushed, sheared and folded material was encountered at the bottom right of the face. Upon completion of the round it was found that the crushed material extended upward and it was immediately decided to place additional 4.0 m Swellex bolts at an angle through the weak zone as the drill time upon placing of the Swellex indicated better quality rock after about 1.5 to 2.0 m. The core of the fault gauge was angling upward and forward away from the tunnel. As fore-poles had been placed from the previous round no over-break occurred in the periphery. The entire left side of the face (app. 75%) consisted of strong quartzite.

Figure 9, MTS2, Fault Gauge Material on Right Side at Ch. 155+666

The excavation of the next rounds was done with a round length of 1.5 m and in sectors. The right side was excavated by bucket / hydraulic breaker only and sealed with shotcrete prior to blasting of the strong rock on left hand side.

During excavation by excavator of this round Ch. 155+666 to Ch. 155+667.5 the fault gauge material collapsed, and in this process three lattice girders came (Ch. 155+666, Ch. 155+664 & Ch. 155+662.4) down and damaging a fourth one (Ch. 155+661

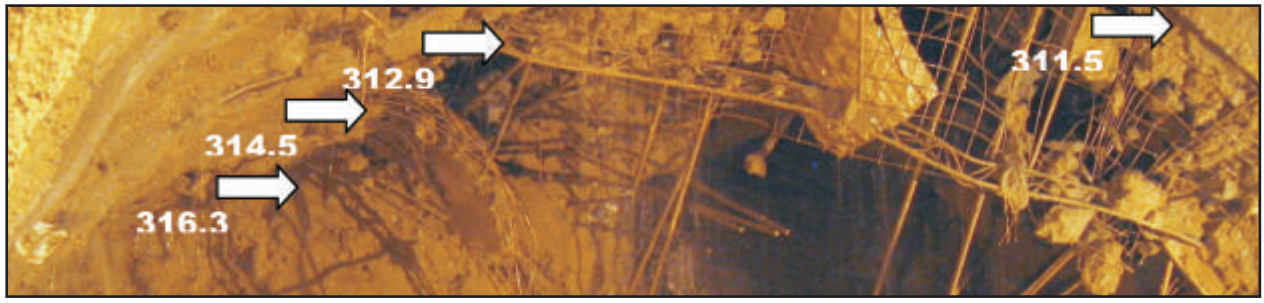


Figure10, MTS2, Pulled down and damaged lattice girders, Ch. 155+666

As material was continuously coming out of the core of the fault gauge and a chimney progressing at an angle of app. 60° out and upward from the face, no work could be undertaken in the immediate area of the collapse although additional anchoring was carried out on the non-damaged rounds.

The collapse came to a stop once the cone of loose material blocked the opening of the forming chimney.

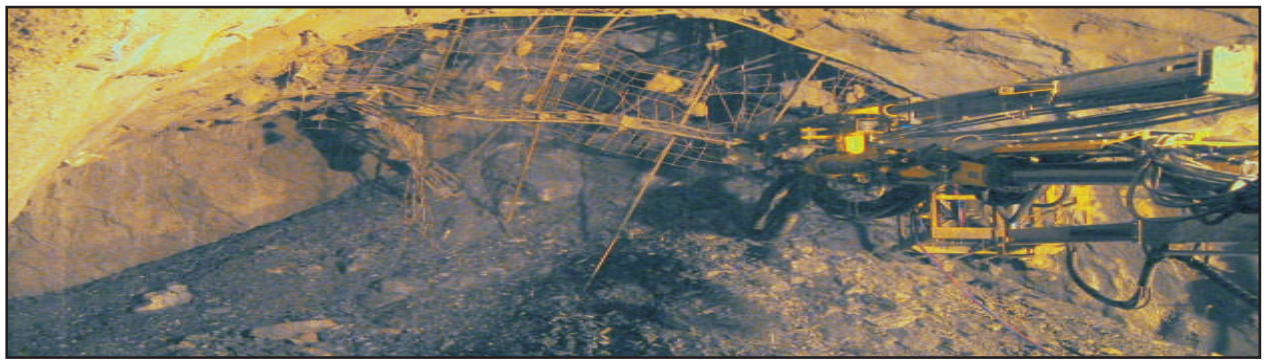


Figure10, MTS2, Pulled down and damaged lattice girders, Ch. 155+666

5.1.2.4 Causes of the collapse

(A) Geological

During percussive probe drilling undetected fault gauge was encountered at app. Ch 155+664.5. The probe drilling carried out did indicate much the same strata as already encountered during previous rounds. Increase in water and increasingly fractured material were encountered whenever the main lithology changed between Quartzite and Shale. The fault gauge encountered at Ch. 155+664.5 to Ch. 155+665.5 consisted of completely crushed material of mm to cm size. Together with a water inflow of (guessed) 5 to 10 l/s from the fault itself this apparently overloaded the fore-poling and LG at Ch. 155+665.8

(B) Technical

Besides the unpredicted geological conditions a number of other factors contributed to the extent of the collapse. The actual core of the fault out of which the majority of the cone of muck material visible in the pictures originated has a size of only 2x1 m. Only the first LG was Directly affected. The shotcrete of this round was only app. six hours old when the fault gauge core aided by the lubrication of the seepage and the hammering of the hydraulic breaker was mobilised. The presence of voids in the crown area was detected during contact grouting carried out as a precautionary measure at Ch. 155+658.5 to Ch. 155+649.5.

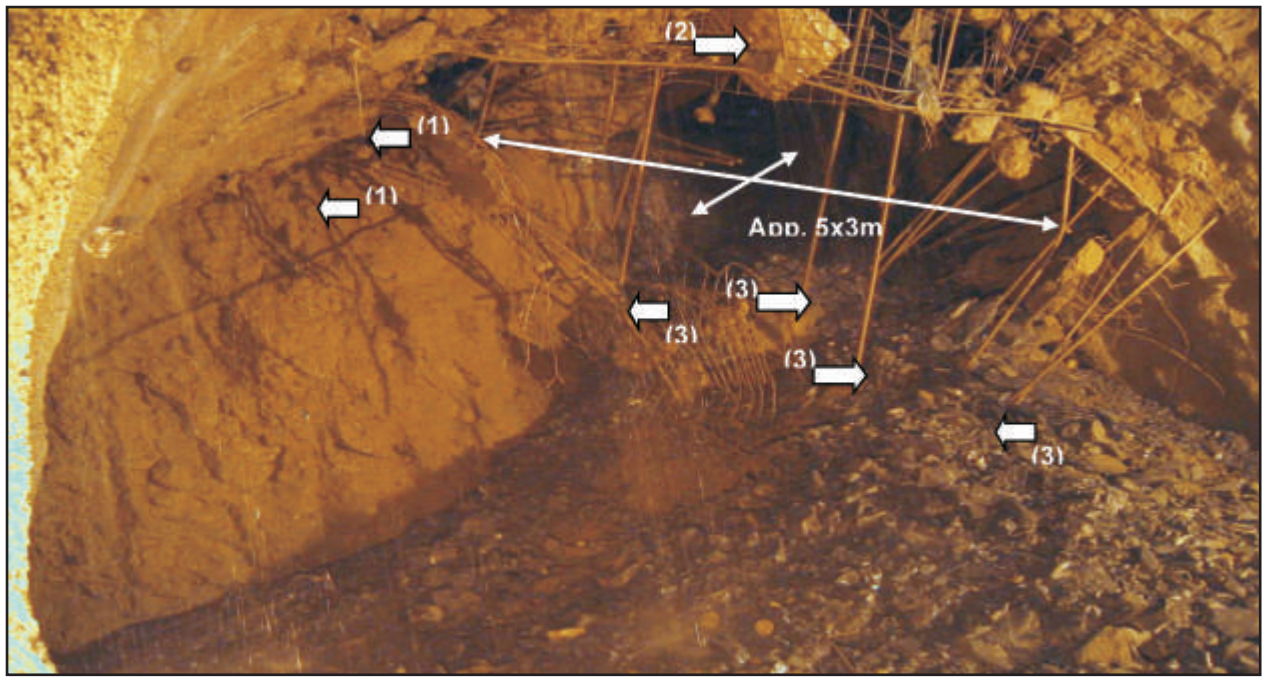


Figure 12, MTS2, Pulled down and damaged lattice girders, damaged supports at Ch. 155+666

1) LG's pulled down up to where shotcrete and rock mass properly bond
2) Corrugated GI sheet behind the shotcrete
3) Straight fore-pole bars

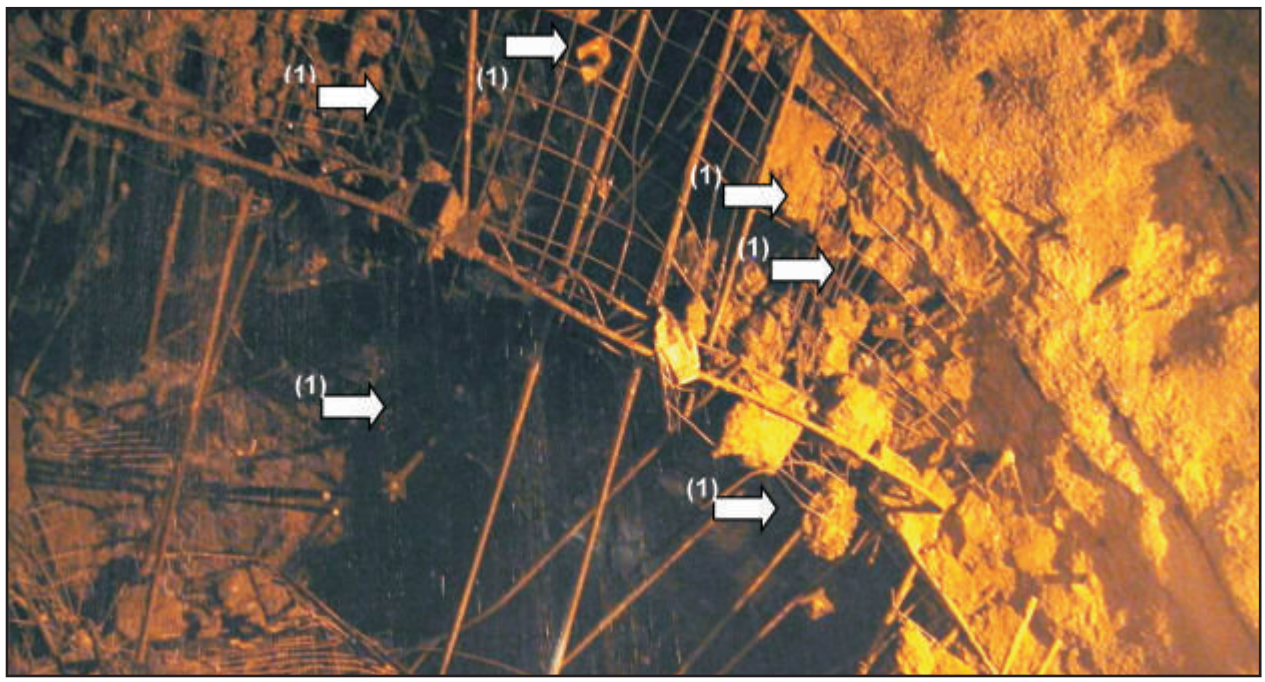


Figure 13, MTS2, Pulled down and damaged lattice girders, punched through Swellex bolts at Ch. 155+666

1) Swellex bolts punched through shotcrete.

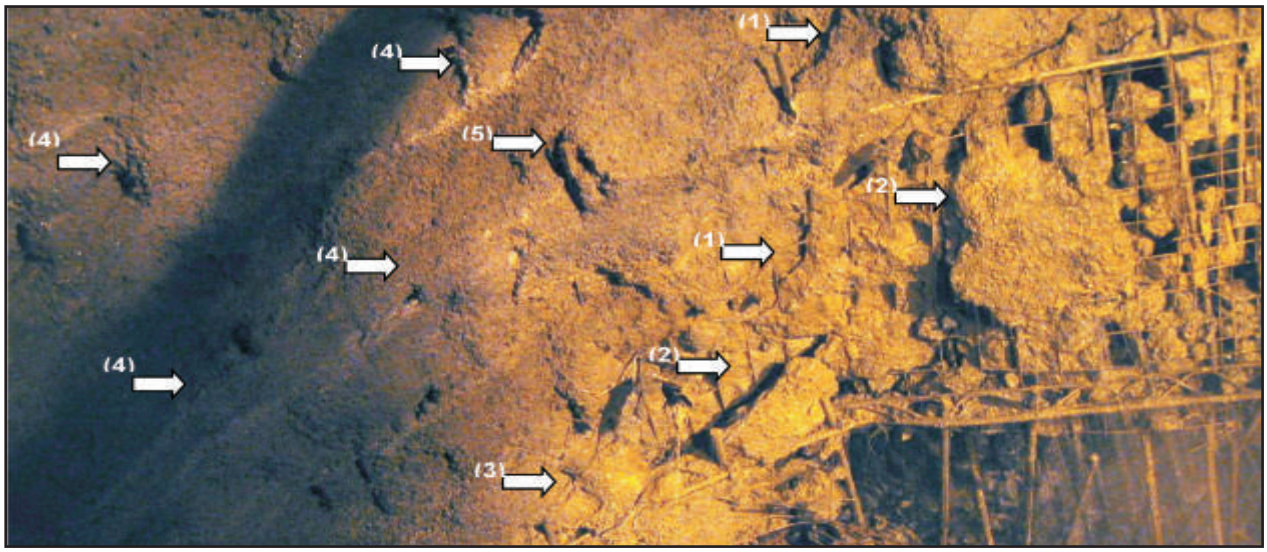


Figure 14, MTS2, Shotcrete shell, detail left side at Ch. 155+666

1) Shotcrete delaminating
2) Coming out in lumps and patches
3) Voids in lattice girder
4) Poor compaction and voids in shell
5) Spray-shadow behind forepole

5.1.2.3 Remedial Works

The installation of a pipe roof and subsequent repair of the damaged lattice girders has been done. The Shotcrete shell has been replaced up to the muck cone which has been secured by shotcrete and wire mesh. Subsequently voids have been filled by concrete and contact grouting. Anchors of 9.0 m length and app. 1.5 m distance have been installed in the repaired rounds and up to Ch. 155+654.5 backwards.

Once all above remedial works were in placed, consolidation grouting had been carried out for the loose material at the right side of the face and additional fore-poling placed as required. Excavation of the right side Ch. 155+662.5 to Ch. 155+665.5 had been done cautiously in 0.5 m rounds up to the face. The second layer shotcrete and anchors had been installed as per the progress of the works. Once the original face was reached, probing has been carried out to determine whether an additional pipe roof would be required or not.

Figure 15, MTS2, Pipe Roof installed at side Ch. 155+659

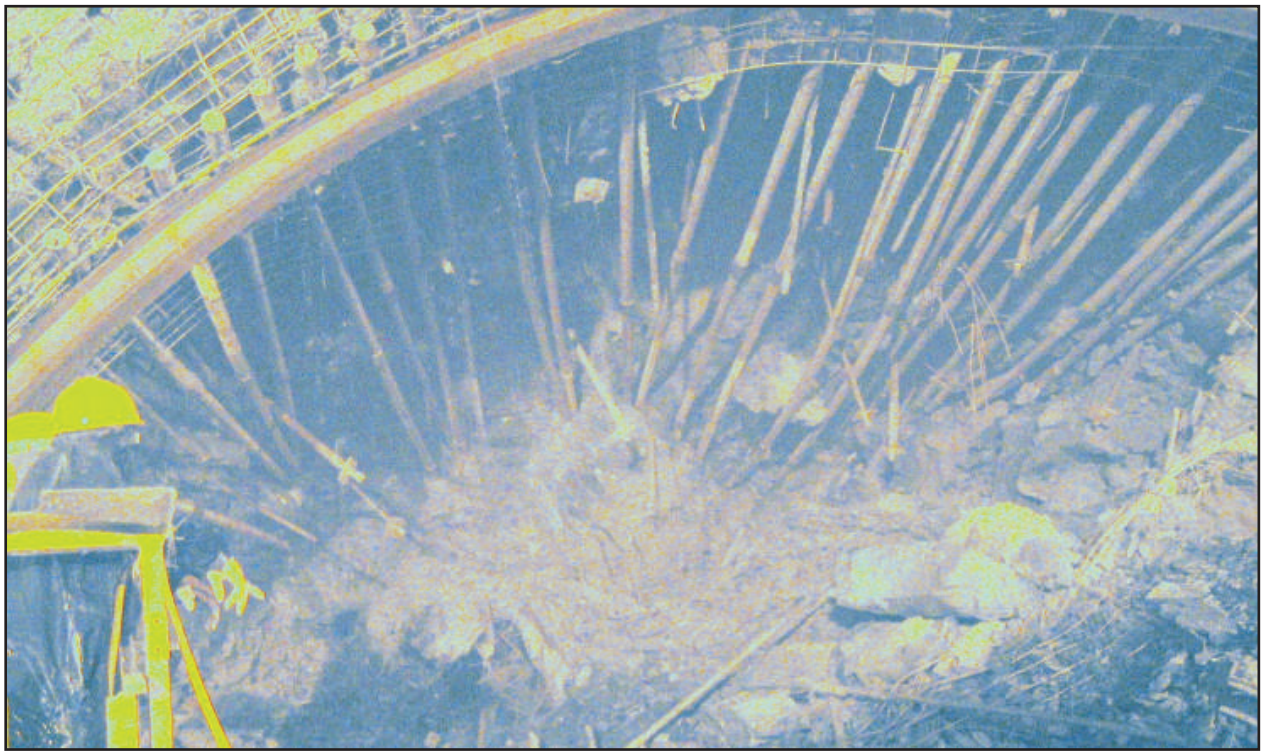


Figure 16, MTS2, Pipe Roof Installed, detail of bad alignment, Ch. 155+659

Figure 17, MTS2, Replaced LG's at Ch. 155+662.9, Ch. 155+661.9, & Ch. 155+660.8

Figure18, MTS2, Repaired Shotcrete Shell, Repair on right side in progress, from Ch. 155+658.5 to Ch. 155+665.5

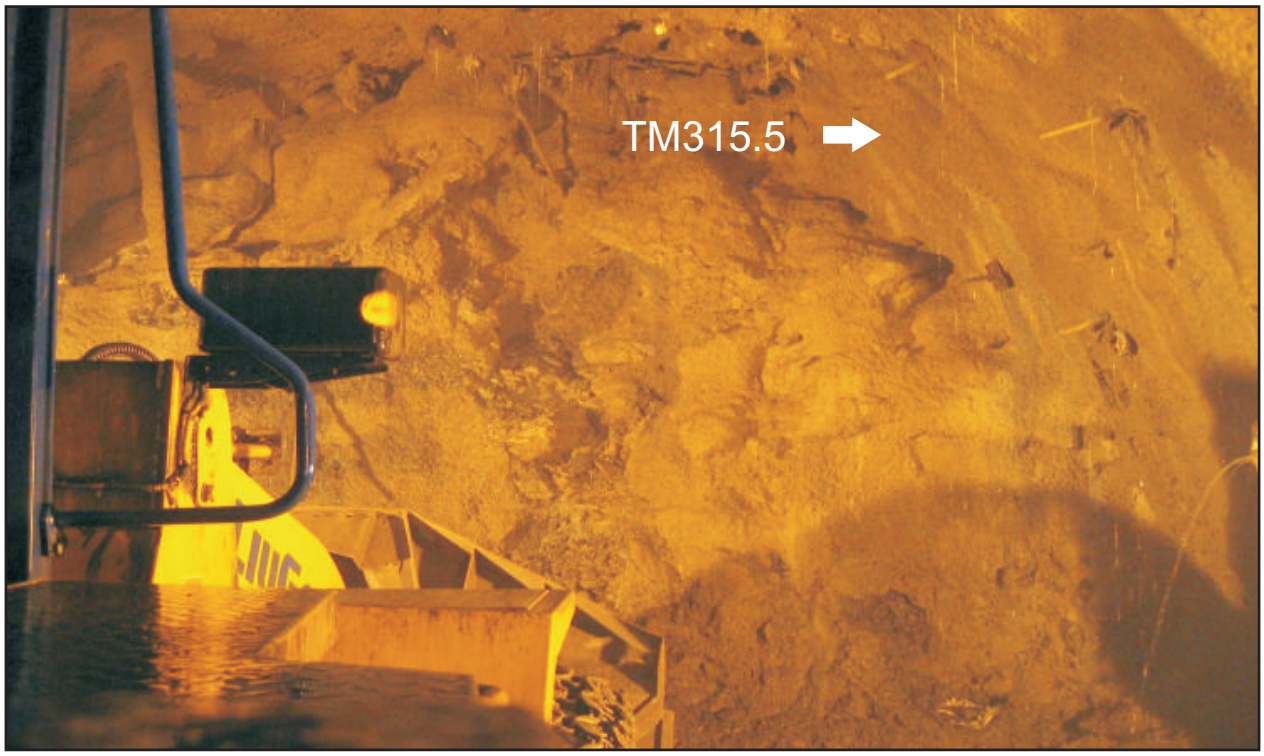


Figure 19, MTS2, Repaired Shotcrete Shell, Backfill Complete, Additional Forepoling and consolidation grouting to started at Ch. 155+664.

5.1.3 Rock fall & cavity formation at Ch. 154+604 in MTS-1 (Main Tunnel South from access tunnel towards South)

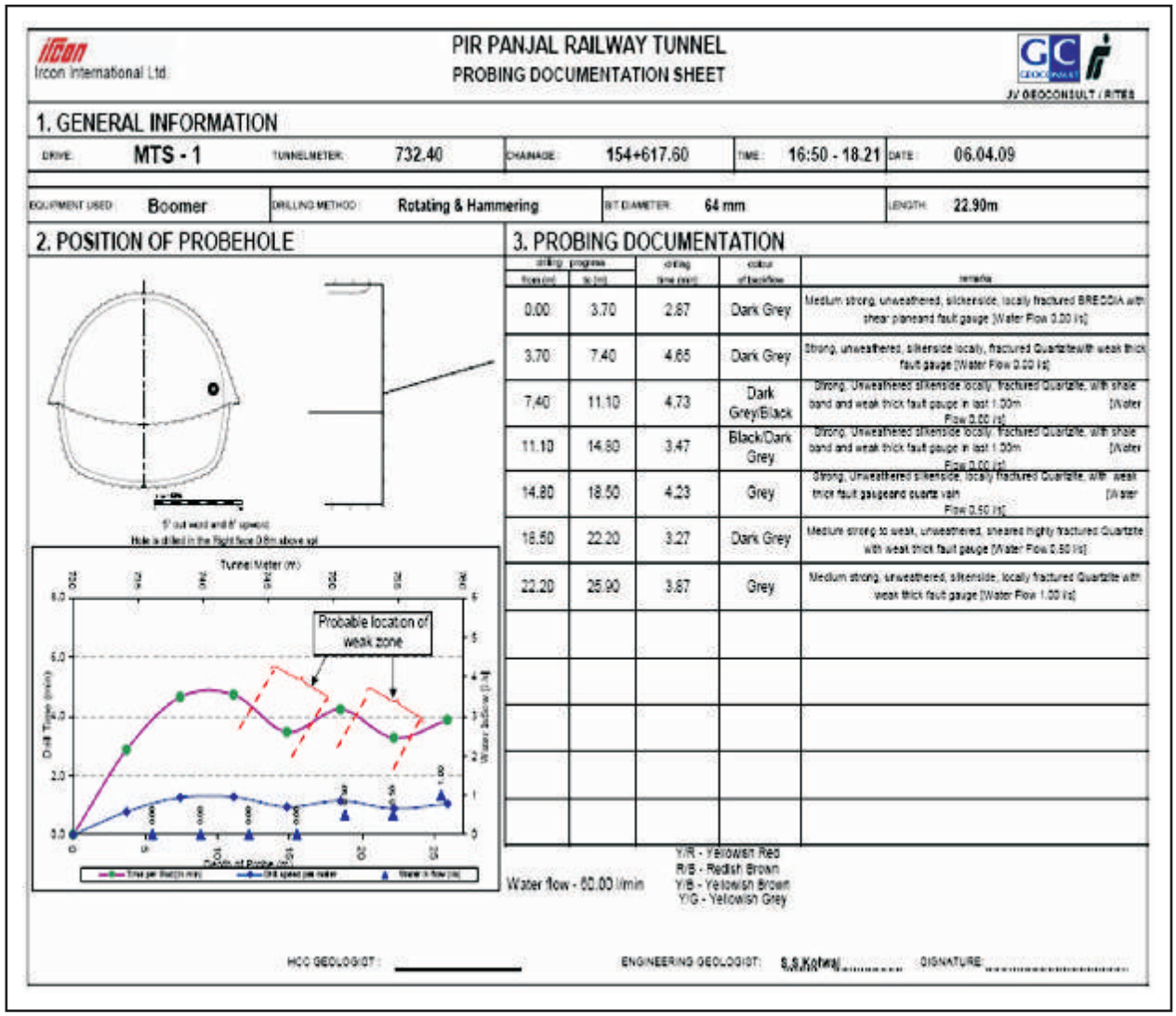
5.1.3.1 Introduction

In MTS-1 (Main Tunnel from Access tunnel towards South) weak zone present in the crown started collapsing inthe night shifts of 25 th TM315.5 April 2009. The collapse was observed at around 6 O'clock (6 AM) of 26 April 2009 at approximately Ch. 154+604.

Figure 20 Rock fall in MTS-1 at Ch. 154+604

At Ch. 154+627.6, a probe hole had been drilled in the right side of the face at around 1.2m above SPL and around 0.8m from the right wall. This hole was drilled with the help of TAMROCK with 64mm dia bit. Length of this probe hole was 22.9m. Reading was taken at the end of each drilling rod which is 3.7m in length hence 7 rod were drilled. Interpretation of geology ahead is done on the basis of flush water, stone chips coming out of the hole and time taken in drilling per rod.

Probe hole drilled suggested a weak zone from 10.5m to 22m that is around Ch. 154+607 to Ch 154+595.5. It was predicted that after 22m of drilling strong quartzite would be encountered (fig – 21).



Ircon International Ltd.

PIR PANJAL RAILWAY TUNNEL
PROBING DOCUMENTATION SHEET

JV GEOCONSULT / RITES

1. GENERAL INFORMATION

DRIVE	MTS - 1	TUNNELMETER	732.40	CHAINAGE	154+617.60	TIME	16:50 - 18.21	DATE	06.04.09
EQUIPMENT USED	Boomer	DRILLING METHOD	Rotating & Hammering	BIT DIAMETER	64 mm	LENGTH	22.90m		

2. POSITION OF PROBEHOLE

Tunnel Meter (m)
Probable location of weak zone
Drill Time (min)
Water Inflow (l/s)
Chainage of Probe (m)
Time per Rod (min)
Drill speed per meter
Water in flow (l/s)

3. PROBING DOCUMENTATION

drilling progress from (m)	drilling progress to (m)	drilling time (min)	colour of backflow	remarks
0.00	3.70	2.87	Dark Grey	Medium strong, unweathered, slickenside, locally fractured BRECCIA with shear plane and fault gauge [Water Flow 0.00 l/s]
3.70	7.40	4.65	Dark Grey	Strong, unweathered, slickenside locally, fractured Quartzite with weak thick fault gauge [Water Flow 0.00 l/s]
7.40	11.10	4.73	Dark Grey/Black	Strong, Unweathered slickenside locally, fractured Quartzite, with shale band and weak thick fault gauge in last 1.00m [Water Flow 0.00 l/s]
11.10	14.80	3.47	Black/Dark Grey	Strong, Unweathered slickenside locally, fractured Quartzite, with shale band and weak thick fault gauge in last 1.00m [Water Flow 0.00 l/s]
14.80	18.50	4.23	Grey	Strong, Unweathered slickenside, locally fractured Quartzite, with weak thick fault gauge and quartz vein [Water Flow 0.50 l/s]
18.50	22.20	3.27	Dark Grey	Medium strong to weak, unweathered, sheared highly fractured Quartzite with weak thick fault gauge [Water Flow 0.50 l/s]
22.20	25.90	3.87	Grey	Medium strong, unweathered, slickenside, locally fractured Quartzite with weak thick fault gauge [Water Flow 1.00 l/s]

Water flow - 60.00 l/min

Y/R - Yellowish Red
R/B - Redish Brown
Y/B - Yelowish Brown
Y/G - Yelowish Grey

HCC GEOLOGIST : _____ ENGINEERING GEOLOGIST: S.S.Kotwal..... SIGNATURE:.....

Figure 21: Probe hole at Ch. 154+617.6 MTS-1

On 26th April 2009 excavation of the face was started after Ch. 154+604 with the help of excavator. When the excavation of the left face was started after completion of right face excavation at around 5.30 am the loosed material (Fault gouge) start falling from the crown. Location of the sheared portion can be seen from the face map generated on at ch. 154+603.6 (Fig 22). As per the RESS, excavation followed support class RC IV. In the previous rounds the loose portion was encountered hence the round length was reduced to 0.9m. Fore polling of 6m length 25 no. SD Bolt had been drilled around the loose portion and near it with a c/c spacing of 400mm. Face bolt of 9m length 3 no. SDR were also drilled at Ch 154+607. Water in flow from the face and from the last 10 m was around 0.5 – 1.5 l/s.

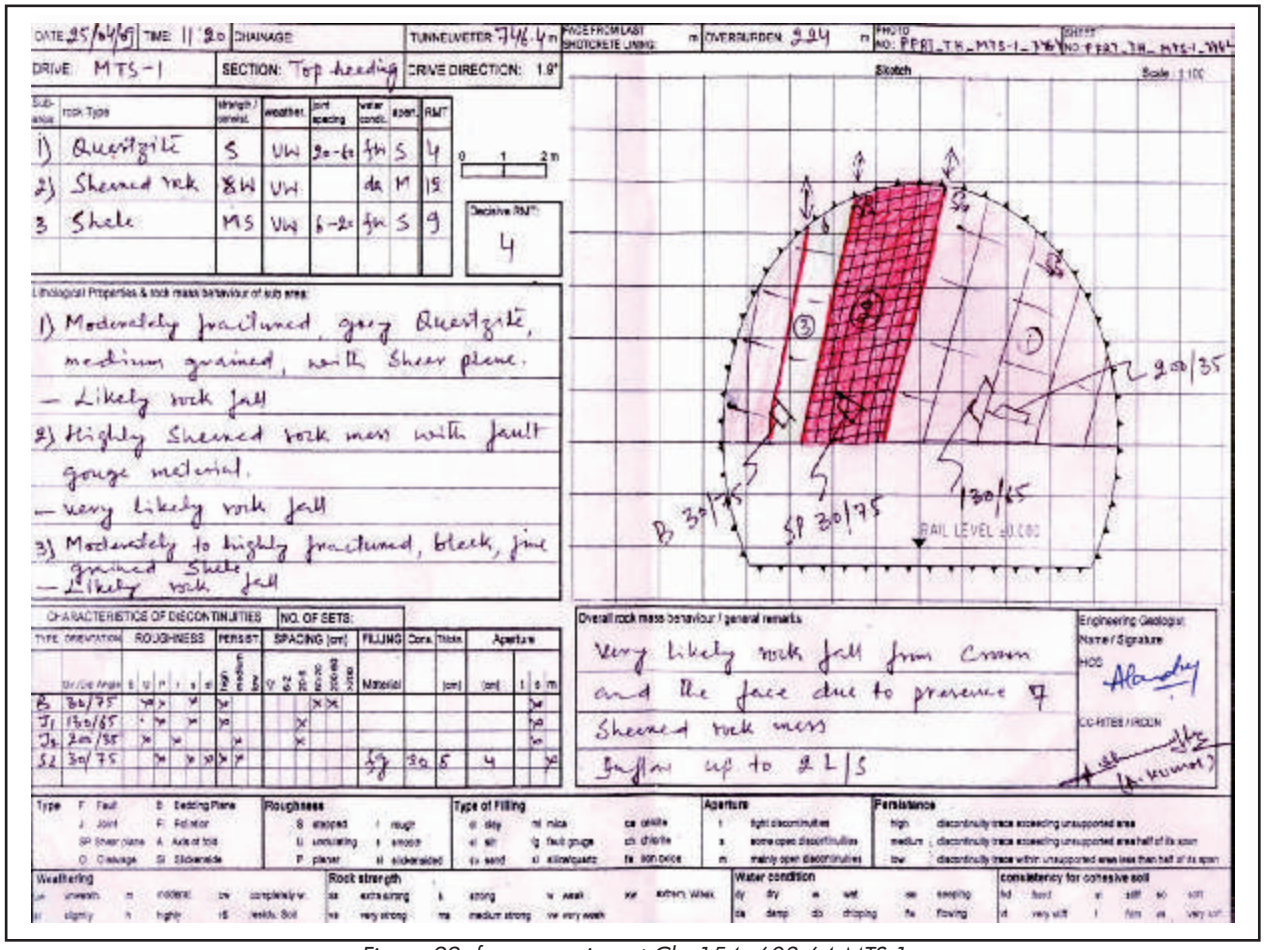


Figure 22: face mapping at Ch. 154+603.64 MTS-1

5.1.3.2 Immediate Measure

Once the loose material from the crown started falling, the excavation of the face was stopped and as soon as possible the sealing (shotcrete) of the face was started. During the shotcrete sealing operation loose material continued to fall from the crown. Sealing of the crown and the face continued till the material stop coming from the crown. Once the face was covered with the loose muck the material coming from the shattered zone stopped.

Once the rock fall stopped strengthening of the previous round was done by spraying a layer of shotcrete on it. Then the loose muck fallen from the crown was covered with wire mess and shotcrete of thickness10cm. 3D monitoring of the target already installed at Ch. 155+608 was taken twice daily and the movement in the rock was closely monitored. 3D reading clearly shows significant movement (Fig 23). To stabilize the area additional rock bolt of 4m length swellex were installed in 8 rounds starting from the last 3 rd round from the face. Each round will have around 10 no. of swellex bolt. After the installation of these rock bolts movement in the tunnel was stopped. This is reflected from the 3D graph.

Due to the collapse, from Ch. 155+609 cracks were observed in the shotcrete. These cracks were dangers for the workers; hence workers were instructed not to work under these cracks. These cracks were covered with additional layer of wire mesh before worker started working for remedial measure. This wire mesh is only for the protection for the man power working in the tunnel.

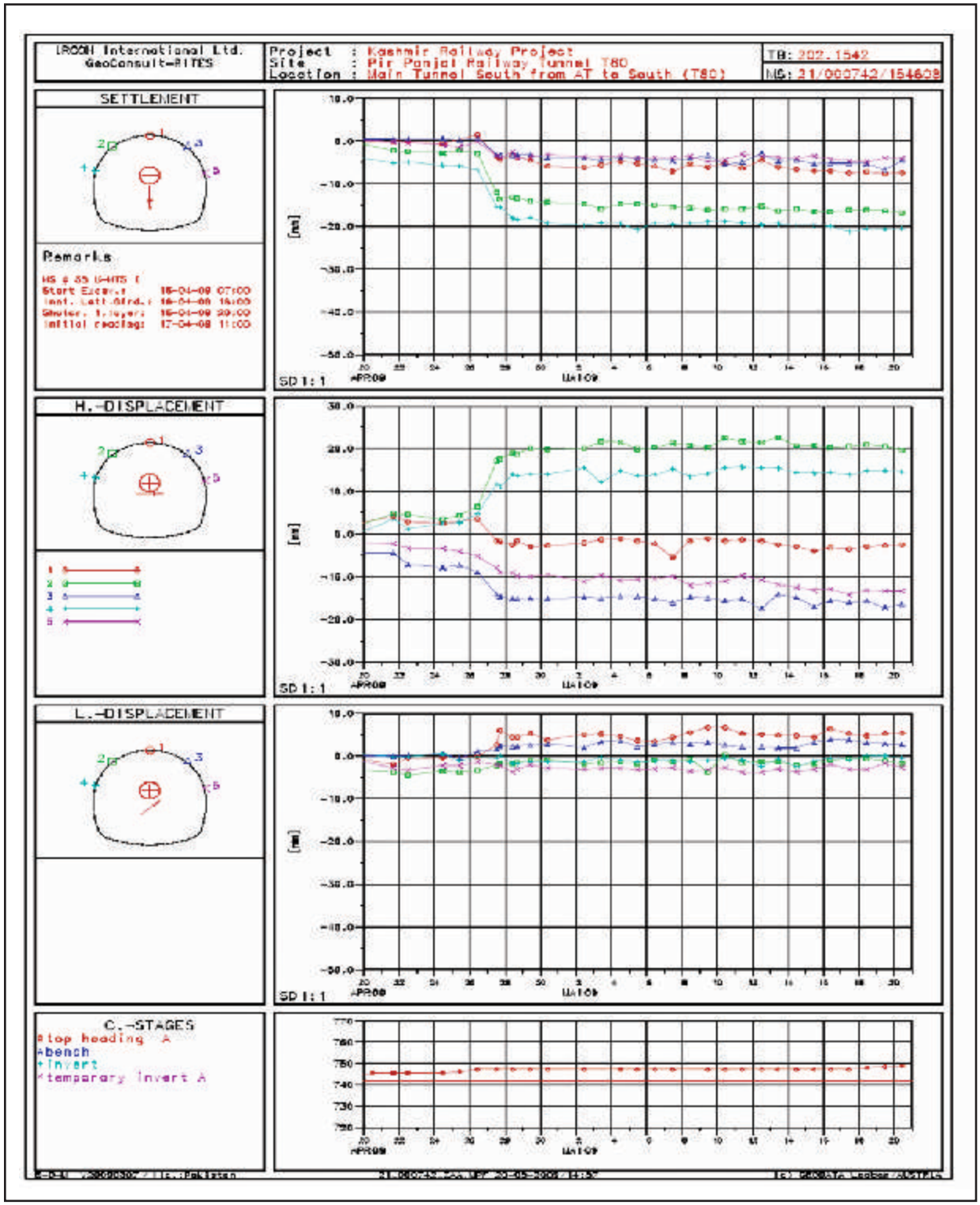


Figure23: Monitoring Result at Ch. 155+608; MTS-1

3D reading showing stability of the cavity and the area around it as remedial measure were started.

5.1.3.3 Remedial measure

Remedial measure included following Point:

- Consolidation of the muck near the face.
- Pumping of concrete in the cavity (Cavity Filling).
- Drilling pipe roof around the cavity (umbrella Formation)
- Consolidation of Face.

To consolidate the muck accumulated near the face, second layer of wire mess with shotcrete was spared. After shotcrete face bolt of 6 to 12 m length, 18 no. SD Bolts were drilled and grouted. After grouting 4 nos. of 4 inch dia pipes were drilled in the cavity. With the help of these pipes concrete was pumped in the cavity. After pumping, 18 nos. SD Bolt 76mm dia 8m long were drilled & grouted around the cavity as pipe roofing. These SD Bolts were used as umbrella for the start of excavation. After grouting of these pipes 2m long perforated radial bolt were drilled in four rounds from Ch. 154+607.5. These perforated SD bolt were grouted for consolidation of the area near the tunnel face. Each round contains 6 numbers of bolts which were drilled at alternate location in each round. As the opening area reduced due to muck accumulation hence longer SD Bolt were drilled after the removal of muck.

5.1.3.4 Resumption of excavation

After completion of repairing work in MTS-1, at Ch. 154+604 and near-by area of collapse, excavation resumed in the tunnel. To start the excavation following stapes were taken:

1) Mucking of the debris from the face was done.
2) Previously excavated round was exposed and lattice girder was erected at 60cm from the last round and complete support was installed with 25 no. of SD bolt as fore-pole of 6m length.
3) Face was closed with 10cm of shotcrete.
4) Consolidation grouting and grouting of the cavity was carried out with the help of 9m long 8no of SD bolt in the last 4 rounds.
5) Excavation of next round of around 60 cm was completed with the help of excavator; installation of all kind of supports was completed excepted fore-pole. Next rounds were also excavated with the help of the excavator of 70 and 90cm with normal support measure.
6) During all these operation one shotcrete mixture with 3 – 4m^3 of shotcrete with shotcrete pump was kept available near the face for emergency.

6.0 Conclusion:

As experienced during the construction of Pir Panjal Tunnel T-80, even after lot of geological and Geotechnical investigation done before the start of work and also continious probing during the execution of work, these above mentioned surprises could not be prevented although the impact of the above challenges were restricted to minimum possible by providing immeediate best possible technical solution, availability of sufficient & requird stock of construction material at site and the intensive 3D monitoring of thge affected portion. The mining work was further started after minimum interuption time.

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XI. Geoconsult/RITES (April 2004): Kashmir Railway Project – Pir Panjal Railway Tunnel, Early Underground Works – Structural Analysis General Cases – Part 1

XII. Geoconsult/RITES (April 2004): Kashmir Railway Project – Pir Panjal Railway Tunnel, Early Underground Works – Structural Analysis General Cases – Part 2

XIII. Geoconsult/RITES (April 2004): Kashmir Railway Project – Pir Panjal Railway Tunnel, Factual Report

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"INCIDENT CASE STUDIES" – A VANTAGE POINT FOR IMPROVING SAFETY DIMENSIONS DURING CONSTRUCTION OF RAILWAY PROJECTS

Ajay Gupta, SHE Expert
Nippon Koei India Pvt. Ltd
/ OCG Consortium
Project Management Consultant,
WDFC Phase-2)

Md. Tasnim Ali Kidwai, Safety Expert
(Oriental Consultants India Pvt. Ltd
/ OCG Consortium
Project Management Consultant
WDFC Phase-2)

Abstract:

Construction work includes many hazardous activities and conditions and thus requires each site worker and staff to be aware of associated risks and dangers on the ground to prevent Serious Injuries and Fatalities (SIFs) on construction sites. The construction work of railway projects is highly labor intensive and at the same time employs extensive use of construction equipment and machinery. Due to its critical working nature and heavy civil & track works, it requires more focus on the effective implementation of safety practices, development of safety culture, positive and innovative approaches towards safety &health to prevent injuries and other losses, which could occur in different levels of severity, some causing minor and major injuries with others resulting in fatality anddangerous occurrences. It is the responsibility at all levels of management, project-linked staff, engineers, managers, supervisors, workers, etc. to pay special attention towards prevention of any untoward incident till the completion and commissioning of the project.

Safety review and analysis in large-sized construction projects on major causes that usually leads to unexpected accidents has revealed some of the key factors, which relates to poor instructions by the supervisors to the workers (mainly unskilled); lack of adequate and effective training; poor supervision and lack of coordination between design team and execution team; poor inspection of temporary structures;lack of workers' awareness and communication on job hazards and risks; over confidence; lack of scheduled maintenance of equipment / machinery; and underestimating potential hazards and their associated risks by staff and workers employed on construction sites.

In order to enhance the performance of safety & health measures in railway construction projects in line with the International & National Best Practices, this paper has discussed the practical safety tips and precautions through **"interactive case studies - (third-part in series)"**during a) Movement of Loaded Transit Mixers on Narrow Roads, b) Erection of Temporary Formwork for Casting of Concrete Structures, c) Erection of Vertical Rebar for Construction of Bridge Piers, and d) Working of Excavators in Excavation Zone, to identify potential hazards, enhance understanding of unsafe acts & conditions, analyze the causes of accidents and suggest possible control measures for their prevention. The depth of analysis elucidated in specific case studies shall help in preventing and minimizing the occurrence of related incidents and contribute to build an efficient and safe working environment/culture on all work sites of the project.

Such practice of continual improvement, knowledge and experience sharing from construction sites for dissemination of information among all stakeholders shall build the railway projects with high standards of construction site safety in a sustainable manner.Understanding of perils at hand and sustaining a perpetual state of alertness is perhaps the number-one best way to prevent accidents.

INTRODUCTION

"An incident is just the tip of the iceberg, a sign of a much larger problem below the surface"– Don Brown

Majority of hazards that occur are preventable if only safety was ensured in the first place. Every large-sized construction project is prone to accidents and at higher risk compared to other sectors. Accidents in construction works lead to severe difficulties to every stakeholder such as the Employer, Consultant, Contractor, Sub-contractor, Workers and the third party. However, accidents can be controlled by establishing proper safety management system on construction sites. All efforts should be made to continuously review the current safety management system in practice in large construction projects to establish a safe and health conscious working environment on construction sites during the entire period. Suitable control measures should be taken to ensure the compliance of all the required safety measures in an effort to prevent any accident in construction sites.

"Accident / Incident Case Studies" is a powerful safety training and information sharing tool which provides many benefits to prevent accidents and helps in wider dissemination and sensitization. Case studies break-down the events leading up to the accident and helps to -

- Identify potential hazards;
- Understand accident causes;
- Discuss possible preventive measures;
- Determine the best methods for preventing a similar accident;
- Generalize the information learned to other safety issues in the workplace; and
- Transfer the analysis, problem-solving, and decision-making skills learned during the case study process to real situations on the job.

It is imperative in large construction projects, such as railways, to take proactive measures and precautions to prevent occurrences of accidents / incidents on the work sites that can happen as a result of carrying out routine activities. Such incidents not only affect the health and lives of the workers, but also slow down progress of the projects.

It is with this objective that a **"series (third-part)of a safety training primer"** has been initiated consisting of case studies on a real situation to provide an effective way to identify potential hazards, enhance understanding of unsafe acts & conditions, analyze the causes of accidents and suggest possible measures for their prevention. Each case study carries an in-depth analysis in a simple and understandable manner on specific situations and real accidents / incidents scenarios on construction sites with real consequences

for the people involved. This helps to expand knowledge relating to similar situations at sites for preventing cases of occurrences of serious injuries and fatalities (SIFs) resulting in enhanced site safety.

It is the responsibility of all project-linked staff, engineers, managers, supervisors, workers, etc. to pay special attention towards prevention of any untoward incident till the completion of the project.

Such construction safety training primer shall enhance awareness and knowledge among employees, engineers, field units' staff, workers, etc. of Employer, Contractors / Sub-contractors, Project Management Consultants (PMC), and other stakeholders to identify the potential risks leading to accidents / incidents / near miss cases and to implement such corrective measures which can ensure prevention of such occurrences on construction sites.

CASE STUDIES

"Accident case studies on a real situation provides an effective safety training and communication tool for engaging staff, managers, workers, drivers, operators, etc. working on construction sites in a discussion about the causes of these injuries and solutions for preventing similar occurrences."

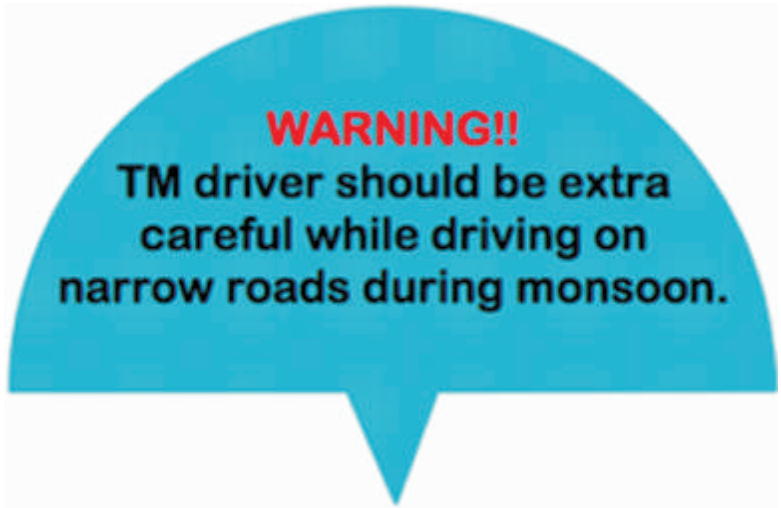
In this paper, following four interactive case studies are discussed along with practical **"Safety Tips"**, which if diligently taken on the construction sites will result in preventing serious injuries & fatalities (SIFs) and loss of life &property. The analysis on a real situation for these selected case studies have actually brought out those safety non-compliances / deficiencies, which could result in occurrence of similar types of incidents. These interactive case studies are related to safety considerations in –

1. Movement of loaded Transit Mixers on Narrow Roads;
2. Erection of Temporary Formwork for Casting of Concrete Structures;
3. Erection of Vertical Rebar for Constructing Bridge Piers;
4. Working of Excavators in Excavation Zone

CASE STUDY - 1: TRANSIT MIXER TOPPLED ON VILLAGE ROAD

A Transit Mixer (TM) Driver after loading from the concrete batching plant took a narrow village road (without shoulders & wet loose soil on both sides) enroute to a bridge construction site for concreting work.

The Transit Mixer driver while giving way to the approaching vehicle got his front tire plunged into wet soil resulting in shifting of center of gravity (CG) of loaded vehicle on one side causing tilting of vehicle and slowly got toppled on the ground entrapping driver inside of the vehicle.

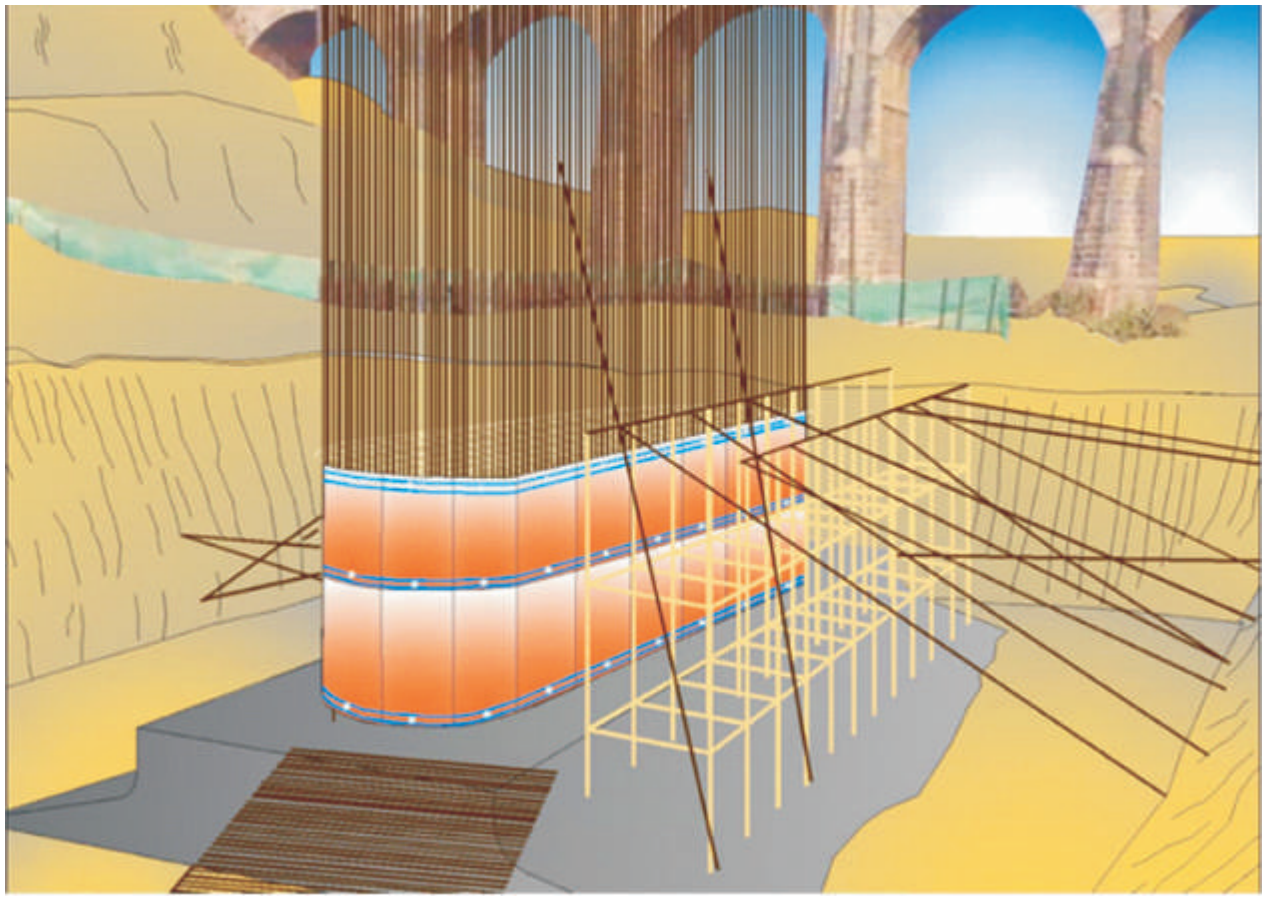


SAFETY TIPS

Operator / Driver	• Avoid driving on very narrow roads during monsoon season and inclement weather. • Obey all traffic rules & regulations. • Keep extra precautions during foggy conditions in winter. • Be prepared for Construction hazards; regularly attend 'Pep-talks / Tool-box talks' conducted by Contractor's site engineer or supervisor. • Keep traffic route plan and understand it properly. • Always wear seat belt, do not use 'Mobile Phone' & 'other electronic devices' while driving the vehicle on roads. Eating & drinking should also be avoided during driving. • Take a break at every two hours. • Never drive vehicle under unsafe behavioral condition (such as under drunken condition, poor health condition, lack of sleep condition, over exhaustion, family issues etc.) • Ensure working conditions of all warning devices like horn, reverse horn/buzzer, flashing lights, etc.
Contractor's Site Engineer or Supervisor	• Transportation route for TM from batching plants to Construction sites should be prepared, included in "Traffic Management Plan", and informed to all TM operators/drivers. • Ensure drivers are fit for duty i.e. alertness, no alcohol & drugs etc. • Drivers should be instructed to follow the safe system of work adopted on site. These may be verbal instructions or written instructions showing the relevant site rules, the site layout, delivery areas, speed limits etc. • Ensure Driver must have valid driving license. • Approach roads should be inspected (Road Hazard Assessment) before start of the work. • Provide regular 'Pep-talks / Tool-box talks' to the drivers and operators and explain the hazards of unsafe driving practices. • Traffic route plan should be provided to all TM drivers. • Ensure drivers are trained on defensive driving.

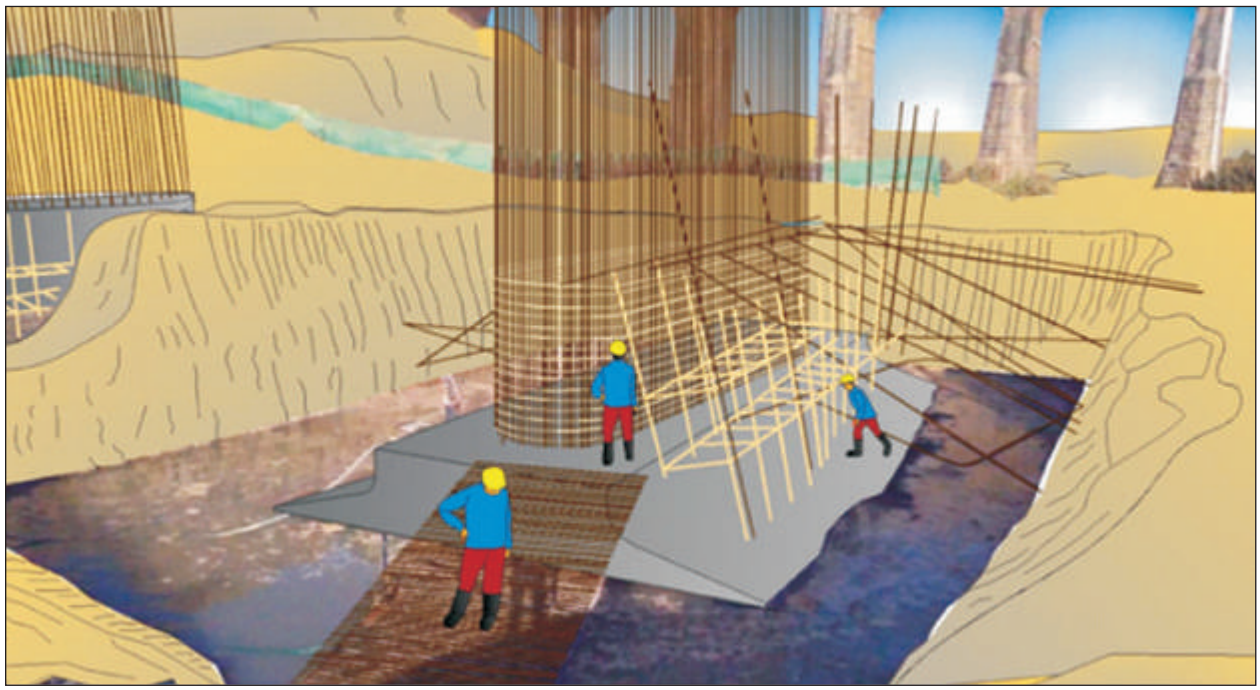
CASE STUDY– 2: CONCRETE FORMWORK FAILURE AT BRIDGE SITE

A formwork for concrete structure was erected for casting of first & second lift of one of the piers for a Major Railway Bridge (MJB). All required lateral and vertical staging supports were also provided to the formwork by means of tie rods & bracings & for working platform, temporary staging was erected to withstand loads. The work for continuous concrete pouring was in progress and the site engineers, supervisors, and workmen were standing in the vicinity.



While the 70 cum (~90%) of the concrete (M-35 grade) was poured and pouring from the last miller/transit mixer just began, the wing nut of one of the tie rods broke away followed by the second wing nut and finally a chain reaction happened causing one nut after the other including tie rods to break away. Due to concrete pressure, the ledger pipes to support the steel shutters buckled and bent away very badly causing displacement of shutters and collapse of entire mass of poured green concrete.

Luckily no site staff or worker got injured as they timely moved away from the site.



Failures of Formwork

Formwork failures are attributed to human error, substandard materials & equipment, omission & inadequacy in design

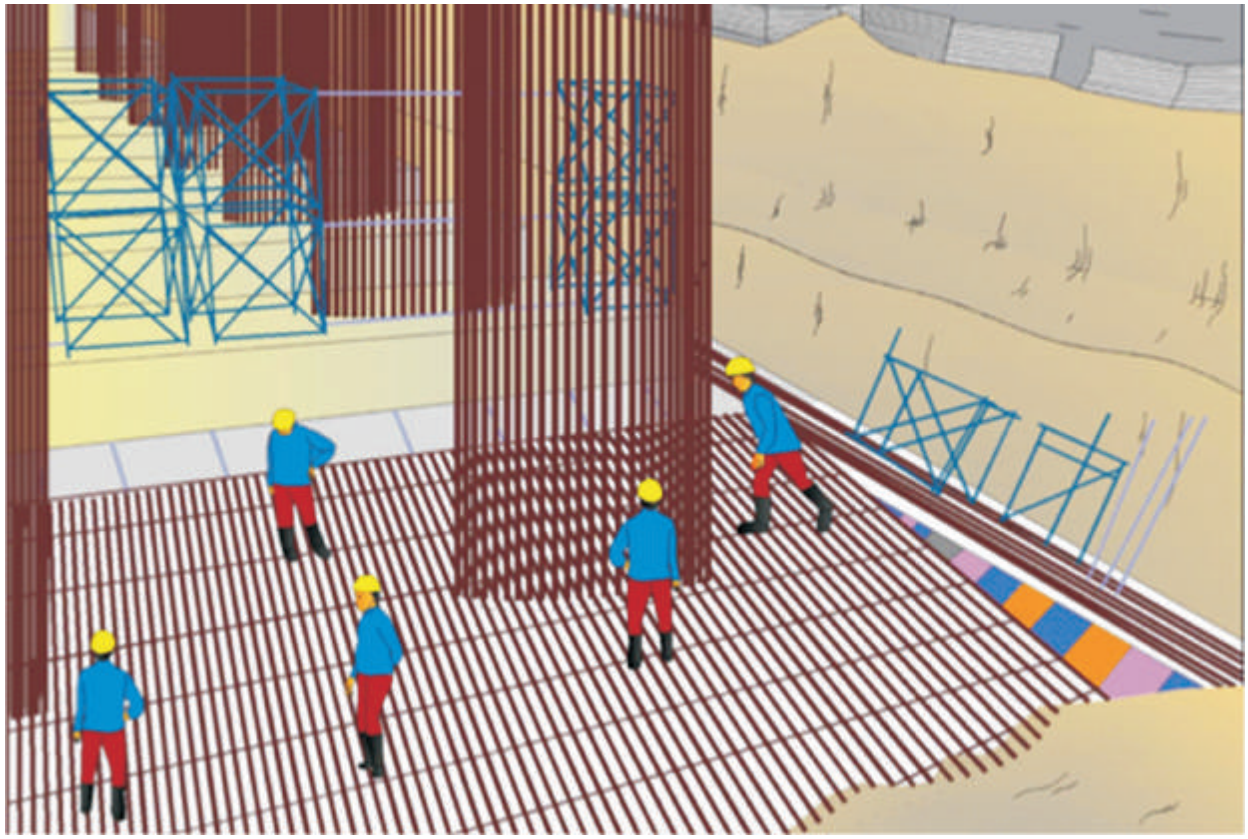
Safety Tips

01. Deploy only skilled workforce having experience in similar works
02. Formwork should be properly designed for the structural elements, consider safe bearing capacity of soil & all the loads it will experience during casting of concrete and also indicate the sequence, schedule, rate and height of concrete pouring
03. The materials used for formwork should have adequate strength to support structural load as well as other loads imposed on it
04. Formwork and temporary supports must be checked, properly tied, footed, braced and supported before loading and before pouring
05. All props should rest on bearing plates or hard bearing surface
06. Loss of material, time, cost and life could be prevented by careful supervision and inspection

CASE STUDY - 3: COLLAPSE OF LONG VERTICAL REBARS

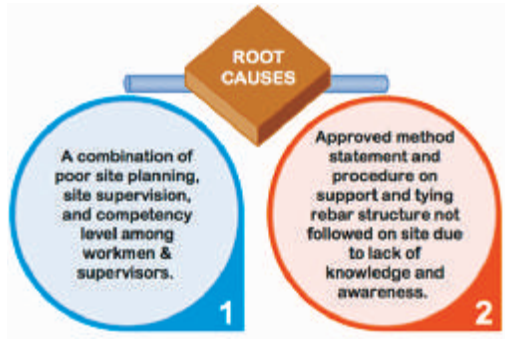
Vertical rebar erection work for constructing an Important Bridge (IMB) for railway project with twin-piers arrangement was being done with each pier consisting of around 172 nos. of 36 mm diameter of free standing vertical steel bars of height around 8 m, but deficient in staging supports and improper provision of cross bars or outer rings to either of the pier free vertical bars.

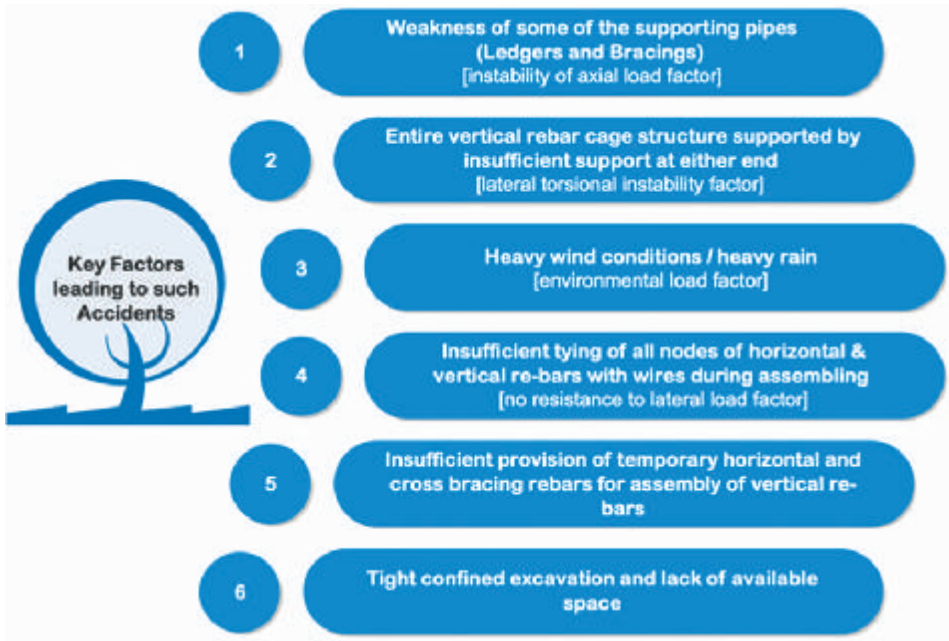
[When safety concerns were pointed out by site engineers, temporary supports were provided in the form of MS bracing pipes, but directly piercing into the soft soil of the surrounding walls of the excavated pit.]



Due to heavy wind & rain conditions, the vertical rebars along the length of one of the piers started sliding to one side of footing where no lateral support arrangements were provided and consequently fell over the second pier and caused collapsing of both rebar cage structures.

[Slow tilting of bars allowed nearly 20-25 workers to move away from the excavation work area and escaped any injury or fatality BUT created an element of fear among workers, supervisors & site engineers]


ROOT CAUSES
A combination of poor site planning, site supervision, and competency level among workmen & supervisors.
1
Approved method statement and procedure on support and tying rebar structure not followed on site due to lack of knowledge and awareness.
2


Key Factors leading to such Accidents
1
Weakness of some of the supporting pipes (Ledgers and Bracings) [instability of axial load factor]
2
Entire vertical rebar cage structure supported by insufficient support at either end [lateral torsional instability factor]
3
Heavy wind conditions / heavy rain [environmental load factor]
4
Insufficient tying of all nodes of horizontal & vertical re-bars with wires during assembling [no resistance to lateral load factor]
5
Insufficient provision of temporary horizontal and cross bracing rebars for assembly of vertical re-bars
6
Tight confined excavation and lack of available space

SAFETY TIPS ON MITIGATION MEASURES

Countermeasures for Avoiding Recurrence	• Provision of temporary horizontal and cross bracing rebars for assembly of vertical rebars. • The cage will require specific measures to be undertaken to ensure that it remains rigid and stable at all stages of the erection. • Stability of reinforcement must be ensured. During the risk assessment phase, the working drawings should be examined to determine whether the reinforcement is detailed in such a way as to provide sufficient rigidity and stability of cages during phased fixing of the bars. i.e. Laps, tying, weld etc. • Tying of all nodes of horizontal and vertical re-bars with wires. • Sequencing of rebar tying and supporting to be strictly followed as per the approved method statements and drawings. • Providing proper supporting arrangements for support of the rebar cage. • All anchoring points, clamps, bracing pipes shall be regularly rechecked for full tightness and adequacy in strength. Guy and bracing system must be designed by a 'Qualified person' • Training of site crew for reinforcement rebars on how to tie and maintain safely. • Training of Foreman, and Rebar fitters in workshop on how to assemble rigidly vertical rebars of 32 mm in diameter to prevent collapsing. • Daily toolbox talks, on-site training & awareness for frontline supervisors and site crew. • Safety bulletins and improved safety posters. • Safety checklists shall be implemented for these specific activities (Reinforcement and Shuttering works). • Deploy adequately trained & experienced site Engineers/Safety personnel at site to ensure safe work procedure during pier reinforcement and shutters. • Job specific safety training to be provided for all Construction Managers and Supervisors at work site. • Shuttering/De-shuttering work should be carried out under constant supervision of Engineer/Supervisor.

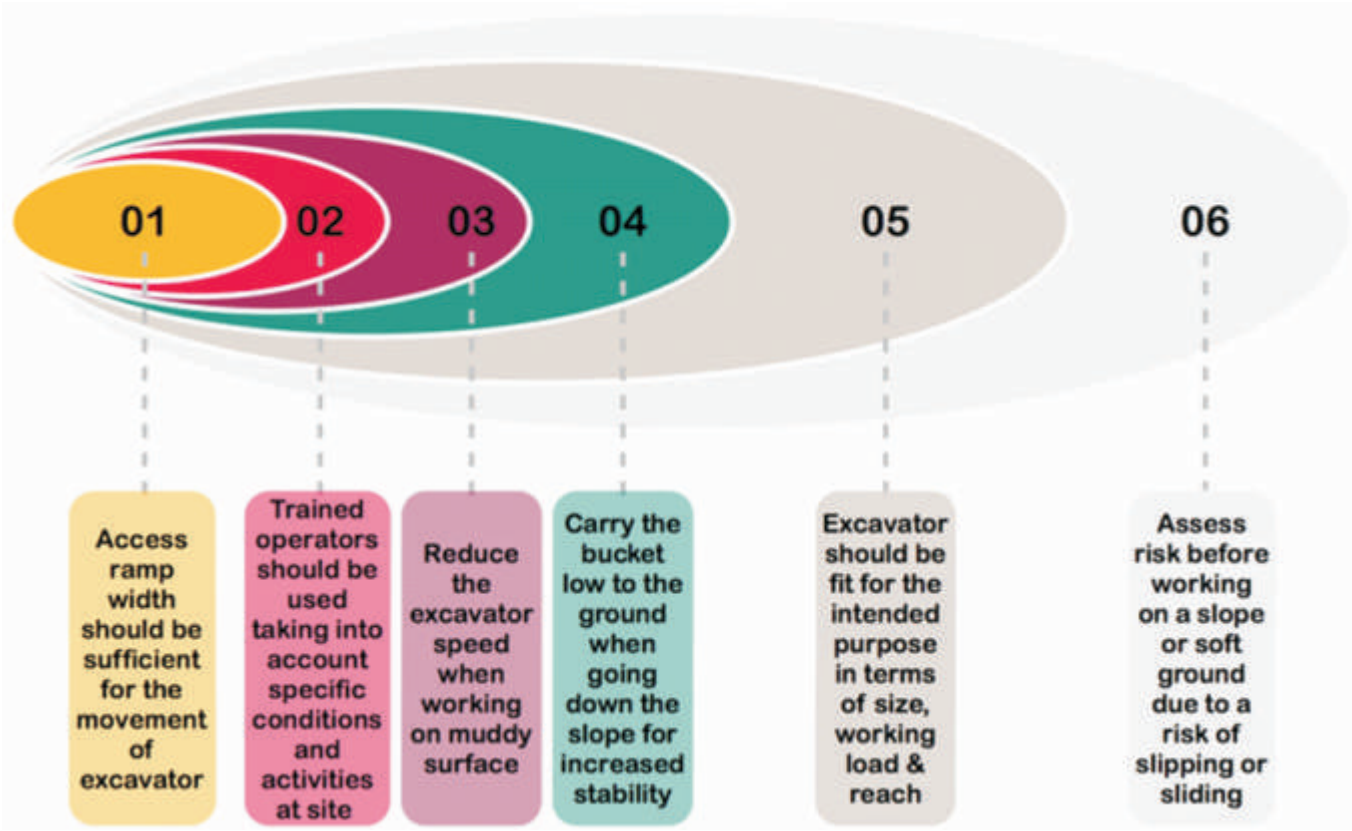
CASE STUDY - 4: EXCAVATOR TOPPLED WHILE GOING INSIDE EXCAVATION ZONE

The operator of an excavator was trying to go inside the excavated zone through a steep access ramp and muddy soil for rock breaking activity for the construction work of an important bridge (IMB) for the railway project.

Due to steep slope and muddy soil, the excavator got overturned due to slipping of its track chain. The operator, however, managed to come out from the cabin unhurt.


Maintain safe access to the area where excavators are intended to operate

SAFETY TIPS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02
03
04
05
06
Access ramp width should be sufficient for the movement of excavator
Trained operators should be used taking into account specific conditions and activities at site
Reduce the excavator speed when working on muddy surface
Carry the bucket low to the ground when going down the slope for increased stability
Excavator should be fit for the intended purpose in terms of size, working load & reach
Assess risk before working on a slope or soft ground due to a risk of slipping or sliding

CONCLUDING REMARKS

This paper has brought out the fact that most accidents on construction sites can be prevented by following proper planning, supervision and inspection; better coordination between design team and execution team; taking simple and appropriate measures based on informed actions; adopting Safe Working Procedures; deploying competent staff and workmen on high risk activities; provision of safety awareness & training; effective communication &consultation; no unsupervised activity without competency certificate; assessing risk assessment prior to carrying out high risk activities; etc. If we work carefully and take appropriate safety measures, there will definitely be fewer work injury cases, and our sites will become a safe and secure place to work in.

It is also true that the severity of injuries caused by poor supervision and inspection and deploying incompetent staff and workmen is very high and potentially fatal. However, such accidents can also be prevented as they are mostly foreseeable. It is important to first recognize the potential hazards and deal with each situation seriously. Only with such right attitude can we rectify / correct them in time to prevent another serious accident/ incident from occurring.

Through the identification of critical causes and effects of incidents in the selected four case studies in this paper, it comes to the fact that lack of knowledge and awareness, human error and substandard materials and equipment are identified as some of the major causes of construction accidents. Negligence or mistakes can happen due to uncertain circumstances. Hence, unavoidable accidents have to be expected in the construction projects. The commitment of all humans involved, from the project manager to the labourer towards good practices would enhance the safety performance in construction sites.

It is expected that different project sites shall disseminate these case studies to train people for prevention of potential accidents and injuries on construction sites.

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"DECODING OF PRACTICAL APPROACHES TO CONTROL DUST POLLUTION DURING CONSTRUCTION OF WDFC PROJECT NEAR RESIDENTIAL AREAS IN GREATER NOIDA, UP"

Ajay Gupta, SHE Expert
Nippon Koei India Pvt. Ltd
/ OCG Consortium
Project Management Consultant, WDFC Phase-2)

Indrani Goswami, SHE Expert
(Nippon Koei India Pvt. Ltd
/ OCG Consortium
Project Management Consultant, WDFC Phase-2)

Abstract:

The construction activities generate a large amount of dust and cause significant impacts on ambient air quality of surrounding areas. Dust pollution is one of the key issues that Contractors/ Sub-contractors ought to address in the midst of rising public complaints and punitive actions and must assume part of the responsibilities for minimizing dust emissions on construction sites. Dust control and its management has to be an integrated part of the project implementation and the Contractors / Sub-contractors must find ways to take measures to keep dust under control at all the times.

Revealing thesystematic and effective pragmatic approach is crucial for mitigating the environmental and health impacts of construction dust on surrounding residential and other sensitive areas. This paper provides a comprehensive examination of construction dust control measures on the basis of detailed site inspection and analysis conducted at ongoing construction work of the WDFC Project at one of its sites located at Dadri in Greater Noida, UP.

It is important to note that in recent years, violation of dust norms during construction and demolition activities and open dumping of concrete waste in Delhi and the National Capital Region (NCR) has invited varying degree of strict actions on the project proponents from the National Green Tribunal (NGT), respective State Pollution Control Boards, regulatory authorities, and other enforcement agencies. Contractors and sub-contractors are regularly

directed and enforced to implement environmental protection measures on sites to comply with mandatory and contractual provisions as well as evolving guidelines and norms on construction dust control and mitigation.
Providing that construction operations form a multifaceted set of activities, there is not a single option, but a multiple option needs to be adopted for controlling dust pollution on construction sites. Although, there are some general approaches to dust control, but practical measures based on comprehensive framework approach need to be followed for improving air quality in and around the construction sites.There is no doubt that construction dust control is becoming new challenge for the construction activities, the suggested measures in this paper will help in improving the performance of dust management from the perspective of practical considerations. The need of the hour is to intensify sincere efforts towards control of air pollution and enhanced compliance level to control dust pollution in the WDFC Project without affecting its progress.

INTRODUCTION

The construction sites normally experience the challenge of dust control and it becomes more imperative if the construction activities are carried out near residential areas or other sensitive areas. Dust control is an important environmental consideration and has to be addressed appropriately. It is important to keep construction dust under control constantly because airborne dust can contribute to air pollution, limit visibility, and harmful to the health of the people. Regularly inhaling of small dust particle sizes can result in respiratory and lung diseases like silicosis, asthma, and hypersensitivity pneumonitis.

Dust from various construction activities contain a wide range of particle sizes and material types, such as silica, and contribute to high concentration of suspended particulate matter (including PM10 and PM2.5) in ambient air, which is recognized as one of the major contributors to air pollution in India. Construction dust emission originates from many types of on-site activities such as earthwork, soil excavation work, bulk material transportation, loading and unloading of dusty materials, open-air material storages, concrete production, stone crushing, cutting and filling, movement of equipment and vehicles, etc. Owing to small sizes, dust is carried from sites even in light winds and may therefore have an adverse impact on the local environment, on the health of local residents, construction workers as well as on other staff working on the site. Blowing dust on construction site is also considered a potential safety hazard.

The Contractors / Sub-contractors engaged in construction activities must have an effective strategy to manage the dust, otherwise the pollution issue may affect the progress of work due to regular public complaints and legal hurdle. Violating prescribed rules by projects can result in punitive actions including ban on carrying out their site activities. In recent years, impact of dust pollution is becoming worse in extreme summer and winter conditions in Delhi and the National Capital Region (NCR). The deteriorating situation every year has been forcing the National Green Tribunal (NGT), respective State Pollution Control Boards, and other regulatory authorities to frequently issue various directives, guidelines, and actions to construction projects to strictly follow all laid down rules and regulations to control dust pollution.

Although, there are some general approaches to dust control, such as sprinkling water every day to suppress the suspension of dust at the construction sites; covering debris and materials when stored or when they are being taken; barricading along the perimeter of construction or demolition sites; use shade nets, tarpaulins or plastic sheets for staging, etc. but practical measures based on comprehensive framework approach need to be followed for improving air quality in and around the construction sites. This paper has focused on this aspect and analyzed composite measures which are able to guide contractors and fulfill their knowledge gap for reducing dust emissions in a meaningful way and

once applied their positive effects can easily be felt and recognized. The suggested approach is categorized into four broad measures – **(a) Supervisory and Monitoring Measures, (b) Regulatory Measures, (c) Technical Measures, and (d) Site Management Measures**. It is crucial that a combination of these measures need to be adopted to handle dust issue on WDFC project sites more effectively instead of merely employing an individual or limited approach. Additionally, the paper has also examined various government orders and notices related to construction dust control for improving the performance of dust management in the construction context.

The WDFC project site at Dadri in Greater Noida, UP is one of such critical locations which requires to give due considerations to dust control aspects to deal with situation arising due to presence of many multi-storeyed residential buildings and major roads around the work site. The Contractor / Sub-contractors are required to adopt appropriate dust reduction measures as per stipulated norms in the contractual and mandatory provisions while carrying out various construction activities for the development of freight corridor.

SITE ANALYSIS FROM DUST POLLUTION ABATEMENT PERSPECTIVE

The construction site selected for evaluation of dust pollution and its control measures is located at Dadri in Greater Noida, UP. The GPS Coordinates of the site are 28o30'38" N, 77o31'34" E. The topography of the site is plain and is influenced by moderate to high wind speed. The typical characteristic of its sensitivity is that it is surrounded on three sides by multi-storeyed residential buildings with dense habitation and wide roads around up to 130 m with major connections between Makoda Chowk and Tilpata Chowk and another connecting to Gulistanpur Village.The site developmental activities for construction of Freight Railway Corridor started from August 2018 and its various facets since then is captured in the actual site photographs.

September 2018

Prior to start of construction activities, the ground was covered with grass and under growth vegetation resulting in soil stabilized conditions and no dust pollution.

July 2019

The construction activities started resulting in working of labour colony; concrete batching plant; material storage; cement godown; movement of construction machinery, equipment and site vehicles; soil excavation for foundation work of station buildings; and other associated activities. These activities resulted in soil disturbances, accumulation of heaps of soil, sand and fine aggregate materials, emission of cement dust during loading and unloading, etc, which cumulatively became potential sources of dust pollution.

September 2020

With construction continued its pace, more activities are added in the area which include station building work; pug mill for production of blanketing material; setting up another concrete batching plant; increased storage of sand, fine and aggregate materials; movement of large number of dumpers and trucks carrying construction materials; Earthwork; ROB construction work; closing of major roads for public vehicles; etc. These activities aggravated the situation of dust pollution and became point of immediate concern due to onset of winter season besides other factors.

However, among all activities, a lone tree existing on the work site was kept under preservation and continued surviving the impact of dust pollution.

September 2018

July 2019

September 2020

TREND OF SITE AMBIENT AIR QUALITY MONITORING RESULTS

The average particulate matter concentration of PM10 and PM2.5 in upwind and downwind directions between January 2018 and September 2020 was measured at Dadri site to determine ambient air quality. The results are tabulated in Table-1 & 2 and graphically represented in Figure-1 & 2 respectively.

The annual predominant wind direction at Dadri site is from WNW to ESE and from E to W and accordingly, the ambient air quality monitoring locations were selected.

Prior to start of construction activities at Dadri site during the period January 2018 to Oct 2018, the average concentration of PM10 in upwind and downwind direction varies from 281.2 to 256.2 µg/m3& 304.2 to 270.8 µg/m3 respectively and the average concentration of PM2.5 in upwind and downwind directions varies from 162.7 to 148.4µg/m3& 179.5 to 161.5 µg/m3 respectively. The high and medium wind speed in summer seasons created turbulent conditions, dust storms and local housing construction activities which caused higher dust and soil borne particles like PM 2.5 and PM10 concentration levels.

From January 2019, the construction works started by setting up of labour colony, concrete batching plant, material storage, cement godown, movement of construction machinery, equipment and site vehicles, soil excavation etc. These activities are considered as potential sources of dust pollution. Further, in winter months, the prevailing calm conditions facilitated more stability to atmosphere and consequently slow dispersion of pollutants generated and help in build up of pollutants in vicinity of the pollutant sources. Lower average mixing height in winter season resulted in less volume of troposphere available for mixing and hence higher PM10 (210.5 - 219.8 µg/m3) and PM2.5 (130.5 - 119.7 µg/m3) concentrations at ground level. However, more construction activities increased in site, but regular water sprinkling and other dust pollution preventive measures shows the downtrend trend of pollutants concentration in the period (April 2019 to July 2020) but in September 2020, air quality at site has become alarming situation.

Table-1: Ambient Air Quality Quarterly Monitoring (Upwind Data in µg/m3)

Dadri Site (Upwind Direction) at CH 138+500 km

Concentration of Air Pollutants in microgram per cubic meter

		2018				2019				2020		
	Standard	**Jan**	**Apr**	**Jul**	**Oct**	**Jan**	**Apr**	**Jun**	**Oct**	**Jan**	**Jul**	**Sept**
PM2.5	60	148.4	162.7	46.8	143.1	119.7	92.4	80.4	77.9	97.2	48.4	73.6
PM10	100	256.2	281.5	82.5	231.6	210.5	148	132.1	138.7	160.9	76.3	170.5
SO2	80	9.2	10.9	9.3	12.8	11.5	12.1	11.7	10.1	12.8	10.3	12.8
NO2	80	21.6	24.2	26.6	28.4	29.8	29.4	29.6	27.4	29.6	21.8	23.4


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PM

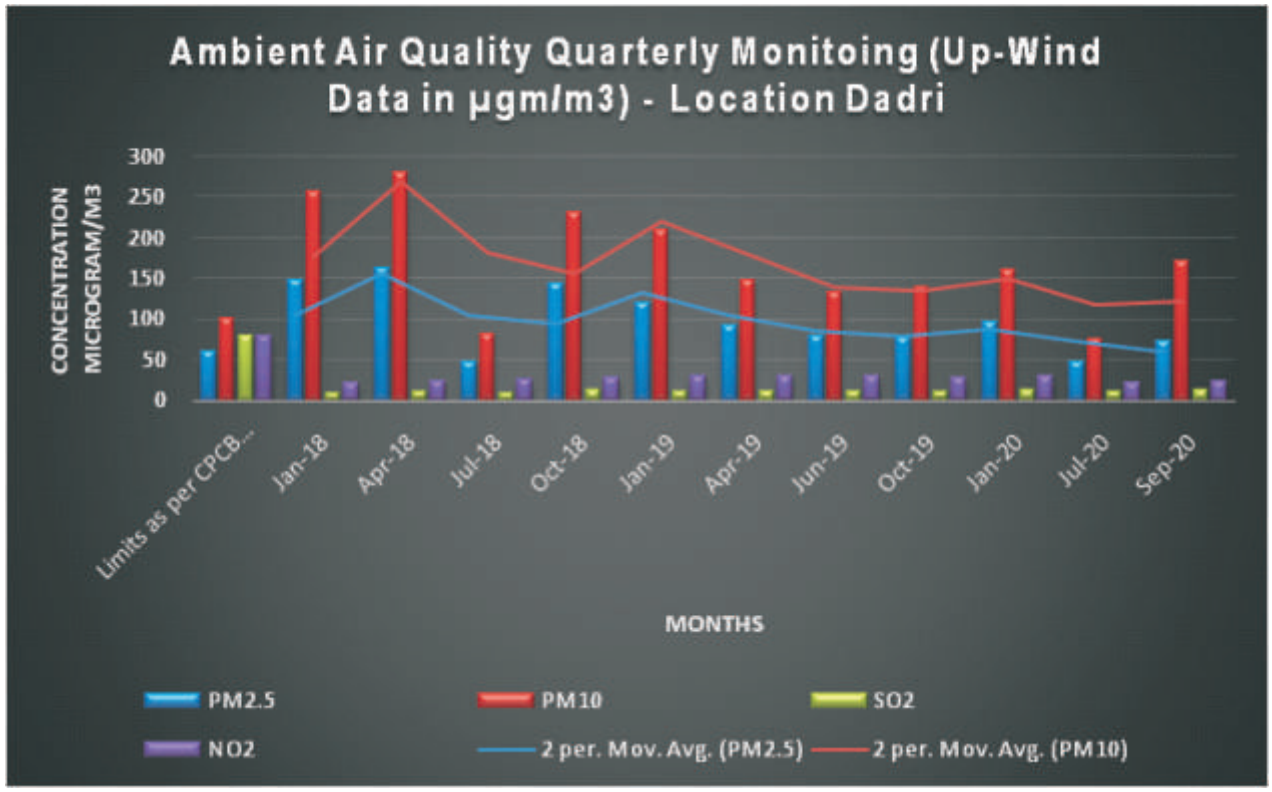


Figure-1: Quarterly Ambient Air Quality Monitoring Results Upwind direction (Jan2018 - Sept 2020)

Table-2: Ambient Air Quality Quarterly Monitoring (Downwind Data in µg/m3)

Dadri Site (Downwind Direction) at CH 138+500 km

Concentration of Air Pollutants in microgram per cubic meter

	2018					2019				2020		
	Limits	**Jan**	**Apr**	**Jul**	**Oct**	**Jan**	**Apr**	**Jun**	**Oct**	**Jan**	**Jul**	**Sep**
PM2.5	60	161.5	179.5	48.2	152.6	130.5	101.6	88.2	90.2	103.8	49.3	58.6
PM10	100	270.8	304.2	86.8	249.6	219.8	168.9	146.1	153	170.4	78.6	132.8
SO2	80	11.7	13.7	11.5	13.8	14.3	12.3	12.6	13.1	14.7	12.5	10.5
NO2	80	24	27.8	29.8	31.3	33.7	30.8	31.4	32.4	34.8	22.8	19.8

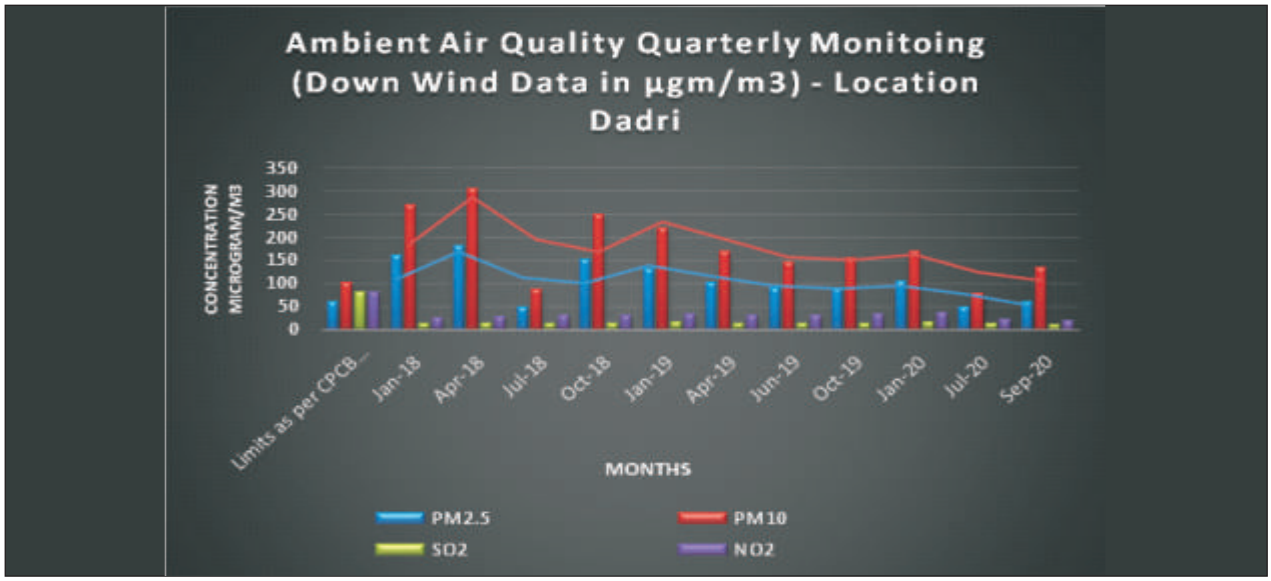
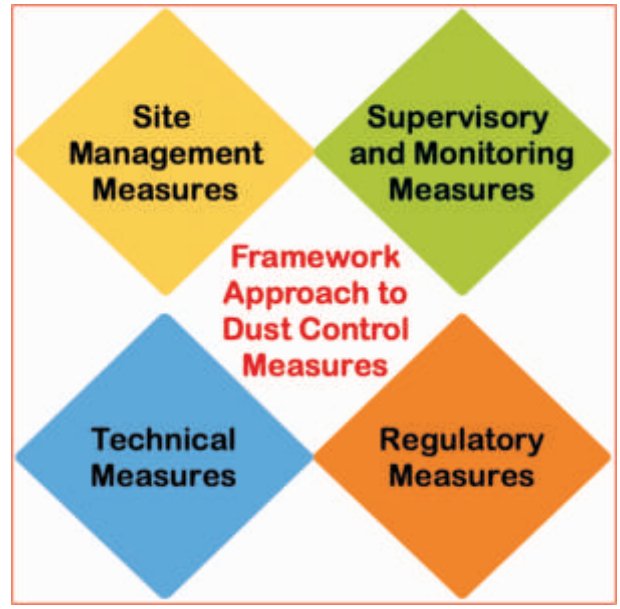


Figure-2: Quarterly Ambient Air Quality Results Downwind direction (Jan 2018 – Sept 2020)

FRAMEWORK APPROACH TO DUST CONTROL MEASURES

In order to control and manage dust pollution near sensitive areas (residential) during implementation of multiple activities simultaneously at the construction sites, a composite framework approach has to be adopted to improve environmental performance in WDFC Project. The basic need for effective control measures is high, but the complex structure of the construction industry, the variability in sources of exposure, it is difficult to implement a simple and potentially effective control measures. The general perception among contractors and construction agencies is to depend heavily on applying basic techniques in the form of sprinkling through water tankers for dust suppression and using green net/ barrication of site premises at required height for arresting dust dispersal, ventilation system with exhaust which though help in reduction of dust emission but cannot control in an effective and desirable manner at all the times.

This paper has analyzed various options which are able to guide contractors on the importance and benefits of respiratory protection by reducing dust emissions in a straightforward way and once applied their positive effects can easily be felt and recognized.



The suggested approach is categorized into four broad measures as depicted in the figure.

These combinations of measures are covered in the next section with analysis and solutions through actual site observations and inspections. It is crucial that a combination of measures need to be adopted to handle dust issue on WDFC project sites instead of merely employing an individual approach.

APPLICATION OF PRACTICAL DUST CONTROL MEASURES

A detailed site inspection was conducted at Dadri Site in Greater Noida at DFC Ch 138+800km to 139+600 km in September 2020 to monitor effectiveness of dust control measures being undertaken by the Contractor considering various ongoing activities, which included earthwork; station building work; operation of pug mill for production of blanketing material; 191H ROB bridge work; public traffic movement on diverted road due to closure of major connecting road between Makoda Chowk and Tilpata Chowk; operation of concrete batching plant; setting up of new concrete batching plant; movement of large number of construction machinery and equipment; and other associated activities.

Based on the site observations and findings, practical action points required to be taken on dust control have been drawn and are covered below -

Supervisory and Monitoring Measures

To improve regular site monitoring and inspection to ensure that dust control measures are effectively implemented

These supervisory and monitoring measures [M1, M2, M3, M4, M5] required to be implemented are –	
M1:	Immediate deployment of Senior Environmental Officer at Dadri site to regularly inspect the implementation of various measures for dust control at all the times.
M2:	Creating Dedicated WhatsApp Group for Dadri site for Daily Updates to all concerned in an actively manner.
M3:	Sharing "Weekly Inspection Reports" to the Project Management Consultant (PMC) regularly for review and analysis and suggesting suitable mitigation measures.
M4:	Regular Monitoring and Supervision by PMC Experts
M5:	Taking immediate actions to address all Public Complaints, follow all NGT/Government orders, and coordination with Statutory Authority.

Regulatory Measures

To comply with major guidelines and legislative directions on Dust Control, which assist in mitigating dust emissions and to achieve intended objectives

These regulatory measures [M6, M7, M8, M9, M10, M11] required to be implemented are –

M6: Display Board on Dust Mitigation Measures

- As per mandatory requirements vide MoEF Notification No. 94 (E) dated 25.01.2018 – "Dust mitigation measures needs to be displayed prominently at the construction site for easy public viewing". Accordingly, appropriate display board has to be put up on actual measures being implemented at the work sites for public viewing at designated locations.

M7: Improving Handling of Construction Materials during Transportation to comply with Mandatory Requirements

Observations

- It is found that dumpers are entering and exiting the site area carrying construction materials (blanketing in semi-dry conditions, sand, aggregates, and other dusty materials) without covering and cleaning of tail and side boards.
- Improper handling of loaded materials is leading to spillage on public roads, which is a potential source of dust pollution, and is easily avoidable.

Mandatory Practices: As per major guidelines and legislative directions, dust protection during transportation is done through three measures -

- Avoiding overloading above tail and side boards;
- Covering top with tarpaulin sheet and securing it properly; and
- Cleaning the outer surface of dumpers before leaving the site, such as removing lumps of loose material deposited on the running board, etc, so that they do not spill on the public roads and leads to dust pollution.

Control Measures

a) Ensure that no uncovered vehicle carrying construction material is permitted to either enter or exit the site;

b) Sub-contractors and Material Suppliers should be instructed to strictly follow the procedure; and

c) Follow the listed guidelines diligently at the work sites to avoid aggravating the dust pollution in and around the DFC work sites.

M8: Unnecessary Heaps of Excavated Soil or Loose Fine Material needs to be Removed or Levelled (with compaction) or Covered or Kept Moist (at all the times)

Observations

- It is found that heaps of excavated soil and loose fine materials are lying either inside or outside the work site area without taking proper precautions to contain dust pollution.

Mandatory Practices

- As per major guidelines and legislative directions -
- No loose soil or sand or C&D waste or any other construction material that causes dust should be left uncovered.
- The dust emission from the construction site should be completely controlled and all precautions taken in that behalf.
- The storage of construction material should be at a designated place.

Control Measures

a) Take immediate action to control dust pollution from the unnecessary heaps of excavated soil or loose fine material lying at many places;

b) If there is a need to retain such heap, cover it properly with a tarpaulin sheet in a secured manner so that dust dispersal in air during wind blowing does not occur.

M9: Provide Water Sprinkling Arrangement (Fixed) at Material Storage Area in an Effective Manner

Observations

- It is found that the current arrangement of fixed/movable water sprinkling with sprinklers attached to the hose pipe and placed on the ground (low height) is ineffective.
- All coarse, fine aggregates and other loose materials must be wetted on its entire surface area from all sides and remain dampened at all the times.
- Alternatively, in case of moisture correction issue, such open lying materials should be covered with a tarpaulin or plastic sheets in a secured manner.

Mandatory Practices: As per major guidelines and legislative directions -

- Material Storages – Care should be taken to keep all material storages adequately covered and contained so that they are not exposed to situations where winds on site could lead to dust / particulate emissions.

- **[Directions:** In accordance with NGT directions in Original Application No. 21/2014, the construction material of any kind stored in the site will be fully covered in all respects so that it does not disperse in the air in any form. In any case, if material is found uncovered and unprotected and the same shall be seized by the corporation besides requiring the owner / builder to pay environmental compensation in terms of the judgement dated 10.11.16].

Control Measures

a) In order to contain dust from a large stock of aggregate material in pug mill and batching plant area, proper arrangement of water sprinkling for dust suppression should be in place.

b) Alternatively, provide covering with a tarpaulin sheet or fabric material to cover construction materials.

M10: Internal Roads at construction site area used for movement of construction vehicles needs to be Strengthened

Observations

- The existing site conditions are dusty and internal road conditions are poor, thereby requiring proper approach to control dust nuisance during regular movement of vehicles.
- Although water sprinkling through water tankers is used to suppress dust on internal roads but this is not effective and cannot be assured at all the times.

Mandatory Practices: As per mandatory requirements vide MoEF Notification No. 94 (E) dated 25.01.2018 -

- Roads leading to or at construction sites must be paved or blacktopped (i.e. metallic roads).

Control Measures

a) Take appropriate action with a most suitable optionto control dust on internal unpaved roads without relying on water sprinkling through water tankers.

M11: Legal Compliance by Timely Obtaining Consent to Establish (CTE) and Consent to Operate (CTO) from the State Pollution Control Board for 2 nos. RMC Plants

Control Measures

- Ensure that required consents are timely obtained from the State Pollution Control Board for two nos. Concrete Batching Plants being set up on Dadri Site.

Technical Measures

To apply various techniques resulting in dust suppression and arresting dispersal of dust in air in such a manner that dust control is achieved throughout and at all the times.

These technical measures [M12, M13, M14, M15] required to be implemented are –

M12: Apply Grassing and Sapling Plantation at the entrance area and site perimeter area for Soil Stabilization and Helping in Reduction of Dust Emission due to Vehicular Movement as well as Having Visual Positive Impact

Observations

- It is found that soil stabilisation in some part of the construction site area, particularly at the entrance, along periphery (inside and outside), etc., can be done by applying grassing and sapling plantation in order to reduce impact of dust pollution.

Control Measures

a) Take appropriate action to control dust pollution through Vegetative Measures, which are easy to do and quite effective.

M13: Provide Wheel Washing Facility to be used by all Vehicles at Site Exit Points prior to travelling on Public Roads

Observations

- It is found that lot of mud / dirt is getting deposited on the surrounding public roads due to construction and site vehicles, when exit the work site area transfer mud / dirt entrapped in their wheels on the roads, which become significant source of dust pollution.

Control Measures

a) As per Contractual and Mandatory Requirements as well as practices normally followed on construction sites, provide effective means of "Wheel Washing Facility" at the site exit points to minimize deposition of dust on the public roads, which helps in reduction of dust pollution.

M14: Strengthen Sprinkling Through Water Tankers on Both Internal and External Roads Adjacent to the Residential Area since the Current Arrangement is 50% i.e. only half of the time dust is suppressed

Observations

- The current arrangement is only partially fulfilling the purpose. Water tanker is operating from 8:00 am to 8:00 pm daily; the capacity of tanker is about 12 KL; total no. of daily round trips made is 3 nos. x 2 times (1 FN and 1 AN).
- Considering that the wetted soil surface normally last for 1.5-2.0 hrs for suppressing dust, the effectiveness is coming out to be only 50%

Control Measures

a) In order to achieve benefit of sprinkling through water tankers on the selected routes throughout, two tankers with each capacity of 12 KL needs to be deployed instead of using only one tanker. Provide arrangement for two tankers and each trip route should be covered four times daily.

b) Ensure nozzles are cleaned and not choked and sprinkling is done uniformly along the profile.

c) Treated wastewater generated from batching plant/ Curing tank/ RO plant could be considered to be used for water sprinkling purpose in internal roads in order to save fresh water.

M15: Entrance area (Approach Road) to the Pug Mill and RMC unit needs to be Concreted

Observations

- The present situation at the entrance to the Pug Mill, material storage area, RMC unit is conducive to dust pollution due to unpaved road and exposed soil surface conditions.
- Excess dust is getting accumulated and redispersed on public road and in surrounding areas due to vehicle movement in and out of the site area.

Control Measures

a) In order to control dust at the entrance area (approach road) to the site, the only option available is to do concreting of the surface for smooth movement of construction vehicles in and out of the site area without resulting in dust dispersal.

Site Management Measures

To regularly dispose and manage waste material, C&D waste etc. from the site so that they don't result in dust emissions and aggravate the situation

These site management measures [M16, M17, M18] required to be implemented are –

M16: Improving Storage of Empty Cement Bags Lying in Open Outside the Cement Go-Down Area

Observations

- It is found that bundle of huge empty cement bags lying in open outside the cement go-down, which acts as a potential source of cement dust pollution during wind blowing.
- Improper handling of cement bag is leading to a potential source of dust pollution, and is easily avoidable.

Control Measures

a) Cement bags should always be stored in an enclosed area, so that emissions of cement dust borne particles into the ambient air can be reduced.

b) Avoiding over storage of material at site and covering top with tarpaulin sheet and securing it properly; and

c) Disposal from site should be in regular interval and cleaning the outer surface after disposal of cement bags which leads to dust pollution.

M17: Maintenance of Green Nets on Regular Basis to serve its Intended Purpose at Site

Observations

- It is found that green net above fencing in pug mill area is totally damaged and not serving its purpose to contain dust during wind blowing.

Control Measures

a) Damaged green net needs to be replaced immediately and maintenance of green net to be monitored.

M18: Improper Control in Handling and Disposal of C&D Waste at Dadri Site for Minimizing Dust Pollution

Observations

- It is found that waste concrete and debris were dumped at couple of places on the work site. There is no designated area earmarked for storage of such waste
- Such type of practice not only leads to soil contamination but also acts as a potential source of dust pollution due to wind dispersal.

Control Measures

a) Temporary storage of C&D waste should be done in a demarcated & designated area.

b) Avoid dumping of such waste at all over the site. Collect already dumped material and store it in a demarcated & designated area.

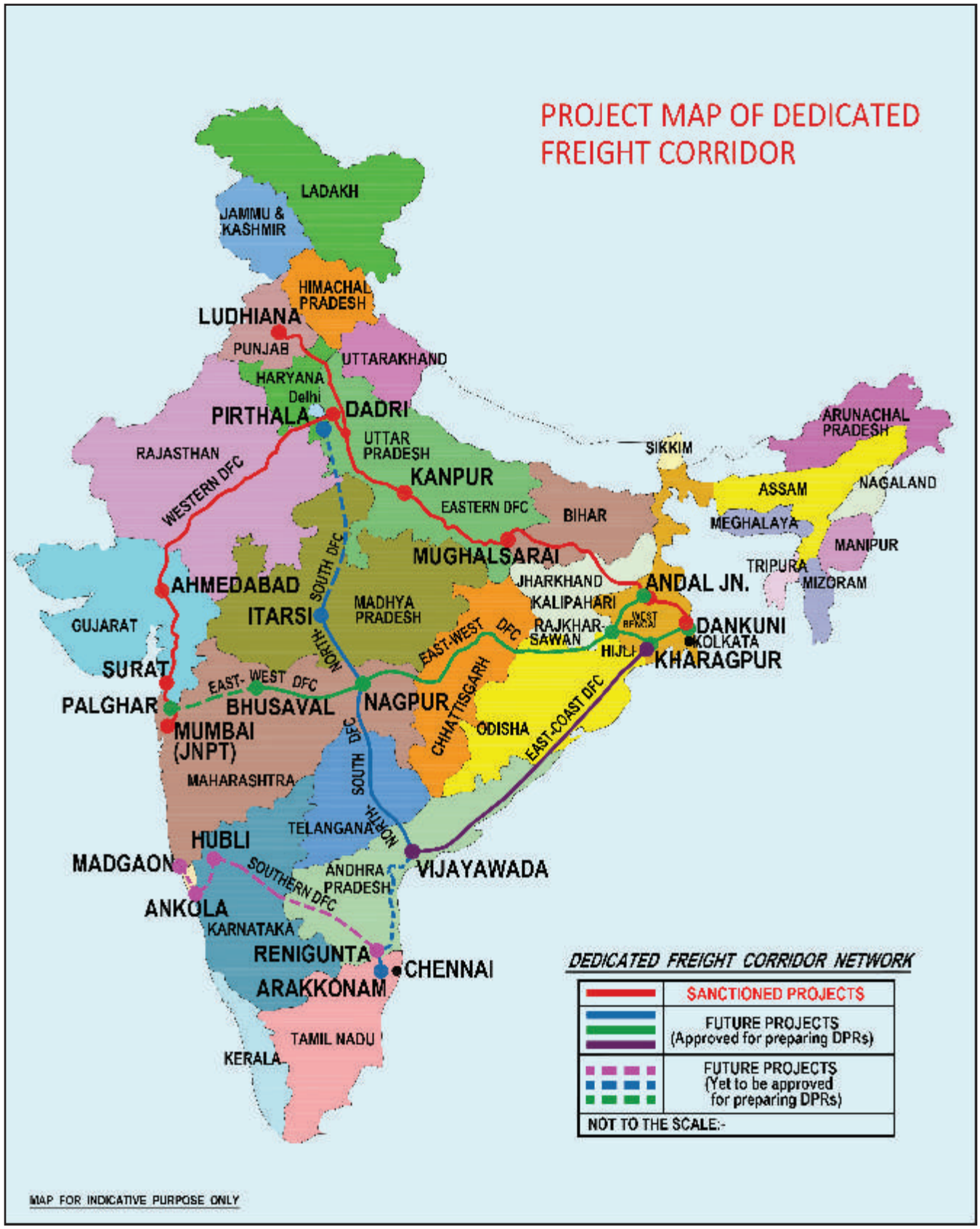
c) Avoid build-up of such waste on the site and manage it properly by either disposal on the designated & authorized location within time or reutilizing within the site itself.

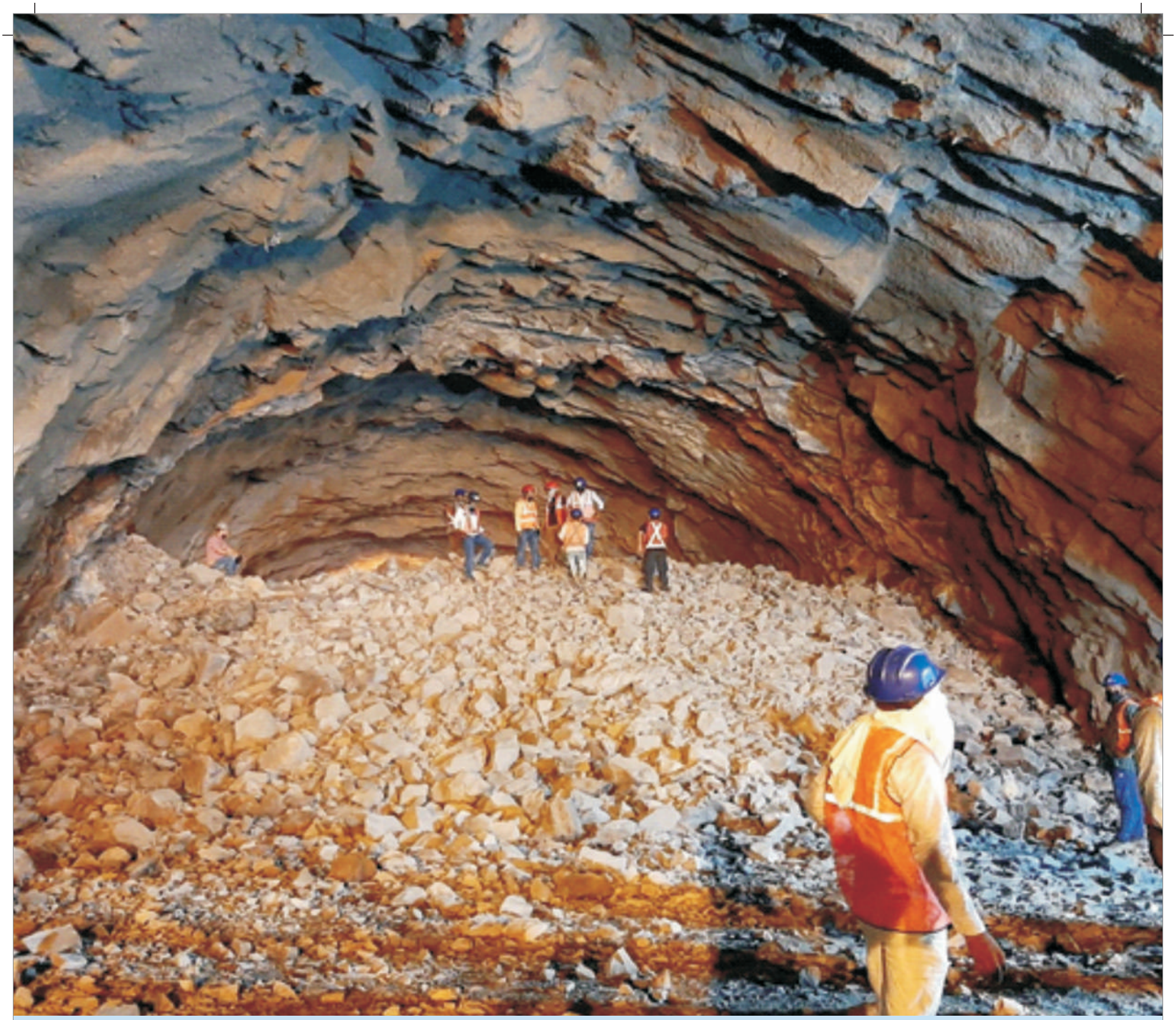
CONCLUSION

Severe environmental pollution resulting from construction dust emissions has attracted many public complaints and strict orders from the State Pollution Control Boards and District Authorities. Dust control is one of the challenges on construction sites and require contractors to act fast and address this issue in a holistic manner. It is crucial that a combination of measures be adopted to handle this issue instead of merely employing an individual approach.

This paper has elucidated various practical control and management measures for different construction activities for controlling dust pollution in and around the construction sites in WDFC project. In recent years, it has also become mandatory to control construction dust emissions in order to avoid penal actions from the regulatory and enforcement authorities.

In order to maintain dust emissions from all types of sources, viz. stationary, mobile, and area, within the acceptable limit, considerable efforts should be made to continuously improve the effectiveness of all of the identified measures. Systematic and effective approaches need to be integrated with the good construction practices to control air pollution and environmental impacts. It requires increased awareness and change of mindset among contractors and its sub-contractors. It has to be understood that there are implementation risks in the form of stoppage of work or hefty penalties in case of non-compliance and non-adhering to the stipulated norms causing delay in timely execution of projects.


PROJECT MAP OF DEDICATED FREIGHT CORRIDOR
LADAKH
JAMMU & KASHMIR
HIMACHAL PRADESH
LUDHIANA
PUNJAB
UTTARAKHAND
HARYANA
Delhi
PIRTHALA
DADRI
UTTAR PRADESH
RAJASTHAN
WESTERN DFC
KANPUR
EASTERN DFC
BIHAR
SIKKIM
ARUNACHAL PRADESH
ASSAM
NAGALAND
MEGHALAYA
MANIPUR
TRIPURA
MIZORAM
SOUTH DFC
MUGHALSARAI
JHARKHAND
ANDAL JN.
AHMEDABAD
ITARSI
MADHYA PRADESH
KALIPAHARI
GUJARAT
RAJKHAR-SAWAN
DANKUNI
KOLKATA
HIJLI
KHARAGPUR
NORTH
EAST-WEST DFC
SURAT
EAST-WEST DFC
PALGHAR
BHUSAVAL
NAGPUR
CHHATTISGARH
ODISHA
EAST-COAST DFC
MUMBAI (JNPT)
MAHARASHTRA
SOUTH
NORTH
DFC
TELANGANA
HUBLI
MADGAON
SOUTHERN DFC
ANDHRA PRADESH
VIJAYAWADA
ANKOLA
KARNATAKA
RENIGUNTA
CHENNAI
ARAKKONAM
TAMIL NADU
KERALA
DEDICATED FREIGHT CORRIDOR NETWORK
SANCTIONED PROJECTS
FUTURE PROJECTS (Approved for preparing DPRs)
FUTURE PROJECTS (Yet to be approved for preparing DPRs)
NOT TO THE SCALE:-
MAP FOR INDICATIVE PURPOSE ONLY



डेडीकेटेड फ्रेट कारीडोर कार्पोरेशन ऑफ इंडिया लि.

Dedicated Freight Corridor Corporation of India Limited

(भारत सरकार का उपक्रम)

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5th Floor, Supreme Court Metro Station Building Complex,
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