Vol.I issue II, Feb 2014

HIM PRABHAT

हिमप्रभात

USBRL Technical News Magazine

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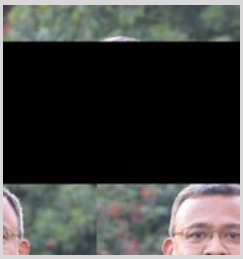
Contents

From Editor's Desk



Udhampur-Srinagar-Baramulla Rail Link Project is about tunnels, bridges, hostile environment and an unpredictable geology of Himalayas which has not been challenged by Civil engineering at this level before. Knowledge and skills have evolved. A Short Insight in methodology adopted for Tunnels T-1 to T-5 of Katra – Dharam Section of the project which has been used by GeoData would excite the readers. The article takes them through a guided tour of excavation and reinforcement in this geology.

The primer on earthquakes, which was introduced in the previous issue, continues. It takes us further into science and mystery of earth. It will certainly shake the readers deeper into the seismic science and the significant theories – Elastic rebound theory, stick slip phenomenon, behaviour of earthquake waves and their propagation and methods of measuring and recording them.

The project is past an important milestone after completion and commissioning of longest transportation tunnel in India – the 11.215 km Pir Panjal Tunnel. Experience of laying ballast-less track system in frigid and sub-zero working will be a delightful reading for both young and more experienced Civil Engineers alike. The article covers the entire gamut of activities for laying this track from survey for fixing the centre line of track and fixing the rail level to casting special sleepers to their fixing, casting the derailment block etc.

The Pir Panjal Tunnel also presented a formidable task of designing, installing and commissioning and testing of a ventilation system – complete with a SCADA – with a view to ensure that the fire safety norms are met are covered in detail in a technical article. This would be useful for Electrical and Civil Engineers alike.

The project has in it many firsts and the tallest. The preparatory work for building the 359 metre high bridge on River Chenab has already negotiated its first steps by fabrication and erection of pylon and cable erection as a part of enabling work for launching of arch of Chenab Bridge. This should be thrilling for engineers who build bridges to span wide insurmountable gaps – this time high in Himalayas – finding their feet in unpredictable slopes on both sides.

Then the other end of tunnel is light and beauty of the vast Valley of Kashmir. The general section has articles on the places of tourist interest in and around the valley. The readers will get in their armchairs a breathtaking tour of the famous Mughal Gardens, beauty of Pahalgam and Sonemarg and ski slopes of Gulmarg, beautiful and sacred mosques of Hazrat Bal, Jama Masjid in Srinagar, history of Aantipore and saffron fields of Pamore, temples in Kheer Bhawani. The area has one of the finest handicrafts of this part of the country and they are introduced in another article in general section. Paper Mache, exquisite embroidery in silk and wool, ornate woodwork, silver and copper ware, hand woven carpets – all appear to be taken form shopping lists drawn by Emperors and their Queens and the nobility are showcased in this article. Health section will bring to their benefit insights into healthy lifestyles to enable them to enjoy in their lives the fruits of their labour and hard work.

Wish you a great reading.

Mohit Sinha
Financial Adviser and Chief Accounts Officer
and
Editor-in-Chief

Appreciation Letters

विजय कुमार गुप्ता
महाप्रबन्धक

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18th December,2013

My dear Kaul,

I am glad to see the first issue of 'Him Prabhat' Technical news magazine giving an accountal of the achievement of technical marvel and the challenges faced by the USBRL Construction Organization of Northern Railway.

The Udhampur-Srinagar-Baramulla Rail Link (USBRL) is one of the very strategic and National importance projects of the Indian Railways. The magazine will not only provide the details of experience gained during the course of implementation of the project but also provide a platform for the project team to share their views. This is a very commendable effort.

I convey my best wishes to the project team of USBRL, KRCL, IRCON and experts from India and Abroad associated with this prestigious project.

With best wishes,

Yours sincerely,

(V.K. Gupta)

Shri Surinder Kaul,
CAO/C/USBRL,
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D.O.No.G/SECR/Misc/536 Dated: 06.01.2014

Dear Sri Kaul,

The inaugural issue of **'Him-Prabhat'** was a wonderful New Year gift. My hearty congratulations to the entire team for bringing out such a publication.

You may like to consider the following suggestions:

(i) Font size may be increased.

(ii) Photographs may be numbered for ease of linking the photographs with description.

(iii) General interest articles, like "Some of the World's Longest Arch Bridges" in the inaugural issue, may be made a regular feature.

Best wishes for the New Year

Yours sincerely,

नवीन टण्डन

(Navin Tandon)

Shri Surinder Kaul
Chief Administrative Officer
USBRL Project, Northern Railway
Satyam Resort Complex, South Extension,
Trikuta Nagar,
Jammu – 180 012 (J&K)

Employee of the Month

Paramjeet Singh

Sh. Paramjit Singh was born on 11th of August'1964 at New Delhi. He completed his primary and secondary education from Delhi itself and did his diploma in Civil Engineering in the year 1987. He joined Railways on 10th of December'1987 at Jammu and was entrusted with the work in the JURL project. Initially, he was involved in preparation of estimates of the project and other technical works involving Design and Drawing and in connection with CRS inspections. He had been instrumented in CRS inspections in connection with Jammu-Bajalta section, Bajalta-Udhampur section, Banihal-Qazigund section and the recently completed Udhampur-Katra section. He has a very rich experience of dealing in commissioning of 4 sections of USBRL project. In his 26 years of carrier working in Railways, he was also sent on deputation to Mozambique and was associated with BEIRA Railway project under the Ministry of Govt. of Mozambique. He was associated with this project till its commissioning and was involved in Design & Drawings of all Permanent Way and Bridges and other allied structures.

Likes	Old Songs
Favourite Food	Masala Dosa, Makki Di Roti & Saag
Favourite Colour	Blue
Best moment	Foreign assignment to Mozambique

Sh. Paramjit Singh says, "It is proud to be associated with commissioning of 4 important sections of USBRL project which has been declared as National Project".

Udhampur Srinagar Baramulla Rail Link Project

#1 Trial run on Udhampur Katra section.

Udhampur Katra section connects the holy town of Katra with Udhampur Terminus of Indian Railway network. With the opening of this section Rail services will be extended upto Katra, all the devotees visiting holy shrine of Mata Vaishno Devi will be greatly benefitted, as otherwise they have to deboard at Jammu and travel by road upto Katra.

The alignment of this section traverses through the Shivalik range of the young Himalaya, characterized by many faults, fragile geology difficult approach roads and many geological surprises were met with during execution. The alignment crossed the Major Boundary Thrust in this area. Engineers working on this section had to face many challenges in constructing Tunnels and Bridges in this region. First tunnel of this section that is more than 3 Km long, crosses Major Boundary Thrust. Work on tunnel remained almost stopped for many years after unexpected collapse of the tunnel at two location due to difficult geology and excessive swelling. International experts were called and work restarted by laying a diversion tunnel. Construction of tunnel has now been completed along with completion of the section and ***the first Trial Train, GM special, was successfully run on the section on 9/12/2013. Completion of the section that was held up for last 6-7 years, is a major achievement indeed.***

Photo-1

GM and PHODs NR arrived at Udhampur on 9/12/2013 for trial run of UHP – Katra section and were given a warm welcome by USBRL Project team (Photo-1).

Photo-2

Before the start of –trial run Havan was performed to pay tribute to Shri Mata Vaishno Devi for having given us the courage and will to successfully completed the work of laying new line upto Katra. The Puja was attended by GM and PHOD Northern Railway and USBRL project team (Photo-2 to 4)

Photo-3

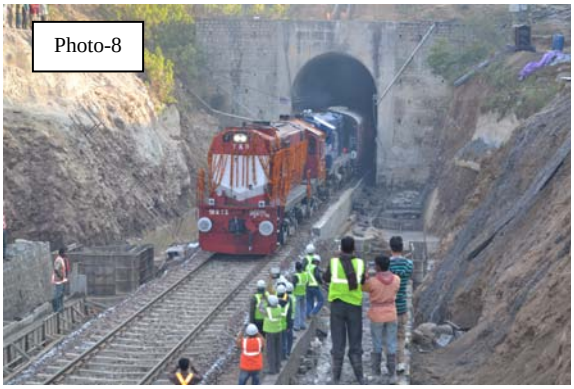
Photo-4

Photo-5

Decorated engine ready for departure to negotiate a newly constructed route upto Katra (Photo-5)

GM/NR on Last Vehicle inspection of UHP-Katra section on 9/12/2013 (Photo-6)

Trial train passing Bridge no 20 (Photo-7)



Trial Train after negotatiating Tunnel No1 (Photo-8)

Trial Train arriving at Katra Railway Station (Photo-9).

Concourse of Shri Mata Vaishno Devi, Katra Station

GM and PHOD NR being received at Katra station, CEE/USBRL presenting bouquet to GM/NR on his arrival at katra after successful trial run of UHP Katra section (Photo-10).


Photo-11


Photo-12

GM/NR PHOD,s NR and Team USBRL performing puja at Katra Station to pay tribute to Goddess Vaishno Devi for successful trial run of the section (Photos-11 to 13)


Photo-13

Photo-14

GM/NR addressing media at Katra Station on successful completion of Trial Run. (photo-14)


Photo-15

Group of Engineers from NR and KRCL visited Bridge no 20 for inspection of Bearings on 26.11.2013.(photo 15)

Photo-16

Engine Rolling was successfully done over Jajjhar Khad Bridge no 186 (old Bridge no 20). Bridge has two spans of 153.4 m each longest in Indian railway and highest pier of 84m height. Engine was rolled successfully on 4/12/2013.(photo-16)

CSM machine was passed over bridge no 186 (old Br no 20) on 30.11.2014. Photograph shows CSM maching passing the Bridge. (photo-17)

First BLT passing over Bridge no 186 (old Bridge no20) on 5/12/2013.(photo-20)

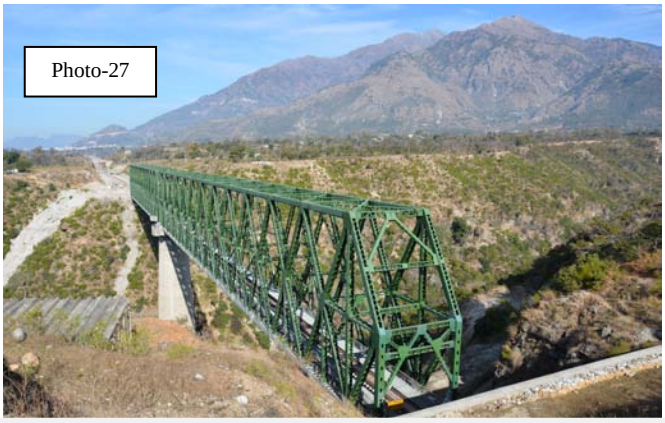
Trial of the UHP-Katra section was done by Engine Rolling on 4/12/2013. On arrival of Engine at Katra Station Team USBRL along with Loco Crew members (photo 19). Engine negotiation Br 20 (photo 18).

Presentation on Tunnel Ventilation Systems in Konkan Railway by Shri Rajesh Agarwal, ED/KRCL on 22/11/2013. In the presentation various aspects considered in design of tunnel ventilation system adopted in Konkan Railway was explained.(photo 21)

Presentation on Stress management by Dr Manu Arora, assistant Professor, Psychtri , Government Medical College on 4/12/2013.(photo 22 & 23)

Presentatinon on Fire Mist Systems based Fire Extenguishers, by shri Dinesh N. Chavan, Director, Murli Techno Pvt Ltd. Held on 3/1/2014.(photo24)

Training was imparted to electrical staff by shri R.K.Choudhury, CEE/C/USBRL on tunnel Safety on 25/01/2014. (photo 25 & 26)



Jajjhar Khad Bridge no 186 (old Bridge no 20). Bridge has two spans of 153.4 m each longest in Indian railway and highest pier of 84m height. In the backdrop are Trikuta Hills, holy shrine of Shri Mata Vaishno Devi.(Photo 27)

In connection with slop stability of Chenab River Slopes at the proposed location of Chenab Bridge site , experts were called from ITASCA and IIT/Delhi. Dr Loren Lorig, Dr Branco Damjanac, Dr Varun and Dr Jat Aglawe comprised the team of experts from ITSCA and Prof. K.S.Rao from IIT/Delhi. The visit was scheduled for three days from 8/1/2014 to 10/1/2014 On the first half of the first day of visit presentation was held followed by Site visit to Anji Bridge Presentation was chaired by CAO/USBRL and ED/KRCL deliberated the Presentation. Also present in the meeting were, CE/Design, CE/Bidge, CE/Rease from KCL and Dy.CE/Design, Dy.CE/Chenab and Dy.CE/Reasi from NR along with their group of officials. ED/KRCL during the presentation deliberated various issues related to slope stability of Chenab Bridge. (Photo 28 & 29)

Team KRCL explaining the vital details of Anji Bridge Site on 8/1/2014. (Photo 30)

Group of experts along with Prof. K.S.Rao and Team USBRL walking down to ADIT negotiating the narrow walk way through the slopes of Anji site. (Photo 31)

Commissioner Railway Safety during his inspection of newly completed UHP-Katra section. (Photo 32 & 33)

Laying Of Ballastless Track System in Pir Panjal

Synopsis

Pir Panjal Tunnel (also known as Tunnel T-80) has been constructed by Northern Railway in *Udhampur-Baramulla-Srinagar-Rail Link Project. This tunnel is 11.215 Km (including Cut & Cover portion of 255 meters) long and is India's longest transportation tunnel. This tunnel has been provided with a 3.0 meter wide road along the track to be used for maintenance and rescue operations. In order to have a maintenance free track inside this long tunnel, it was decided to provide ballastless track inside this tunnel since conventional ballasted track requires frequent track attention to maintain the track geometry through a number of ballastless track technologies exist now a day, Rheda-2000 ballastless track system has been adopted in Pir Panjal tunnel. The prerequisite of providing any ballastless track system is high degree of precision and quality during construction stage as it becomes difficult to alter the track parameters or repair it later. This paper deals with the various steps and methods which have been adopted for construction of Ballastless track system in Pir Panjal Tunnel.*

1 Introduction

Rheda – 2000 ballastless system using Semi Pre-cast Bi-Block sleepers of M-55 Grade and Vossloh 300-1 U Fastenings has been used to provide ballastless track in tunnel T-80. In this system the Semi Pre-cast Bi-Block sleepers are embedded in the RCC concrete bed and the rails are held on sleepers with fastenings. The sleepers are produced in sleeper factory.

2 Structure of ballastless track system

The structure of the ballastless track system adopted in Tunnel T-80 consists of: -

- ✓ Rails
- ✓ Fittings
- ✓ Sleepers
- ✓ Insitu Concrete

2.1 Rails

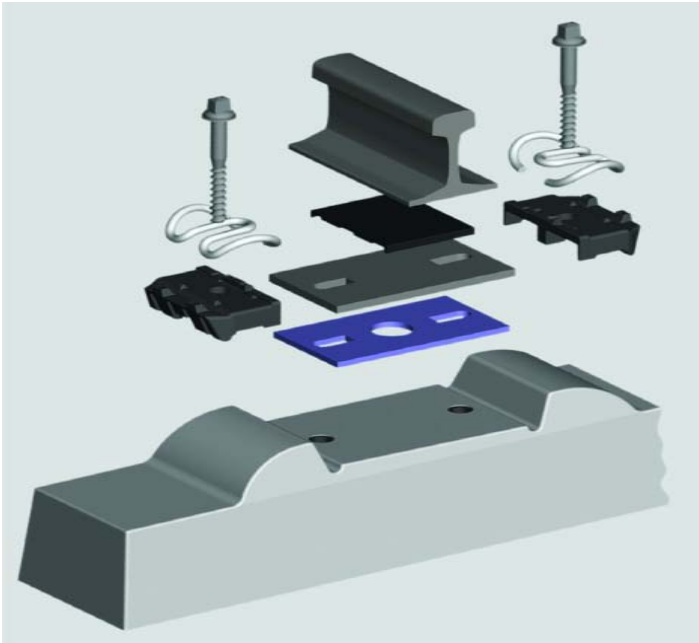
The rails used in Pir Panjal Tunnel are 60 KG HH rails. These rails have been imported from Austria.

2.2 Fittings

Vossloh slab track system with tension clamp (Photographs 1 & 2) has been used as the fittings for ballast less track in tunnel T-80. The fastenings are composed of the following parts per sleeper:

- ✓ Elastic Pads 2 Nos.
- ✓ Steel Base Plates 2 Nos.
- ✓ Rail pads 2 Nos.

By
Vinod Kumar,
Deputy Chief Engineer/C/Banihal



Photograph 1: Fittings

Photograph 2: Assembled fittings

- ✓ Angle guide plates 4 Nos.
- ✓ Sleeper Screws 4 Nos.
- ✓ Plastic Dowels 4 Nos.
- ✓ Tension Clamps 4 Nos.

rail and sleepers.

2.2.1 Elastic Pad (Photograph 3)

The elastic pads are provided on rail seat of the sleepers and substitutes for the elasticity of ballast bed.

2.2.2Steel Base Plate (Photograph 4)

Hot rolled wide steel plates are provided between rail pad and elastic pad to ensure proper distribution of load on elastic pads.

Photograph 3: Elastic Pad

Photograph 4: Steel Base Plate

2.2.3Rail Pad (Photograph 5)

Rail pads are provided to support rails and are placed below the rails in between the angle guide plates.

Photograph 5: Rail Pad

2.2.4Angle Guide Plate (Photograph 6)

Angle guide plates are provided to laterally hold the rubber pad below rails at the same position. Two numbers of angle guide plates are provided per block of sleeper.

2.2.5Sleeper Screw (Photograph 7)

The sleeper screw is provided for fastening of tension clamp with sleeper and to provide the required toe load.

2.2.6 Plastic Dowels

The plastic dowels are embedded in sleepers during casting of sleepers.

Photograph 5: Rail Pad

Photograph 6: Angle Guide Plate

Photograph 7: Sleeper screw

Photograph 8: Tension Clamp

2.2.7Tension Clamp (Photograph 8)

Tension clamps provided over the guide plate and tightened by bolts provide nominal toe load of 9 KN per clamp i.e. minimum toe load of 18 KN per fastening point. The rails are permanently tightened by spring actuation with a long elastic spring. Any tilting and lifting of rail is also prevented by the tension clamp as the middle bend of clamp absorbs the same.

2.3 Sleepers

The sleepers for this Ballastless System are Semi Pre-cast Bi-Block sleepers which consist of two blocks (Photograph 9) which are linked with each other with two lattice girders. These lattice girders prevent relative movement of independent blocks and simultaneously act as reinforcement for the twin blocks. Two plastic ferrules and bursting coils per block are cast in the blocks which hold fittings. These sleepers were produced at Manwal Sleeper Plant set up by the contractor specifically for this purpose.The brief procedure for production of sleepers is as under: -

Photograph 9: Semi Precast Bi block Sleeper

The approved moulds (Photograph 10) are cleaned with the help of wire brush and then they are oiled.This is followed by placement of reinforcement lattice girders, plastic ferrules and bursting coils. The concrete is produced in the batching plant and manually filled into the moulds. Materials for production of concrete are tested in a frequency as prescribed in the relevant IS codes. After filling the moulds with concrete, it is compacted by vibrating the moulds by high frequency vibrators (9000 RPM) attached to the vibrating table. The moulds are then shifted to the steam curing chambers.

Photograph 10 : Moulds with lattice girders and dowels

Steam curing of moulds is done so as to achieve minimum demoulding characteristic compressive strength of 40 MPa in one day. After the mould has been placed in the steam chamber, pre-curing for 2 Hrs at 30°C is done followed by 2 Hrs of rising period at the rate of 16°C per hour and then the standing period of 5 Hrs at the maximum temperature of 60 ^{o} C. Temperature of chamber is reduced to 30 ^{o} C in next 2.5 Hrs.

After steam curing, sleepers are demoulded and transferred to water curing tanks. Submerged curing of sleepers is done for 15 days so as to achieve characteristic compressive strength of 55 MPa.

2.3.1Quality Assurance in Production of Sleepers

The production of sleepers has been done as per the approved Quality Assurance Plan which enumerates control of processes through Receiving Goods Inspection and in-Process inspection.

- ✓ **Receiving Good Inspection**

All the raw materials i.e. Cement, Aggregates, Mixing water, Plastic Screw dowels, Track Fastening materials and Reinforcement etc. are inspected in regular intervals as specified in relevant IS and DIN codes.

- ✓ **In-process Inspection**

In- process inspection of all the processes involved in casting of sleepers has been defined as per relevant codes and frequency. Such inspections ensure standardization of production process and minimize deviation from the approved quality.

All the sleepers are inspected during in -process inspection after curing of sleepers and before dispatch for the following: -

- ✓ **Surface Condition**

Sleepers are visually inspected for any defects in the surface condition of the sleepers as per the stipulations of European Standard DIN EN 13230-1 and only those sleepers which are found free from any surface defects like blow holes, honeycombing and cracks are then further inspected for cracks in rail foot bead.

- ✓ **Cracks in Rail seat**

Cracks in rail seat which are not visible are detected with the help of acetone. Those sleepers having cracks on rail seat are rejected and rests are checked for the dimensions.

- ✓ **Dimensional Inspection of Sleepers**

Sleepers found free from all the surface defects are inspected for dimensional tolerances. Standardized precision gauge templates are used for inspection of sleeper dimensions. Following tolerances has been specified: -

S.No.	Description	Dimension in mm
D.1	Outer to outer length of reinforcement	2702+-5
D.2	Outer to outer length of Sleeper	2473+-10
D.3	C/C distance of rail seat	1765+-1.5
D.4	End to End spacing of rails seat measured 28 mm above rail seat	2139.6+-1.5
D.5	Gap between blocks	645+-6
D.6	Length of Blocks	914+-8
D.7	Length of Rail Seat measured 28 mm above rail seat	375.7+-1
D.8	Slope of Rail Seat	1 in 20 +-0.5
D.9	Concrete Cover to Lattice top from top of the block.	70+-3
D.10	Height of Concrete Block	142+5/-3
D.11	Width at Bottom of Concrete Block	286+-5
D.12	Cross Twist between blocks	<0.7 mm
13	Flatness of Rail seat	1 mm on base of 150 mm

2.4 INSITU CONCRETE

In situ concreting in Ballastless track in Tunnel T-80 is being done in three stages as under: -

- ✓ Plain Cement Concrete (PCC)
- ✓ Track Concrete Layer (TCL)
- ✓ Derailing Block (DB)

2.4.1PLAIN CEMENT CONCRETE (PCC)

PCC is placed over the drainage layer (tunnel without invert) or permanent invert concrete (tunnel with invert) at 764 mm below rail level up to 473 mm below rail level. This 291 mm thick M-20 layer acts as a base concrete layer. The PCC is cast in segments of 50 m length.

2.4.2TRACK CONCRETE LAYER (TCL)

The ballast-less track in Tunnel T-80 consists of semi pre-cast bi-block RCC sleepers manufactured using M-55 Grade Concrete with the lower part of lattice girders projecting outside the concrete body of the sleeper. For rail fixing, dowels which are part of fittings are embedded while casting the sleepers. These sleepers are embedded in RCC layer of 243 mm thickness. This layer is called Track Concrete Layer (TCL) and is of M-35 grade concrete. The TCL consist of two layers of reinforcement with both bottom and top layer composing of rebars of 16 mm ø in longitudinal direction and transverse direction. The track concrete layer is placed over 291 mm thick M 20 grade PCC base layer concrete. The procedure for casting of TCL is explained in the following paragraphs.

Placing of Sleepers

The precise track centre at every 5.4 m on straight track is marked by the survey team using Total Station on the already laid PCC as explained in para 3.0 below. The sleepers are shifted inside the tunnel using pick and carry crane and tractor – trolley. The sleepers are then placed at 600mm spacing c/c along the centre line of the straight rack over the PCC.

Fixing of Rails

The elastic pad, steel base plate, rail pad, inner angle guide plate and inner sleeper screw are first fixed on to the sleepers and then the rails are shifted over the sleepers by manually lifting the rails with help of track jack and rail tongues. Then the outer angle guide plates and sleeper screws are fixed. The sleeper screws are tightened with the help of torque wrench and initial torque of 120-150 Nm is applied on them after insertion of tension clamps on the rail foot and maintaining the gauge with due consideration to the track centre line. The use of torque wrench ensures the even bracing of rails. The outer screws are tightened first followed by the inner one.

Fixing line and level

The track is then lifted with the help of spindles (Photo 11) fixed at very third sleeper (1.8m) to the designed level which is pre-marked on tunnel wall as a continue line by survey team using Digital Leveling Instrument. The spindle brackets are provided in the middle of sleeper spacing with the spindle on the inner side of the rail. At the location of rail joint, one sleeper at the most remains unsupported i.e., the normal distance of providing spindles at every third sleepers is interrupted. The track is leveled and adjusted to match the marked track centre line and designed levels. The alignment is maintained by using turn buckles (Photo 12) bearing against the tunnel wall on one side and road concrete on other side. The sleeper distance and squareness is checked and corrections made as required so that track parameters are within the tolerances.

Photograph 11: Rail supported on spindle

Photograph 12: Lateral support by turn buckles

Placing and binding reinforcement

After the track has been supported on spindles and aligned with the help of turn buckles along the required centre line, both longitudinal & transverse reinforcement is placed (Photo 13) starting from bottom layer to top layer and tied with the help of binding wire. The top layer reinforcement is tied with the lattice provided in the bi-block sleepers so as to avoid any displacement of sleeper during concreting. The minimum concrete cover of 30 mm as specified in drawings is being ensured for concreting.

Photograph 13: Placing and binding of reinforcement in TCL

Concreting

Before commencement of concreting all the track parameters are measured and recorded and it is ensured that these are within permissible track tolerances. In order to protect fittings and rails from splashing of concrete during casting of TCL, these are covered with sheet covers.

Concrete of M-35 Grade manufactured in automatic batching plants and transported in transit mixers is used in TCL. The entire thickness of TCL is filled in one layer with bottom of TCL at 473 mm and top at 230 mm from rail top. The compaction of concrete is ensured by needle vibrators. The central portion of TCL is made rough to receive concrete for Derailment Block. After the completion of concrete for TCL, the fittings and rail foot are cleaned from any residual concrete.

When the concrete becomes sufficient hard, the rails are made free by loosening the tension clamps by unscrewing the sleeper screws so that the shrinkage stresses of the concrete are not locked up by the fixed rails. Generally, the clamps are being released when the concrete becomes sufficient hard by about 6 hrs. The spindles are removed after 12 hrs of concreting and the holes created by spindles are filled by non shrinkable cement grout.

DERAILMENT BLOCK

The derailment block is laid with same grade of the concrete as in TCL i.e. M-35. Special fabricated shuttering plates (Photo 14) are used for casting of derailment block. The derailment block performs the functions of guard rail on normal track. The width of derailing block in the central portion is 1173 mm with height of 230mm. The clearance of 250mm of derailment block from gauge face of the rail is maintained. Also clearance of 180mm is provided on non gauge side of the rail. The clearances are kept such that the sleeper fittings could be removed easily on one hand and road vehicle could move over the track on other hand in case of emergency.

Photograph 14: Shuttering Plates for Derailment Block

Photograph 15: Derailment block shuttering fixation in progress.

Photograph 16: Finished Ballastless Track System inside Pir Panjal Tunnel

3. SURVEYING

Surveying is done in following two parts: -

- ✓ Fixing the centre line of track i.e. Northing & Easting coordinates.
- ✓ Fixing the rail level i.e. elevation.

1.1 FIXATION OF CENTRE LINE

This is done with the help of total station (Photo 17). Temporary Bench Marks are provided at every 50 m by fixing the

Photograph 17: Alignment fixation by Total Station

Photograph 18: Centre line marking on reference plate with mini prism

Bireflex targets (Photo 19) or mini prism (Photo 20) arrangements. Small MS plates of size 25mm x 12mm x2mm (Photo 21) are welded with 8mm dia bolts. Holes of 8mm dia are drilled in the PCC at approximate centre of the track and the plates are fixed in these holes (Photo 22). These MS plates are fixed at distance of 5.4 meter i.e. every 9th sleeper. Two sleepers are placed over the two adjacent reference plates matching the centre of sleeper over the punch mark (Photo 18) on reference plates. A nylon cord is stretched at the right hand outer edge of these two sleepers and all the sleepers in between these two sleepers are placed in alignment by touching the right outer edge of the sleeper with the nylon cord. When the track is lifted and rails are placed over the spindles after fixing the rail level the centre line of the track may disturb. For adjusting the centre line after placing the rails on spindles, half gauge (Photo 23) is used. One rail is adjusted with respect to centre line by using the turn buckles and other rail gets adjusted automatically due to fixed gauge of sleepers. Turn buckles are provided at every third sleeper and rests on the web of the rail. A wooden block is placed between turnbuckle and rail web to avoid damage to the rail.

Photograph 19: Mini Prism

Photograph 20: Bireflex target

Photograph 21: Reference plate

Photograph 22: Reference plate with punch mark

Photograph 23: Half Gauge for adjusting alignment

3.2 FIXATION OF RAIL LEVEL

Rail levels are fixed with the help of digital leveling instrument (Photo 26) and bar coded staff (Photo 27). Building monitoring points (Photo 24 & 25) are fixed inside the tunnel lining at every 50 meter interval to be used as Temporary Bench Marks. The designed levels of the track are transferred on right hand rail by Spindle jacks by lifting/lowering these. The levels of left rail are corrected by using the cross level and gauge.

Photograph 24: Building Monitoring Point

Photograph 25: BMP fixed inside lining

Photograph 26: Digital Leveling instrument

After completing the reinforcement work, the track parameters are again checked & corrected. Gauge & cross levels are checked with the help of Gauge Cum Level and alignment of track is checked by taking versines at every 10 m on 20 m chord. The track parameters in the BLT are maintained to the following tolerances.

S.N.	TRACK PARAMETER	NEW BALLASTED TRACK (PARA316 OF IRPWM)		*BALLASTLESS TRACK*	
		TOLERANCES	**MEASUREMENT CRITERIA**	***TOLERANCES***	***MEASUREMENT CRITERIA***
1	Gauge	2mm(Sleeper to Sleeper variation)		*+/- 1mm (Over prescribed gauge)*	*On Each Sleeper*
				1 mm (Sleeper to Sleeper variation)	*On Each Sleeper*
2	Sleeper Spacing	20mm (w.r.t. theoretical spacing)	(Each Spacing)	*+/- 5mm*	*Each Spacing*
3	Square-ness of Sleepers			*+/- 2mm*	*Each Sleeper*
4	Cross Level	+/- 3mm	Every 4th Sleeper	*+/- 1mm*	*Every 2M*
5	Alignment	+/- 2mm (On St. Track)	On 10M Chord	*+/- 2mm*	*With 20M Chord half overlapping*
		5mm variation over theoretical versines (On Curves of R>600M)	Every 10M using 20M Chord	*+/- 2mm (Versine variation over theoretical versines*	*With 20M Chord*
		10mm variation over theoretical versines (On Curves of R<600M)	Every 10M using 20M Chord		*With 20M Chord*
6	Longitudinal Level	50mm (With reference to approved longitudinal sections)		*+/- 4mm*	*Longitudinal level profile with Station at every 20M in relation to designed layout.*
7	Square-ness of F/P Joints	+/- 10mm	Every Joint	*+/- 5mm*	*Every Joint*
8	Twist	2mm/Mtr on St & Curved Track and 1mm/Mtr on transitioned portion.	(Para 607 of IRPWM)	*2mm on 3.60M base.*	

Disclaimer: - This article provides only guidance regarding execution of Ballastless track and in no way should be used or misunderstood as endorsement to one particular system of Ballastless track.

Railway Tunnel Ventilation Systems on USBRL Project (Northern Railway)- An Experience

2.0 Introduction:

Mainly three types of accidents occur in Tunnels i.e. Derailments, Collisions and Fires. Unlike on open track, accidents involving fire are critical. Safety in tunnels is the result of optimum combination of infrastructure, operations and rolling stock measures. A general principle shared by all Railways can be summarized as -

i. Prevent accidents
ii. Mitigate the impact of accidents
iii. Facilitate escape and
iv. Facilitate rescue.

These measures should be considered in the context of coherent safety plan adopted to local conditions and circumstances. In this regard consideration needs to be given to the balance of cost in increasing safety in tunnels against the overall resources available to mitigate safety risk within the entire Rail system. The Ventilation system is one of the elements of overall safety plan in Railway tunnels.

3.0 Requirement of Ventilation Systems:

Ventilation system is required in Railway tunnels as a part of overall safety plan to achieve the following aims:-

ii. To provide sufficient air for better fuel combustion for diesel engines.
iii. To dilute CO/CO_2 level emitted through exhaust of diesel engines.
iv. To improve visibility by extracting dust particles.
v. To maintain temperature inside the tunnel.
vi. To mitigate the impact of a tunnel fire and to facilitate the escape and rescue operations in the vicinity of the fire.

Lighting Arrangement and Jet Fan in Tunnel T-80

By
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Next Issue will cover SCADA System for Tunnel Ventilation & Safety Systems

i. To keep emergency exits, cross passages and safety tunnels free of smoke.

The Tunnel Ventilation system can be designed to achieve above aims within choosen boundary conditions, such as Emission Values, Fresh Air Requirement, Operating Strategy, Rescue Procedures, etc.

1.0 Guidelines for Ventilation System in various documents:

There are different guidelines for Smoke Extraction/ Ventilation system in various documents available, as summarized in the following paragraphs with relevant extract:-

3.1 IRBM- 1998 Chapter 10 Para No- "1007(B) Ventilation of Tunnels"

"**V** Design of Ventilation System of Tunnels

V(i) The essential requirement of a ventilation system of tunnel are as under :-

a) It should ensure sufficient airflow relative to moving train, to keep the concentration of pollutant gases inside tunnel within permissible limits.
b) It should ensure sufficient air flow to prevent locomotives from over-heating and to keep thermal effects within desirable limits.
c) It should ensure that pressure transient are within acceptable limits.

V(ii) The amount of air flow and type of ventilation arrangement required depends upon the level of concentration of pollutants and maximum temperature likely to be attained inside tunnel due to movement of trains. Level of concentration of pollutants and maximum temperature likely to be attained inside tunnel depends upon the following factors:

a) Type of locos.
b) Gradient inside tunnel
c) Length of train
d) Speed of the train
e) Time interval between two trains
f) Ambient temperature
g) Length of tunnel
h) Cross section of tunnel
i) Direction of prevailing winds etc.

V (iii) As large no. of factors are involved, it may be difficult to estimate pollutants concentration & maximum temperature likely to be attained analytically. Thus, **mathematical modeling and simulation studies are necessary for design of ventilation system.** As factors governing designs of ventilation system vary considerably from site to site, therefore design for ventilation of each tunnel has to be developed separately.

V (iv) Normally on single line sections, tunnels having length up to 2kms, may not require provision of artificial ventilation but it should be ensured that levels of concentration of pollutants during passage of trains are not likely to exceed threshold levels. **Tunnels having length more than 2kms may require provisions of artificial ventilation, by means of shaft with or without provision of fans, depending upon results of simulation studies."**

3.2 DPR for USBRL Project (Oct 1999) issued by CAO/C/N.Rly.

"Chapter **VIII**

8.9 Ventilation and Electrification of Tunnels.

8.9.1 A tunnel having length more than 2km is considered a long tunnel and forced ventilation is needed in those tunnels.

8.10.4 Incident of fire

The design of ventilation system does not cater for the increased fumes likely to be encountered as a result of a fire inside the tunnel. **In fact the operator in the control room shall not switch on any fan in case of fire inside the tunnel as the fanning action may propagate fire further.**

8.10.10.1 Jet fans shall be used for ventilating the tunnels where shafts are not provided. Longitudinal ventilation of tunnels shall be effected by means of jet fans suspended from the ceiling of the tunnels. A series of jet fans shall deliver air in the desired direction at high velocity.

8.10.10.2 The size and number of jet fans will be designed as to clear the diesel smoke and other pollutants from the tunnel within 15 minutes of operation and maintain an air flow at a velocity of 4-5 m/sec. It shall also be possible to clear the tunnel of the pollutant with half of the number of jet fans with 25 to 30 minutes time. The overall size of the jet fan unit shall be such as to clear the height for 25 KV AC Traction system."

3.3 As per Report of the Task Force of N.Rly. (dt. 21.03.2005)

"Review of the Operation, Maintenance and Safety Requirement of the new line under USBRL Project.

Chapter 8

"Para 2.2 Ventilation in tunnels for Diesel or Electric Traction" :

In long tunnels circulation of air is reduced due to the confined spaces, which may result in slow dissipation of locomotive smoke and fumes, stale air (if no wind outside) and smoke produced in maintenance activities like welding etc. The purpose of forced (artificial) ventilation is to maintain flow of air inside the tunnels so that fresh air can come in from outside. At speed the piston effect of a moving train is adequate to circulate the air. Forced ventilation is usually required only if the train is moving slowly or has come to stop.

On Jammu-Udhampur section forced ventilation with fans has been provided in tunnels longer than 2000 m because of Diesel Traction (with multiple locos) as proposed in the DPR. The same criteria should be adopted on Udhampur-Qazigund section if diesel traction is adopted. Ventilation should also provided in tunnels longer than 500m situated up to 800m beyond the outermost stopping signals on either side of a crossing station or IBH, to remove smoke when a train hauled by multiple diesel locos stops for a long time inside a tunnel at a signal.

If the route is electrified, then due to no smoke emission from locos, ventilation needs get reduced so ventilation should be provided only in tunnels longer than 3000 m on straight and tunnels longer than 2000 m on curves sharper than 1 degree only. Ventilation will not be required in smaller tunnels near stopping signals. As most of the tunnels longer than 2000 m on this section are on curves of more than 1 degree, **this effectively means Ventilation of tunnels longer than 2000 m**.

However, ventilation of significantly reduced capacity shall be required to maintain flow of air inside the tunnels to clear it of stale air and fumes and smoke from other sources. It will also be adequate if a diesel loco (mostly a single loco for short period) is sent for some repair work in case of failure of OHE, because ventilation will be required only when a train stops for a time, **controls for operating the ventilation fans should be provided at nearest station to be operated by the ASM when the driver conveys the information to him on the mobile communication network.**

With electric traction the requirement of Ventilation is reduced, so there will be saving, but the amount of saving will depend on extent of forced ventilation as a measure against fire.

Chapter 10 – "Para B ventilation in tunnels as a measure against fire":

a) In the DPR tunnel ventilation is not recommended as safety measure. It states that tunnel ventilation system to be designed for normal train working condition with diesel traction.

b) In long tunnels circulation of air is reduced due to confined spaces, which may result in slow dissipation of stale air, locomotive fumes and smoke produced in maintenance activity like welding. The purpose of forced (artificial) ventilation for normal train operation is to maintain flow of air inside the tunnel. In the event of a fire, in the early stages when the fire has not engulfed the vehicles and the passengers are making an escape from the fire, smoke should not accumulate as it hinders visibility and in extreme case it can cause death by suffocation. **In long tunnels, ventilation fans provided for normal ventilation can be used to dissipate smoke in early stage of fire.**

c) Forced ventilation is also used in tunnels for fire fighting for which much powerful fans than those provided for normal train working are required. However, unchecked and unregulated forced ventilation to move out the smoke can increase the fire also. It has been found that in the Mont Blanc road tunnel fire (year 1999) more deaths occurred because the ventilation system was not operated in the right sequence. Whereas in the fire in Tauern road tunnel in Austria (also in year 1999) fire could be effectively controlled with ventilation.

The UIC report on Tunnel safety also highlights that without a good design and right operation (speed, direction of throw of air, segregation etc.) ventilation may cause more harm than good. **Forced ventilation for firefighting is basically effective in controlling and regulating the spread of fire and keeping one side of the tunnel free of smoke to enable rescue and fire fighting**. On Jammu-Udhampur section forced ventilation with fans has been provided in tunnels longer than 2000 m because of **diesel traction and not as a measure against fire**, as recommended in DPR. **In event of fire, ventilation fans are shut down**.

d) To get the best out of forced ventilation as a measure against fire this should be **provided in tunnels longer than 5000 m only on case by case basis considering all other fire measures taken in the tunnel**. For example for effective forced ventilation, it is sometime necessary to have ventilation adits and shafts. If this is not feasible in a tunnel then a suitable designed atomized water spray system with normal forced ventilation for removing smoke would be adequate.

e) Forced ventilation should be got designed by reputed and experienced firms to get the best out of the system in fire incidents. The operators manning the ventilation system should be well trained so that they are able to make decision to appropriately control ventilation depending on the nature, extent and intensity of fire and other relevant factors."

3.4 UIC 779-9 R Report on Safety in Railway tunnels:

The UIC report emphasizes the aspect of infrastructure measures. It also deals with operation and rolling stock, so far as it is necessary to define infrastructure measures in a comprehensive way. The term "infrastructure" includes construction works as well as fixed installations. Provisions in different clauses are as under:-

UIC- 779-9R:- "I-25 Smoke Extraction System/ Ventilation Systems :-

General Description and Goal

A distinction must be made between three main situations:-

a) Main Tunnel: Mechanical smoke extraction system in the tunnel in order to draw out smoke or to create a defined air stream in order to obtain a smoke free side for rescue.

b) Smoke extraction if a tunnel on a double-track line consists of double-bore single-track tubes or at passages between double-bore single-track tubes (to keep the parallel tubes free of smoke, to prevent air streams).

c) Safe places: ventilation systems to keep emergency exits, cross passages or a parallel safety tunnel free of smoke (produce overpressure).

Relevant aspects:-

- For normal operation a ventilation system in general is not necessary (exceptions on non-electrified lines are possible). This is clear difference to road tunnels.
- Clear distinction between fans, which have to create a longitudinal airflow only and extraction system to pull out smoke locally.
- To move an air column in a tunnel needs a high performance system. Running trains are mostly much more efficient, so that a ventilation system can only work well, if running trains have left the tunnel or stopped.
- In special situation, alternative measures like doors may be suitable.
- Situation which have to be treated specially
- Combination of tunnel and underground stations → different situation.
- Smoke extraction in the rescue station of a very long tunnel →different situation.

Specifications:-

a) No specification for the main tunnel (see also recommendation).

b) Combination of double-track/ single-track tunnel or at passages between double-bore single-track tubes: the ventilation/smoke extraction system has to be designed so that smoke transfer from one tube into the other through the passage between the two tubes is reduced to a minimum. A detailed concept and sufficient dimensioning of the system are necessary.

c) Safe places: The ventilation system designed so that smoke transfer into the safe place is reduced to the minimum when opening doors to main tunnel. If there are alternatives to an active ventilation, which fulfils that requirement, it is acceptable as well (e.g. doors).

d) Fans for a longitudinal airflow need space.

Impacts on Safety:-

a) Longitudinal air flow in the main tunnel

If the airflow is strong enough, it guarantees one smoke free side, where people are safe and rescue actions can take place.

- The decision about an optimal airflow/direction is a difficult one. There is a possibility of people on the wrong side. If decision is wrong, e.g by lack of information, the situation might become even worse.
- To start and accelerate the airflow needs time even more if an existing direction has to be changed.
- An intensified airflow mixes up the air and reduces clear/sharp smoke layers.
- Remark: **for railway application, the positive effect of longitudinal ventilation is a matter of controversy**.

It cannot be compared with road tunnels, where different ventilation systems, e.g. a transversal ventilation, can be easily installed.

a) Keeps safe places free of smoke.

Note:-

+ The measure is generally recommended as safety measure.
- The measure is not recommended as a safety measure.

Further Effects:-

- Ventilation/smoke extraction systems need high maintenance to keep it reliable.
- Extraction system needs a chimney: depending on the location it can pose problem (e.g. in densely populated area).

Cost – effectiveness:-

New Tunnels:-

a) Smoke extraction as general measure, poor cost effectiveness considering the unclear effectiveness and expected high investment and maintenance cost.

b) and c) : Medium to poor because of presumably high costs.

Assessment:-

New tunnels:-

a) Smoke extraction in main tunnel: not recommended as standard measure to control smoke spread.

b) and c) Recommended for specific situations, where safe areas should be kept free of smoke (e.g. parallel tubes, emergency exits). In order to achieve this goal, alternative measures such as doors or locks may also be adequate."

3.5 Technical Specifications for Interoperability (TSI) – Safety in Railway Tunnels (SRT) Chapter-4 gives the characterisation of the Subsystem for Infrastructure, Subsystem for Energy, Subsystem for Control-Command and Signaling, Subsystem for Rolling Stock and it gives about the Fire Protection requirement for Structure, Fire Detection, Facilitates for self rescue, evacuation and rescue in the event of incident, Emergency Exists, Cross Passages, Emergency Lighting, Emergency Communication, Escape Sinages, Escape Walk Ways, Access for rescue services, Rescue areas outside Tunnel, Water supply, Fire Extinguishers, etc to design any Ventilation system.

3.6 Recommendation C.2 05 of document No TRANS/AC.9/9 dated 1st December 2003, **"Recommendations Of The Multi-Disciplinary Group Of Experts Of Safety In Tunnels (Rail)"** of Economic and Social Council gives as under:-

"Smoke Extraction system/Ventilation system - The assessment of the air flow in a tunnel should consider tunnel and train aerodynamics, the fresh air supply (for physiological needs), the control of heat and smoke from a fire and the control of pollution (diesel). Ventilation design should take into account the associated risks and costs**. Ventilation systems must be designed to keep emergency exists, cross passages and safety tunnels free of smoke**."

3.7 Comprehensive Code of Practice for Electrical systems to be adopted on J&K Project issued by RDSO vide letter No. EL/1.2.20/J&K dated 28.08.2009.

Para-5 – "The tunnels shall be provided with ventilation system suitable & feasible as per site requirement i.e longitudinal Jet fan or vertical centrifugal shaft systems in terms of Railway Board's letter No. 2008/Elect (Dev)/150/3 dated 18.12.2008. **This will be applicable to all the tunnels which are more than 1 Kms".**

3.8 Recommendation of Tunnel Ventilation Committee 2008:

The recommendation of Committee on Tunnel Ventilation (safety, relief and rescue) circulated vide Railway Board letter No. 2008/Elect. (Dev.)/150/3 dated 18.12.2008 are as under:-

2.1 Till such time a code of practice for ventilation and safety in Rail Tunnels is evolved, UIC's Technical Specification of Inter-operability (TSI) relating to "Safety in Rail Tunnels" (SRT) as followed in Trans-European conventional and high speed rail system, effective from Ist July'08, may be adopted.

2.2 RDSO shall be nodal agency for evaluating the requirement of ventilation, illumination and safety inside the tunnel. The TSI-SRT includes a number of safety measures that may be considered by RDSO for implementation.

2.3 Computational Fluid Dynamic (CFD) and Risk Analysis may be carried out for designing an effective ventilation system for the tunnels by engaging specialized agencies overseas (as indicated in the report) or such premier institute (IITs) in India, having wind tunnels/aeronautical engineering test facilities. As the USBRL project does not have any additional tunnel, the CFD analysis may be conducted for tunnels of different sizes: 1-3 km, 3-5 km, more than 5 km and those with stations located inside the tunnel for finalizing the design. Lighting and associated electrical drives and control systems shall also be part of the analytical study.

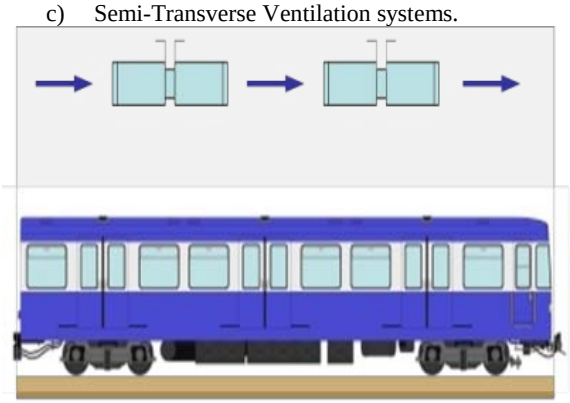
3.0 One Director each from Electrical Engineering Directorate (Power Supply) and Civil Engineering Directorate in RDSO may be associated in designing tunnel ventilation. CEE/C/J&K/NR may be associated for execution of scheme in USBRL Project.

4.0 Board (ML) has approved assigning of this work to ED (PS & EMU), RDSO".

4.0 Various Ventilation System:

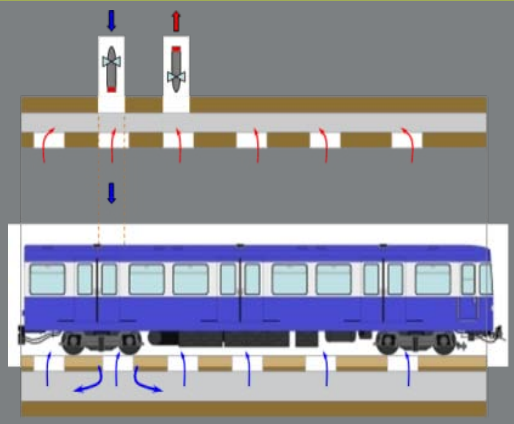
There are various Ventilation systems used on different Railways which depends on the Geographical Conditions, Tunnel Parameters and Tunnel Design etc. For academic interests, 3 types of Ventilation systems are summarized below:-

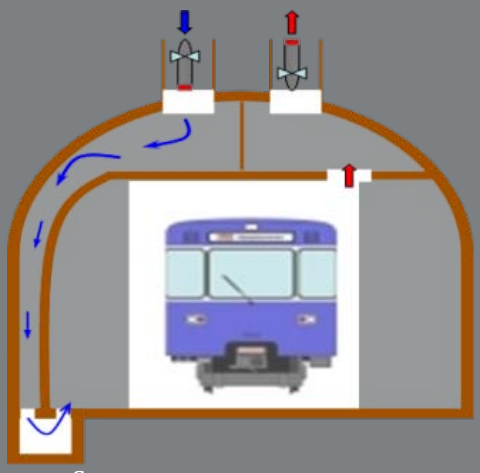
a) Longitudinal Ventilation system.
b) Transverse Ventilation systems.
c) Semi-Transverse Ventilation systems.



4.1Longitudinal System

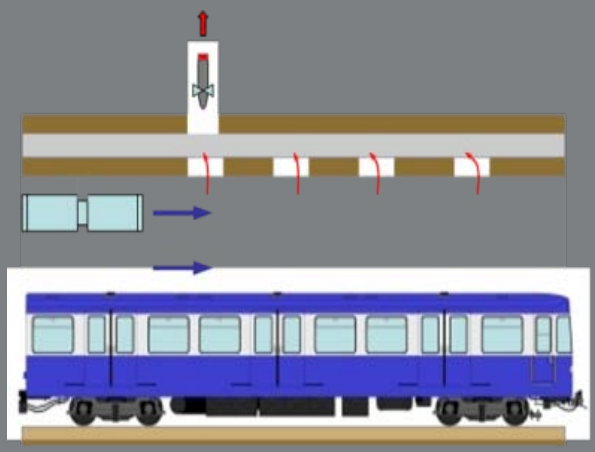
- Longitudinal system is provided where shafts in tunnels are not provided.
- Air set in Motion along Tunnel Axis
- Portal to Portal, Same speed though out the Tunnel length
- No Division into Aerodynamic Segments
- Low Cost, Does not need Transverse air Egress Points
- Time to Purge Foul Air depends on Air Flow Velocity, Tunnel Length

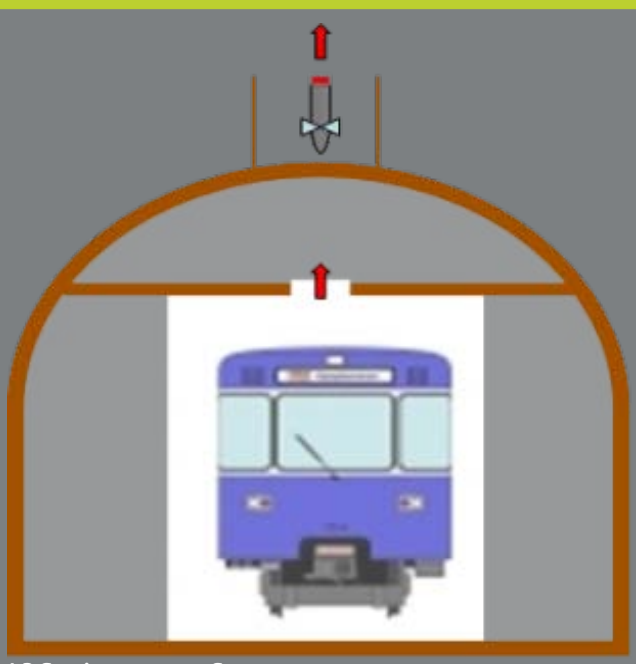




4.2Transverse System

- Transverse System is suitable for tunnels where ventilation shafts are provided.
- Two Independent Ducts (Fresh Air Inflow and Exhaust air exit)
- Can create Aero dynamic Sections (In case of Fire)
- May Need Transverse Exit Routes (Low Overburden Ventilation Shafts, Stations in Metros
- Costlier to Install, and operate (More Aerodynamic Losses) .





4.3 Semi-transverse System

- Combination of Longitudinal and Transversal System.
- Separation of Fresh and Exhaust air.
- Reversible.
- Fire Case Fresh Air through Portal, Exhaust through Ventilation Stack, Permitting Aerodynamic Separation.
- Normally, fresh air Through Ventilation Stacks.
- Larger Tunnel X-Section.

5.0 Design considerations:-

5.1 Tunnel Geometry

- Length, Cross-section Area
- Wall friction (Lined/unlined)
- Gradient
- Distance between adjacent tunnels

5.2 Traffic

- Direction of traffic – Bi-directional
- Speed
- Load of trains
- Traffic density i.e. time interval between two successive trains.

5.3 Natural/Environment

- Altitude – air pressure & air density
- Natural wind direction and velocity
- Temperature – outside & inside of tunnel

5.4 Natural Buoyancy- Due to difference of air density resulting from temp. & moisture.

- Positive buoyancy - less air density, air becomes lighter - air moves upward.
- Negative buoyancy–higher air density, air becomes heavier - accumulates inside the tunnel.
  Example:-
- Natural buoyancy -temp. outside tunnel -8 deg. C & inside tunnel 24 deg. C will create +50.94 Pa (+ve buoyancy)
- Natural buoyancy-temp. outside tunnel 35 deg. C & inside tunnel 24 deg. C will create 14.80 Pa (-ve buoyancy).

5.5 Emission and Fire load

5.5.1 Calculation of fresh air demand

- To dilute gaseous emissions
- To dilute particulate emission
- For Diesel loco for better fuel combustion
- To maintain temp. within tolerable limit
- Time to restore safe condition inside the tunnel
- Waiting time for next trains to enter

5.5.2 Specific emission data for Diesel Locos :- As per M/s GC-RITES Report of T-80 are given in table 1.

5.5.3 Threshold levels considered for Tunnels on USBRL Project:- As per M/s GC-RITES Report of T-80 are given in table 2.

5.5.4 Fire Load:- Considered for T1, T3 and T-80 are given in table3.

6.0 Parameters Monitored and Controlled for Ventilation in Tunnels.

6.1 Visibility Sensors:-

Visibility is monitored in Infrared Units with necessary reflectors which monitor the density of smoke between the IRU and the reflector. It indicates the percentage level/status of visibility to pre set values on PC Control Station. Alarm will sound in the control room along with indication when the visibility falls below the pre set prescribed limit.

6.2 CO Sensors:-

Gas monitoring equipments are used for monitoring the level of Carbon Monoxide (CO) in the tunnel with sensors placed on the wall at suitable locations. The values (pollution level) measured are displaced on PC Control Station. When the level of the toxic gases rises beyond a preset limit (> 50 ppm) at any of the locations, an audio-visual will be activated in the control room.

6.3 Wind Velocity Sensors:-

Wind Velocity and direction indicator is opto-electronic anemometer type with measuring range 2 to 5 m/s, complete with its own suitable power supply arrangements. The display of wind velocity and direction is available on the PC Control Station.

6.4 Temperature Sensors:-

Tunnel temperature monitoring equipments are used for monitoring the tunnel ambient temperature with sensors placed at suitable locations inside the tunnel. When the tunnel ambient temperature rises beyond a pre set limit (> 40˚C), an audio-visual alarm shall be activated in the control room.

6.5 Train Location Sensors:-

Train monitoring arrangement works on the principle of location of a moving object by obstruction of an Infrared Beam. Infrared units are provided on the one wall of the tunnel. The reflectors are mounted opposite Infrared units tunnel walls. If for any reason, the train stops inside the tunnel for more than 10 minutes, an audio alarm will sound on the control console and Red indicators of the occupied tunnel segment shall start flashing, alerting the control room operator.

Emission g/kWh	Standards				Measured emission data		
	ORE	**UN**	UIC	US EPA	WDM2/ ALCO 2530 HP	WDM3A/ ALCO 2530 HP	WDM4/ ALCO 4000 HP
CO	3	**6.7**	3	6.71	0.52	0.72	0.56
NO_X	12	**12.7**	10	10.73	13.56	12.42	7.62
Particle	0.5	**0.8**	0.25	0.30	?	?	0.39

Table 1

Pollutant Gas	8 Hours Exposure	15 Min. Exposure	Design Limit on USBRL (T-80)	Sensors Provided
CO	50 ppm	400 ppm	50 ppm	√
NO	25 ppm	35 ppm	90% of NOx	X
NO_2	4 ppm	5 ppm	10% of NOx	X
Sum : NOx	29 ppm	40 ppm	25 ppm	X
CO_2	5000 ppm	18000 ppm	Not Defined	X
SO2	5 ppm	5 ppm	Not defined	X
Particulates (PM)	Not defined	Not defined	<0.012m^-1(extinction coefficient)	√
Temperature	40˚C			√

Table 2

T1	T3	T80
15 MW	15 MW	40 MW

Table 3

7.0 Ventilation systems adopted on Indian Railways:

7.1 Ventilation system adopted on KONKAN Railway.

SN	Name of Tunnel	Length (in km)	Type of Ventilation and Velocity
1	Natuwadi	4.5	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s
2	Parchuri	2.6	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s
3	Karbude	6.5	Centrifugal fan , Velocity 2.5 m/s
4	Barcem	3.4	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s
5	Karwar	2.9	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s
6	Tike	3.8	Longitudinal axial flow (Jet fan), Velocity 1.9 m/s
7	Berdewadi	4.0	Longitudinal axial flow (Jet fan), Velocity 1.9 m/s
8	Sawarda	4.0	Provision of ventilation system on hand.

7.2 Tunnel Ventilation system provided on Central Railway.

SN	Tunnel No.	Length (in km)	Section	Type of Ventilation
1	25 C	2.2	Karjat-Lonavala	Longitudinal axial flow (Jet Fans)

7.3 Ventilation system provided on Eastern Coast Railways.

SN	Tunnel No.	Length (in km)	Section	Type of Ventilation	Remarks
1	T-23	1.4	Raigada-Korapur	Longitudinal (Jet Fan)	High gradient, sharp curves, heavy goods traffic with multiple locos.
2	T-25	1.6	Raigada-Korapur	Longitudinal (Jat Fan)	

7.4 Ventilation system on Northern Railway:

7.4.1 Tunnel provided with Ventilation system on Jammu-Udhampur section.

SN	Name of Tunnel	Length (in km)	Section	Type of Ventilation
1	T-7	2.4	Jammu-Udhampur	Longitudinal axial flow (Jet Fan), Velocity- 3-4m/s

7.4.2 Tunnel provided with Ventilation system on USBRL Project.

SN	Name of Tunnel	Length (in km)	Type of Ventilation and velocity
1	T-1 (23)	3.120	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s
2	T-3 (25)	2.497	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s
3	T-80	11.215	Longitudinal axial flow (Jet fan), Velocity 3-4 m/s

7.4.3 Tunnels under construction on USBRL Project are listed below will be needing the Ventilation system:

SN	Tunnel No.	Chainage		Length (m)
		From	To	
	UDHAMPUR-KATRA SECTION			
1	1	2.180	5.290	***3120***
2	3	12.23235	14.71550	***2497***
	KATRA-DHARAM SECTION			
3	T-1	30.00	33.160	***3160***
4	T-2	33.212	38.375	***5163***
5	T-3	39.201	42.210	***3009***
6	T-5	42.980	48.940	***5960***
7	T-6	51.935	55.400	***3465***
8	T-12	58.525	60.662	***2137***
9	T-13	61.004	70.372	***9368***
10	T-14/17	70.651	78.920	***6269***
11	T-15/18 + T-40/41	77.019	92.536	***15517***
12	T-42/43	93.315	95.910	**2595**
13	T-47	99.092	101.184	***2230***
	DHARAM-BARAMULLA SECTION			
14	T-48	99.998	110.184	***10186***
15	T-49	111.500	124.245	***12745***
16	T-74R	125.310	133.910	***8600***
17	T-80	152.600	163.560	***11215***

Lighting Arrangement in Tunnel T-1

Jet Fan Installed in Tunnel T-1

8.0 Comparison of UIC Recommendations 779 – 9-R with safety provisions in Tunnels on USBRL Project.

Various UIC requirements are tabulated below which have been adopted in Tunnel T-1, T-3 and T-80 on USBRL Project.

System/Facility		T-80	T-1	T-3	UIC	Cl. of UIC 779-9R
Fire protection requirement for structures	Tunnel structure design	√	~	~	√	I-22
Escape Routes/ Lateral/ Vertical exits/cross passage/Handrail	Every 1000 meter/Parallel service Tunnel	~	~	~	√	I-40, I-43, I-44, I-45, I-46 & I-47.
Track Drainage System	Remove water from Tunnel.	√	√	√	√	I-26
Power Supply	Two dependent power supplies	√	√	√	√	I 65 & I-67
	Diesel Generator	√	√	√	~	
	Substation on Portals & inside Tunnel.	√	√	√	~	Design requirement
	UPS for Critical feature	√ (120 min)	√ (90 min)	√ (90 min)	√ (60 min)	I-67
Lighting System	Tunnel Lighting	√	√	√	~	
	Emergency Lighting	√	√	√	√	I-41
Fire Detection system	Alarm Push Button	√	√	√	~	
	Smoke Detector	√	√	√	√	I-23
	Control system	√	√	√	√	I-68,
Fire Fighting in Tunnel.	Water Line & Hydrants	√	√ **	√ **	√	I-64
Fire fighting for Equipment Room	CO2 dry powder fire extinguisher provided.	√	√	√	√	I-24
Systems on UPS	Emergency Lighting	√	~	~	√	I-41
	Escape Signs	√	√ *	√ *	√	I-40
	Emergency Phone	√	√	√	√	I-42
	Fire detection system	√	~	~	√	I-23
	Train detection system	√	√	√	√	I-3
	Radio / Speaker System	√	√	√	√	I-66
Ventilation Control	Regular operation (air-quality)	√	√	√	√	I-25
	Emergency Option (detection, velocity)	√	√	√	√	I-25
Note:- *- Refracted Boards **- WM Trolley Mounted & Backpack Fire Fighting Equipments						

It is seen that certain items are not provided as per UIC recommendations as deliberate decision in view of cost consideration mentioned in paragraph 1.1(iv).

9.0 Simulation Studies for Tunnels T-1 & T-3 (By Dr. Bent A Borresen & Dr. Bard Venas).

9.1 Object of study:

The object of the study was to simulate and visualize the effect of longitudinal tunnel ventilation on visibility through smoke for the case of a typical locomotive fire inside a specific tunnel cross section.

9.2 Method

The simulations were performed using the Computational Fluid Dynamics (CFD) code ANSYS CFX from ANSYS, Inc. This is one of the absolute world leading CFD codes and is used worldwide in a number of industries, ranging from aeronautical and automotive to combustion processes, HVAC and fire analysis.

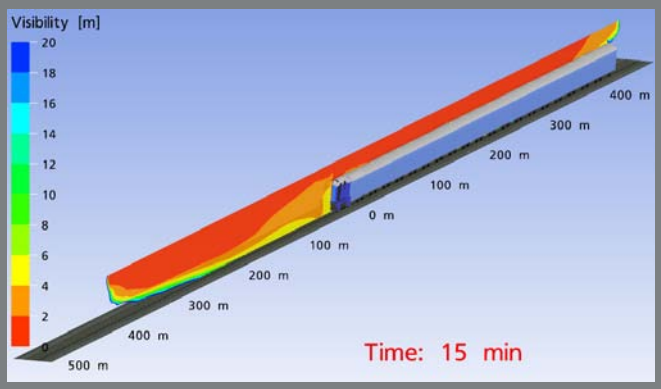
In CFD simulations the fundamental equations for fluid flow and heat transfer are solved directly for a geometrical 3D computer representation of the problem. The simulations include direct calculation of air flow pattern, turbulence levels, temperatures and mixing of gas components.
In these fire simulations the combustion process was included as well, using a one-step reaction (fuel + Oxygen -> products) model with turbulent combustion following the eddy dissipation concept.

9.3 Result of simulation studies

CFD simulations have been performed for a typical train fire in a locomotive inside a tunnel, from the fire starts and 15 minutes forward in time. Two simulations were performed, respectively for situations without and with longitudinal tunnel ventilation installed (i.e. jet fans).

9.3.1 Without Jet fans

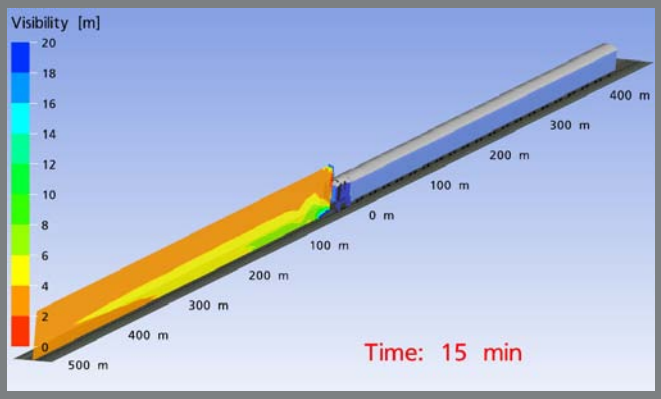
Without ventilation the simulations show how smoke layer builds up and spreads outwards 300-400 meter to both sides of the locomotive. The smoke layer continues build up and is eventually brought back towards the fire by the air flow near the tunnel floor. After 15 minutes the entire cross section is filled of smoke.



No ventilation, 15 minutes after start of fire: visibility through smoke shown as contours along centreline of tunnel.

9.3.2 With proper longitudinal ventilation, using Jet fans

Starting the ventilation 1 minute after the fire start, the train is kept free from the smoke for the entire duration of the simulation, pushing all smoke in the opposite direction. The ventilation velocity employed here is 3 m/s at full capacity.



10. Outcome of 3 D CFD analysis for Tunnel T-80.

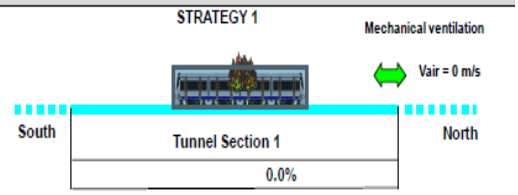
10.1 For Pir Panjal tunnel, T-80 on Qazigund-Banihal section, study for 3D CFD analysis of train fire was done by M/s HBI Germany. In tunnel T-80, for normal operation 25 fans of 49 KW have been provided whereas in case of fire 15 fans are adequate to maintain the critical velocity of 2.4 m/s to provide the safe escape of passengers in one direction and extraction of smoke in other section.

To ensure the adequacy of the system, CFD analysis for six different situations of Tunnel fire was conducted and it was seen that critical velocity of 2.4 m/s is required to prevent backlayering of fire with heat release rate of 25 MW.

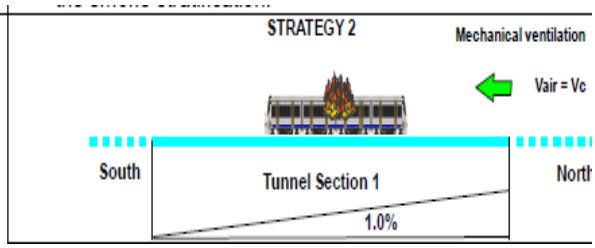
All the six scenarios were presented for simulations for the following time steps:

t = 200 s
t = 400 s
t = 600 s
t = 800 s
t = 1000 s
t = 1200 s

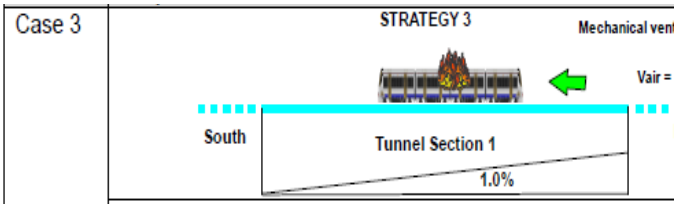
10.2 The six scenario cases are tabulated below

Case	Graphical overview
Case 1	

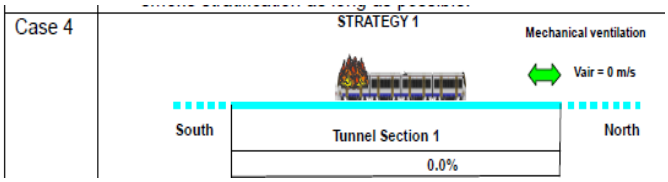
-The train on fire is located in the middle of Section 1.
- In difference to most other cases, no tunnel slope is implemented in Case 1, which is considered to be appropriate for providing stagnant tunnel air. Any introduction of a slope would have required a more complex balancing of time-dependent, fire induced thermal draught effects. In reality, the balancing would need to be achieved by ventilation control.
- The fire origin is in the middle of the train.
-Strategy 1 is considered with mechanical ventilation in order to have no longitudinal air flow (stagnant air column) and to maintain the smoke stratification.

Case 2	

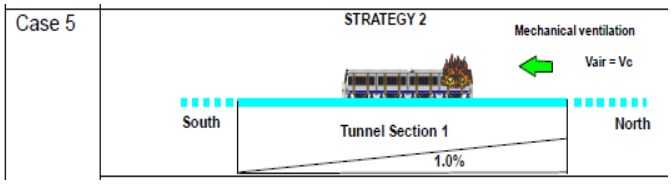
- The train on fire is located in the middle of Section 1 where the maximal tunnel slope is observed (critical scenario).
- The fire origin is in the middle of the train.
- Strategy 2 is considered with the mechanical ventilation activated in order to achieve the critical velocity. The tenability conditions downstream of fire are investigated.



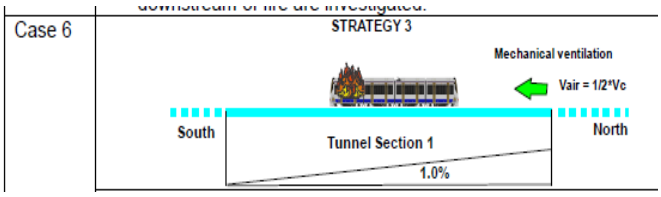
- The train on fire is located in the middle of Section 1 where the maximal tunnel slope is observed (critical scenario).
- The fire origin is in the middle of the train.
- Strategy 3 is considered with a reduced power of the ventilation system (less than critical velocity) in order to maintain the smoke stratification as long as possible.



- The train on fire is located in the middle of Section 1.
- In difference to most other cases, no tunnel slope is implemented in Case 4, which is considered to be appropriate for providing stagnant tunnel air. Any introduction of a slope would have required a more complex balancing of time-dependent, fire induced thermal draught effects. In reality, the balancing would need to be achieved by ventilation control.
- The fire origin is in the south-end of the train (worst case scenario regarding the escape conditions).
-Strategy 1 is considered with mechanical ventilation in order to have no longitudinal ventilation (stagnant air column) and to maintain the smoke stratification.



- The train on fire is located in the middle of Section 1 where the maximal tunnel slope is observed (critical scenario).
- The fire origin is in the north-end of the train (worst case scenario regarding the escape conditions).
- Strategy 2 is considered with the mechanical ventilation activated in order to achieve the critical velocity. The tenability conditions downstream of fire are investigated.



- The train on fire is located in the middle of Section 1 where the maximal tunnel slope is observed (critical scenario)
- The fire origin is in the south-end of the train (worst case scenario regarding the escape conditions)
- Strategy 3 is considered with a reduced power of the ventilation system (less than critical velocity) in order to maintain the smoke stratification as long as possible.

Accordingly, Proof Consultant M/s HBI Germany for Ventilation systems, E&M and SCADA systems has certified the adequacy of systems and design considered over conservative.

11. Brief on Ventilation system provided for T-1 & T-3 on UHP-Katra section:

11.1 Tunnel T-1 on Udhampur-Katra section

Tunnel T-1 of length 3.1 km is located in Udhampur-Katra section and work was started in 2000 by Civil Engineering department. Electrical work was awarded in 2007, but due to collapsing of tunnel work, work was stopped. Now after construction of diversion tunnel, the major items for ventilation and illumination supplied and erected are:-

A) Illumination:-

For illumination, 400 Nos of Wall mounted, CFL fittings of 55W with degree of protection IP-65 are provided at a spacing of 15m on both side walls at 3.2m height inside the tunnel. Total lighting load is 22kW. The illumination level achieved is 15Lux min.

B) Forced Ventilation:-

24 Nos of 22kW, 2950 rpm bidirectional jet fans at a spacing of 126m are provided in tunnel to achieve proper ventilation and to keep CO level and temperature level within limits. The load of jet fans is 528kW. CO level to be maintained below 50ppm and temperature level within 40˚C.

C) Power Supply System:-

Technical data of Power Supply System:-

Power Supply System	-	-11KV from PDD
Main Sub-station Rating	-	2x1000kVA, 11kV/415V & 2x750kVA,415/3.3kVA
Remote Sub-station Rating	-	1x300kVA (oil-cooled), 3.3kVA/415V
Middle Sub-station Rating	-	1x300kVA (dry-type), 3.3kVA/415V
DG set Rating for Ventilation and Lighting	-	500kVA
DG set Rating Lighting only	-	82.5kVA
Emergency Backup	-	2kVA UPS for sensors for 90min

D) Remote Control System:-

Technical Data for Remote Control System:-

Location of Control Room	-	Above Main Sub-station at Katra End
Visibilty sensors	-	6 Nos
CO sensors	-	6 Nos
Wind velocity sensors	-	4 Nos
Temperature sensors	-	30 Nos
Train Location sensors		18 Nos

11.2 Tunnel T-3 on Udhampur-Katra section

Tunnel T-3 of length 2.497 km is located in Udhampur-Katra section and work was started in 2002 by Civil Engineering department. Electrical work was awarded in 2007, and almost all the work of supply, erection, testing and commissioning of the material was completed by the agency for ventilation and illumination of the tunnel in 2008. Since the section was not opened, it was necessary to keep the installations in working order, therefore AMC was operated to operate jet fans on regular basis in order to avoid the damage/jamming of fans due to heavy moisture in tunnel.

The electrical works comprise of:-

A) Illumination:-

For illumination, 325 Nos of Wall mounted, CFL fittings of 55W with degree of protection IP-65 are provided at a spacing of 15m on both side/walls at 3.2m height inside the tunnel. Total lighting load is 17.875kW. The illumination level achieved is 15Lux min.

B) Forced Ventilation:-

20 Nos of 22kW, 2950 rpm bidirectional jet fans at a spacing of 120m are provided in tunnel to achieve proper ventilation and to keep CO level and temperature level within limits. The load of jet fans is 440kW. CO level to be maintained below 50ppm and temperature level within 40˚C.

C) Power Supply System:-

Technical data of Power Supply System:-

Power Supply System	-	11KV from PDD
Main Sub-station Rating	-	2x750kVA, 11kV/415V & 2x500kVA,415/3.3kVA
Remote Sub-station Rating	-	1x300kVA (oil-cooled), 3.3kVA/415V
Middle Sub-station Rating	-	1x300kVA (dry-type), 3.3kVA/415V
DG set Rating for Ventilation and Lighting	-	500kVA
DG set Rating Lighting only	-	82.5kVA
Emergency Backup	-	2kVA UPS for sensors for 90min

D) Remote Control System:-

Technical Data for Remote Control System:-

Location of Control Room	-	Above Main Sub-station at Udhampur End
Visibility sensors	-	5 Nos
CO sensors	-	5 Nos
Wind velocity sensors	-	4 Nos
Temperature sensors	-	24 Nos
Train Location sensors		15 Nos

Ventilation systems provided in Tunnel T-1 & T-3 have been approved by CEE/NR based on RDSO's approval.

11.3 Ventilation system for Pir-Panjal Tunnel T-80 on Quazigund-Banihal section:

The Pir Panjal Tunnel, T-80 of length 11.215 km is located in Banihal-Qazigund section, which is largest Railway tunnel on Indian Railway. The civil work was started in 2004. The breakthrough of tunnel was achieved in Oct 2011. All Civil and Electrical works were completed in 2012-13 and the tunnel was inaugurated by Hon'ble Prime Minister on 26 June2013. Electrical works in the Tunnel include Illumination, Ventilation and SCADA systems.

The electrical works comprise of:-

A) Illumination:-

For illumination, 1826 Nos of Wall mounted, T-5 fittings of 28 W with degree of protection IP-65 are provided at a spacing of 06 m on 3 m wide motorable path at a height 2m lower edge beneath fire main inside the tunnel for emergency and maintenance purposes. 137 nos, HPSV lamps of 150 W at a distance of 80 m with a degree of protection IP-66 at a height of 5.75 m provided for normal lighting. Total lighting load is 71.68 kW. The illumination level achieved is between 5 to 25 lux.

B) Forced Ventilation:-

25 Nos. of 49 KW, 1450 rpm bidirectional jet fans are provided in a group of five fans in main tunnel to achieve proper ventilation and to keep CO level and temperature level within limits. 03 Nos. similar jet fans are provided in access tunnel for facilitating rescue operations during emergency conditions. 02 Nos. of 2.64 KW axial fans are provided to prevent entry of smoke and dust particles in the access tunnel. The load of jet fans is 1372 KW and axial fans is 5.28 KW. CO level to be maintained below 50ppm and temperature level within 40˚C.

C) Power Supply System:-

Technical data of Power Supply System:-

Power Supply System on North Portal	-	33 kV double circuit from PDD
North Portal Sub-Stations	-	2x3150 kVA, 33 kV/11kV; 2x 250 kVA, 11 kV/415 V; 2x 1500 kVA, 433 V/11kV.
DG set at North Portal Sub-Station	-	2 x 1500 kVA, 433V
Power Supply System at South Portal	-	33 kV double circuit from PDD
South Portal Sub-Stations	-	2x3150 kVA, 33 kV/11kV; 2x 250 kVA, 11 kV/415 V; 2x 1500 kVA, 433 V/11kV.
DG set at South Portal Sub-Station	-	2 x 1500 kVA, 433V
Niche Sub-Stations (5 Nos.) (Inside Tunnel).	-	2 x 500 kVA, 11 kV/415V
Emergency Backup for controls and emergency lighting.	-	7 Nos of 60 kVA UPS with 120 min backup

D) Tunnel Control Centre:-

Technical Data from Both (North and South) Equipment Room Buildings is collected at Tunnel Control Centre through OFC/PLC network:-

Location of Tunnel Control Centre	-	At Banihal Rly Stn
Air velocity sensors	-	21 Nos
CO/Dust particle sensors	-	21 Nos
CCTVs	-	193 Nos
Linear Fire Detection Cable	-	Throughout Tunnel
Escape Route indications	-	440 Nos (at a distance of 50m on both side)
SCADA system	-	Illumination, ventilation systems, Power Supply, cameras, all sensors are controlled by SCADA.

Ventilation systems provided in Tunnel T-80 was approved by Railway Board (ML) based on RDSO's approval.

12. Review & Conclusion

12.1 The ventilation system provided in rail tunnels is not a fire fighting system in itself but a system to provide a safe escape route to passengers for small duration in one direction by directing the smoke in other direction, in case of fire emergency.

12.2 As per the existing guidelines of IRBM, the Ventilation system is being provided in the Tunnels having length of more than 2 km on Indian Railways. Based on these guidelines, Ventilation systems have been provided in the Tunnels on Konkan Railway, Eastern Cost Railway and Northern Railway.

12.3 In view of the multiple instructions given in the various documents (referred in para 3.1 to 3.8), the length of Tunnels needing Ventilation system is not clearly specified as to for what tunnel length, Forced Ventilation should be adopted, for diesel traction or for electrified routes. Presently tunnels more than 2 kms length are being ventilated on USBRL Project.

12.4 For Katra-Banihal section, depending upon the requirement based on Tunnel designs with Escape Tunnel or without Escape Tunnel, Consultant for Detail Design and Engineering need to be appointed for Ventilation systems specific to each tunnel design. Effort should be made to keep similar systems on all tunnels in order to reduce inventory of maintenance spares and training of staff.

12.5 It is necessary to get the guidelines issued for provision of Ventilation system in the Tunnels for electrified routes and non-electrified routes for all future works and for tunnels being constructed on Katra-Banihal section, since Railway Board has given the technical approval for providing ventilation systems in T-80 only being such a system provided for the first time on Indian Railways.

Flux-Cored Arc Welding (FCAW)

The superstructure of Chenab Bridge is a continuous welded girder. In fabrication of this superstructure, an important process of welding being employed is Flux-Cored Arc Welding (FCAW). This process was developed in early 1950s, but has not been widely used in India so far. This article explains the basic concept and method used in FCAW, its different variants and its relative advantages and disadvantages.

FCAW Process

In Flux-Cored Arc Welding, a consumable electrode containing a flux is continuously fed under conditions of constant voltage or constant current. The consumable electrode is of tubular construction with an outer metal sheath filled with fluxing agents plus metal powder. Protective flux is inside the tubular wire. The wire feed unit takes the filler wire from a spool and feeds it to the arc through a welding gun at a pre-determined and accurately controlled speed. Specially knurled feed rolls are generally used with flux-cored wires to assist feeding and to prevent crushing of the consumable. An overview of the equipment set-up is shown in Fig.1.

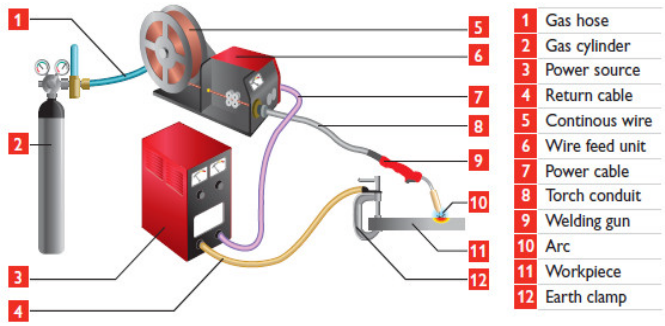
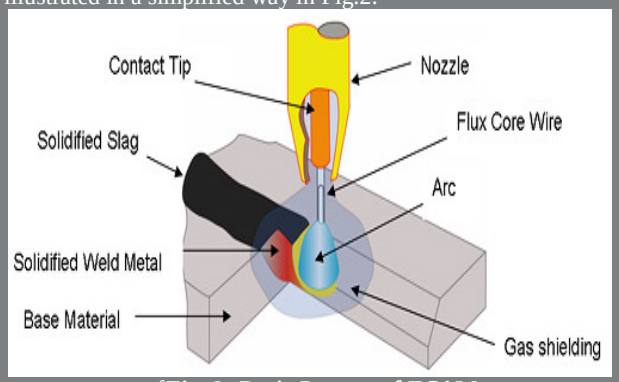


Fig.1: Schematic Diagram

The process uses the heat generated by a DC electric arc to fuse the metal in the joint area. The arc is struck between the filler wire and the work piece. Due to the heat generated by arc, melting of filler wire and the work piece in the immediate vicinity takes place. The entire arc area is covered by a shielding gas that protects the molten weld pool from the atmosphere. Generally, the flux itself provides the necessary protection from the atmosphere by producing both gaseous protection and liquid slag. Sometimes, the shielding gas in FCAW is supplied externally also. The basic process of FCAW technique is as illustrated in a simplified way in Fig.2.



f***Fig. 2: Basic Process of FCAW***

Types of FCAW

Based on the manner of providing the shielding gas, there are two types of Flux-Cored Arc Welding method. In first type, there is no need for external supply of the gas. In such a case, the core contains flux and various ingredients which decompose and generate a shielding gas for protecting the arc when exposed to the high temperatures of welding. Generally, an extension nozzle is used to support and direct the long electrode extensions that are needed to obtain high deposition rates.

Main advantages of this type are equipment portability, good penetration into the base metal and little effect of windy conditions. The drawbacks are that this process can produce excessive, noxious smoke and slag removal is quite difficult and time-consuming.

In the other type of FCAW, the shielding gas is supplied by an external source. The gases generally used for this purpose are Carbon Dioxide (CO_2) or Argon (Ar) or a combination of both (CO_2/Ar). A combination of 25% CO_2 and 75% Argon is the most commonly used gas in this method because it produces a stable arc, fewer spatters, and allows more of a spray transfer. In some cases, a mixture of Argon and Oxygen (Ar/O_2) is also used as shielding gas. This method is preferable for welding of thicker and out-of-position metals. In this, the slag created by flux is easy to remove and quality of weld is comparatively better. However, this method is suitable only for welding in closed chamber because windy conditions may cause loss of shielding gas which may result into induction of defects like porosity of the weld. Scheme of shielding by external gas is illustrated in Fig.3.

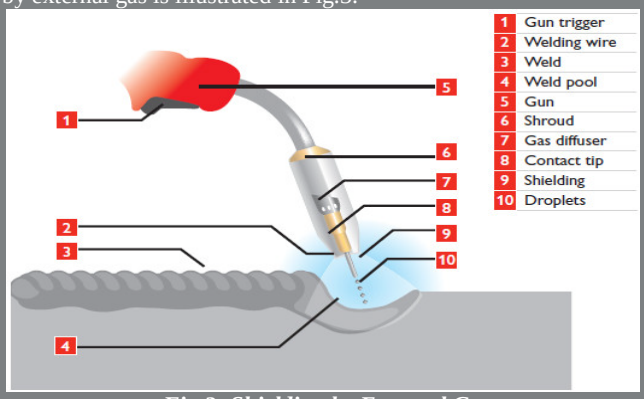


Fig.3: Shielding by External Gas

General Requirements

General requirements for the materials and equipment in the FCAW process are as listed below:

1. **Shielding Gas:** Carbon Dioxide / Argon.
1. **Metal Consumables:** FCAW wire.
2. **Other Consumables and Accessories:** Anti spatter compounds, Contact tips, Cylinder trolleys, Earthling clamps, Nozzles and torches, Hoses and fittings, Welding cable.
3. **Gas Equipment:** Regulator and flow meter.
4. **Other Equipment:** Fume extractors, Welding machines, Wire feeder.
5. **Personal Protective Equipment:** Aprons, Boots, Eye protection, Dust masks, Ear muffs, Face shields, Gloves, Hand shields and helmets.

By
Vikas Boora,
Executive Engineer/USBRL

Advantages

Flux Cored Arc Welding process offers number of advantages over the other methods of welding. Some of the advantages are enumerated here:

- In FCAW, deposition rate is quite high on account of the fact that it can use larger diameter wires.
- This process makes it possible to achieve deeper penetration with relatively lesser number of melting defects.
- FCAW can be used for welding in all positions easily. As compared to Shielded Metal Arc Welding (SMAW), it calls for lesser skill requirements from the welder.
- This method is cost-effective and gives faster progress as the welder down time for electrode changing is minimised.
- FCAW gives quality welds with good appearance with lesser effort.
- This type of welding can be employed for a wide range of steel types and over a large range of component thickness conveniently.

Disadvantages

In spite of numerous advantages, FCAW suffers from certain inherent drawbacks also. Some of these are:

- External gas shielded version of FCAW is sensitive to wind effects as wind may cause the breaking of protective gas layer and intrusion of moisture and other external impurities. However, this drawback can be overcome to a large extent in the self-shielded version of FCAW in which no externally supplied gas is used.
- The equipment used in FCAW is not as portable as the one used in Manual Metal Arc Welding (MMAW).
- As compared to Gas Metal Arc Welding (GMAW) and Shielded Metal Arc Welding (SMAW), more smoke and fumes are produced in Flux Cored Arc Welding.
- Storage and handling of wire for FCAW calls for higher degree of care and sensitivity in order to prevent damage and corrosion.
- Sometimes, access to the joint to be welded may be restricted on account of the size of welding gun.

A Short Insight in the Design Methodology for Tunnels T1-T5

Abstract:

This paper addresses the design methodology (Civil Works) used by Geodata (GD) in the tunnels (T1- T5) of the USBRL project of Norhern Railway, and more specifically the classification of the rock mass behaviour during excavation using an innovative approach developed by GD. In addition, it focuses on the practical application of this method with the so called "GD multiple graph", which may be used for preliminary design as well as during excavation to determine the rock mass behaviour and select the most appropriate support section. This classification approach uses a combination of two (2) analyses: the first is a quantitative assessment of the deformation index of tunnel face and cavity and is based on the results of stress analysis (continuum or equivalent-continuum model), while the second focuses on the gravitational instabilities and is based on a geostructural analysis (discontinuous model) using the RMR to quantify the geostructural characteristics of the rock mass and its self supporting capacity. The matrix that results from the double classification system approach allows for an upfront optimal focus of the design problem and a rational choice of the stabilization measures as a function of the most probable potential hazard. In both analyses a probabilistic approach is used to capture the variability and uncertainties of the geomechanical and boundary conditions.

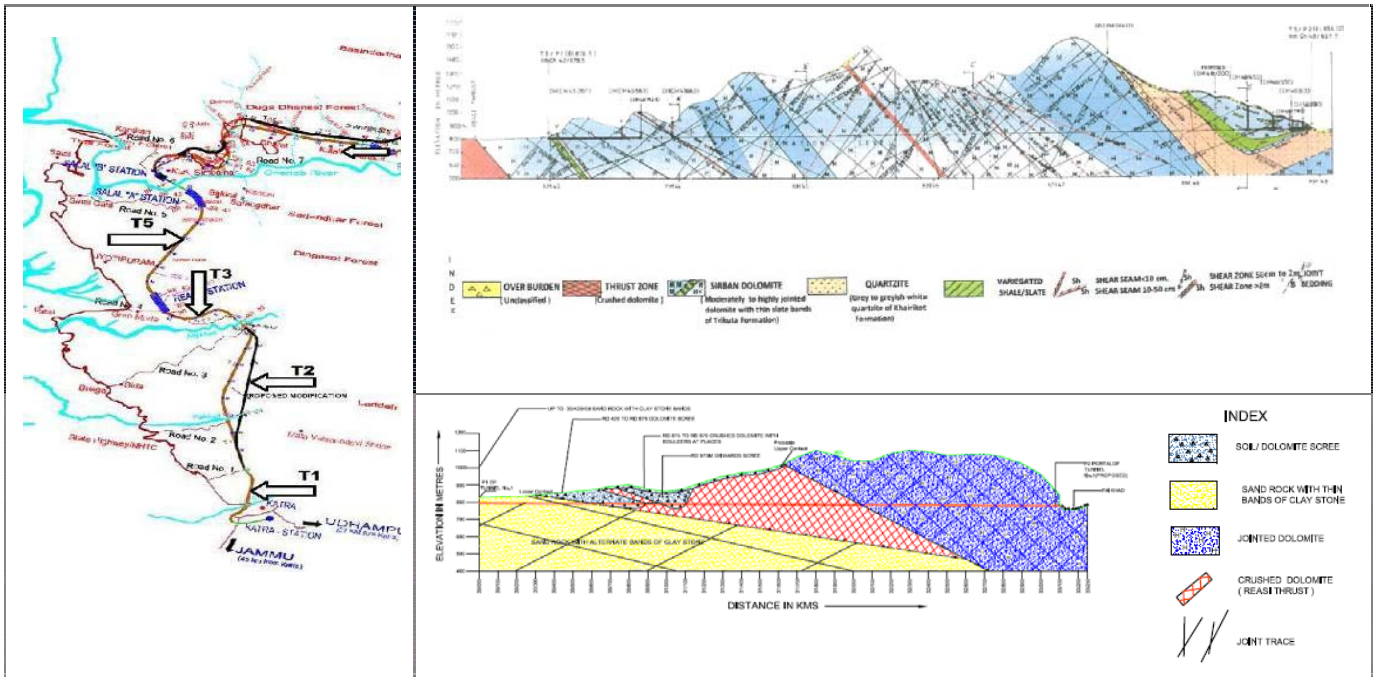
PROJECT DESCRIPTION:

The new Rail Link Project of 271 km long between Udhampur-Srinagar-Baramulla (USBRL) is one of the most important Indian Railways' projects in the J & K State with the aim to connect the Kashmir valley with the whole Indian Railways' transportation network. Geodata Engineering S.p.A. has been engaged to provide Design Consultancy for the Tunnels T1 to T5 proposed to be constructed with NATM approach.

Current Status of Tunnels:

- T1 in its current modified alignment is 3160m long out of which, 1020m have been excavated on the P1 side and 108m on the P2. It starts at Ch 30+000 (P1 portal at Katra) and ends at Ch 33+160 (P2 portal at Paikhad bridge).
- T2 in its current modified alignment is 5163m long. Excavation works of the T2 tunnel have not started yet.
- T3 tunnel **starts at** Ch 39+201(P1 side) and is 3009m long. Excavation was completed in September 2012 and final lining is currently in progress.
- T5 is 5959m long out of which, 1096m have been

excavated on the P1 side and 267m on the P2. It starts at Ch 42+978.50 (P1, Reasi end) and ends at km 48+937.50 (T5P2, Bakkal).



By
Chrysanthos Alexandrou (Project Consultancy Head, Structural Engineer M.Sc)
Dimos Papantonis (Senior Engineering Geologist M.Sc)

Regional Geological Setting:

The project, geologically, is located in the lesser Himalayan Zone, which has suffered by the tectonic activity of the Main Central Thrust (MCT), the Murree thrust, the Panjal thrust and by the still active Main Boundary Thrust (MBT) to the south, known also as the Reasi Thrust (RT). Due to this intensive activity which occurred through the process of folding, faulting, thrusting, overthrusting, slope and gravity induced movements, the rock mass has intensely deformed, highly jointed, sheared and shattered into fragments of small blocks (like sugar cubes) and in some cases into completely mylonitised and decomposed particles (shear zones), which in presence of water turns into running ground.

Local Geology along Tunnel T1:

The first 600m of the tunnel is in the Middle Siwalik Formation, which is composed of very soft, grayish sandstone, siltstone intercalations, thin bands of clayish shale and boulder-conglomerates.
In the central 1500m portion the tunnel crosses the Reasi Thrust (RT) zone, which is formed mostly of crushed gritty material and fragments of dolomite (scree material), often charged with water. This regional tectonic boundary, known as MBT or RT, represents one of the most active zones of the Himalayas from a tectonic point of view.
The final 1060m portion of the tunnel passes the Sirban Dolomite Formation, which thrusts over the Middle Siwalik Formation and forms generally hard and highly to moderately jointed cherty dolomites and limestones with at least three (3) major joint sets, some of which are associated with shear zones and occasionally are charged with water.
Tunneling through the Reasi Thrust Zone, especially when charged with water, is difficult and time consuming since crushed material starts flowing (running) into the tunnel. To tackle such difficult ground conditions special excavation methods and support measures such as: multidrifting methods, advance drainage, pregrouting, advance roof support using a pipe roof umbrella arch etc. have to implemented.

Local Geology along Tunnel T5:

The T5 tunnel passes through the following Geological formations:
Sirban Group, a carbonate complex of a Permo-Carboniferous age, in which dolomite is predominant and is thrusted over the Siwalik Formation along a NNE steep dipping thrust. Proceeding towards the NE, these carbonate rocks are overlain by Eocenic sequence of the Murree Zone. The middle and the SW part of the T5 tunnel (T5P1 side) is characterized by the presence of Trikuta Formation, while in the NE sector (T5P2 side) by the presence of the Khairikot Formation, both belonging to the Sirban Group.
Trikuta Formation, consisting mainly of hard and thinly to thickly bedded dolomite with thin bands of slates. The dolomite is moderately to highly jointed and at places Cherty, Blocky, or Crumbly and Sheared.
Khairikot Formation, comprising of quartzites, dark grey and variegated slates and dolomite/limestone bands. The rock of the Khairikot Formation falls under extremely poor to good category.
Tunneling through highly jointed dolomites may give rise to problems of over-breaks and rock-fall or roof collapse due to intersection of closely spaced transverse and cross joints with bedding joints.
Flowing ground conditions, cavities and chimney formation may also occur within this category of rock due to increase in joint and crushing intensity. In addition, squeezing conditions are also likely to be met in crumbly and sheared dolomites, especially when charged with water and under high overburden.
Occurrence of heavy seepage of water and formation of cavities at the crossings of shear zones in the tunnel are anticipated and hence will require special and suitable tunneling techniques and support systems such as those outlined for T1 tunnel to negotiate the difficult zones.

introduction

The design and construction of long and deep tunnels, particularly those at great depth, is generally associated with a high level of risks due to a number of uncertainties involved, and the success of such projects depends very much on the correct choice of the excavation method and the support sections.

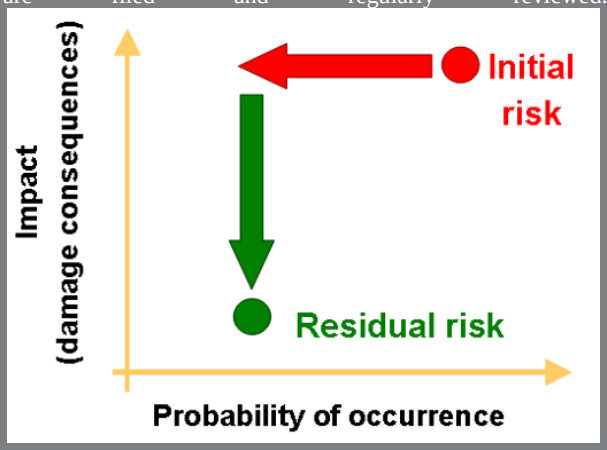
In making the correct choice for a given project, the presence of adverse conditions and the frequency of their occurrence are of paramount importance to the choice.

The point is to recognize the risks and "to be wise a priori", since most risks can be effectively managed through the use of a Risk Management Plan (RMP), which should be adopted from the early design stages to the construction and operation phases, to minimize the occurrence of risks and/or mitigate their consequences. The key elements of a typical RMP for a tunnelling project are:

- Risk identification;
- Risk evaluation or quantification;
- Risk mitigation (i.e., definition of primary responses to the identified risks including correct design-construction choices);
- Assessment of residual risks;
- Pre-design of counter measure for the management of residual risks during construction.

Normally, a RMP is defined to manage properly the Residual Risks, the Accepted Risks, and any new risks that may arise in the subsequent stage. A RMP requires pre-design of the so-called "Counter Measures" as well as a corresponding set of rules for the activation of each counter measure in the subsequent (especially construction) stage. Furthermore, a RMP should not be static, but dynamic, in other words, it should be constantly reviewed and updated. A RMP is based on the following principal definitions:

- A **hazard** is a potential inherent source of damage.
- The **impact** expresses the damage intensity or consequence upon individual's health and safety and/or integrity of property and environment resulting from one or more *hazards* being occurred.
- The **probability of occurrence (P)** of a hazard event is an expression for its perceivable likelihood of occurrence.
- The **risk,** broadly speaking, can be defined as a combination of the related hazard/s occurrence likelihood and its/their elementary or combined effects (*damage*).
- The **initial risk** is the risk level evaluated in the absence of any preventive risk mitigation or reduction measures.
- The **residual risk** quantifies, at any stage of a Project, the level of risk exposure after preventive mitigation or reduction measures have been adopted. To reduce the initial risk, one can either seek to lower the risk probability of occurrence, or its potential impact or both, as shown in **Figure 1-1**.
- The **hazard and risk register** is an archive where all the relevant information about the hazards and the associated risks are filed and regularly reviewed.



- ***Figure 1-1*** *- Risk reduction strategy*

From the risk assessment point of view and according to past experience there is a deep conviction that:

- Tunnel design and risk assessment are mutually dependent of each other and must go hand-in-hand;
- A good and useful risk assessment can be obtained only through a correct understanding of the design and the construction process(es) involved, and only if it is done by a multi-disciplinary team of experienced people;
- A sound and vigorous design of a tunnel can be achieved only if it is developed on the basis of a comprehensive risk assessment.

From the risk management point of view it is strongly believed that:

- The tunnel design itself is one of the most effective measures to reduce the initial-risk levels. Thus, time-wise, risk analysis should be done through and in parallel with the design development process and construction, and more important, the analysis of the initial risks should guide the development of the tunnel design.
- The correct choice of the excavation method for a given tunnel is the "first risk-mitigation measure" or simply, the primary response to the identified principal risks.

GENERAL APPROACH

The Detailed Designs of the KRCL tunnels (T1-T5) were developed principally in accordance with the SIG (Italian Tunneling Association) "Guidelines for Design, Tendering and Construction of Underground Works", 1997 and were adapted to the KRCL contract requirements.

These "Guidelines" are based on identification of the "key points" and their organization into "subjects" representing the various successive aspects of the problem to be analyzed and quantified during design/tendering/construction. The degree of detail of each "key point" depends on the peculiarities of the specific project and design stage. The process involves the following essential phases:

A. General setting of the underground work
B. Geological survey, and
C. Geotechnical-Geomechanical studies
D. Prediction of mechanical behaviour of the rock masses
E. Design choices and calculations
F. Design of auxiliary work and tender documents
G. Monitoring during construction and operation

OBSERVATIONAL METHOD

The principles of the Observational Method were first described in detail by R.B. Peck (1969), who set forward the procedural steps summarized in Figure 1-2.

The design developed is typically based on analyses, however analysis cannot replace judgment. Possible modes of failure – particularly those of a sudden or brittle nature, or those which could lead to progressive collapse – must be identified and assessed carefully.

It is a fundamental element of the Observational Method to overcome the limitations of analysis by addressing actual conditions with sound engineering judgments. Feedback and assessment from observations (monitoring data) must be timely collected and interpreted in order to confirm predictions or to provide adequate warning of any undue trends in ground movements or loadings.

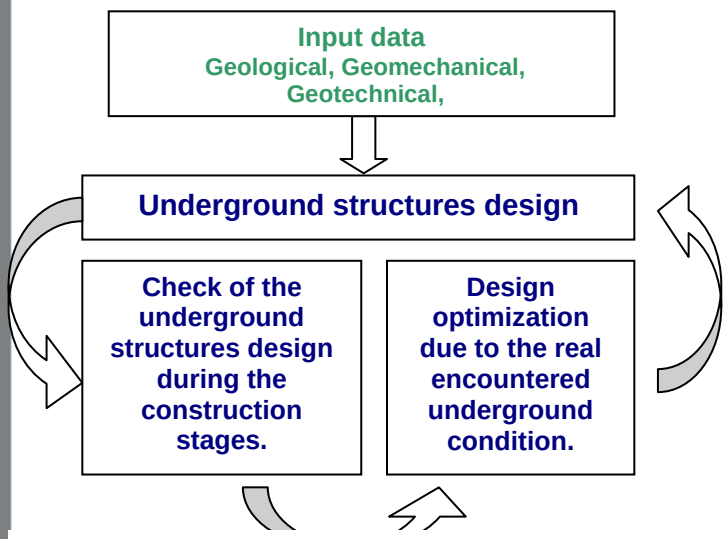


Figure 1-2 *- Observational method*

In addition, while the adopted design approach follows some common concepts of other approaches, it places a stronger emphasis on the prediction of the rock mass behaviour during excavation that is based on real parameters and not on a purely visual observation that may be subjective. This way, a deeper understanding of the real behaviour can be acquired and the appropriate counter measures adopted..

DESIGN METHODOLOGY

GD CLASSIFICATION OF THE EXCAVATION BEHAVIOR

Empirical methods (e.g. Q System) which follow the simple steps of establishing the input parameters, calculation of the Q-value and subsequent definition of the support system is an overly simplified approach with many limitations in the case of highly jointed or crushed dolomite and shear zone or worst yet the Reasi thrust encountered on the KRCL project where supplementary methods must be applied (Palmstrom and Broch [2006]). Emprical methods, if used for Geomechanical Classification, have a number of limitations, such as:

- They are more reliable for dimensioning radial stabilization measures in fractured rock masses where mainly gravitational failures occur. Their application to weak rocks and/or to structurally complex rock formations is problematic;
- According to SIG, Geomechanical Classification can not be the only means of design, particularly in more detailed phases and permanent lining. The same opinion is shared by Bieniawski (1997) who recommends that rock mass classification of its own should be used for preliminary purposes only;
- Similarly, Hoek & Brown (1980) recommend geomechanical classification only for general use in preliminary design;
- The limits of using only empirical design methods are even more evident under difficult geomechanical conditions, where:
  - Analytical method is essential for the study of the ground-structure-interaction and dimensioning of stabilization measures;
  - Special interventions are often necessary (e.g. face/contour pre-confinement, pre-support, rock mass improvements etc) generally not proposed by classification systems

Contrary to the above, the GD design approach for evaluating the response upon excavation and then the most probable hazard is analytical and is performed for each rock mass unit (geomechanical group) necessarily taking into account both stress analyses and geostructural analyses, as shown in Figure 2-1.

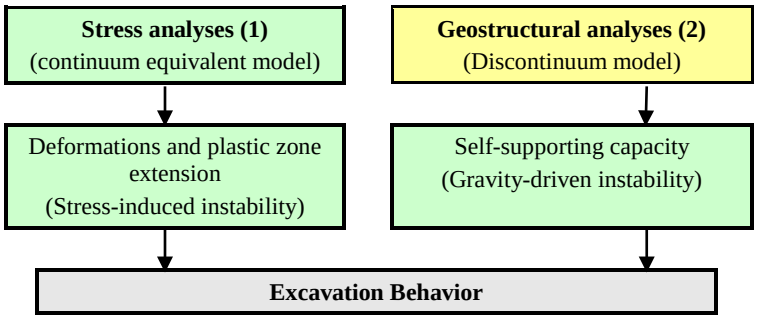


***Figure 2.1**: Flow-chart illustrating the rationale of the excavation behaviour forecast analysis*

Stresses analyses (1): are based on a continuum or continuum-equivalent geomechanical model; they are mainly aimed at defining classification indexes and expressing the potential intensity of the expected deformation phenomena.
In the common practice, quite often "competency" indexes are being used, which represent the ratio between stress conditions around the tunnel perimeter and the mobilized rock-mass strength (Hoek & Marinos, 2000) or alternative indexes, based on more developed analytic tools, which directly express the expected behaviour in terms of deformations and/or extent of the plasticized zone, as the one adopted in the analysis of the KRCL project.

- *Empirical methods*, which by quantifying the rock mass typical parameters, output indications on the expected behaviour are obtained, especially in terms of self-supporting capacity (e.g. Bieniawski's RMR system);

The matrix that results from such a double classification approach allows
for an optimal upfront focus of the specific design problem and leads to a rational choice of the type of stabilization measures as a function of the most probable potential deformation phenomenon (→Hazard) that is associated to the different stress and geostructural combination (Table 2.1). In both systems a probabilistic approach is used to capture the variability and uncertainties of the geomechanical and boundary conditions.

The GD methodology involves the following basic steps:

- Definition of the **Geomechanical Groups** (**GG**);
- Evaluation of the excavation behavior for each GG;
  - Definition of **Behavioral Category** (BC), and
  - Definition of **Geomechanical Hazards** (GD classification, Note 1)
- Choice of the Stabilization Measures (definition of the support section types) for each expected hazard;
- Dimensioning and verification of temporary supports and final lining with the evaluation of the relative Safety margins (through the capacity-demand analysis);
- Note 1: Geomechanical hazards are mainly related to ground behaviour upon excavation, thus taking into account the intrinsic properties of rock masses and the associated stress conditions.

↓ ANALYSIS →			Geostructural →	Rock mass				
				Continuous ↔ Discontinuous ↔ Equivalent C.				
Tensional↓				RMR				
Deformational response ↓	δ_0 (%)	R_{pl}/R_0	Behaviour category ↓	I	II	III	IV	V
Elastic ($\sigma_\theta<\sigma_{cm}$)	negligible	-	a	STABLE				
			b	↕	UNSTABLE WEDGES	↔		CAVING
Elastic - Plastic ($\sigma_\theta\geq\sigma_{cm}$)	<0.5	1-2	c	SPALLING/ ROCKBURST				
	0.5-1.0	2-4	d					
	>1.0	>4	e		↔			SQUEEZING
			(f)	→ Immediate collapse of tunnel face ↑				

***Table 2.1**: General scheme of the excavation behaviour (GD Classification*)*

Notes: (*) Russo and Grasso, 2006; δ_0=radial deformation at the face (prevalent classification criterion); R_{pl}/R_0=plastic radius/radius of the cavity; σ_θ=max tangential stress; σ_{cm}=rock mass strength. In the brittle failure domain, the deformation indices of the stress analysis are not representative and can be taken just as an indicator of the increasing potential of failure. The limits of shadow zones are just indicative.

Geostructural analyses (2): can be broadly grouped in two (2) sets:

- *Limit equilibrium methods*, which are normally utilized when both rock mass spatial patterns of discontinuities orientation and geomechanical properties are well known;

Additional comments to Table 2.1**:**

- The occurrence of 'rockburst' phenomena is dictated by the presence of brittle rocks of high strength, while, in other cases, the occurrence of shear failure mechanisms is more probable.

- The 'squeezing' behaviour is characterized by relevant time-dependent deformations and its occurrence may be foreseen in connection with rocks of low strength and high deformability; in other cases, deformations are mainly of plastic character (not viscous) and often associated with a caving behaviour.

In both cases, additional analyses are performed to predict the severity of the phenomena.

The steps involved in defining the behaviour categories are schematically depicted in Figure 2.2.

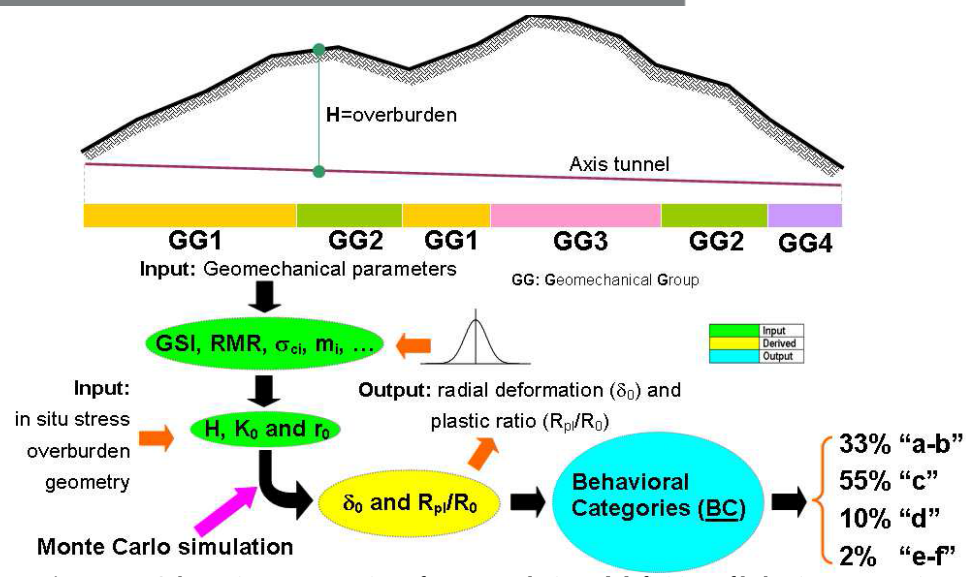


***Figure 2.2**: Schematic representation of stress analysis and definition of behaviour categories*

In the stress analysis **(1)** of the classification process, the excavation behaviour of the different rock masses (GG) are analysed under the existing stress conditions at tunnel level, under the theoretical hypothesis of absence of any design interventions.

The assessment of deformation response to excavation taking into account the radial deformation at the face (δ_0) and the ratio R_{pl}/R_0 of different Rock Mass Unit (RMU) and for the hypothesized stress conditions at tunnel level is carried out by integrating a probabilistic approach with the "Convergence-Confinement Method" (CCM, Carranza-Torres, 2004).

Table 2.1, shows six (6) Behaviour Categories (BC) which are defined below in detail. They range from the best ("a" class) to the worst condition ("f") (Russo et al. 1998). More precisely, on the basis of stress analysis, four (4) conditions are identified as a function of the cited deformational index (δ_0) and a further subdivision is considered for the special cases of stable condition (class "a") and of immediate instability of tunnel face (class "f"):

- **Behavioural category "a-b":** the strength of the rock mass exceeds the stress level at the face and around the cavity. The ground behaviour is elastic and in general deformations are of negligible magnitude. Instability phenomena may be only related to wedge failures and this possibility is low if, for the absence of discontinuities, the rock mass can be assimilated to a "continuum" (category "a") and is high, in the opposite case, if it may be related to a "discontinuum" medium (category "b").
- **Behavioural category "c":** the stress level at the face approaches the strength of the rock mass (i.e. $\sigma_\theta \approx \sigma_{cm}$). Therefore, the behaviour is elasto-plastic but resulting in minor instabilities. The radial deformation ($\delta_0 = u_0/R_0 < 0.5\%$), where: u_0 is the ratio of radial displacement at the face (u_0) and R_0 to the equivalent cavity radius. Away from the face, on the periphery of the cavity, the stresses exceed the strength of the rock mass, resulting in the formation of a plastic zone around the excavation, frequently having a width less than R_0 (i.e. $1 < R_{pl}/R_0 < 2$).
- **Behavioural category "d":** the stress level at the face exceeds the strength of the rock mass (i.e. $\sigma_\theta > \sigma_{cm}$). The deformation at the face $\delta_0 = 0.5 \div 1.0\%$, while away from the face the indicative ratio Rpl/R0 is often in the range of 2÷4. This condition is frequently comparable with the lower limit of Severe squeezing (Hoek & Marinos, 2000).
- **Behavioural category "e":** differs from category "d" with respect to the magnitude of deformation at the face and away from the face. At the face $\delta_0 > 1.0\%$ while the ratio R_{pl}/R_0 is very high (frequently >4). This condition is frequently comparable with the lower limit of Very severe squeezing (Hoek & Marinos, 2000).
- **Behavioural category "f"**: is characterised by immediate collapse of the face during excavation (impossible to install support). This behaviour, not necessarily highlighted by stress analysis, is generally associated with non-cohesive soils and cataclastic rock masses such as those found in fault zones, especially under conditions of high hydrostatic pressure and/or high in-situ stresses.

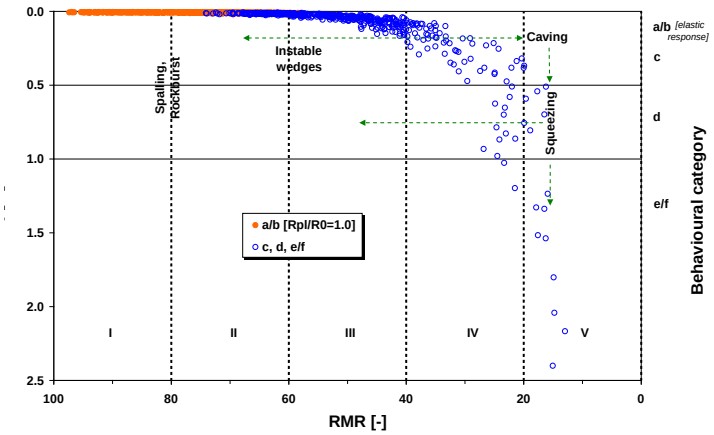


***Figure 2-3** – Example of application of the probabilistic approach for evaluating the expected excavation behaviour and related hazards.*

More specifically, the following procedure is applied:

- Input parameters are used with the most appropriate probabilistic distributions and for the lithostatic pressure the mean value between horizontal and vertical in-situ stress are considered;

- The Monte Carlo method is used for the probabilistic analysis, with Latin-Hypercube sampling mode (1000 trials), to randomly generate each possible parametric combination;
- The Convergence-Confinement method (CCM) is applied to each parametric combination, to probabilistically quantify the classification indexes and behavioural categories.

An example of application of the described probabilistic-analytical method is shown in Figure 2-3. In such a way, the probability of occurrence of the different excavation behaviour (→*Hazards*) is derived for each analyzed rock mass (GG) and, consequently, the associated support section types.

DEFINITION OF THE SUPPORT SECTIONS (MITIGATION MEASURES)

On the basis of the expected geomechanical behaviour and related hazards, the appropriate mitigation measures and consequently, the support section types are defined, following the basic rational simplified in the scheme of Figure 2-4 and in the related Table 2-2 and 2.3. Different instability phenomena (hazards) involve different **Design actions** and **Mitigation measures**

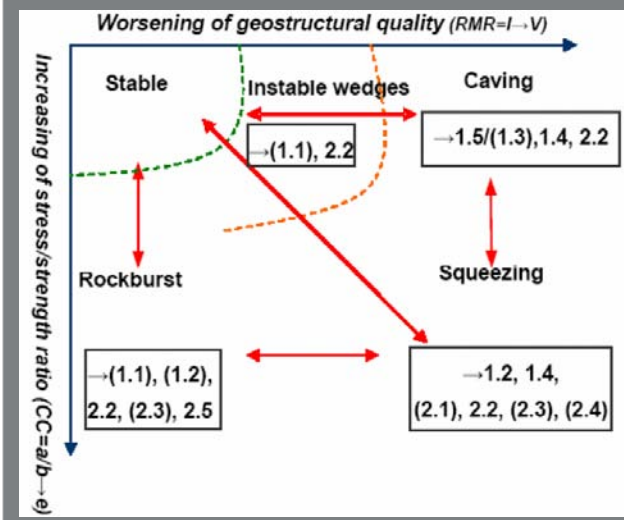


Figure 2-4:

Rational for the basic selection of mitigation measures as a function of the excavation behaviour (Russo and Grasso, 2006, see Tab.2-2)

***Table 2-2** – Example of mitigation measures for different excavation behaviour (Fig.2-4)*

SN	Design action *	Stabilization measures (example)
1	**In advancement to the excavation**	
1.1	Pre-confinement of unstable wedges; increase self-supporting capacity of rock mass	**Forepoling**
1.2	Pre-reinforcement of rock mass contour	**Pre-requalification of rock mass by fully connected elements; grouting**
1.3	Pre-confinement of the excavation contour	**Sub-horizontal jet-grouting canopy**
1.4	Tunnel face pre-reinforcement	**Injected fiber-glass elements, jet-grouting, etc.**
1.5	Pre-reinforcement of excavation contour	**Umbrella arch**
2	**During excavation**	
2.1	Over-excavation to allow convergences	
2.2	Radial confinement	**Bolting (instable wedges confinement); Shotcrete (SFRS or with wire mesh); steel ribs**
2.3	Rock mass reinforcement	**Requalification by means of fully connected elements**
2.4	De-confinement (to allow convergence for stress unloading)	**Sliding steel-ribs; joints and/or deformable elements in the shotcrete**
2.5	**Rockburst protection**	**Anchored double-torsion steel mesh, integrated by high energy adsorbing system (steel mesh/yielding bolts/fibre-reinforced shotcrete)**

Notes: *Stabilization measures are generally supplemented by systematic drainages, as resulting by continuous probing in advancement to excavation.

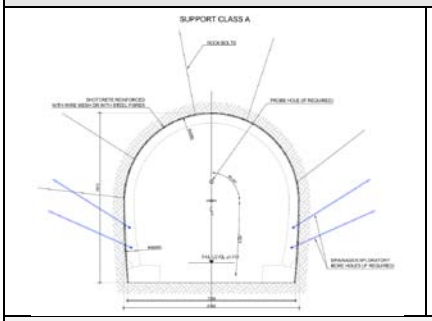
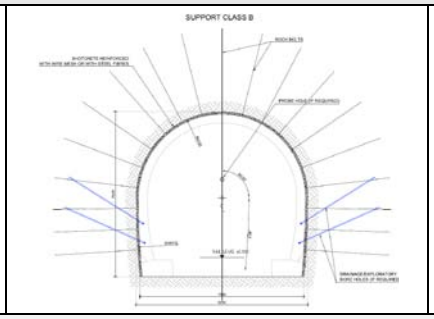
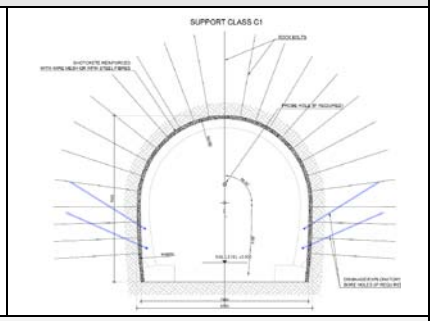
The rational behind the section (support) type selection, as a function of the geomechanical classification of reference, is summarized in Table 2-3.

Table 2-3 – Criterion of application of the support section types, as adopted for T1 Tunnel

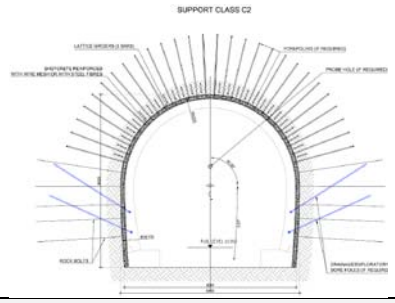
Prevalent Hazard		Geomechanical classification		Excavation behaviour	Section Type
Gravity driven	**Stress induced**	**GD**	**RMR**		
H1	**Wedge instability/ Rockfall**	**a**	**I**	Stable rock mass, with only possibility of local rock block fall; rock mass of very good quality with elastic response upon excavation	**A**
		b	**II**	Rock wedge instability; rock mass of good quality with elastic response upon excavation	**B**
		c	**III**	Pronounced tendency to rockfall; rock mass of fair quality, with possible occurrence of a moderate development of plastic zone	**C1**
H2	**Spalling/ Rockburst**	**c**	**I-II**	Mild brittle failure even associated to rock minor rock block ejection; overstressed hard, good rock mass (→Minor spalling/rockburst)	
		c	**I-II**	Sudden brittle failure; overstressed hard, good rock mass (→Moderate spalling/rockburst).	**(C3)**
		c	**I-II**	Sudden and violent brittle failure, even associated to rock block ejection; highly overstressed hard, good rock mass (→Severe spalling/ heavy rockburst)	**(C4)**
H3	**Plastic deformations/ Squeezing**	**d**	**III-IV-(V)**	Development of plastic/viscous deformations; overstressed fair to poor rock mass, resulting in a significative extrusion of tunnel face and radial convergences (→Severe Squeezing)	**D**
		e	**III-IV-(V)**	Intense development of plastic/viscous deformations; overstressed fair to poor rock mass, resulting in a large extrusion of tunnel face and radial convergences (→Very Severe Squeezing)	**E**
H4	**Caving/ Flowing ground**	**c**	**IV**	Gravity-driven instability; reduced self-supporting capacity of poor rock mass, generally associated to a moderate development of plastic zone	**C2**
		(e)/f	**V**	Severe gravity-driven instability, with immediate collapse of the tunnel face/excavation contour, including flowing ground; very poor quality, cataclastic rock mass, generally under conditions of high hydrostatic pressure/water inflow (fault zones, etc.)	**F**

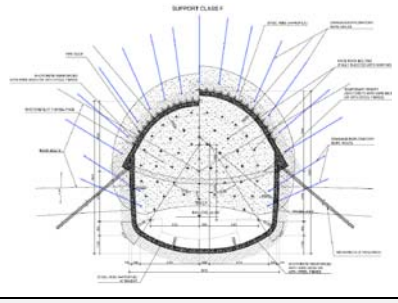
Notes: The terms for Rockburst and Squeezing intensity are referred to the Canadian Rockburst Support Handbook (CRSH,1996) and Hoek & Marinos (H&M, 2000), respectively. Incidentally, in the specific case for T1 tunnel, the application of the section type C3 and C4 it is not likely to be applied.

Table 2-4 – Section type definition for D & B

Gravity Driven Instabilities: Wedge Instability/Rock fall		
		
Support Class A, B and C1		
Main Design Action	**Mitigation Measures**	
Confinement of rock wedges	Bolts and fiber reinforced shotcrete (SFRS)	
Control of water pressure/inflow	Drainage in advance	
Long term stability	Concrete final lining	

Gravity Driven Instabilities: Rockfall/Caving & Severe Caving (Faults ..)

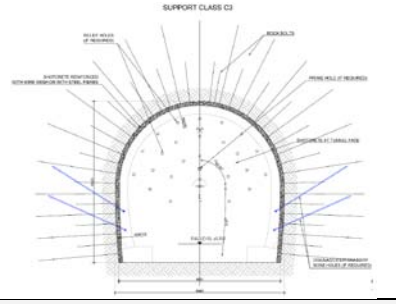




Support Class C2, and F

Main Design Action	Mitigation Measures
Increase self-supporting capacity	Forepoling – Pipe roof umbrella
Stabilization of tunnel face (F)	Pre-reinforcement by fiberglass elements (F)
Control of water pressure/inflow	Drainage in advance
Radial reinforcement and Confinement	Lattice girders, Steel ribs, SFRS, Anchor bolts
Long term stability	Concrete final lining with invert (F)

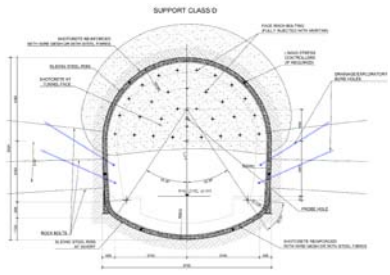
Stress Induced Instabilities: Brittle failure: Rockburst

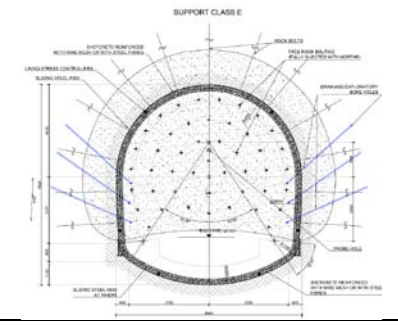


Support Class C3

Main Design Action	Mitigation Measures
Control brittle failure/Rock ejection	Short radial bolting and wire mesh
Control of waster pressure/inflow	Drainage in advance
Radial reinforcement and Confinement	SFRS, Anchor bolts
Long term stability	Concrete final lining

Stress Induced Instabilities: Plastic/viscous behaviour: Squeezing





Support Class D (severe squeezing) and E (very severe squeezing)Resistance (D) and Yielding (E) design principle

Main Design Action	Mitigation Measures
Stabilization of tunnel face/contour	Pre-reinforcement by fiberglass elements
Control of waster pressure/inflow	Drainage in advance
Active load reduction (E)	Over-excavation. Sliding ribs, Joint in shotcrete or LSC elements
Radial reinforcement and Confinement	Steel ribs, SFRS, Anchor bolts
Long term stability	Concrete final lining

Distribution of the various support types along the tunnel length is established on the basis of the criterion of application as shown in the example below for T1 tunnel, Figure 2.5.

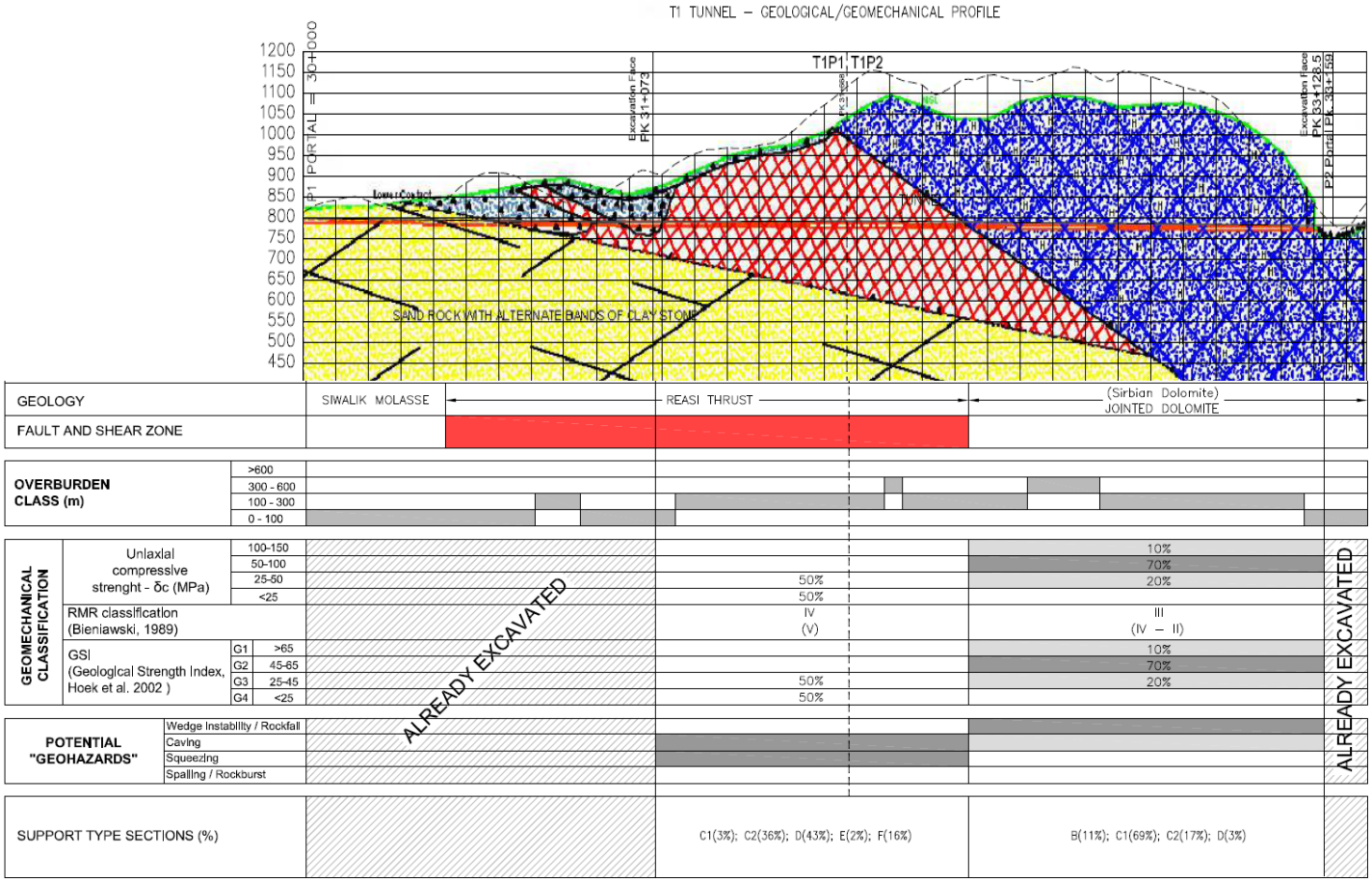


***Figure 2-5** – Support type distribution, Tunnel T1*

IMPLEMENTATION OF THE GD CLASSIFICATION SYSTEM

The practical implementation of the GD classification system in the preliminary design phases, as well as during tunnel construction can be readily obtained by using the multiple diagram of Figure 2-6. An illustrative example is provided below for reference.

Explanation Notes:

1) The Competency Index (IC) is the ratio between rock mass strength (σ_{cm}) and the max tangential stress (for circular tunnel and k=1, $\sigma_\theta = 2\gamma H$, where: γ is the rock mass density and H is the overburden).

2)

3) The GSI (Geological Strength Index) in the first quadrant (I) is obtained by the "**quantitative**" approach proposed by Russo (2007, 2009): Alternatively, the original "**qualitative**" chart of Hoek and Marinos, (2000) can be used as well and then enter quadrant II directly with the GSI value.

4)

General steps on the use of the Multiple graph:

The graph is entered from the first (I) quadrant (lower right hand side) and proceeding clockwise to the left bottom graph (II), then up to the third (III) and then to the right on the fourth (IV) quadrant

(i.e. I□IV). The steps in the use of the multiple graph are as follows [in parenthesis the representative property]:

I. Determine **GSI**: Rock block volume [V_b] + Joint Conditions [jC] □□Rock Mass Fabric [**GSI**]

II. Determine □$_{cm}$: Intact strength □[$_c$] + Rock Mass Fabric [GSI] □□Rock mass strength [□$_{cm}$]

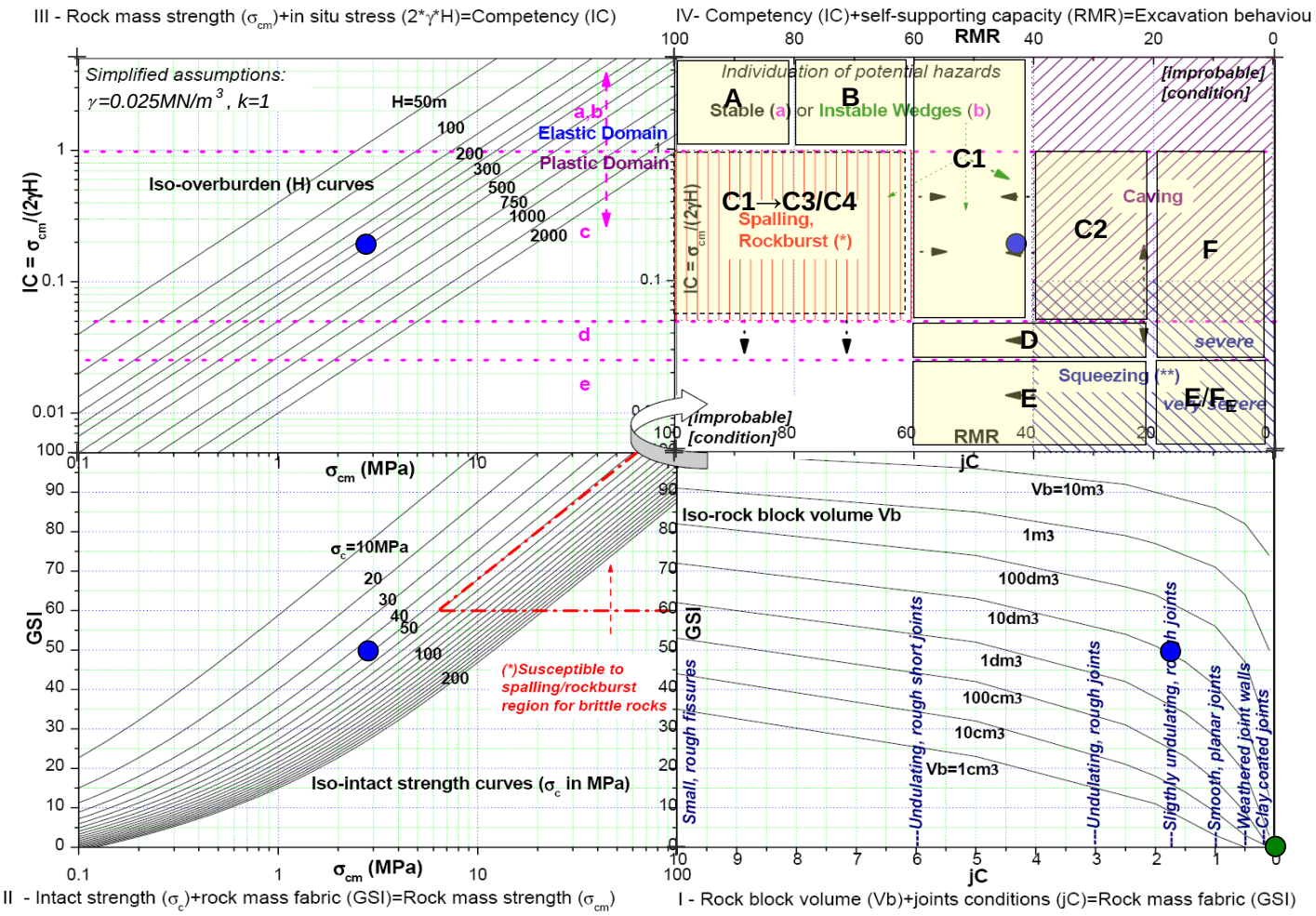
III. Determine **IC**: Rock mass strength□[$_{cm}$] + In situ stress□[□] □□Competency [IC]

IV. Determine Hazard & support category: Competency [IC] + Self-supporting capacity [RMR] □□Excavation behaviour [*Hazards*]

Illustrative example:

I. Fractured dolomite with Rock block volume Vb □□10dm^3 and slightly undulating, rough joint jC=1.75 □□GSI □□50

II. With GSI □□50 and Intact rock strength □$_c$=50MPa □□Rock mass strength □$_{cm}$=2.8MPa



(*) only for the susceptible region, otherwise the development of plastic region and moderate radial convergences are more probable depending also from the length of the potential proned zone: given a possible "silo effect", for short zones included in good quality rocks, a caving behaviour it is most likely

CONCLUSSION

The behaviour of young Himalayan rock masses cannot be easily determined due to the uncertainties in characterizing their anisotropy and heterogeneity. The problem becomes more difficult when zones of completely crushed and sheared dolomite are encountered. When charged with water, this completely decomposed material will manifest itself as running or flowing ground and under high overburden may experience squeezing. In this complicated medium, a proper methodology for rock mass classification, such as the one described, that will take into account both the results of stress analysis as well as the geostructural characteristics of the rock mass and then its self-supporting capacity is of paramount importance to assure a rational choice of the stabilization measures. The double classification system used by Geodata for design together with the more practical application of the multiple graph for rock mass classification during excavation allow for an optimal focus of the design problem followed by a rational choice of the stabilization measures as a function of the most probable potential deformation phenomena and thus help to increase safety and optimize the overall excavation process.

Acknowledgements: the authors would like to thank Dr Giordano Russo and Engineer Michele Palomba of Geodata Engineering S.p.A. for their review and valuable comments.

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Cavity Formation and its Rectification in Adit-II of Tunnel T-48 in Dharam-Banihal Section of USBRL Project

Introduction

Adit-II of Tunnel T-48 in Dharam-Quazigund section is located at Kohli Village around 6.35km from South Portal of T-48 along the tunnel alignment, in Gool Tehsil of Ramban District, J& K. The length of this Adit is 803.00m.

On 24th October, 2013 during excavation at Chainage 147.80m for the next round i.e. for Chainage 149.30 m, sudden heavy inflow of water (approx. 230 liters/sec) was observed resulting in cavity formation characterized by sliding of debris and large block fall from the crown and face portion of the tunnel (Fig .1). Mucking was almost completed for the excavated portion when the incident occurred. The support system was already installed up to Chainage 147.80m following B-2 class of excavation and support system, which included placing of one layer of wire-mesh (150x150x6mm), Lattice-girder (4bars 25mm dia), 150mm of shotcrete layer (M 30) and 8 nos. of Rock Bolts of 4.00m length of SN/SDR/Swellex type as per site conditions with maximum Round length for excavation of 1 to 1.5m.

Fig .1 Cavity formation

Background/Probable Reason for Cavity formation: -

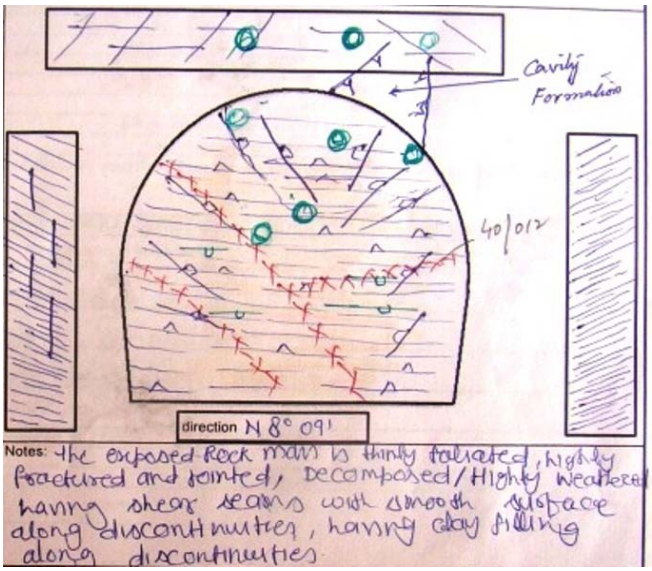
On 19th October'2013, probe hole of 16.00m from the chainage 138.80m was done. It suggested rock mass of sheared phyllite/carbonaceous phyllite ahead, in moderately to highly weathered conditions. But there was no indication of water ahead. Also sheared portion at chainage 154.80m was detected. On the same day, water outflow from drainage holes done on side walls and water in dripping condition from around chainage120.00m onwards from crown portion could be seen, but no water from excavated tunnel face was observed.

On 24th October'2013, heavy water outflow with discharge of around 230 liters/sec was observed which gradually reduced to 115 liters/sec on 30th October, water continuously draining out of the face. It again gradually rose to 145 liters/sec on 8th November after rainfall earlier on 7th November and again started coming down. It was again observed to be at the rate of 45 liters/sec on 14th November. The above factors points toward probability of the presence of a localized underground water reservoir/aquifer encountered during excavation on 24th October, which usually gets recharged through the joints within the rock mass and can remain perched due to its particular joint orientation.

Heavy water discharge from crown portion

Rock class Type

The rock mass was phyllite with thin bands of carbonaceous phyllite and quartz veins, thinly foliated with three prominent joint sets. It was highly weathered/decomposed, and numerous shear seams 10-20 cm thick criss-crossed the rock. Two major shear sets were present. Infilling within the joint aperture was soft clay.



Tunnel Excavation Face Geotechnical Description

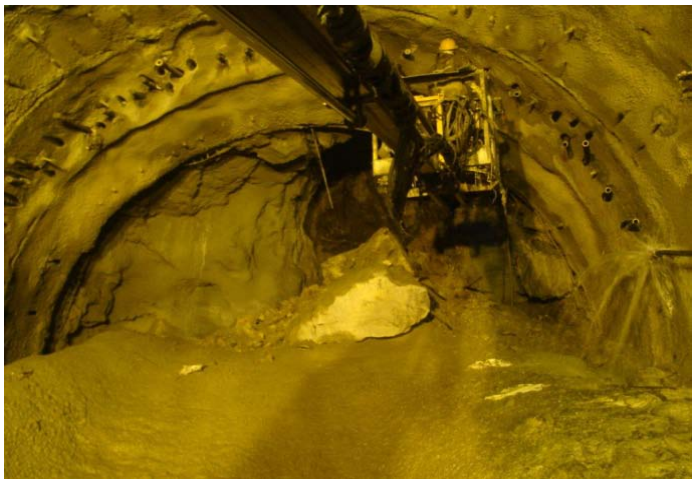
By
Sh Sameer Singh,
Executive Engineer/C/USBRL /Sangaldan

Mode of failure

The mode of failure was sliding from the face and block falls from the crown. The block was formed due to the conjugation of the joints and shear plane. The clay gouge material present within the joints of rock mass around the cavity region was washed away with the flowing water, consequently the cohesiveness lost and the failure occurred. After the major failure on 24th October, the loose falls and debris flow continued till 4thNovember

Countermeasures taken

- ✓ All tunneling activities were stopped immediately as soon as the failure occurred and measures were taken to stabilize the face as soon as possible. The pile of muck was placed against the tunnel face and stabilized by wire mesh and shotcrete to limit further face collapse or erosion due to heavy water discharge.



Ramp at base and pipe roofing at crown

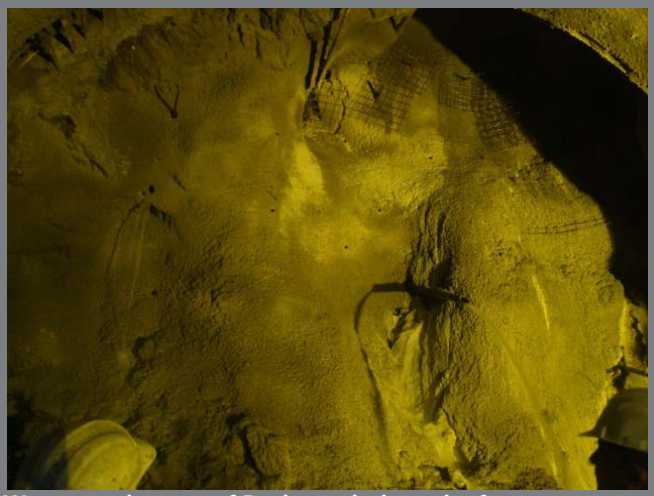
Sealing of the face was done with wire-mesh and shotcrete
Pipe roofing (23 nos./76mm dia/12m long) was done starting from Chainage 144.80m onwards, with grouting for **providing umbrella arch and increase in the stand-up time of the tunnel opening**.
Installation of 10 to 12 number of Swellex rock bolts (12m long) at the shotcrete face along with thick shotcrete layer was done for face support and to prevent further face as well as crown collapse. Swellex rock bolts was preferred for its rapidity of installation, no grouting to be done and could serve as drainage at the face also.

Thick wall with facebolts

- ✓ Systematic rock bolting (8nos./6-9m long) above the springing level, starting 8 rounds behind the face i.e. from Chainage 135.80m onwards, at a spacing of 1.50m was done to increase the shear capacity of the ground and to give additional support to the previously supported portion that could have been influenced by adjacent cavity portion above the crown in front due to stress-redistribution .Rock bolts below springing level were already provided as a part of B-2 class of excavation and support system followed earlier.

Systematic Rock Bolting

- ✓ Drainage holes upto 18.0m long were drilled behind the face from the left and right side walls to intercept and divert the water from face and to lessen the water pressure behind. As flowing water continued from the face after drilling drainage holes on the side walls, drainage holes on the face were also drilled.



Water coming out of Drainage hole at the face

- ✓ After completion of face stabilization and water control activities, spray shotcrete in the cavity was done.

- ✓ Installation of lattice girder close to the face together with wire-mesh and shotcrete was done at 0.75m spacing, starting from chainage 148.55m (C-1 type support system was followed). The pipes were left behind at Chainage 149.30m within the shotcrete to fill the concrete into the cavity. Later the cavity was filled up with concrete through those pipes only. With effect from 5th November 2013 tunnel excavation at Adit-II was restarted, following C-1 class of excavation and support system, which includes providing of two layer of wire-mesh (150x150x6mm), face shotcrete sealing of 100 mm (M30), Shotcrete layer of 200mm (M30), Face fibre glass element (8-15 no./12m long), Rock bolts (8nos./4m long-SN/SDR/Swellex type), with a round length of 0.75m to 1.0m along with pipe roofing with 27nos./12m long SDR bolts.

Placing of lattice girder with wire-mesh

PROFILE

SAMEER SINGH

Sameer Singh, is a young IRSE officer, looking after the prestigious USBRL project at Sangaldan.He belongs to Lucknow District of Uttar-Pardesh and has done his schooling from Lucknow itself. He graduated in civil engineering(B.Tech) from Indian Institute of Technology, Roorkee and joined the Indian Railway Service for Engineers as 2008 batch officer.

He took over his present venture as Assistant Executive Engineer/Construction at Sangaldan, Ramban district, in July 2012, and was promoted on 2013 as Executive Engineer/Construction.

Sameer is looking after the work of execution of tunnes,T-48 in Dharam Quazigund section. The work has been entrusted to HCC through IRCON.

Sammeer has previously worked as Assistant Divisional Engineer/Jalandhar Cantt and was looking after the Permanent Way maintenance work for 300 Km of track length. In this tenure Sameer has successfully carried out Mechanised Track Maintenance, Track Renewal, Rehabilitation of distressed Bridges and other important work like CTR (complete track renewal) with PQRS machine for more than 20Km of track. He also completed successfully NI work of Jalandhar city yard.

Name Sameer Singh
Place of Birth Lucknow, U.P.
D.O.B. 09/02/1979
Favourite Music Old Hindi Songs (esp. Kishore Kumar)
Favourite Food Home Cooked food
Best moment of my life My daughter

Sameer find his present Endeavour interesting and challenging despite all odds like remote location of the area, tough weather conditions, severe winters, frequent road blockage while commuting around the work area or travelling up to Jammu. Sameeer is proud to be associated with this project of National Importance .This is a unique kind of project of Indian Railways as Rail Link in Young Himalayan Range is being done for the first time. Sameer Says, **" It is a very challenging job to work here in tough conditions in the hilly terrain of Tunnel sites or harsh weather conditions prevalent in this part of J&K. As an Engineer, here we are exposed work of Tunnel T-48 in Dharam-Qazigund section, and associated activities. Railways have left a very deep impact in the lives of people here. It has touched the areas which are remote in every sense, and earlier untouched, not connected by any means of transportation whatsoever. One such remote area, Sumber village, in Ramban district, in which one of the portal of Tunnel T-48 lies, a Railway station has been planned. New road has been built to reach the tunnel site at Sumber, providing connectivity to the area in the process, vastly impacting the whole lifestyle of local people, with large number of vehicles plying in the area now, with access to all the basic amenities made possible. We are fortunate enough to be part of such an endeavour on the part of Railways, which is going to transform the life of people in the long term".**

Self Climbing Crane for Erection of Chenab Bridge

Synopsis:-
The erection scheme of world's highest railway bridge under construction will make use of a Cable Crane. This bridge comprises of 467 m span steel arch at height of 359 m from the river bed level. The article describes the features of this unique Cable Crane system which itself qualifies for the world record. The Cable Crane was commissioned on 31st Aug2013 by Member Engineering, Railway Board.

1.0 **Introduction:**

The Railway Bridge under construction over river Chenab is primarily composed of two portions - Main arch portion and via-duct portion. The main arch portion will be fabricated using 9000 MT steel over 467 m span. The crown of the arch is at a height of 359 m (approx.1200 ft) from Chenab river bed and at a height of 850 m from the mean sea level (msl). At this height it is supposed to be the highest Railway Bridge in the world. The deep and steep gorges at both ends of the arch with such a height has necessitated to establish a set of world class Cable cranes, to facilitate the erection of the Arch along and its trestles.

Picture 1. Pylons With Cable Cranes

Design:

Both the cable cranes have been designed for 20 ton lifting capacity each and 40 ton combined lifting capacity with tandem bar and are to ply on a pair of 54 mm dia suspension cable over a span of 915 m between two pylons at Kauri and Bakkal end of the Bridge with height 127.7 m and 105.7 m respectively. Keeping in view its importance and workability, the pylons have been designed by M/S VCE, Austria and the cable crane have been manufactured and supplied by M/S SEIK, Italy under Third Party Inspection by M/S TUV, and IRS. The functioning of the cable cranes with high lifting capacity, at such a height and over a long span, is first of its kind and makes it unique in the world.

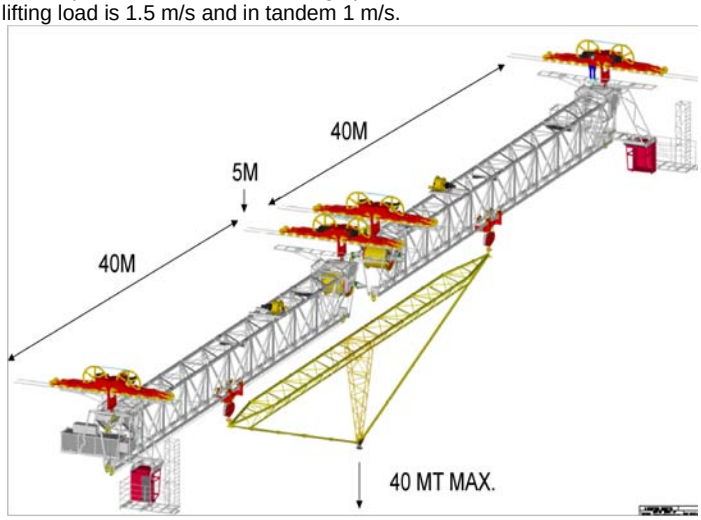
[redacted]

By
S.Rashid Mahmood, Dy.CE/Fabrication/Chenab Bridge
Prasanna Swain,AEN/Fabrication/Chenab Bridge

Picture 2. Cable Cranes Connected with Tandem

3.0Salient Features:

Some of important features of the system as awhole, which may be of utmost importance and attract the attention of the Engineers, are the huge amount of concrete in foundations, structural steel fabrication in Pylon, self weight and /different speed parameter of the cable cars, etc. In particular, the concrete in foundation, working out to be 3284 m^3, for Kauri and Bakkal end foundations 1874 m^3 and 1410 m^3 respectively, itself is something special ever used in the foundations for a subsidiary work. The structural steel used for the Pylons are IS 2062 Grade "C" steel, to the tune of 1198.6 MT. 32 wheeled cable cars, with self weight of 20 ton each will be plying on 54 mm dia suspension cables having a sag of 39.89 m, with a travel speed of 3 m/s. The hoisting speed of each cable car at maximum lifting load is 1.5 m/s and in tandem 1 m/s.



4.0 **Fabrication & Erection of Pylons**:

Amongst the activities involved from inception to commissioning of the system, the most important activity was the fabrication of Pylons followed by their erection to the present shape. A Pylon is, basically a two legged structure, tied together with tie beams and each leg is fabricated out of four built-up box structures braced to gather with bracings. In general, the built up box sections of 250 mm x 250 mm and built up I- section tie beams of sizes 150,175x200 mm and 200x250 mm have been fabricated as per British Standard (BS 5400-6) using Indian Standard IS 2062Grade-C (Fe 410 WC) structural steel plates.

Erection of the Pylons, owing to the typical site conditions with adverse climatic features, remained a major challenge for the job. For a better appreciation to erection, different modules of the Pylon were erected in three phases – initially first three modules were erected with the help of Hydraulic crane and then tower crane was used up to 40 m followed by the Climber crane for rest of the modules.

Picture 4. Erection in progress

Picture 5 Erection with Climbing Crane.

5.0 **Taking theSuspension Cable across the River :**

One of the important activities among the fabrication of Pylons and erection of Cable cranes was the crossing of 54 mm dia suspension cables, across the river Chenab at the critical location. Not only the suspension cables were required to be crossed across the river, at the same time those were required to be crossed over both the Pylons. Thus, for the entire procedure, starting from lifting of cables to a height of 127 m at Kauri end, crossing them to Bakkal end and finally lifting them to cross over Pylon at Bakkal end, a special arrangement was developed at site, comprising a set of winches at ground level, pulleys at the top of Pylon and steel balls at both ends. To start with, 8mm dia wire rope was crossed over the Pylons with the help of winch-pulley arrangements, then the free end of the wires was tied to the steel balls and left to freely roll down to the river from both ends. With the help of a locally available boat, the wires from both ends were joined to gather using “D” shackles. Finally the 8 mm wire was released from the restrained winch at Kauri end and pulled to be rolled at Bakkal end. Subsequently, in the same way 16mm, 32mm, and ultimately 54mm suspension cables were made to reach from Kauri end to Bakkal end.

Picture 6:Steel Balls Fabricated at Site to Cross the Wire Rope.

6.0 **Backstays:**

58 mm dia Back stay cables have been provided to the Pylons to control, monitor and govern the movement of Pylons, each standing on pivot pin support at the centre. Every Pylon has been provided with 8 backstay cables, one end of which are fixed to the pylon through spelter socket which are pinned with the Clamps attached with the pylon and other ends are rounded up with the back stay anchorage foundations. Finally, the back stays are stressed to the design tension of 465 KN before the commissioning of cable cars.

Picture 7 Foundations of Backstays.

7.0 Conclusion:

The Pylons and cable cranes, as a complete system, for a swift erection and incremental launching of main Arch span, at an extreme difficult Himalyan terrain, has been commissioned on 31.08.2013 by Member Engineering, Railway Board and will be an Engineering marvels as the system is put in place for use. Undoubtedly, as has been rightly brought out by M/S CBPU, the contractor concerned for the job, this cable crane having longest span in the world with 40 ton combined lifting capacity would certainly find a place in the GUINESS Book of world records.

Quake Tremor or Temblor

Synopsys

In first part of this series an insight was presented about the causes and origin of earthquake. Emphasis was given on the principal of isostacy, continental drift theory, plate tectonic theory and mechanism for causes of earthquake. This second part of the series deals with, "what happens during an earthquake". As deliberated in part one, this part stars with the elastic rebound theory and stick-slip phenomenon.

Elastic rebound theory

In 1906, H.F. Reid put into clear focus the concept of elastic rebound theory , based on the study of the rupture which occurred along the San Andreas fault. The concept of elastic rebound theory is better described through fig 1a.,

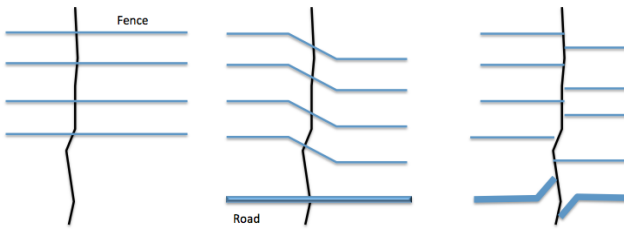


Fig 1a series of fences across fault line.

Fig 1b Fault become active, deformed fence due to relative motion of land mass along the fault line. Also shown is the alignment of road built across the fault at this stage.

Fig 1c After Earthquake

Fig 1 shows a fault line (black color). As is normally expected the landmass on both the side of the fault line are in relative motion with respect to each other. If series of fences are build across the fault line that are perpendicular to it, the relative motion of the land mass will gradually distort the fences as shown in fig 1 b. at this point if a road is constructed across the fault it will have a geometry as shown in fig 1b. Finally, the continuing deformation across the fault plane due to relative motion of the land mass will result in buildup of stress strain which exceed the material strength. A rupture will then initiate at some critical point in the fault zone and will propagate through the fault plane. This will result in release of energy and permanent displacement along the fault plane. The condition after the event will be depicted as shown in figure 1 c. large offset will be visible along both fence and road. After the release of energy the fence will become straight and the road will be locally curved. The strong ground shaking adjacent to the rupture zone will cause severe damage to any structure build across or near to this zone. However the strong ground shaking initiated at the fault rupture zone that radiated in all direction is more devastating because this has a greater area of influence. Opposite to this the ground motion at a greater distance are very small and are generally not preserved but the ground motion adjacent to the fault rupture zone are so strong that they cannot be measured by normal instrument.

Stick slip phenomenon

To bodies sliding past against each other over a common surface exhibits the stick slip phenomenon. If a force applied is more than the static friction, then there will be relative motion between the two bodies. At this state the static friction value will reduce to Kinetic friction and this sudden reduction in friction value will result is sudden jump in velocity of movement (state is slip). With this the bodies are set in motion, the resistance offered by dynamic friction accumulates until it exceed the driving force. The relative motion is again set to zero and friction value increases to static (state is stick). Driving force again accumulates until is exceeds the static friction and again slip state is activated. The cycle continues until the accumulated strain energy is dissipated.

The point on the fault surface where rupture first begins is called focus and point on the ground surface directly above the focus is called epicenter.

Consider a hypothetical situation, where in rupture along a fault line is controlled and allowed to happen along a unit length. When the rupture happens the sudden release of energy along the fault plane will be accompanied with large displacement of two sides. This will initiate a elastic wave that will propagate in all direction i.e. radial from the source. This wave will be recorded as a single pulse at the recording station as shown in figure2a. The corresponding velocity and acceleration waves will be as shown in fig 2b and 2c.

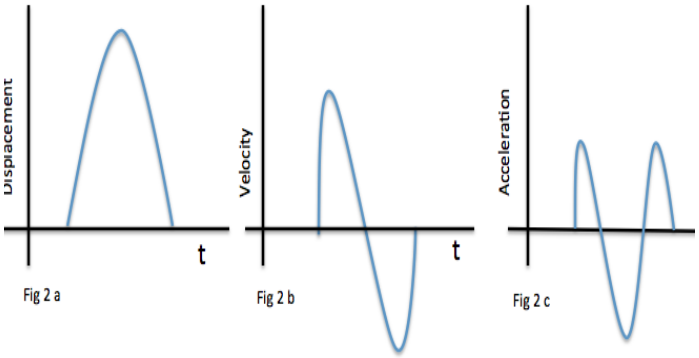


Fig 2 a Fig 2 b Fig 2 c

However if we look at the record of some typical earthquake they are more complicated than the one shown on figure 2a, 2b or 2c. One such famous earthquake record of El Centro earthquake of 1940 is shown in figure 3. The record for this earthquake is much more complicated than simple acceleration, velocity and displacement pulse shown in figure 2a, 2b or 2c and it is probable that the generating mechanism is correspondingly more complicated and complex. Possible reasoning for such variation is that, an actual earthquake involves sequences of rupture along the fault surface (recall the slip stick mechanism deliberated above). Each successive earthquake is the source of a simple earthquake wave. Since they occur at different location and times, the ground motion recorded at far off station will be a random combination of all these individual simple waves, giving a final look as shown in figure 3.

By
Sangrah Maurya
Deputy Chief Engineer/Design/USBRL Project

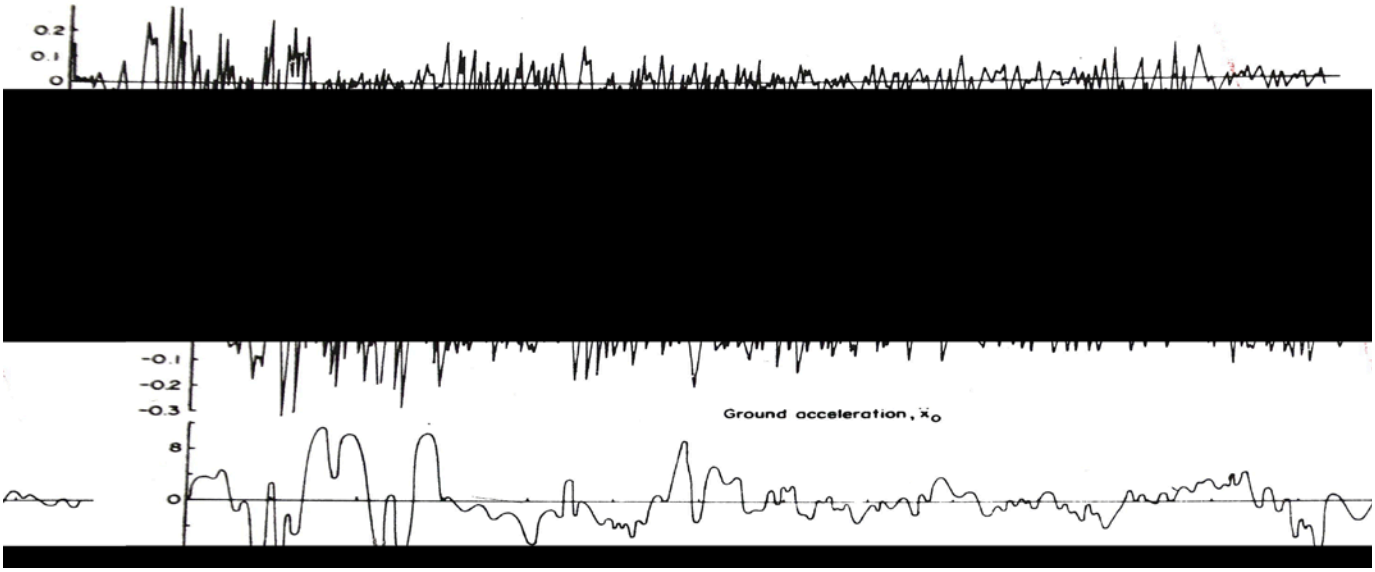
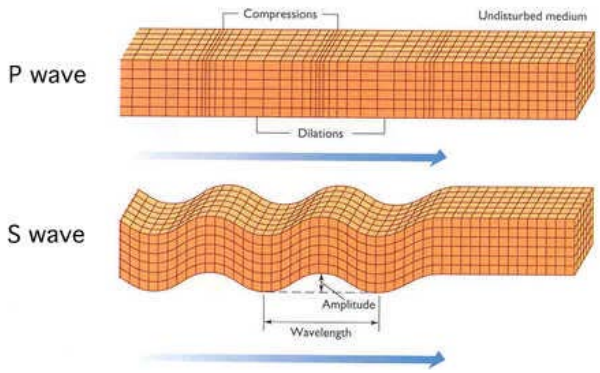


Fig 3

Above is a plot of Imperial Valley (California) earthquake of May, 18,1940. This was recorded at El Centro instrument site, which rest on some 5000 feet of alluvium and is located some 4 mile from the causative fault break. This record represent the strongest ground motion thus far recorded. The plot above shows the record of first 30 sec of the earthquake. The ground velocity and displacement are obtained by successive integration of the acceleration record. The PGA is 0.33g and max velocity is 13.7 in/sec.

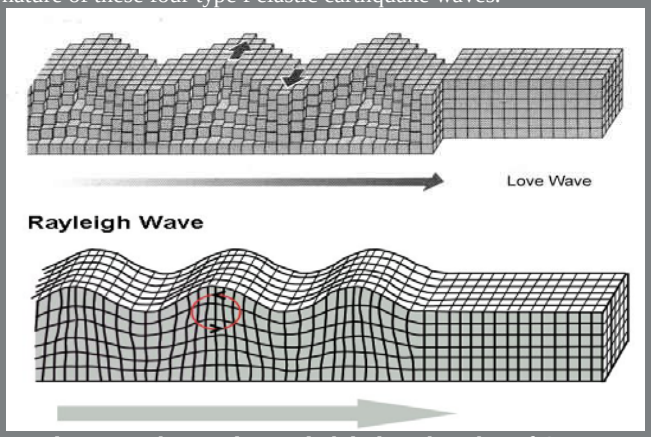
Propagation of Earthquake waves

During an earthquake the energy is propagated through the earth surface and deep within the earth's interior. When energy waves travel deep within the earth two types of waves are generally developed. "P" waves and "S" waves. P waves or primary waves are basically formed when material oscillates parallel to the direction of propagation. These are normal stress waves inducing an alternation between compression and tension deformation, like sound waves. "P is derived from primary as these waves have the highest velocity and are first to be recorded or from Pressure waves as they are formed from alternating compression and rarefactions. Both P and S wavy make up the high frequency component of strong motion earthquake. P wave travel at a speed of 5 to 13 km/sec, compared to range of 3 to 8 km/sec for S wave, velocity in each case increases with depth.



The "S" waves or shear waves, the material particles moves in a direction perpendicular to the wave propagation path, inducing shear deformation. "S" waves move only through solid as liquid and gases do not support hear stresses. The P waves move more rapidly through rocks and therefore are the first to arrive at any given point; in contrast the S waves travel more slowly and therefore arrive after the P waves. Both P and S are also called as seismic body waves.

When the energy released is prorogated near the surface rather than deep in the earth interior, two types of waves namely Rayleigh and Love waves are generated. The Rayleigh waves are tension compression waves similar to the P waves except that their magnitude diminishes with distance below the surface of the ground. Similarly the Love waves are counterpart of the "S" waves; they are shear waves that diminish rapidly with distance below the surface. Both these waves are called surface waves because they fade out as get further from the surface. Their velocity is lower than the velocity of the seismic body waves, but because of their long duration and large amplitude they can be most destructive type of seismic waves. Figure illustrates the nature of these four type f elastic earthquake waves.



R and L waves have velocity slightly less than that of S wave. R waves are generated whenever waves propagating through a continuous medium (such as the P and S waves) reach a free surface. The energy input to structures on or near the ground

surface comes predominantly from Rayleigh waves. These also tend to attenuate rapidly with distance from the surface.

Love waves result from the presence of a distinct discontinuity at some depth from the free surface of the medium through which the body waves propagates. Surface waves forms a significant portion of the strong ground motion in the epicentral region and also make up the dominant long-period phases of the shallow-focus earthquake. Also the short period high-energy components if seismic waves tends to be damped out much faster than the longer period waves, so that at some distance from the epicenter, the ground motion predominantly of long period oscillation.

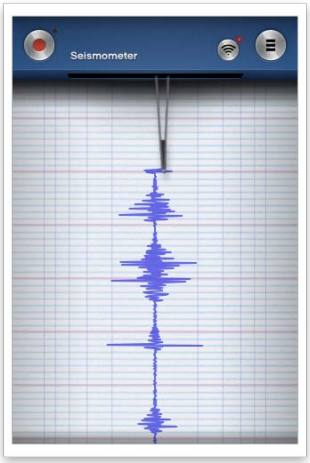
P waves are not destructive in comparison to the Rayleigh's and the s waves, they are most destructive and responsible for damage to structures.

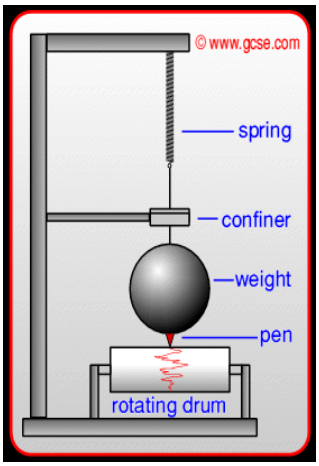
For local and nearby earthquakes the difference in arrival time of the P and he S waves can be used to determine the distance to the event. For earthquakes that have occurred at global distances, three or more geographically distinct measuring station recording P-wave arrival time permits locating the origin of earthquake.

SEISMOMETER

Seismometer is an instrument used to record ground motion during an earthquake.

A simple seismometer of first generation used to be sensitive to motion in one plane only and records the ground motion for that particular plane only. The principle of a seismometer is simple to understand. Consider a rotating drum attached to a frame and a spring mass system attached to the frame. As the ground shakes the relative motion between the ground (and frame and



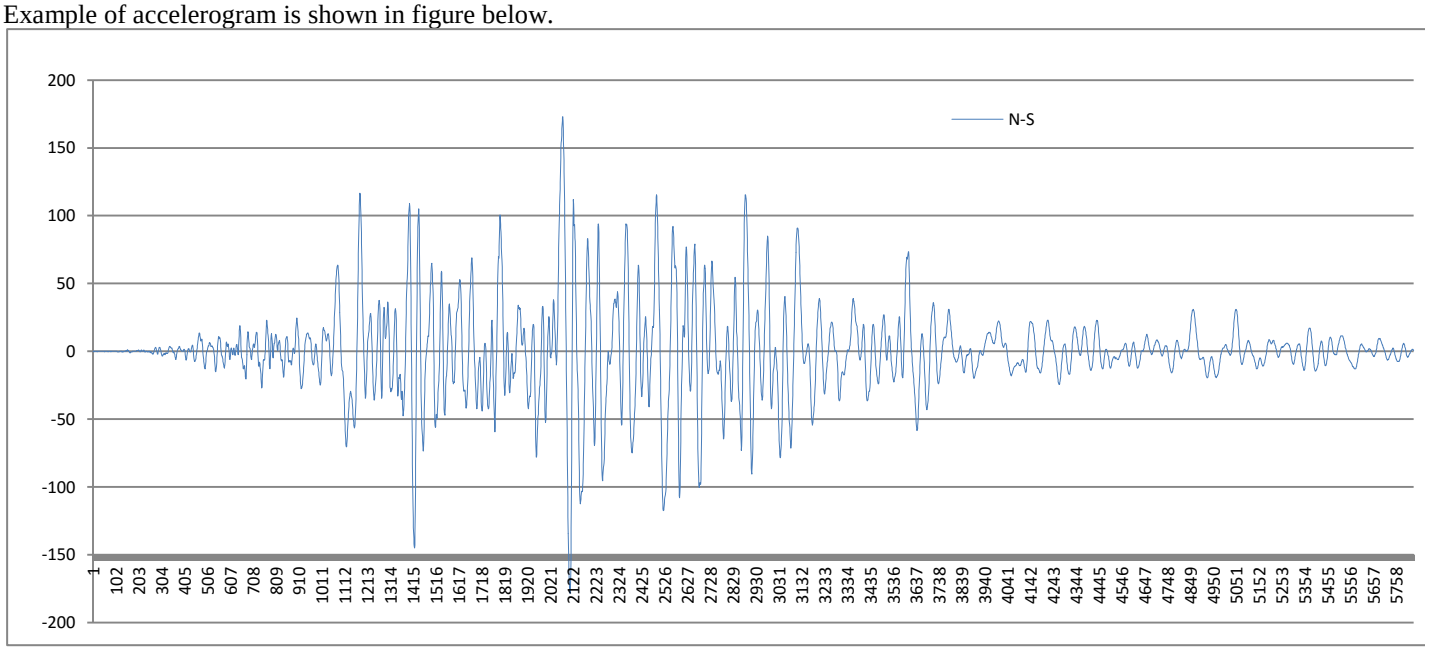


rotating drum) and the spring mass system provides a measure of the vertical ground motion. If a pen is attached to the mass and drum made to rotate, the relative motion between the weight and earth can be recorded to prepare history of ground motion called seismogram.

Present day seismometers are much advanced and quipped with electronic sensors, amplifiers and electronic recording devices and capable of measuring the ground motion in all the three plane and can measure motions with wide range of frequencies.

Another category of seismometer is called accelerograph. They are deployed to measure strong ground motion and measures acceleration. The measure value can be mathematically integrated to give velocity and displacement.

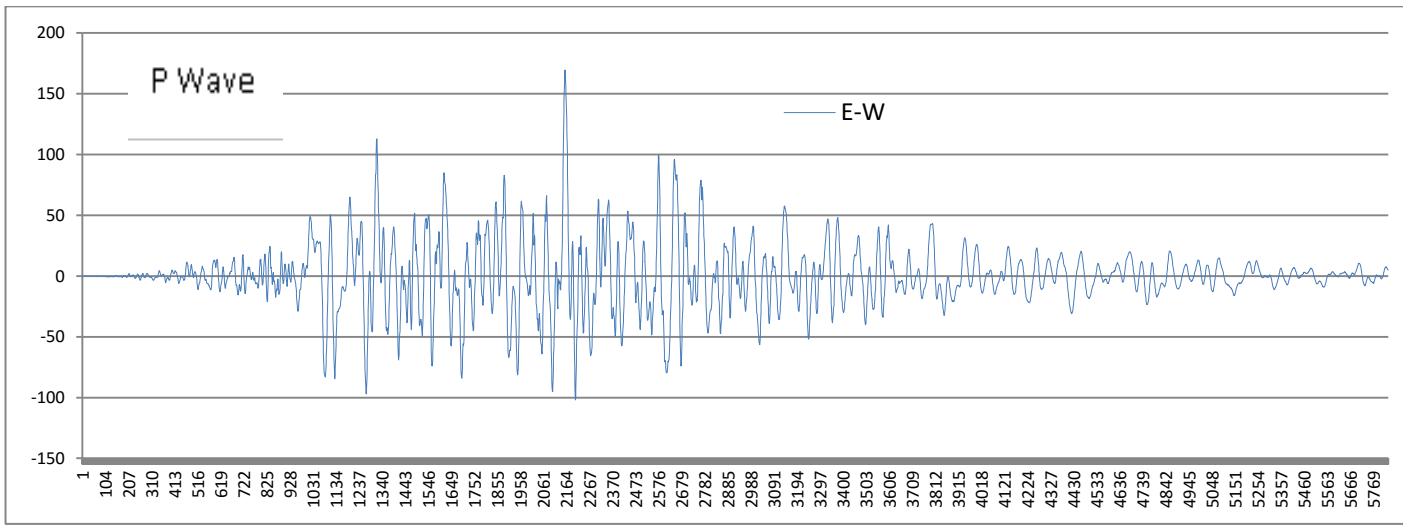
Example of accelerogram is shown in figure below.



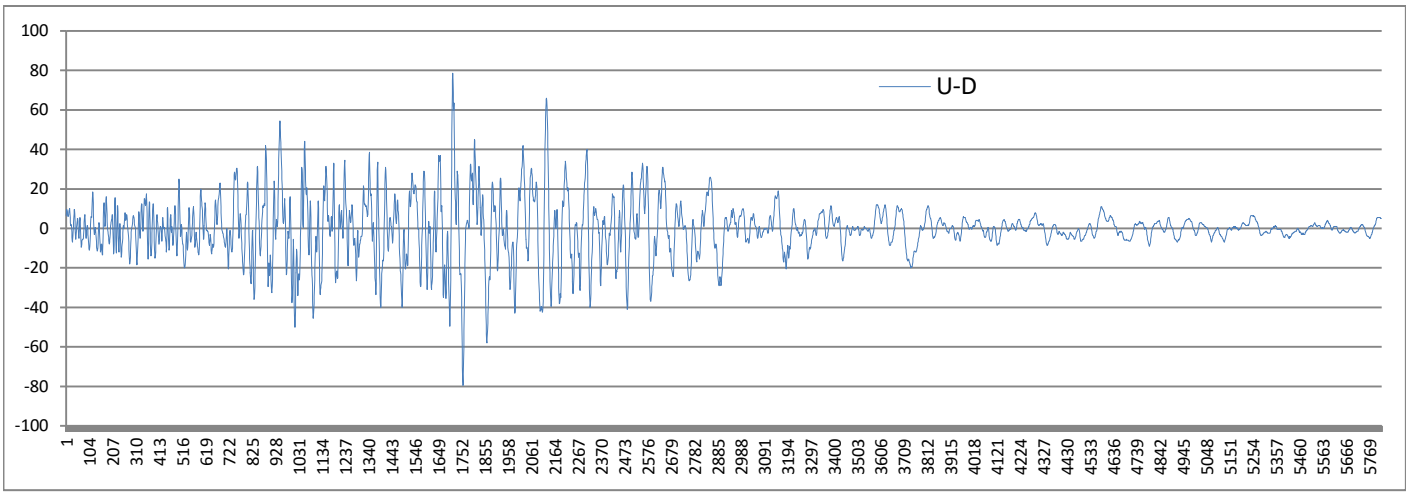
Accelerogram, Horizontal ground shaking in N- S direction

The measurements of acceleration are in Gal, where 1 Gal is equal to 0.01 m/s² (1 *g* = 981 Gal)

The three components of ground motion recorded by a strong-motion accelerograph provide a complete description of the earthquake, which would act upon any structure at that site. However the most important feature of the record obtained in each component, from the standpoint of its effectiveness in producing structural response, are amplitude, the frequency content and the duration. The amplitude is generally characterized by the peak value of the acceleration or Peak ground acceleration (PGA).



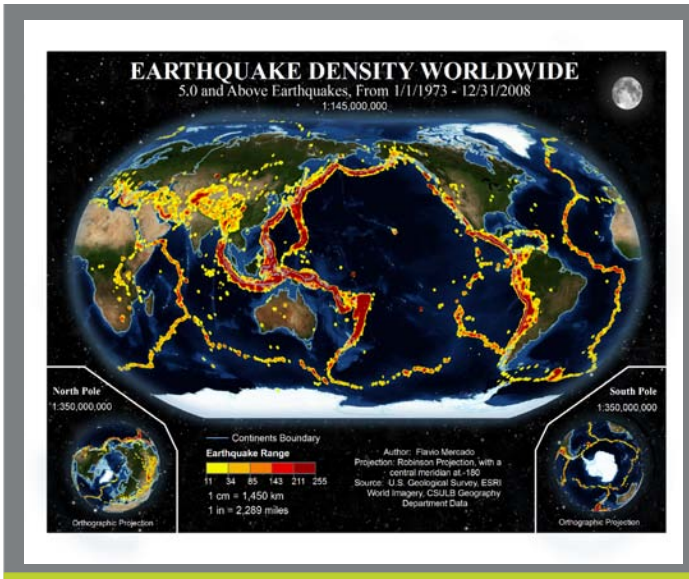
Accelerogram, Horizontal ground shaking in E-W direction
The measurements of acceleration are in Gal, where 1 Gal is equal to 0.01 m/s² (1 *g* = 981 Gal)



Accelerogram, vertical ground shaking in U-D direction
The measurements of acceleration are in Gal, where 1 Gal is equal to 0.01 m/s² (1 *g* = 981 Gal)

In the acceleragraph shown in figure the peak values are (N-S) 178.5 (E-W) 169.5 (U-D) 79.5 for two horizontal and one vertical direction respectively. The frequency content can be represented roughly by the number of zero crossings per seconds in the accelerograms and the duration by the length of time between the first and the last peaks exceeding a given threshold level.

To be concluded…



Art and Crafts of Jammu and Kashmir
Magic without Illusions

"Kashmir is paradise on the earth" it can be seen in its natural beauty as well as in art and craft.The state of Jammu and Kashmir is famous the world over for its unique and splendid work of art and crafts. Travel through even the remotest parts of the state will give an insight into the world of art and craft in Jammu and Kashmir. Just about everything that is seen in Jammu and Kashmir has some kind of art work done on it. The most prominent is the embroidery work on the shawls and the cloths of Kashmiri people are very mesmerizing to be not noticed. The work of magic also can be seens in wood works, steel wares, Papier-mache.

Weaving and Embroidery : Shawls and carpets are famous woven products of Kashmir. The shawls made with ***Pashmina*** fabric, Ring shawl which is so fine that it can pass through a ring, Jamavar shawl with its symphony of colour schemes depicting architectural and mythological figures interwoven with landscape designs are popular. Carpet making is the national craft of Kashmir. It was introduced here by Sultan Zain-ul-Abidin. Hand-woven pile carpets (***kalins***) harmoniously depicted with floral and other designs are the most popular. The namda, felt rug made from beaten wool embroidered all over, the gabba- a floor covering, prepared from old woollens in a variety of forms and designs, the chain-stitch rug, made from Hessian cloth and coarse wool, over which floral and other motifs are worked are also famous.

Hand wowen carpets

Hand Woven Carpet

The embroidery of Kashmir, called ***kasida***, is world-famous. Varied, rich in colour, elaborate in detail and exquisite in execution, the kasida patterns are freely drawn by the naqqash mostly from memory. The finest kasida work, particularly embroidered on shawls or saris, has no 'wrong' side.

Pashmina Shawl

Namda Carpets

Papier-mache craft: Papier-mâché craft was also introduced into the Valley by the great monarch, Sultan Zain-ul-Abidin, who has been aptly called the Akbar of Kashmir. The products, beautifully painted over with ornamental patterns, comprise picture-frames, pen-cases, screens (which can view with the Chinese counterparts), tables, tea-pots,

writing sets, candle-sticks, handkerchief and tie boxes, vases, stamp boxes and other utility goods whose need is now fairly widespread. Green fields sloping towards the snow-capped mountains, sparkling streams running over rounded rocks, shikaras and lotuses blooming on the lakes, are the favourite papier-mâché patterns. The craftsmen have introduced brass and metal lining for the new style of papier-mâché goods which makes them more durable and useful.

Silver and Copperware: Plain and inlaid silverware of Kashmir are in great demand. The silverware includes silver tea-sets, flower vases, toilet sets, scent chests, ornamental picture-frames, cigarette-cases, Tumblers, etc. Designs include leaves of the chinar and the lotus etc. The Kashmiri artisan also produces excellent products of copper-ware

Samovar

By
O.P.Yadav,
Dy.FA&CAO/USBRL

consisting mostly of cooking pots and samovars (tea-kettle of Russian origin) and sundry articles for the household or the mantelpiece. There is a good demand for lovely copper trays inlet into tables of carved walnut-wood.

Wood Carving Wood carving is one of the best known cottage industries of Kashmir. Walnut and chinar wood**,** are the main material for the wood-carving. Furniture and toilet articles such as chairs, cabinets, writing-or dining- tables, jewellery boxes and ornamental caskets are the popular products.

Some of the walnut wood products-cigar boxes and trays, table-tops, handkerchief and collar boxes-are delicately carved. Floral designs of almost every conceivable variety are made with great accuracy of detail in chased or raise work.

Khatam-band is a speciality in Kashmir woodwork and comprises ceilings of rooms, made from thin panels of pine wood, cut into geometrical designs. Builders of houseboats have kept this old craft alive. The shrine of Khwaja Naqshband, near the Jama Masjid of Srinagar, presents the best example of this craft.

Art and craft is something that you will see, touches every aspect of life in J&K. Be it the clothes they wear or the homes they live in, everything in some way or the other has crafts involved in it. Most of these things are brilliant enough to be taken home as souvenirs of your travel to J&K. Lal Chowk and Badshah Chowk in Srinagar and Vir Marg and Hari Market is Jammu are the best places where you can indulge in shopping.

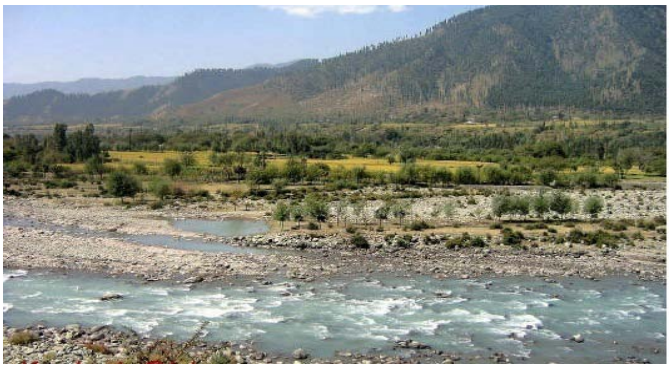
Banihal

Banihal is a small town situated across the river Bichlari which is formed by various mountainous streams which ultimately joins river Chenab. Banihal is surrounded on all the sides by mighty Pir Panjal which needs to be crossed, to enter Kashmir valley .Before 1956, it was Banihal pass through which Kashmir could be reached. It was only after the construction of 2.5 Km long Jawahar tunnel in 1956 that made crossing of Pir Panjal became safe and convenient. Pir Panjal remains snow laden for a large part of the year. Avalanches are quite common during winter in between Banihal town and Jawahar tunnel.This has given rise to many a infamous local lore and attached frightening names such as "Shaitani Nallah",etc Similarly, between Ramban and Banihal another infamous location exists, where due to incidences of shooting stones, the gorge is called "Khuni N ve nullahs.

Figure 1 A view of Banihal from a Hill Top

Geography

Banihal lies in the Pir-Panjal ranges of the Himalayas. It is located at 33.42°N 75.20°E with an average altitude of 1666 meters above mean sea level. The main river flowing through the area is river Bichlari which is one of the main tributary of river Chenabiew of nature's flawless and elegant beauty in the veil of cloud and snow. These places though are still unexplored, if developed have the huge potential for promotion of tourism.



River Bichlari flowing through Banihal Valley

Submitted by
Sh Vinod Kumar, Dy. CE/C/Banihal
Sh.Vikas Goel, XEN/C-I/Banihal
Sh Shalinder Kumar,XEN/C-II/Banihal

Demography, Food and Culture

Banihal tehsil consists of twenty four villages having total population of 94,487 as per 2011 census. The total population of the Banihal town is around 3000 people with the literacy rate of 77.6%. Rice is the staple food of the people. Maize is also consumed occasionally. Agriculture is the main occupation in the area and other poultry and livestock also supports large population in the area. People here cherish Salted tea, which is a distinct feature in their food habits, particularly during breakfast. People cultivate food grains and vegetables to meet their own needs which are typical in the hilly regions as plain fields are scarce. Kashmiri is the most common language spoken by inhabitants of this area. Culture is predominantly Kashmiri, a glimpse of which can be seen in '*Phiran*' a distinct Kashmiri attire worn as a final layer in winters and loose enough to accommodate a small '*Kangri*' (fire pot, a kind of *angithi*) inside to brace through extreme winter.

Figure 2 People wearing Phiran during winters in Banihal

Climate

Banihal features a subtropical highland climate which is predominantly cool during winters, and moderately warm during summer. Temperatures typically range from−4 °C to 31 °C over the course of a year with the average during winters being 3.2 °C and that during summers around 24 °C. Snowfall

Figure 3 Banihal during winters

in the region, which historically has took place in the month of December, has over the last fifteen years been happening in January or early February every year. The maximum snowfall received in recent times was 176 cm in January 2012.

History

Banihal finds mention in many ancient and medieval writings. Rajtrangini (Historical Chronicle on Kings of Kashmir written by Kashmiri Brahman "Kalhana" in 1148 AD) mentions this place, a very narrow mountain valley, as Visalta. This region, in King Uccalas' time was an escape route from Kashmir for unwanted elements of the Valley. In Jaysimha's time (1128-49) a small fort is stated to have existed just below the old Banihal Pass, called by the name of Bansalla which literally meant, a jungle or grove of trees.This castle belonged to Khasa Lord Bhagika, ruler of the old principality of Vishalta, the present Banihal region.

Abu-Fazal, King Akbar's official historian may have passed through this route on his way to or back from Valley of Kashmir. He had derived the appellation of Banihal from Bansalla. He also makes a mention of a temple at Banihal, dedicated to the Goddess Durga,
Abu Fazal in his notes, says Banihal derives its origin from Bhanusita or Bhanusata i.e. rocks of the Sun or land of the Sun.
According to Rajtrangini, Visalata or Banihal is identified with the valley drained by rivulet Bichlari, flowing through the area, a tributary of river Chenab. This hill district situated immediately to the South of Divsar and Shahabad Parganas of Kashmir (District Anantnag) named after the mountain pass of that name, to which it forms the approach. Because of its geographical position, difficult accessibility of the region, and harder mountainous life style, Banihal always proved to be a safe escape route, and safe refuge to the revolting Princes, disgruntled chieftains, and conspirators from Kashmir, against the Kings of Kashmir. Rajtrangini has made a mention of many such nobles, Khasas and Damaras. Banihal Pass having the lowest height above level formed the easier outlet from the valley for the pedestrians in the Pantsal range. Rebel Chieftains from Kashmir, like Dhanchakka, Bhiksachara and Sujji and many others also stayed at Banihal and planned an invasion of the valley.

Jawahar Tunnel

Figure 4 Jawahar Road Tunnel

Jawahar Tunnel, named after the first Prime Minister of India, was constructed for round-the-year surface transport by Alfred Kunz and C. Barsel (between 1954 and 1960). The Jawahar tunnel has been operational since 22 December 1956. The length of tunnel is 2.85 km at an elevation of 2,194 m and it has one lane road in either direction. It is situated between Banihal and Qazigund on NH 1A that has been renumbered NH 44.

Tourist Places

Daksum

Past Mughals gardens with their tinkling fountains, through the breathtaking splendour of the springs at Kokernag, lies Daksum around 60 Kms form Banihal. Quite away from it all, tucked away in a densely forested gorge, Daksum would be completely silent but for the Bringhi river which gushes though it. Daksum is a walker's paradise. Up the hills which are swathed in coniferous trees, past gurgling brooks, the simple, haunting notes of a flute will waft down to you from where an unseen shepherd tends his flock. For in the hills surrounding Daksum, suddenly you will find yourself in grassy meadows where sheep are taken to pasture. Daksum is a reviving experience - the bracing mountain air, the solitude, the densely clad hills, and beyond them, snow covered mountains all contribute to Daksum's mystique, making it the perfect retreat.

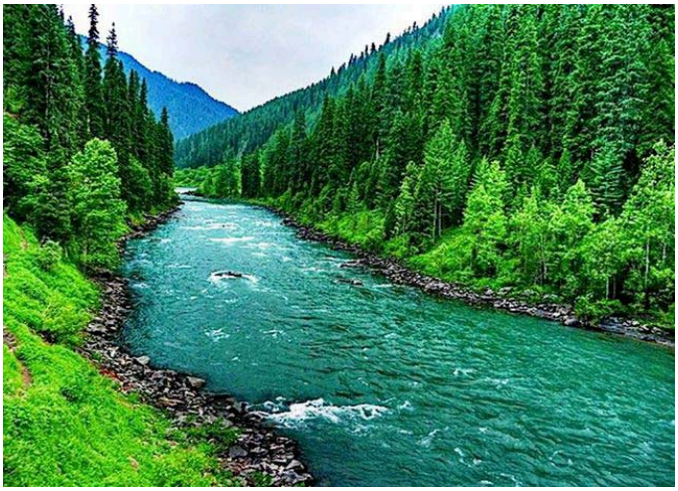


Figure 8 A view of Daksum

Kokernag

Situated lower of the Bringhi valley, Kokernag (2,020 m, 50 kms from Banihal), is set amidst sprawling gardens fragrant with the bloom of thousands of flowers. The Kokernag spring bubbles at seven places at the foot of the forested mountain. The water of the spring is famous for its medicinal and digestive properties.The moment you enter the green valley of Kokernag, you are welcomed by the cool and fragrant air of the mountains, an air that brings with it the perfume of the blossoming flowers which you see all around this picturesque vale.
Perhaps the most important tourist attraction of a tour to Kokernag is the PapashudanNad, the magical and curative spring which draws thousands of tourists to the valley each year. Home to the largest fresh water spring in Kashmir, Kokernag is known for its collection of springs, which in totality produce an image of the claws of a cock, a

trait to which the vale owes its name. Blessed with rich a soil which promotes the growth of several varieties of plants and flowers, a tour to Kokernag is made even more perfect by the presence of a number of accommodation options in the region.

Figure 6 A view of Kokernag Spring

Important Projects:

Banihal Rail Tunnel

A new 11.215 km (7 mile) long Banihal-Qazigund tunnel (also known as Pir Panjal railway tunnel) for the Kashmir Railway line connecting Banihal with Qazigund area of Kashmir Valley has been commissioned on 26th June 2013 by Prime Minister Dr.Manmohan Singh. The tunnel is 8.40 m wide with a height of 7.39 m. There is a three meter wide road along the length of the tunnel for the maintenance of railway tracks and emergency relief. The tunnel's average elevation at 1,760 m is 440 m below the existing road tunnel. The rail tunnel facilitate transportation during winters when inclement weather forces closure of the road tunnel and Srinagar-Jammu highway. Pir Panjal Railway Tunnel is India's longest and Asia's third longest railway tunnel (28 km long Taihang Tunnel in China is the longest and 21 km long Wushaoling Tunnel in Gansu, China is the second longest).

First train from Srinagar to Banihal after negotiating Pir Panjal Tunnel

First train from Srinagar to Banihal at Banihal Station

Four Lane National Highway Tunnel:-

Construction of a new 8.45 km (5.25 mi) long Banihal-Qazigund road tunnel started to widen NH 1A to four lanes. It is a double tube tunnel consisting of two parallel tunnels - one for each direction of travel. Each tunnel is 7 meter wide tunnel and has two lanes of road. The two tunnels are interconnected by a passage every 500 meters for maintenance and emergency evacuation. The tunnel's average.elevation is at 1,790 m is 400 meter below than the existing road tunnel's elevation and would reduce the road distance between Banihal and Qazigund by 16 km .

भिक्षुक

मैं क्षीणकाय अज्ञान तिमिर से अविरक चल,
भूखा प्यासा निज व्यथा सुनाने आया हुँ।
दुःख की सरिता जिसको प्रतिफल नहलाती है,
मुठ्ठी भर दाने हेतु हाथ फैलाता हूँ।

मै नही चाहता अधिक क्षुआ अतिरिक्त अन्न,
संचय करनेकी है मुझमें कुछ चाह नही।
करता मैं दुंआ तुम्हारी और सभी जन की,
कुछ दो या कुछ भी मत दो परवाह नही।

के.के.मिश्रा.
स.अभियंता / निर्माण,
कौडी / रियासी, उ0रे0, जे.एण्ड.के.

Diet for Diabetes

How to Control Diabetes?

1. **Regular health check-up .**
2. **Food choices.**
3. **Activity choices.**

1. Regular Health Checks:

- Regular follow up with a clinician, as advised by your physician.
- Regular self monitoring of blood glucose (SMBG).
- Screening for complications at regular intervals.

2. Healthy Eating Helps Control Diabetes:

Small to medium servings of a variety of foods
To eat same time each day. Not to skip meals
To eat about the same amount each day, as far as possible

Protein Intake:

12-20% of daily calories (1 gm/kg/day).
From both animal and vegetable sources
Vegetable sources: Less nephrotoxic than animal proteins.
Patient with nephropathy should limit to less than 12% daily (0.8 gm/kg/day).

6 myths about food for people with diabetes:

Myth # 1:
True or False?

- People with diabetes can eat as much as they want as long as it doesn't have sugar.

FALSE:

- Sugar is a carbohydrate, like bread, cereal, and potatoes.
- All carbohydrates raise blood sugar.
- Sweets / sugars tend to have more carbohydrates in "smaller packages".
- Sweets can be included in a healthy diet – plan ahead and know how many carbohydrates they contain.

By
Dr. Steven George,
Dy.CMO/KRCL/Reasi

Fat Intake:

<35% of total calories
Saturated fat <10% of total calories
Polyunsaturated fats 10% of total calories
Cholesterol consumption < 250 mg/day
Moderate increase in monounsaturated fats such as groundnut oil and olive oil (up to 20% of total calories).

Carbohydrate Intake:

Carbohydrate intake is determined after protein and fat intake have been calculated.
Emphasize on whole grains, starches, fruits, and vegetables
Fiber same as for nondiabetics (20g to 35g).
Rate of digestion related to the presence of fat, degree of

Myth # 2:
True or False?

- People with diabetes should only eat foods sweetened with sugar substitutes instead of sugar.

FALSE

- People with diabetes do not need "special foods".
- It's about the total amount of carbohydrates in the food.
- Foods sweetened with sugar substitutes may still have carbohydrates that can cause the blood sugar to rise.
- Read "Nutrition Facts" on food labels for total carbohydrate content.

Myth # 3
True or False?

- People with diabetes should not eat too many starchy foods, because starch raises blood glucose and makes you gain weight.

FALSE

- People with diabetes can eat starchy or carbohydrate foods. These foods have many important nutrients.
- Fiber is one of the important nutrients.
- Fiber is filling and helps lower blood cholesterol and possibly blood sugar.
- High fiber foods are whole grain breads and cereals, fruits, cooked or canned dried beans, and vegetables.

Myth # 4:
True or False?

- People with diabetes should eat lots of protein to stay healthy and strong.

FALSE

- Protein is needed to build and repair body tissue.
- People with diabetes do not need more protein.
- Most people need 1gm/kg of protein foods per day.
- Controlling portion sizes and choosing lean meats can help prevent heart disease, a complication of diabetes.

Myth # 5:
True or False?

- People with diabetes don't have to worry about eating fat because it doesn't affect blood sugar.

FALSE

- Fat does not affect blood sugar, but can increase the risk of heart disease.
- Heart disease is the most common complication of diabetes.
- A heart healthy diet which is low in fat, saturated fat, salt and high in fiber and includes heart healthy oils can reduce this risk.

- Best choices are lean meats, fish, poultry, low fat dairy products, fruits and vegetables, canola or olive oil.
- Add less fat and salt.

Myth # 6:
True or False?

- People with diabetes should not eat snacks because snacking makes them gain weight and makes the blood glucose too high.

FALSE

- Snacks can be helpful in keeping people from getting too hungry and overeating.
- Snacks can be helpful in preventing low blood sugar for people using insulin or medication to increase insulin secretion.

The key is to plan healthy low fat, low calorie snacks.

Eat More Fruit and Vegetables, Choose More High Fibre Foods

To help maintain blood glucose levels and cholesterol levels

Include more fruits, vegetables, pulses & oats in diet

To maintain a healthy gut:

Include Wholegrain cereals, brown bread, and brown rice.

Reduce animal or saturated fat intake

Use low fat milk, low fat spread instead of butter, use oil which are high in unsaturated fat, like olive oil

Use less Fat for Cooking

Opt for Grill, dry-roast, microwave or steam cooking.

Reduce Salt Intake

Cut down on added salt, use alternative seasoning, avoid pickle and papad.

Summary

- There is no "Diabetic Diet", it starts with healthy eating.
- Eat about the same time each day.
- Don't skip meals!
- Eat a variety of foods.
- Watch serving sizes especially for carbohydrates.
- Use less fat, sugar, salt and alcohol.

See a health care provider to help you develop a plan to take charge of your diabetes

जुनून ए आजादी

जुनून ए आजादी की राह क्यू भूल गए है, हम यारों।
दिए जो शहस्त्र वीरों ने अपने प्राण क्यू भूल गए है, हम यारों।

जुनून था एक ऐसा उनमें, देश की खातिर मर मिटने को।
जुनून था एक ऐसा उनमें, देश की खाजिर कुछ कर गुजरने को।

मातृभूमि उपनी की खतिर मर मिठे जो हंसते हसते।
वतन उपने की खतिर कठ मरे जो कतरा कतरा।

बतिदान उनका ऐसा चुकाया है, न कभी न ही चुकाया जाएगा,
इस मिट्टी का एक एक कण याद उनकी दिलाएगा।
दिलो में था जिनके दहकता लावा, क्यूँ भूल गए है, हम उनकों।

जो मिली है, हमें आज ये आजादी,
जो ले रहें हैं, हम थे सुःख की सॉसे
देन हैं। उन वीरों की चढ गए सुली पर हसते हसते ।

जब तक सीने में थे, उनके प्राण
तब तक उठने न दिया, वतन पर बेपाक निगाहों को।
जब कभी आगे बढं तो मोड दिया तुफानों को।
जब कभी गरजे सिह के समान तो थर्रा गए दुश्मन के सीने।
एक हुंकार से जिन्होने छीन ली दुश्मन की सॉसे।
क्यूँ भूल गए हैं ऐसे मतवालों को हम यारों।

टापसी वेर भाव में क्यूं पडे है, हम यारों।
टाओ मिलकर या करें, उनकी कुर्बानी को।
ज़ुनून ए आजादी में फनाह हुए, क्यूँ भूल गए
है, हम ऐसे मॉ के जवानों को।
उठने न देगें ए वतन तुझ पर गुस्ताक निगाहों को।
चीर देगें, फाड देगें, दिल को दुश्मनों के सीनों से,
जब तक है, लहूँ का एक भी कतरा इस सीने में।
तब तक लहराता रहेगा, प्यारा तिरंगा आसमां के सीने में।

संधीरकुमार
(कनि०अभि०)
उपमुख्यअभियन्ता/निर्माण
रियासी

Lifestyle diseases

Lifestyle modification is the application of environmental, behavioural and motivational principles to the management of lifestyle, to maintain body in an optimum shape, physically and mentally, to extract most out of life.

Humans, as other animals were designed to work physically to procure food, the effort so needed was hard enough to stop them far short of indulgence, thus establishing a balance between earning and burning of ATPs. But with our extraordinary modernisation and mechanisation, where most of our basic works including our movement has been taken over by machines, where moving a pen or a mouse can give you enough resources to buy enough to keep on munching forever, where modern appliances are trying hard to make most of our muscles vestigial. We are entering into era of lifestyle diseases.

Lifestyle diseases are diseases that appear to increase in frequency as countries become more industrialized and people live longer. They can include, atherosclerosis, some kinds of cancer, chronic liver disease or cirrhosis, chronic obstructive pulmonary disease, Type 2 diabetes, heart disease, metabolic syndrome ,cervical spondylosis, osteoporosis, insomnia, depression etc..

Most of the diseases mentioned are multifactorial, i.e. genetic traits, environment, food, work, stress etc play a role. In most cases precipitation of diseases can be prevented or delayed with lifestyle modification at right time or at least better managed after its onset.

Lifestyle modification is basically making the body do what it was designed for, therefore better to call it lifestyle rectification.

Let's give it try

The beginning should be with analysis of one's lifestyle i.e. food habit, work profile, sleep pattern etc., than an attempt should be made to gradually shift to what is good for us.

Food habit: our intake should be small and frequent, based on calorie and nutritional needs.

Breakfast can consist of a glass of milk, oats/ dalia/ brown bread/couple of eggs/fruits or any similar alternative. Timing is equally important, consistency should be attempted, and 8 am to 9 am should be the target period.

Lunch may be broken into two parts, a couple of chapattis with liberal amount green fibrous vegetables, a bowl of mixed pulses and salads at around 12 noon; it can be followed by a single chapatti with some vegetable at around 4 pm.

For someone who needs to be in field , suggestion is that his lunch box should consist of chapatti rolls stuffed with dry vegetables, wrapped in a foil to make it easier to gobble up at desired time, at any place(remember your cream rolls in your school days). A hand sanitizer may help to take care of hygiene.

Dinner should be light, protein rich, should be at least 2 hours before sleep. It is advised to have water after an interval to prevent over distension of stomach, this helps in mitigating Gastro oesophageal reflux disorder, a problem presenting with feeling of retrosternal burning sensation.

Try to be as natural as possible, processed and refined food stand nowhere in comparison as far as fibre and nutrient content are concerned, minimise the amount of oil, salt and sugar in cooking. Protein gives less than half the amount of calories per gram in comparison to fats and carbohydrates, it is needed for body building and repair of wear and tears, try to increase its proportion.

Work out

Compare the body to an organization, having different wings. It is a fact that the wings that are having more work, are better taken care of, similarly parts of the body made to work regularly are provided more nutrition by the body, and they are always in a better shape.

Therefore try making your body work. All your muscles are meant for different activities, make them do their work. Use some weight for your biceps, triceps, deltoid, pectorals etc. They will maintain tone, give you a better shape, and enhance your personality. Try to be fair to antagonist set of muscles, e.g. Work on triceps along with biceps; biceps flexes and triceps extends. Weight bearing increases mineralisation of bones, strengthens them. Take care of your back, maintain correct posture, and avoid watching television lying down, with couple of pillows punishing your neck; always work on strengthening your back muscles, neck muscles; this will help fighting backaches and cervical problems.

Swimming, cycling, running, brisk walking, badminton etc are great forms of exercise; either can be opted depending on your preference and facility. There are people who have been able keep a check on diabetes and hypertension, by combination of strict dietary control and regular workout; however, such an attempt should always be backed by regular medical consultation.

By making your body work, you are able increase consumption of glucose and fats in your body, thereby preventing their excessive and pathogenic storage. Reducing your Body Mass Index is an act of determination, patience and perseverance. Emptying your immortal fat cells by burning them out has to be followed by keeping them deprived.

Challenges

1. On start of your dietary control you will have hunger pangs, irritation, weakness etc; be patient, with time your body will be accustomed. Hunger pangs can be taken care by having lots of water; it will give you some relief.
2. Elements of nature may interfere with your outdoor activities, always have a backup plan, a break for couple of days may turn into a break for couple of months, guard against irregularities.
3. For beginners, initial stiffness may dampen the spirit, be assured that in a week you will start feeling better, don't give up.
4. Group activities are good, but can have its own disadvantage, at times the group starts sharing excuses for giving misses.

Cautions

1. People with any medical problem should take a medical opinion before opting for any suitable exercises.
2. People with osteoarthritis should prefer cycling or swimming to walking or running.
3. A good pair of sports shoes is mandatory.
4. Warm up and stretching is important to avoid strains and spasms.
5. You should stop immediately in case you develop any discomfort or pain and should seek advice. Never force yourself against any niggle or pain, this may lead to chronic problem.
6. Don't expect quick results, never over exert, and show perseverance.

Shaping yourself is a sculptor's job, never be miser or impatient in effort.

Dr Pankaj Singh
Sr DMO, Jammu,
Northern Railway

Love in Hills- Sangaldan A Success Story

Sangaldan's prosperity is based on a relationship built on reciprocity and affection, writes Bivabasu Kumar

An arduous six-hour drive from Jammu through the tangle of rocky and winding mountain roads to Sangaldan can sap one's energy. But the breeze over the hills and the intermittent rain can make one's journey to AFCONS' Konkan Railway Corporation Limited (KRCL) project site seem like a hide-and-seek game.

AFCONS is almost finishing construction of five BG single-line railway tunnels on the Katra-Laole section of the Udhampur-Srinagar-Baramulla Rail Link (USBRL) project. The total length of the tunnels, including cut and cover, is approximately 8500m. The Sangaldan village (185 kilometers from Jammu), around which the tunnels are situated, is full of geological variations. The closeness between soft clay and foliated rock mass makes tunnelling in the area a daunting task.

And it's not just the tough terrain, but the erstwhile terrorist attacks that makes this project one of the most challenging jobs. While AFCONS has quietly advanced in its mission, it's the locals on the hills, who have started appreciating the company's positive impact on their lives over a period of eight years.

"AFCONS is providing us with many facilities. We now have plenty of water to drink, medical facility, transport in any kind of crisis… what else can we ask for?" says Mahtaba Begum, who owns a small tea shop near one of the tunnels (Tunnel 44) in Dalwa (two kilometers from Sangaldan).

Mahtaba has been living there for decades with husband, Gulam Mohammad, eldest son, Manzur Ahmad, who is employed with Northern Railways, youngest son Altaf Hussain, who is working with AFCONS, and two daughters (both married). Originally farmers, Mahataba was rendered jobless after the Northern Railways acquired their land (against compensation). The family of six used to stay in a small hut. Though they had enough to fend off poverty, lack of activity and an accident made her husband mentally unstable. It's then when Mahtaba decided to start the tea shop which, today, gets healthy business from workers in the area.

"Now, we have the tea shop and my sons are working. By God's grace and thanks to the company, we have sufficient to live happily. We don't have any regrets. We'll pray that the company continues to work for locals with such passion," Mahtaba adds.

Before AFCONS set base at Sangaldan, the nearest medical facility was the district hospital at Ramban, which is about 45 kilometres from the region. Today, AFCONS provides medical help to the locals from first aid to availing ambulance at any time of the day.

"Earlier, we had to walk for over two hours to reach Ramban. Now, in case of any emergency, we get ambulance or vehicular facility to reach the district hospital. The company restores road connectivity after heavy rains or during snowfall," mentions Mahtaba.

Courtesy
AFCONS Newsletter INSIGHT

Mohd Iqbal, who is medical assistant at the colony dispensary, is equally ebullient. "I was jobless after I completed my diploma in pharmacy. But after AFCONS came, they employed me and I have since then treated so many locals. It is more satisfying that as a local I am being able to help my own people," he says.

There are around 300 to 400 families in the Sangaldan region. Till six years back only two buses connected the people of this region to Ramban. But after AFCONS came, the road connectivity improved with wider roads, repair work and maintenance.

"We now have private vehicles on this route. Earlier, there were only two buses from Ramban. The road connectivity has made life much easier for us," says another local, Mohd Amin Bhat.

Bhat started as a simple villager. But, today, he has established himself as a reputed contractor in the region. "I started as partner to another contractor from Jammu for Tunnel 40-41. This transition from a simple villager to an established contractor from Sangaldan wouldn't have been possible without AFCONS," he says.

According to Bhat, there was no awareness within the locals about the outside world. The majority of the population here are farmers, a small percentage have government jobs and the kids study in Government Middle Schools (upto class eight), Primary Schools (upto class five) or the Government Higher Secondary School at Sangaldan. Private academies have started coming up recently after the locals became more aware about the importance of education. "We now have free water, ambulance on phone call, medicine etc. AFCONS is now like a second home. Our interpersonal skills have improved after interacting with the engineers and the seniors who come from other cities," Bhat explains.

While the kids focus on studies, they are extremely passionate about cricket. Mushkoor Wani (18-years-old) is a Virat Kohli fan and wants to play in the Indian team some day.

"I like batting and we regularly play cricket in the school ground. We are inspired by Parvez Rasool," he says in between a cricket match at the Sangaldan Higher Secondary School ground. To facilitate kids' sporting activities, the company has refurbished a playground in a nearby school.

The Sangaldan market was wiped out by heavy rain and subsequent landslide in 2006. AFCONS provided immediate shelter to the families. The company compensated the villagers for their losses.

In 2009, the nearby Dharam village was devastated by heavy landslide. Though the government gave villagers land it was too rugged for habitation. AFCONS levelled the land and helped locals to set up their new abodes.

In various other ways, the company has touched upon the lives of the people. In the Tattapani area, the AFCONS team helped with material for temple construction. At Sangaldan, the team assisted in infrastructure development for *Ramleela*. They also set up a footway to the *Mazar* (Dargah) for locals.

With better roads and development, the villages now draw more attention from private vehicle operators. While the locals have breathed a sigh of relief, AFCONS continues to work selflessly and with a silent prayer on its lips.

-- Bivabasu Kumar is the Corporate Communications Manager at Afcons Infrastructure Limited.

CHALLENGES & ACHIEVEMENTS

1. Transporting heavy machinery to site was a challenge as the old Dharamkund Bridge could only withstand payloads of 10 tonnes.

2. A magazine was constructed for storage of explosives and a diesel pump was installed at site.

3. Cabinet approval was obtained for quarry under forest land. It was the first time that the J&K government gave such permission considering the project's national importance.

4. In some areas tunnelling was safely executed where the overburden/rock cover was less than 1D.

5. Due to Muree Thrust, the entire rock mass in the project area is deformed and thrust-affected.

6. The presence of nullahs and fresh water springs led to water ingress inside tunnels sometimes to the tune of 1500litres per minute.

7. AFCONS logged a record progress of 68m tunnelling in one month with permanent steel supporting system and cycle time of 18 hours in poor geology.

8. Thirty gantries were completed of 9m in one month which is a record.

Check List for Tunnel alignment

Check list for tunnel alignment

- ✓ Does the tunnel passes through the young mountains?
- ✓ Is there any intra thrust zone?
- ✓ Are there active and inactive fault/thrust zones?
- ✓ Where are the thick shear zone?
- ✓ Is rock cover excessive?
- ✓ Is pillar width between tunnels adequate?
- ✓ Are there thermic zones of ground temperature that are too high?
- ✓ What is the least rock cover or shallow tunnel beneath the gullies/river/oceans?
- ✓ Are there water-charges rock masses?
- ✓ Are there swelling rocks?
- ✓ Are Joints oriented unfavorably or is the strike parallel to the tunnel axis? Is the tunnel along an anticline(favorable) or syncline(unfavorable)?
- ✓ Mark expected tunneling condition and corresponding methods of excavation along all alignment according to chapter 7
- ✓ In which reaches, open/single-shield/double-shield, should TBMs be used in very long tunnels?
- ✓ In which reaches are conventional drill and blast methods recommended?
- ✓ Is it likely that a landslide-dam will be formed and lake water will enter the tailrace tunnel and powerhouse cavern, and so forth?
- ✓ What are the expected cost of tunneling for different alignment along their period of completion?
- ✓ What is the possible surveying error, especially in the hilly terrain?

Seepage during excavation of Tunnels

It may so happen that during tunneling alternate inclined beds of impervious (shale, phyllite, schist etc.) rock and pervious rock (crushed quartzite, sandstone, limestone, fault etc.) are encountered. Heavy rain/snow charge the beds of pervious rocks with water like an aquifer. While tunneling through the impervious beds into a pervious bed, seepage water may suddenly gush out. This flooding problem become dangerous where the pervious rock mass is squeezing ground due to excessive overburden. In two projects in the Himalayas, the machine and Tunnel Boring Machine (TBMs) are partially buried.

Seepage should be monitored near the portal regularly. The discharge of water should be plotted along the chainage of the face of the tunnel. If the peak discharge is found to increase with the tunneling, it is very likely that sudden flooding of the tunnel may take place with further tunneling.

Chimney formation.

There may be local thick shear zones dipping towards a tunnel face. The soil/gouge may fall down rapidly unless it is carefully supported immediately after excavation. There are chances of formation of a high cavity/chimney along the thick shear zone. The chimney may be very high in water-charged rock mass. This cavity should be completely backfilled by lean concrete.

Project Alignment

Station	Km
Baramulla	118
Sopore	110
Hamre	103
Pattan	94
Mazhom	86
Budgam	72
Srinagar	60
Pampore	54
Kakpora	49
Awantipora	38
Panzgam	32
Bijbehara	25
Anantnag	18
Sadura	11
Qazigund	154/0
Banihal	136
Arpinchla	120
Sumber	108
Sangaldan	89
Basindadhar	71
Dugga	61
Salal – B	52
Salal – A	50
Reasi Road	43
Katra	25
Chakrakwal	9
Udhampur	55/0
Ramnagar Road	43
Manwal	32
Sanger	22
Bajalta	11
Jammu Tawi	0