Career Profile of

Lt. Gen. Mahendra Singh Gosain
Director, Border Roads Organisation

Recipient of S.B. Joshi Memorial Award for Excellence in Bridge & Structural Engineering for the year 1996, cited by Alumni Association of College of Engineering, Pune

Date of Birth:
- 2nd August, 1933

Educational Qualification and Training:
- BE (Civil), CME, Pune

Professional Experience and Training:

- Commissioned in the corps of Engineers Indian Army in Dec, 1953.
- Commanded field engineering Company in Bhutan and Arunachal Pradesh
- Commanded engineer regiment in East Bengal, successfully carried out engineering operations in 1971 Bangladesh war.
- Commanded Border Roads Projects in Nagaland, Manipur, North Assam and Arunachal Pradesh.
- Constructed roads and permanent bridges in difficult and inhospitable areas both during peace and war.
- Director General of Border Roads in 1991.

Publications:
- Published many technical articles.

Honors & Awards:
- Chief of Army Staff Commendation Card.
- Many distinguished service awards by President of India like PVSM, AVSM.

Affiliation with Professional Bodies:
- Fellow, Institution of Engineers.
- Member of Military Engineers, IRC, CRRI, NIT Highway Engineering.

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1996 Lt. Gen Mahendra Singh Gosain FIE, PVSM, AVSM, VSM.

Lt. Gen Mahendra singh Gosain, was born on August 2, 1933 in a remote village in Garhwal, Uttarakhand. He had his education in various districts of U.P and did his Engineering from College of Military Engineering Pune.

He was commissioned in the Corps of Engineers, Indian Army on 13 December 1953. During service, he obtained many professional qualifications such as Defence Service Staff College. Senior Defence Management and Higher Command. He is member of various Technical and Academic bodies such as institution of Engineers and Military Engineers and was the Vice President of the Indian Roads congress. He was council member of the Central Road Research institute and National Institute of Training of High- Way Engineering. He was director of the Indian Road Construction Corporation and Technical Advisor on the Border Roads tot the Government of India.

In the Armed Forces he served throughout the country in various capacities. He Started his career as an Military Engineer in the Kashmir Valley. He qualified as a paratrooper and later took part in GOA operations. He commanded a field Engineering Company in Bhutan and NEFFA (now Arunachal Pradesh.). He Commanded an Engineer Regiment in East Bengal and successfully carried out Engineering tasks in 1971 Bangladesh operations. He served as a Commander works Engineer In Military Engineering service. There after he commanded two Border Road Projects as Chief Engineer in Nagaland, Manipur and North Assam and Arunachal Pradesh. He was Commandant of the Bombay Sappers, commander of the Sub Area in Punjab and Chief Engineer of the Eastern Army. He took over as Director General Boarder Roads, in May 1987 where he served for more than four years. He retired from this post on 31 August 1991.

During his service as an Army Engineer, he had plenty of opportunity to construct roads and bridges, both during peace and war. His tennure in the Border Roads in Bhutan, Nagaland, Manipur, Arunachal Pradesh and later as a Director General of Border Roads gave him the opportunity to construct many roads and permanent bridges in difficult and inhospitable areas.

He was awarded many distinguished service awards by the President of India. He was awarded Chief of Army Staff Commendation Card, while serving in Nagaland. He was awarded Vishist Sewa Medal for meritorious service during Bangladesh operations. He was awarded Ati Vishist Sewa Medal for his distinguished service of an exceptional order, while service as chief Engineer Project Vartak In Upper Assam & Arunachal Pradesh. He was awarded Param Vishist Sewa Medal as Director General Border Roads for his distinguished and meritorious services of exceptional order.

2 BRIDGING PROBLEMS OF MOUNTAIN ROADS CONSTRUCTED BY THE BORDER ROADS ORGANISATION

Lt Gen (Retd) M.S. GOSAIN
Director General (Retd)
Border Roads Organisation

2.1 Introduction

Roads Construction in the Himalayas stared in early 1960. The armed Forces and the Border Roads organization have connected these remote areas to the main land by constructing roads right up to the borders. Bridging is an integral part of road construction. The road construction agencies initially constructed temporary bridges/ crossings which were subsequently converted into semi- permanent equipment bridges. Now permanent bridges are being constructed to replace the equipment bridges.

Himalayas are young and unstable mountains with extreme weather conditions and few local resources. Construction of permanent bridges poses numerous problems which have been successfully tackled by the Border Roads Organization. Enough expertise has now been achieved to speed up construction of permanent bridges on the turbulent rivers in the Himalayan Mountains in the North and North East.

The chapter includes the author's presentation on activities of BRO, highlighting the major bridges constructed by BRO, in mountains of Himalayas.

2.2 Border Roads Organization (BRO)

Road Communications in the Himalayan North and North – Eastern regions remained virtually non-existent unto the late fifties. Bridle paths, mule tracks with foot bridges and few fair weather jeep tracks were the only access routes to remote border areas.

In the early sixties the Chinese presence on the door of our traditional border was taking the shape of a distinct threat. The Himalayas were no more impregnable. Our Nation's Armed Forces had to move closer to borders for the defense of our Country. Roads had to be constructed upto farthest outpost before it was too late.

It was against this backdrop of grave national emergency that the Border Roads Organization (BRO) was set up in March 1960 and the two Projects raised on 7 May 1960, with the then Prime Minister, Pandit Jawaharlal Nehru as the first Chairman of the Border Roads Development Board (BRDB)

Starting with two Projects in the East & West in 1960, the need was so intense that expansion took place over-night and many more Projects were raised. Today the BRO has 13 Projects. The BRO is working in Rajasthan deserts, Andaman & Nicobar islands and other remote areas. BRO has its own Centre at Dighi Camp Pune and adequate facilities for repair and overhaul of equipment and machinery both in the East & west. The deployment of all the projects of the BRO, all over India, is shown in *Fig. 2.1*.

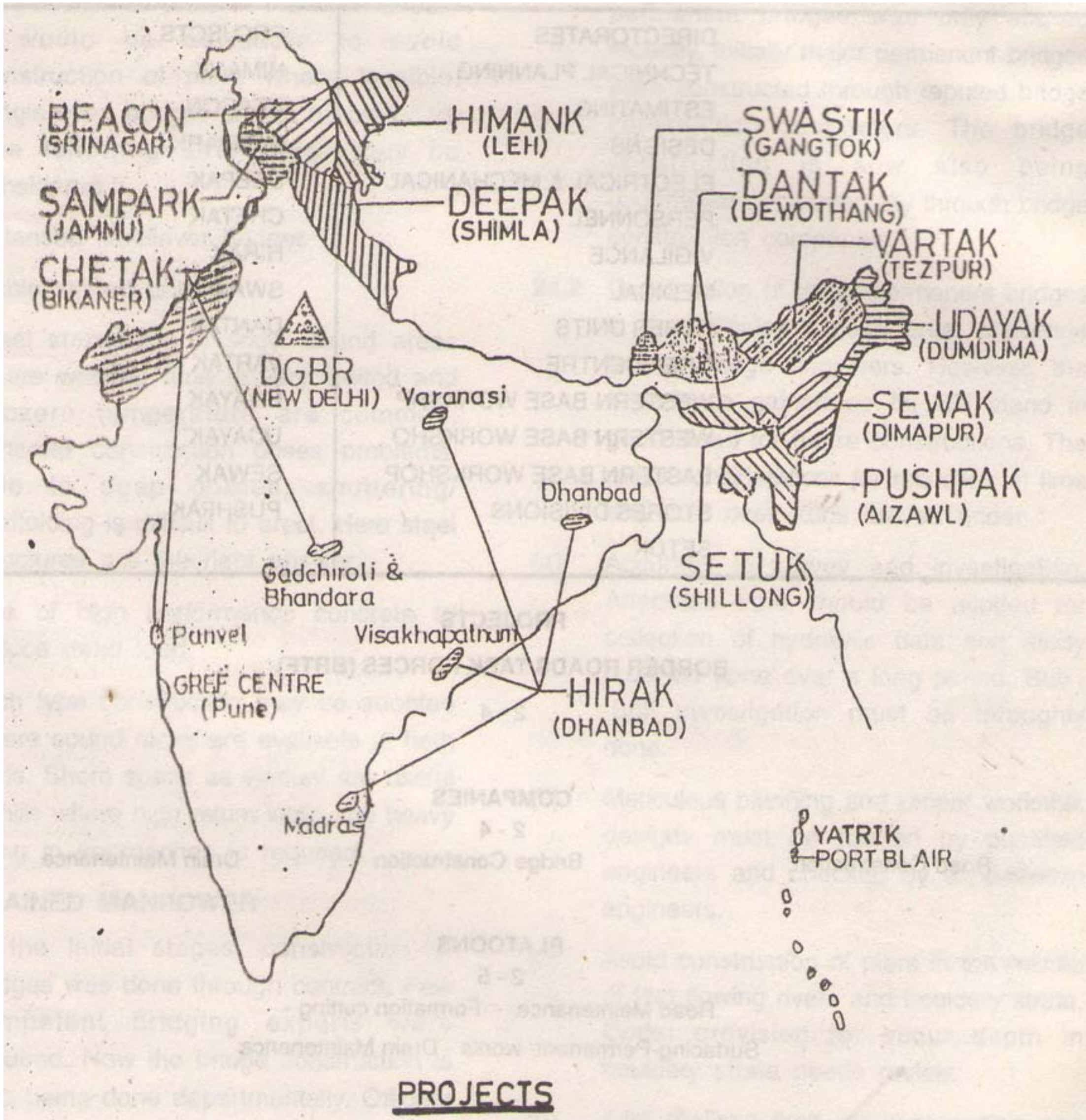

Fig 2.1 Map Showing the Projects of BRO

2.2.1 Objective of BRO

Today the main task of the BRO is the vanguard activity of development namely the construction of roads to link up the isolated/remote areas with the Indian heart land and assist in the integration of the Nation by creation and improvement of road communications not only in the North & North- East but all distant and remote areas.

Today one can travel from one end of the Himalayas to the other (upto the remotest Pockets) on good surfaced roads fit even for heavier axle loads. These roads have provided infrastructure for socioeconomic development of the Border States, integration of our tribal population with main stream of the national life, industrialization and economic advancement. This has brought a sea change in the thinking, outlook and aspiration of these people. Besides generating employment, BRO has brought joy and happiness to millions of homes in the North, North Eastern States and other remote areas.

The Organization is a premier road construction agency in the country and ranks amongst the largest in the world. Many of its personnel have served in the Indian Road Construction Corporation Ltd., In Libya, lraq, lran and Yemen Arab Republic.

2.2.2 Organizational Structure

BRO is fashioned exactly on the line of Army with Director General as its head. He is responsible to the Border Roads Development Board for technical, administrative and financial matters. The BRO carries out the road construction departmentally. Contracts are given only for intricate bridging and specialized works. The organizational chart is shown at table 2.1.

Table-2.1
Border Roads Organization
Border Roads Development Board (BRDB)

Directotates	Projects
Technical Planning	Himank
Estimating	Beacon
Designs	Sampark
Electrical & Mechanical	Deepak
Personnel	Chetak
Vigilance	Hirak
Medical	Swastik
Other Units	Dantak
Gref Centre	Vartak
Western Base Workshop	Udayak
Eastern Base Workshop	Sewak
Stores Divisions	Pushpak
	Setuk

Director General Border Roads (DGBR)
Finance Branch

PROJECTS
BORDER ROADS TASK FORCES (BRTF)
2-4
COMPANIES
2-4

Road Construction. Bridge Construction Drain Maintenance

PLATOONS
2-5
Road Maintenance –Formation Cutting
Surfacing-Permanent Works-Drain Maintenance

The average annual work load is in the range of Rs. 750 Crores. The strength of the force is 42 thousand with mechanical equipment holding of over Rs. 400 crores.

As a diversification, the Border Roads Organization has also constructed Buildings and Air Fields, in the difficult and remote areas.

2.2.3 Achievements

The Border Road Organization has the unique distinction of having constructed the highest motor able roads in the world. The road at Khardungla Pass, 18380 ft above the sea level, is kept open throughout the whole year, the highest motor able bridge, unique of its type in the world founded on glacier beds has found a place in Gunnies Book of world Records. An unparalleled feat in the history of highway construction is a continuous stretch of over 250 km. of road ranging between 14000 ft and over 17000 ft traveling through the rugged Himalayan ranges.

Since its inception in 1960, the Border Roads organization has constructed 25,500 km of roads of which 23,000 km have been surfaced. Its yearly work load is as under:

Formation Cutting	:	700 km
Surfacing	:	1600 km
Permanent Works	:	140 km
Bridging	:	1200 mtrs/24 crores.

The BRO has also supported the Armed Forces in 1962, 1965, 1971, OP PAWAN (Srilanka) operations and in all insurgency areas.

2.3 Bridge Construction in The Border Roads Organization

Bridging of gaps and rivers is an essential part of road construction. In the initial stages of construction of roads in border areas, the primary objective was to open roads as early as possible. And make the remote areas accessible. In order to cross the water gaps falling on the road alignment, as soon as formation cutting was done, temporary arrangements were made such as fords, low-level causeways and timber bridges. Common suspension bridges on wire ropes fit for use by jeeps were also used in a few areas. On certain roads, leading from plains to the hills, timber or log bridges were provided. On major rivers. Rafting was resorted to with boats and /or pontoons which could carry vehicles and equipment also. These were followed by equipment bridges like Bailey, Hamilton, Inglis, Stock- span, portable steel bridges and Bailey Suspension bridges. These bridges are extensively used in the Army. Apart from the above, stiffened Girder suspension Bridge and some steel Truss Bridges fabricated by private firms, were also provided. This system and procedure continues even today in the new roads under construction.

2.3.1 Road Policy of BRO

As per policy, on roads of BRO, minimum CI 18 (IRC C1 B) single lane bridges are to be provided. In exceptional cases C1 9 bridges capable of taking a 3- ton lorry may be provided. These bridges were to be replaced in due course, on a selective basis, by permanent bridges of IRC C1 A/40 or IRC C1 70 load class depending on the status of the road. However, in practice, many of the equipment bridges have been in use for over 30 years without replacement and are functioning satisfactorily. However, these bridges are only of single lane width, therefore, the process of replacing equipment bridges by permanent bridges was started especially on priority roads.

While replacement of equipment bridges by permanent bridges was mainly for General Staff (GS) roads and National Highways in the BRDB programme, the policy for agency-roads was to provide bridges as required by the sponsoring agency. On NEC roads, the requirement was only construction of equipment bridges to Class 18 load, whereas on BCCL roads in Project Hirak, all bridges were to be permanent double lane bridges of Class 70 load . On Indo - Bangladesh Border roads, permanent bridges were to be provided for 3- ton vehicles i.e. class 9. on certain Sensitive Border Areas (SBA) roads, C1ass 18 timber bridges were accepted as per practice in the area. With the introduction of heavier vehicles and equipment and higher axle loads by army, the need to replace equipment bridges on GS roads assumed priority.

The activity related to permanent major bridges commenced in 1964-65 in a modest way both in Western and Eastern sectors. It was mainly on NH lA in J&K and the access roads to Bomdila, Ziro and Along in Arunachal Pradesh under Project Vartak. To plan these, a Bridging Cell was organized at the headquarters. In the beginning major permanent bridges were enthused to the contractors as this required high degree of specialization. However, due to many problems in the remote and inaccessible in the remote and inaccessible areas and reluctance of the contractors the bridging activity is now also being under – taken departmentally. As the activity gained momentum bridging cell has been strengthened to the bridging Directorate with a Chief Engineer for planning and monitoring. A Chief Engineer Bridging in the Eastern Sector has been raised to execute and supervise works on sub soil investigation teams and bridge construction companies have been raised to construct major permanent bridges.

2.3.2 Bridge Policy of BRO

Major bridges have been constructed and are under construction both through contract and departmentally in all the projects. The bridges constructed consist of single span to multi-span bridges of lengths 30 meters to 1000 meters. A variety of standards and specifications have been adopted as under:

Open well and raft foundations involving pneumatic sinking in a few cases. The sub-structure in abutments and piers are of mass concrete, RCC and columnar pier.

In super structure, a wide variety of systems have been adopted as follows:

- Pre-stressed concrete girder
- Pre-stressed concrete box girder
- Pre-stressed concrete T-beam
- Pre-stressed box girder with counterweight type cantilever.
- Balanced cantilever box-girder
- Steel girder
- Steel lattice girder
- RCC box girder, RCC T- Beam, RCC girder
- RCC deck over PSC girder

2.4 Bridging Activity In The Mountains

As the BRO is working in various terrains throughout the country the most problematic are has been the high altitude and mountainous areas in the North & North-East. The road and bridge construction activity in the Himalayan Mountains is most difficult due to remoteness, terrain, topography, weather and geological conditions. The high rainfall above 300 mm, high altitude and both phenomena together are present in many regions in the Himalayan Sector. These affect the efficiency and performance of men, machines and material. Added to this is the difficult logistic support problems and scarcity of even otherwise common materials like water, stone and sand.

2.4.1 Characteristics of Bridges in Himalayas

The main characteristics affecting construction of Bridges in the Himalayan Mountains are:

- High velocity
- Flash floods
- Scouring effects
- Boulders in river beds.
- Unstable geological formation
- Uncertain ground conditions
- Climatic Conditions- extreme cold, high rainfall
- Turning Circle and space for bridge Construction.

Thus the substructure construction has to be meticulously planned and executed as this is the key to successful bridging in the mountains. The long time has also to be provided for construction.

In the last three decades over 125 permanent bridges have been completed in extremely difficult terrain and adverse climatic conditions. In addition over 90 bridges of about 7000 m length are in various stages of constructions and about 255 bridges of over 21,000 m are in the planning stage. The experience gained, problems encountered and lessons learnt can best be brought out by selected case studies. Case studies of most difficult and problematic bridges have mainly been brought out.

2.5 Case Studies

2.5.1 Khardungla Bridge

The road Leh – Chalunka passes over khardungla pass at an altitude of 18380 feet. The alignments of the road near khardungla passes over an ice body which was an obstacle for free vehicular traffic. Glaciologists and experts opined that the ice body was in state of flow and proposed realignment of the road. The realignment would be completed over a period of 2 to 3 Years. Major General commanding 16, Border Roads task Force planned, designed and constructed a 90 ft Bailey Bridge on the ice body. The bridge was constructed in 4 days at a much lesser cost and permitted free flow of traffic. The bridge also enabled the traffic to be kept open during the winters. The bridge though only 90 ft in length has the following unique distinctions.

- It is worlds Highest Altitude Motor able Bridge.
- It is a semi permanent bridge across an ice body.
- It is founded upon body

The bridge finds its name in the Guinness Book of world Records.

2.5.2 Khuni Nalah Bridge

Khuni Nalah is situated at Km. 166.77 on NH lA, Jammu-Srinagar Road. The Nalah is slide- prone with rubble and boulders coming down resulting in a large number of casualties and accidents. Initially a tunnel was made to pass traffic safely. However, with the increase in traffic, the tunnel proved to be a bottle neck. It was therefore decided to construct a bridge down stream which would also avoid the rock slide area. The bridge was constructed in Sept 1976. However, the odd flying stones would always fall on the bridge which was a danger to the traffic and the bridge itself. A wire mesh barrier was constructed to check the flying debries. However, in 1985 a big boulder broke through the wire barrier and damaged the bridge cutting through some reinforcements. The bridge was repaired in 1987

2.5.3 Bridge Over River Chenab At Akhnoor

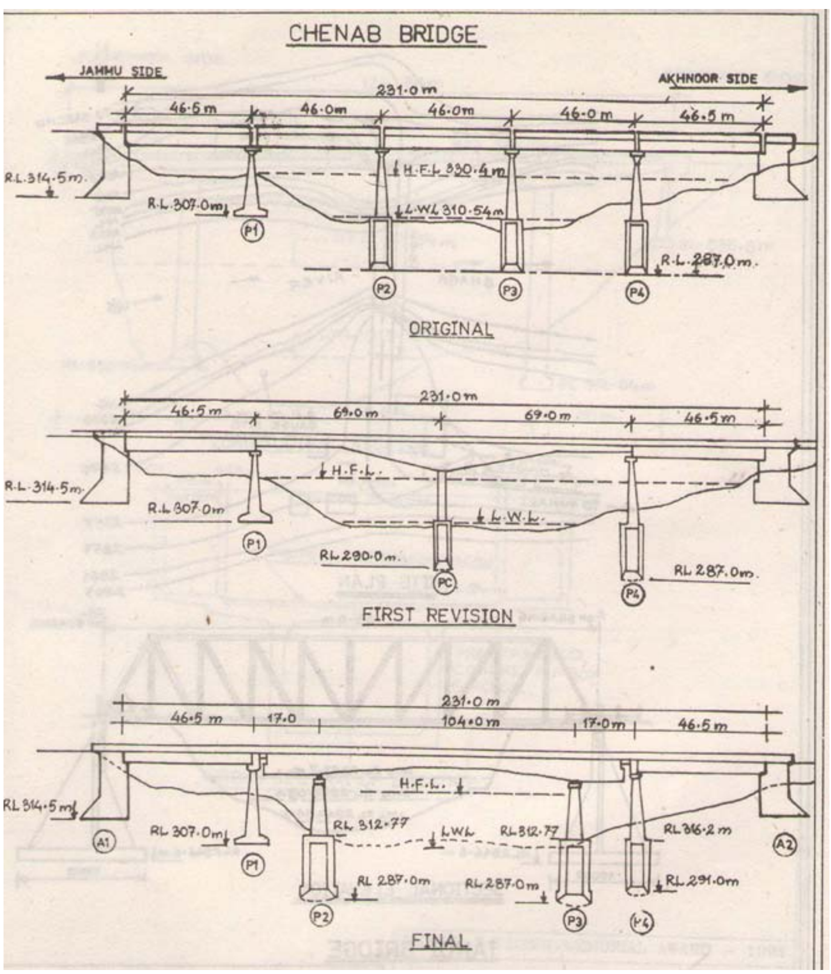

Fig 2.2 Bridge Over River Chenab At Akhnoor

The bridge, as shown in *Fig. 2.2,* is located in Jammu/Akhnoor sector of J & K over turbulent river Chenab with a maximum flood discharge of 22240 cumecs. The banks/bed material comprise of loose boulder/sand over conglomerate cemented with compact soil/sand. It was proposed to construct a 230 m long bridge with five spans each of 46 m. The work was awarded during July 76; it progressed indifferently due to incorrect assessment of resources, and severe problems encountered another contractor in Dec. 86. He too could not progress satisfactorily due to immense difficulties encountered during sinking of wells in conglomerate, and fast currents. During Sept 92 floods, a steel bridge located down stream in close vicinity was washed away. The contractor has now suspended the work on the plea that it was not possible to undertake construction of any structure in the midstream and recommended revision of design parameters and entire bridge scheme. The revised bridge proposal is under consideration.

2.5.4 Steel Truss Bridge Over River Chenab

There was a three span truss bridge 138’20m span on Jammu side and 2 spans of 34.7m on Akhnoor side. On 10 Sept 92 due to unprecedented rise in the River the main span of the bridge was washed away. The road link was snapped. The reconstruction of bridge was entrusted to the Railways. They in collaboration with M/S qudricon designed the centre span. It was decided to use Calendar Hamilton bridge components to be joined together by Quadricon Unishear joints.

The estimates for the bridge were revised a number of times and ultimately Es. 5.2 Crores was projected. The work was started in January 1993 and completed on 13 April 1994. However, this is a temporary arrangement and permanent bridge would be required to be constructed as planned.

2.5.5 Bridge At Tandi Over River Bhaga

This bridge with proposed span of 45m,as shown in Fig. 2.3, is located at an altitude of over 2500 m in snow bound area of Lahul valley in Himachal Pradesh. Due to hazardous climatic conditions and severely restricted working period, foundations were completed in almost five working seasons. It would perhaps have been advisable to plan a longer span bridge with shallow foundations

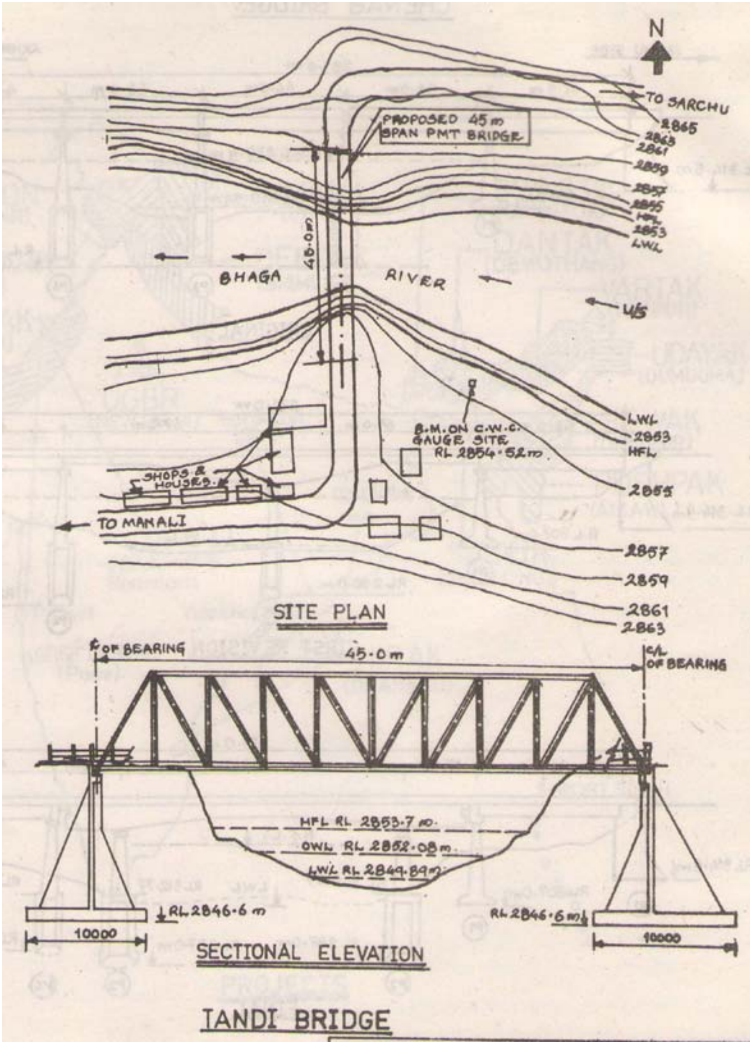

Fig2.3 Bridge At Tandi Over River Bhaga

2.5.6 Kirtinagar Bridge at Km 124.32 on R J Road

The bridge over River Alaknanda, as shown in *Fig, 2.4*, was started in Aug 1983 and completed in June 1990 at the cost of 1.77 crores. The bridge involved construction of two abutments and two piers. The superstructure was balanced cantilever pre-stressed concrete box girder.

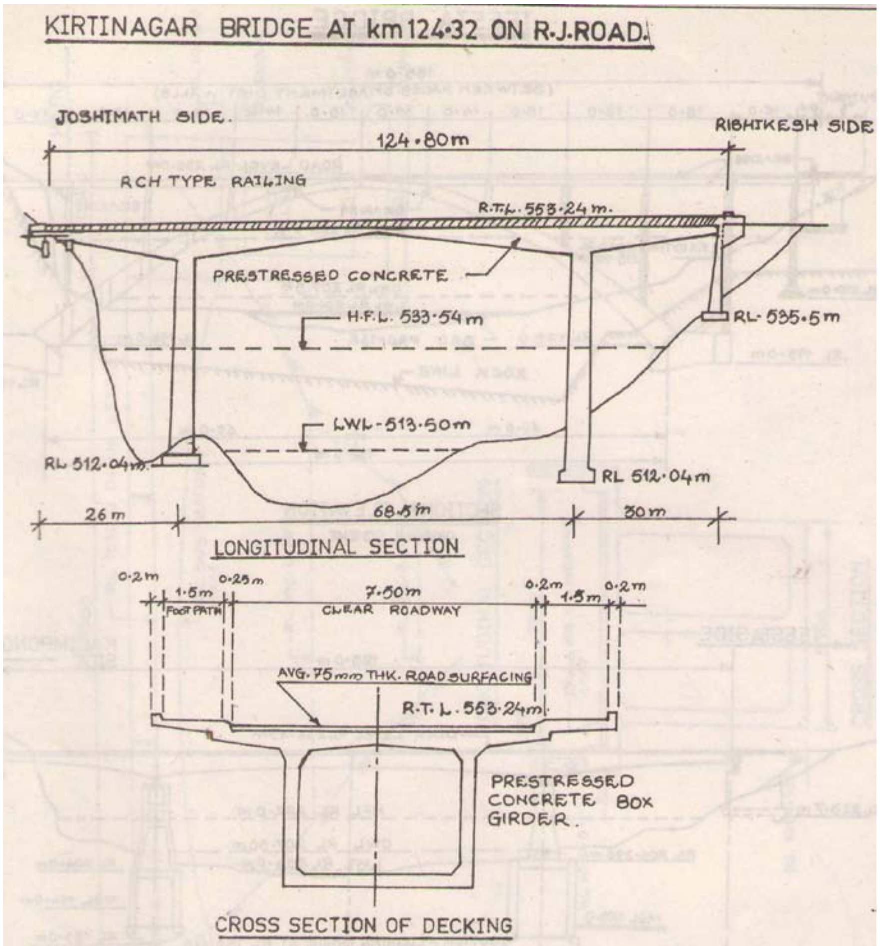

Fig 2.4 Kirtinagar Bridge at Km 124.32 on R J Road

2.5.7 Bridge Over River Teesta

This bridge, as shown in *Fig. 2.5*, is situated on NH 31 A on Siliguri-Gangtok road over River Teesta a turbulent river. The bed consists of big boulders/rocky strata. A contract for 185 m long arch bridge was awarded in March 1988. Due to foundation problems, the span arrangement was changed to suit balanced cantilever type in 1991. the finalization of these change took almost three years on resumption. Further delay occurred during sinking one of the wells due to sudden dip in the rock. A situation which could possible have been avoided by undertaking additional bore holes during sub-soil investigation. The bridge was ultimately completed during April 96.

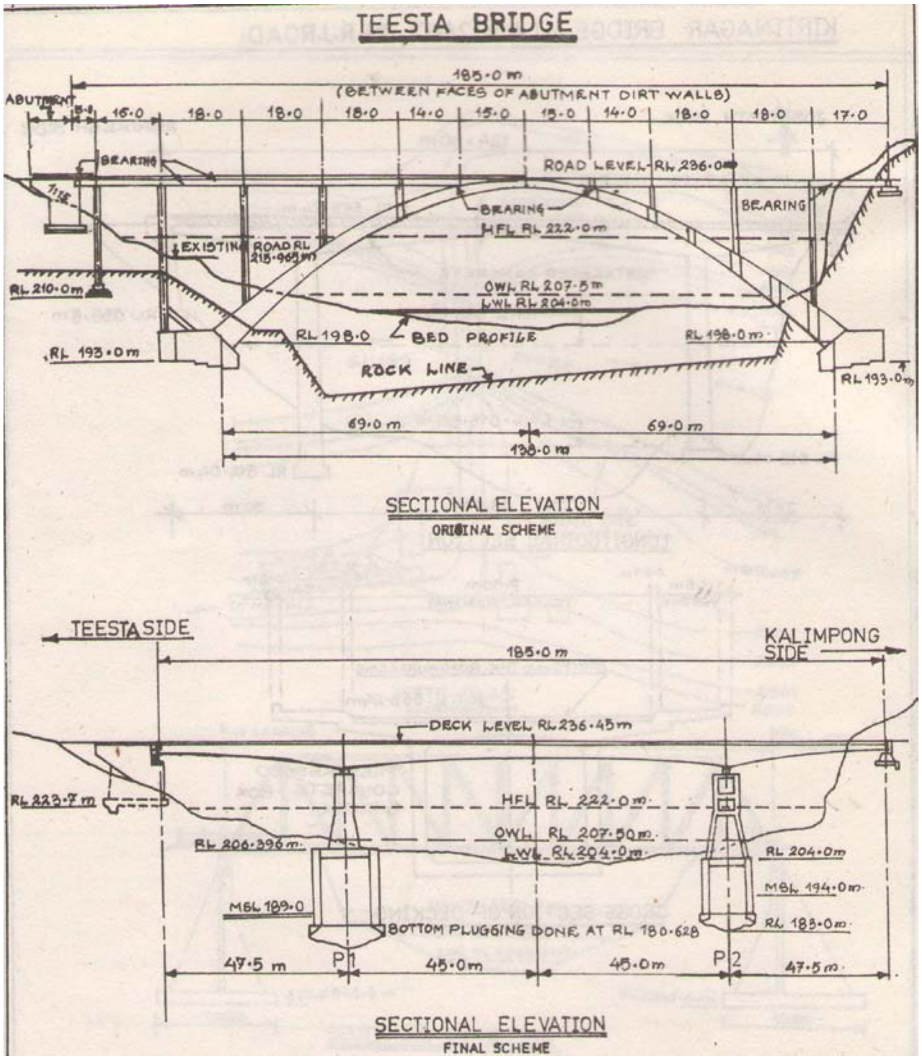

Fig 2.5 Bridge Over River Teesta

2.5.8 Confluence Bridge Over Wandchu

The 98m bridge, as shown in *Fig.2.6*, on road Thimpu-Paro in Bhutan was started in May 1988 and completed in July 1990 at the coast of Rs. 236.94 Lakhs. It has open foundation abutments and pre-stressed concrete suspended span. The bridge was inaugurated by Her Royal Highness, the sister of the King of Bhutan and named as “FRIENDHIP” bridge.

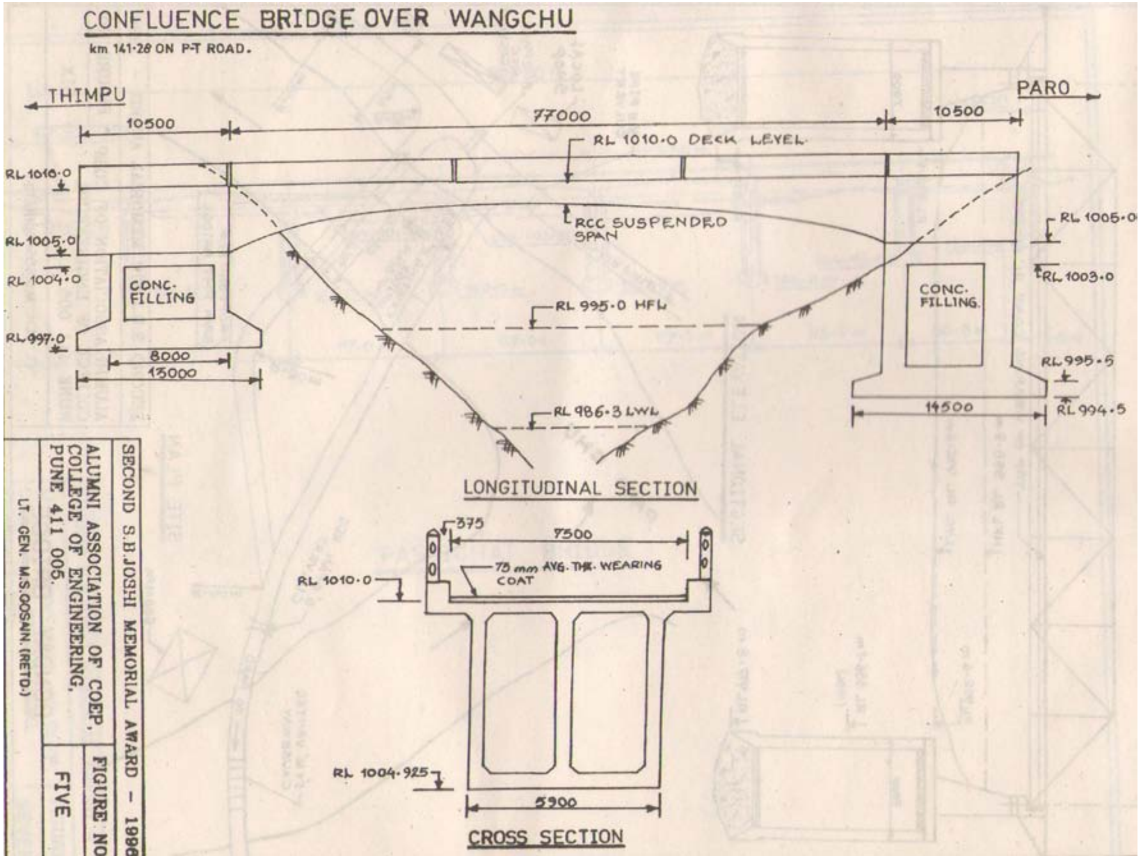

Fig 2.6 Confluence Bridge Over Wandchu

2.5.9 Bonday Bridge Over Paro-Chu

The bridge, as shown in *Fig. 2.7*, located near Paro in Bhutan in high altitude area with sub Zero temperature, is provided with pre-stressed steel superstructure, Due to restricted working period, it took more than two working seasons to sink the abutment well by about 15m in boulder strata, Pre-stressed steel superstructure considerably facilitated speedy construction besides effecting economy in cost of approaches.

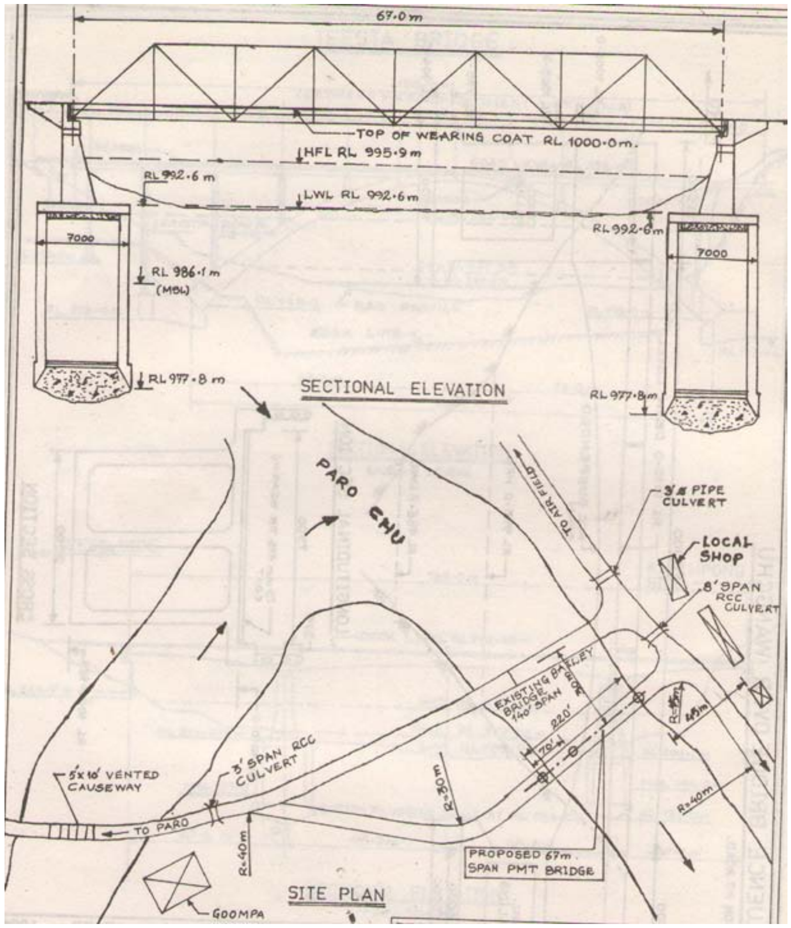

Fig. 2.7 Bonday Bridge Over Paro-Chu

Isnu bridge over the same Paro- Churoad is a similar bridge. The two bridges were cited the Indian institution of Bridge Engineers award for excellence in construction

2.5.10 Passighat Bridge Over River Siang

The 703m long bridge, as shown in *Fig.2.8,* across River Siang (Barahmaputra) is under construction in Arunachal Pradesh. The works contract on this bridge was awarded during Nov 1987. There are seven spans with six piers and two abutments. Well foundations have been proposed for the piers and abutments. The contract does not provide separate rate for pneumatic sinking. The investigation and farming the proposal was undertaken by specialist consultants. To date it has been possible to sink one of the wells upto 30m below LWL as against the designed parameter of 51.50 m. During floods the wells in mid stream got tilted/shifted heavily and took two working seasons to correct the tilt/shift within the permissible limits.

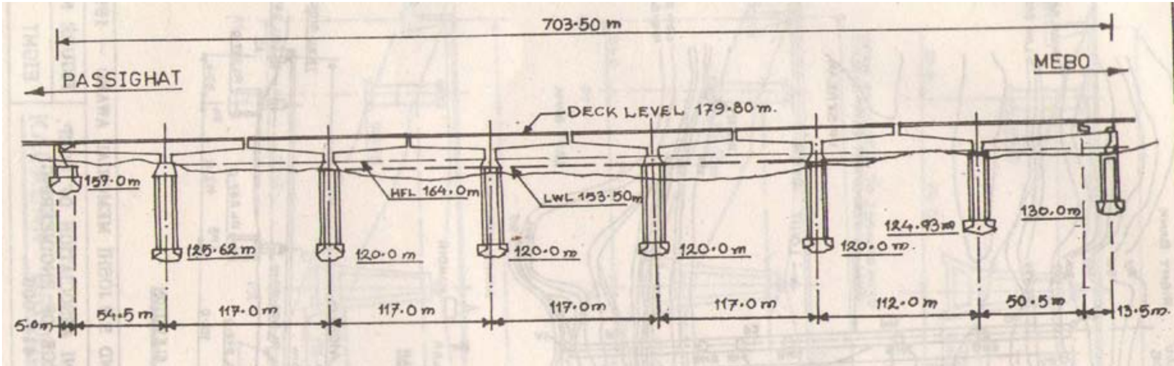

Fig 2.8 Passighat Bridge Over River Siang

The firm has brought out the following difficulties in sinking of wells.

- Boulders encountered during sinking are of very big size (upto 3000 mm size) requiring extensive blasting with attendant danger of damage to well steining.
- It is beyond human endurance to adopt pneumatic sinking below 30m from LWL, due to the very high pressures built.
- Ineffectiveness of open grubbing in compact boulder strata
- In absence of separate rate for payment for pneumatic sinking there is a financial crunch on the job.

On review, plugging of wells below abutments and two piers at 30 m below LWL was decided. The wells in the midstream are yet to be sunk even upto 30 m below LWL. The Project has been delayed essentially due to practical difficulties in sinking and non – availability of proper codes/guidelines for accurate estimation of scour in bouldery bed.

2.5.11 Rahmakund Bridge Over River Lohit

The Contract for the bridge was awarded during Mar 89 for construction of a 410 m long bridge, as shown in *Fig. 2.9*, over river Lohit in Arunachal Pradesh. It is a very turbulent river carrying large river emerges from a gorge to plains at this point. With the presence of boulders in the bed pneumatic sinking was inevitable. However, because of hard strata underneath the boulders- bed, the rate of well sinking was very slow. Another major bottleneck was shifting of stores to far bank due to non- availability of approaches at other end. So far only one pier has been plugged.

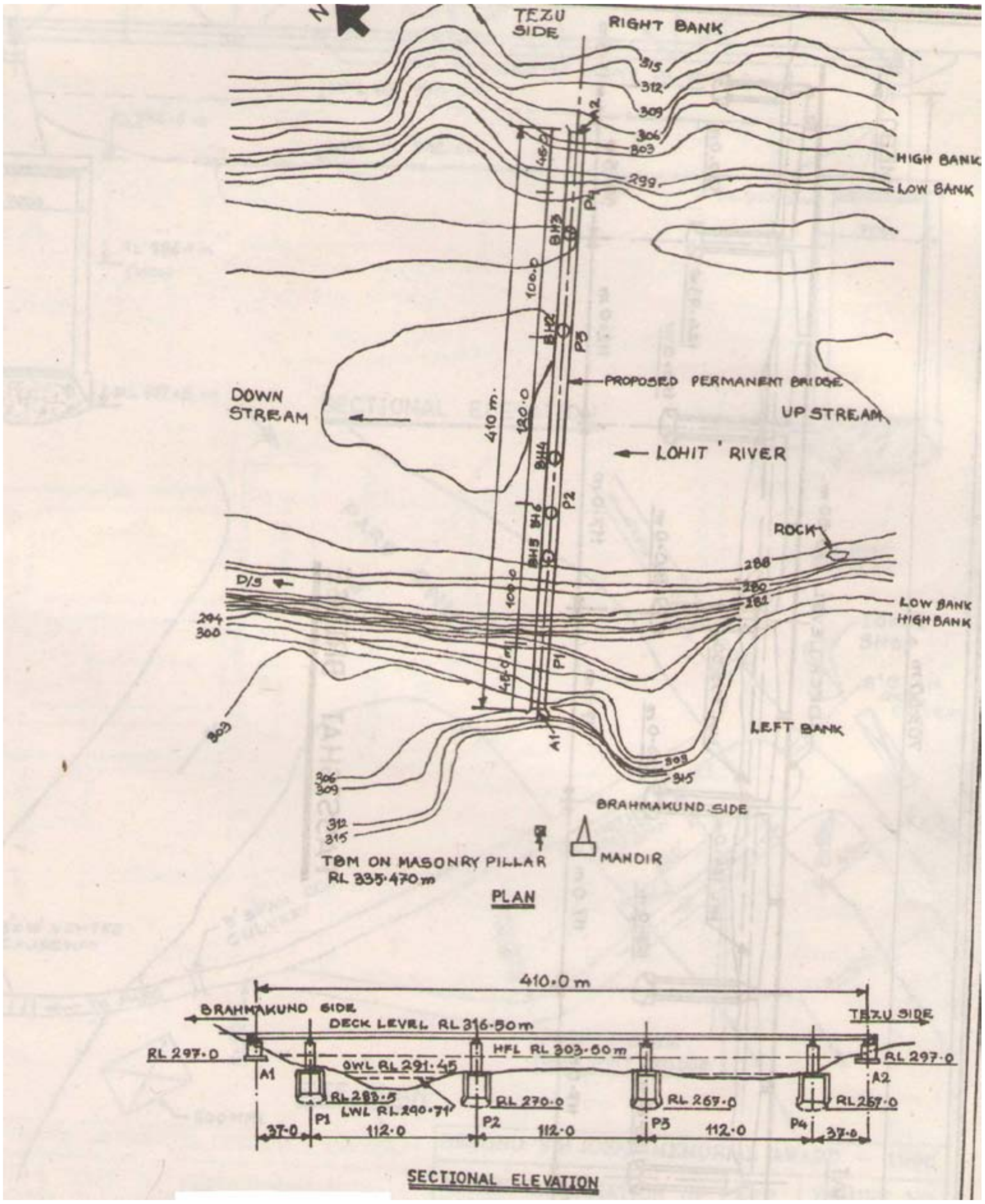

Fig 2.9 Rahmakund Bridge Over River Lohit

2.5.12 Kaladan Bridge On Road Lungleh-Tuipang

The Contract for the bridge was awarded during Nov 87 for the construction of a 300 m balanced cantilever bridge of five spans with open foundations across river Kaladan in Mizoram. The bridge is shown in *Fig.2.10*. Subsequently, the length of the bridge was reduced to 285 m by shifting the Lungleh side abutment by 15 m towards river side to avoid shifting of a Church and a transformer of high voltage electric line. Later, Tuipang side abutment was omitted and the bridge scheme rearranged into four spans to avoid pier in the middle of the river. During excavation due to severe dewatering problem the proposed foundation levels could not be attained due to sudden dipping of rock at foundation level. The pier was further shifted by 5.5 m towards Tuipang side abutment. All the foundations have since been completed; the bridge is expected to be completed by March 97. The Completion of the project has been delayed mainly due to incorrect assessment of resources, problems of induction due to remoteness of area, hostile climatic conditions and revision of the proposal during construction.

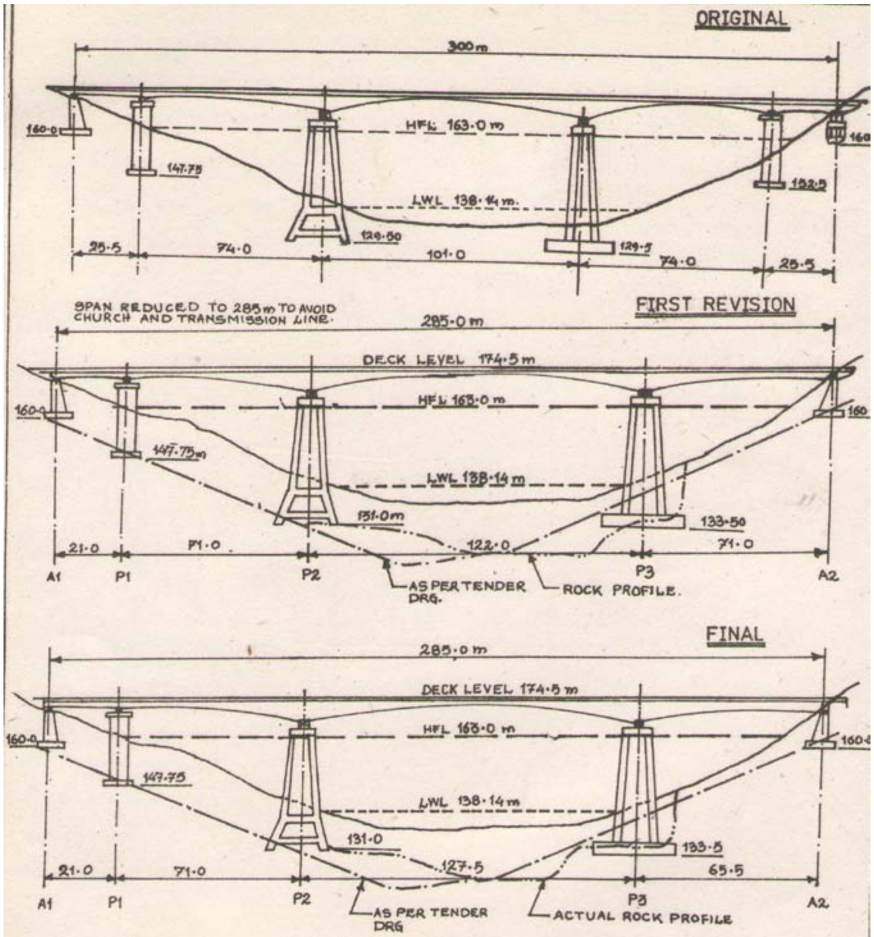

Fig 2.10 Kaladan Bridge On Road Lungleh-Tuipang

2.6 Major Problems Encountered

Construction of permanent bridge in the remote Himalayan Region was a challenge to the Bridge Engineers. The unstable mountains with unprecedented and unpredicted flow, pose many problems. High Altitude and cold weather posed problems for designers and construction engineers. The main problems encountered were:

(a) Selection of correct bridge site

(b) Non –availability of correct hydraulic data, HFL, current velocities, scour depths and other details of high floods.

(c) Incomplete sub-soil investigations (SSI) affecting bridge schemes and subsequent changes in the proposals.

(d) Lack of adequate competitive bidding due to remote and hazardous areas, hostile climatic conditions, poor infrastructure conditions, poor infrastructure and lack of experience in these areas.

(e) The execution was delayed due to change in site, design parameters and span arrangements. Some of these are unforeseen viz change in course of rivers.

(f) Design and construction of Sub-Structure is more important in these areas compared to the super structure. Sinking of wells is very slow and generally takes more than one working season. This results into excessive tilt and shift to wells during floods and takes considerable time for correction. At times such wells have to be abandoned and the scheme/span arrangements/design to be revised.

(g) The smaller diameter wells require deeper foundation and tend to become structurally unsafe if founded at higher levels.

(h) Pneumatic Sinking can be under taken only upto 30m below low water level as the air pressure beyond this depth becomes excessive for human endurance. The sinking of wells even upto 30m below LWL is very slow of 0.50 to 1.5 m per month depending upon the type of strata, Blasting during well sinking is laborious and it damages the well steining inspite of provision of steel plate.

2.7 Remedial Measures

2.7.1 Long range plans for general investigation and surveys

Depending upon the overall priorities the investigation of sites and collection of hydraulic data should be commenced well in advance.

2.7.2 Time for Surveys

Sufficient time should be allowed for ground surveys, so that all the relevant details are collected as accurately as possible. Observing HFL, scour, flow spread etc should be done for over two or more seasons. Performance of existing bridges in the close vicinity if available should be studied.

2.7.3 Supervision

The proposal for bridge constructions should be checked on ground by senior engineers. Monitoring of ground survey and investigations is also important to get correct date and timely completion. Bridge Supervision Cells with trained and experienced officers are now trained and experienced officers are now being provided for major and important bridges to ensure proper and timely execution.

2.7.4 Sub soil investigations

Thorough and detailed sub-soil investigation is very important. In case of foundations resting on rocky strata, it is desirable to drill a number of holes over the entire foundation plan area to ascertain its continuity so as to avoid changes in design during execution. SSI may be dispensed for bridges upto 60 m where the abutments are on firm ground and open foundations can be planned.

2.7.5 Bridge Types

Considering numerous problems encountered during construction of piers in the main stream it would be advisable to avoid construction of piers where feasible. Single span bridges should be preferred. The following alternatives may be considered:

(a) Balanced cantilever bridges

(b) Cable stayed bridges

(c) Steel structures. In snow bound areas where working time is very limited and subzero temperature are common, concrete construction poses problems. Due to deep gorges, shuttering/ scaffolding is difficult to erect. Here steel structures are the right answer .

(d) Use of high performance concrete to reduce dead load.

(e) Arch type construction may be adopted where sound rocks are available at both ends. Shore spans as viaduct are useful in hills where high return walls and heavy filling in approaches is required.

2.7.6 Trained Manpower

In the initial stages, construction of bridges was done through contract. Few competent bridge experts were required. Now the bridge construction is also being done departmentally. Officers and staff should be properly trained and retained for bridging operations. This will improve efficiency and economy.

The site investigation and data collection teams, with Sub-Soil investigation teams need to be motivated, trained and kept on such jobs for long periods.

2.8 Conclusion

The chapter gives a birds eye view of the construction of bridge the Border Roads Organisation, which has completed 35 years of its dedicated and hard work in road building. Construction of major permanent bridges was only started recently. Initially major permanent bridges were constructed through reputed bridge construction contractors. The Bridge construction is now also being undertaken departmentally through bridge construction companies.

Construction of major permanent bridges in the Himalayas poses great challenge to the Bridge engineers. However, the experience gained so far will stand in good stead for future constructions. The major considerations for reductions in time and cost over-runs are as under:

(a) Accuracy in survey and investigation. Adequate time should be allotted for collection of hydraulic data and study must be done over a long period. Sub-Soil investigation must be thoroughly done.

(b) Meticulous planning and proper workable designs must be framed by qualified engineers and checked by experienced engineers.

(c) Avoid construction of piers in the middle of fast flowing rivers and boulder strata. Code provision for scour depth in boulder strata needs review.

(d) Allot realistic time for construction and completion of the bridge depending on availability of working time and other factors.