# NEWSLETTER


## Department of Roads (DoR)

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Vol. 29
August 2022


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## 1. Appointment of new Director General

Er. Arjun Jung Thapa has been appointed as a new Director General (DG) of DoR on 2079/02/25 BS (8th June 2022). This is his second tenure as a DG of DoR. The responsibility of DG was taken over by acting DG Er. Shiva Prasad Nepal after retirement of former DG Er. Shiv Hari Sapakota on 2079/01/19 BS (2nd May 2022). The new DG has affirmed that DoR will have following priorities in his tenure.

1. Continuation of Bio-engineering more intensively by establishing nurseries and implementing slope stabilization works under all Road Divisions and Project Offices.
2. Planning, Designing and Constructing modern office buildings in all Federal Monitoring Offices and Road Divisions Offices.
3. Strengthen Laboratory facilities in all Road Divisions and Projects Offices to enhance quality of construction and maintenance works.
4. Accelerate publication work of different guidelines and manuals that are useful for design, construction, supervision and maintenance works.
5. Accelerate the preparation of typical Designs/Drawings for short and long span bridges.
6. Establish DoR's own state of art training Center at Gajuri with modern facilities.
7. Focus on Road Assets Management works of DoR.
8. Development of curriculum for training in different areas.

## 2. Major achievements during tenure (17/2/2021-30/12/2021) of former DG Er. Shiva Hari Sapkota

1. Enhanced Good Governance in contract administration to resolve chronic contracts in DoR.
2. Initiated to work for institutionalization of Engineering Governance in DoR.
3. Enhanced road safety works in National Highways focusing on Pillar two of action plan i.e. Safer Roads.
4. Enhanced all types of road maintenance works on the National Highway focusing mainly on pothole repair of roads under DoR jurisdiction and keeping it pothole free.
5. Accelerated the preparation of typical Design/Drawings for short and long span bridges.
6. Continued of Bioengineering and Road Asset Management works.

## 3. Annual Progress of Fiscal Year 2078/079

*PME Unit, DoR*

| S. N. | Details | Units | Annual | | |
|---|---|---|---|---|---|
| | | | Target | Progress | Progress (%) |
| 1 | Blacktop Road | Km | 1800 | 618 | 34.33 |
| 2 | Gravel Road | Km | 800 | 335 | 41.87 |
| 3 | Earthen Road. | Km | 350 | 280 | 80 |
| 4 | Reconstruction and Rehabilitation of blacktop Road | Km | 600 | 423 | 70.5 |
| 5 | Periodic maintenance | Km | 550 | 250 | 45.45 |
| 6 | Bridge Construction | Nos | 300 | 282 | 94 |
| | Annual Financial Progress: | | | | **55.18%** |

## 4. Design and Construction of Dhobi Khola twin Network Arch Bridge

***-Dr Bijaya Jaishi, SE, FRSMO, Kathmandu***

### *4.1 Introduction*

The Network Arch is an arch structure where the hangers supporting the lower tie (deck) are inclined in opposite directions and they cross one another at least twice. The idea of a network arch bridge was developed by Prof Per Tveit from Norway in 1950's. The advantages of network arch bridge are:

- It could be useful at the bridge sites with boundary conditions on approach road gradient or vertical clearance or waterway requirement below soffit.
- It will ensure unaffected river morphology and aquatic lives with no pier as obstruction in river flow.
- It has a better aesthetic view than conventional bridges.
- The cost will not exceed conventional bridge cost.
- It can be constructed with locally available materials and construction technology.

A long effort has been carried out by DoR before implementing the construction of Dhobi Khola Bridge. DoR, Bridge Branch had carried out four days training on network arch bridge in 2013 in DoR after series of discussion among Mr Bishnu Prasad Shrestha, Mr I.A. Khan, OBE, ICE representative, Mr Nareshman Shakya and author of this article at World Bank Kathmandu. Two gentlemen from Bangladesh, Mr M.A Sobhan, CEng FICE and Mr. Samy Muhadmad Reza, DPM were the main tutors. Similarly, seminars and presentations had been organized several times. Then, Kathmandu Valley Road Improvement Project (KVRIP) awarded a Design and Build contract for construction of twin network arch bridges at two places, namely Bagmati and Dhobikhola bridges in 2016. The Bagmati Bridge is still under construction and Dhobikhola bridge has already been opened to traffic. There is also another network arch bridge above Bishnumati Khola at Paropkar which is almost completed. The credit for successful completion and operation of these network arch bridges goes to all high level DoR officials, above mentioned personnel, Bridge Branch DoR, associated consultant and contractor.

Fig. 4.1: Google map of bridge site

This bridge site is located at Km 0+850 at Bijulibazar along Arniko highway. The google co-ordinates of the bridge site is 27°41'25"N, 85°19'42"E. The Google image of the bridge site is shown in Fig. 4.1. The twin bridges are constructed upstream and downstream of the existing bridge. The twin bridges serve bridge crossing for widened portion of Arniko highway. The contract for construction of this bridge was awarded in 2071/09/13 (28th Dec, 2014 AD) as a Design and Build contract. The contractor was Jayee Construction (P.) Ltd. Design review consultant was Design Planning and Management Consultant Ltd., Bangladesh.

The construction was completed and opened to traffic in 2077 B.S. (2020 AD). This bridge has set up many records in the bridge construction history in Nepal and will be a great milestone in the era of modern bridge construction in the country. Dhobi Khola arch bridge. It is the first network arch bridge in Nepal. It is also the first bridge in Nepal that uses lead rubber bearing.

### *4.2 Salient features:*

The elevation and cross section of the bridge is shown in Fig.4.2. The salient features of this bridge is presented below:

Total length of bridge = 51.45 m

Arch Span (L) = 50.35 m

Arch Rise = 9.68m

Span Rise ratio = 5.20

Number of arch ribs = 2

Size of main arch rib = End:1m (B) x 1.7m (D); Mid:1m (B) x 1.038m (D)

Total width of bridge = D/S:12.0m; U/S:10.5m

Contract amount (Both bridges U/S and D/S): NRs. 131,385,000.00 (with PS and VAT)

Original cost estimate (Both bridges U/S and D/S): 187,012,447.00 (with PS and VAT)

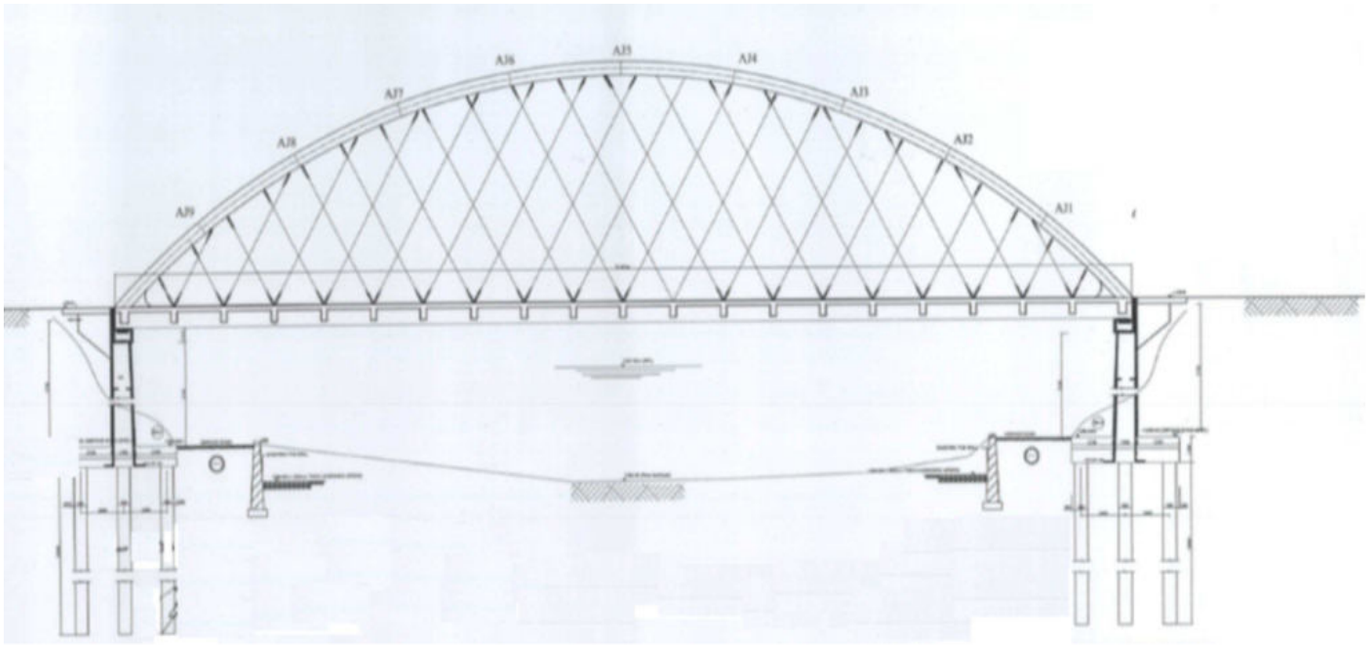


Fig. 4.2 : (a) Elevation of bridge

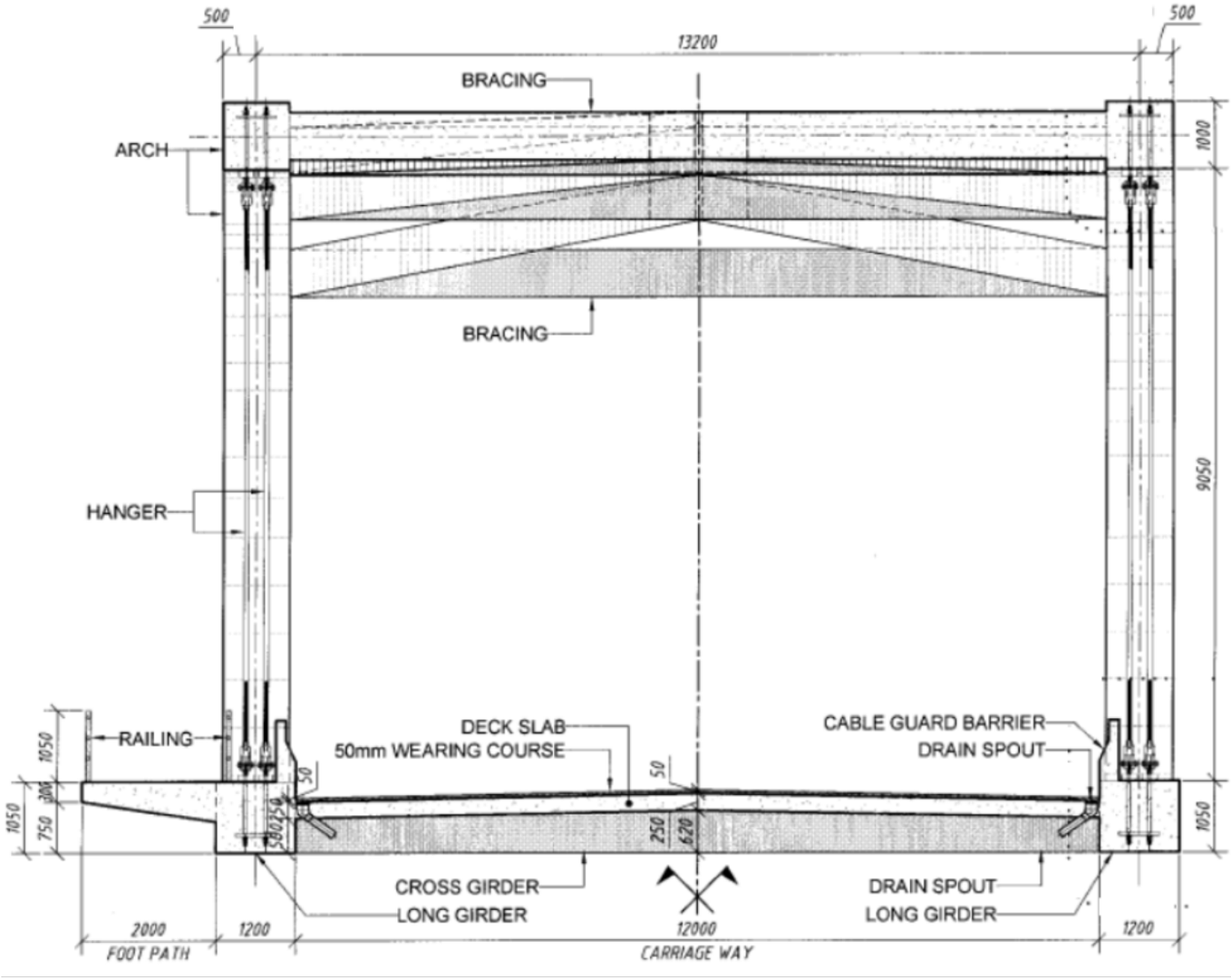
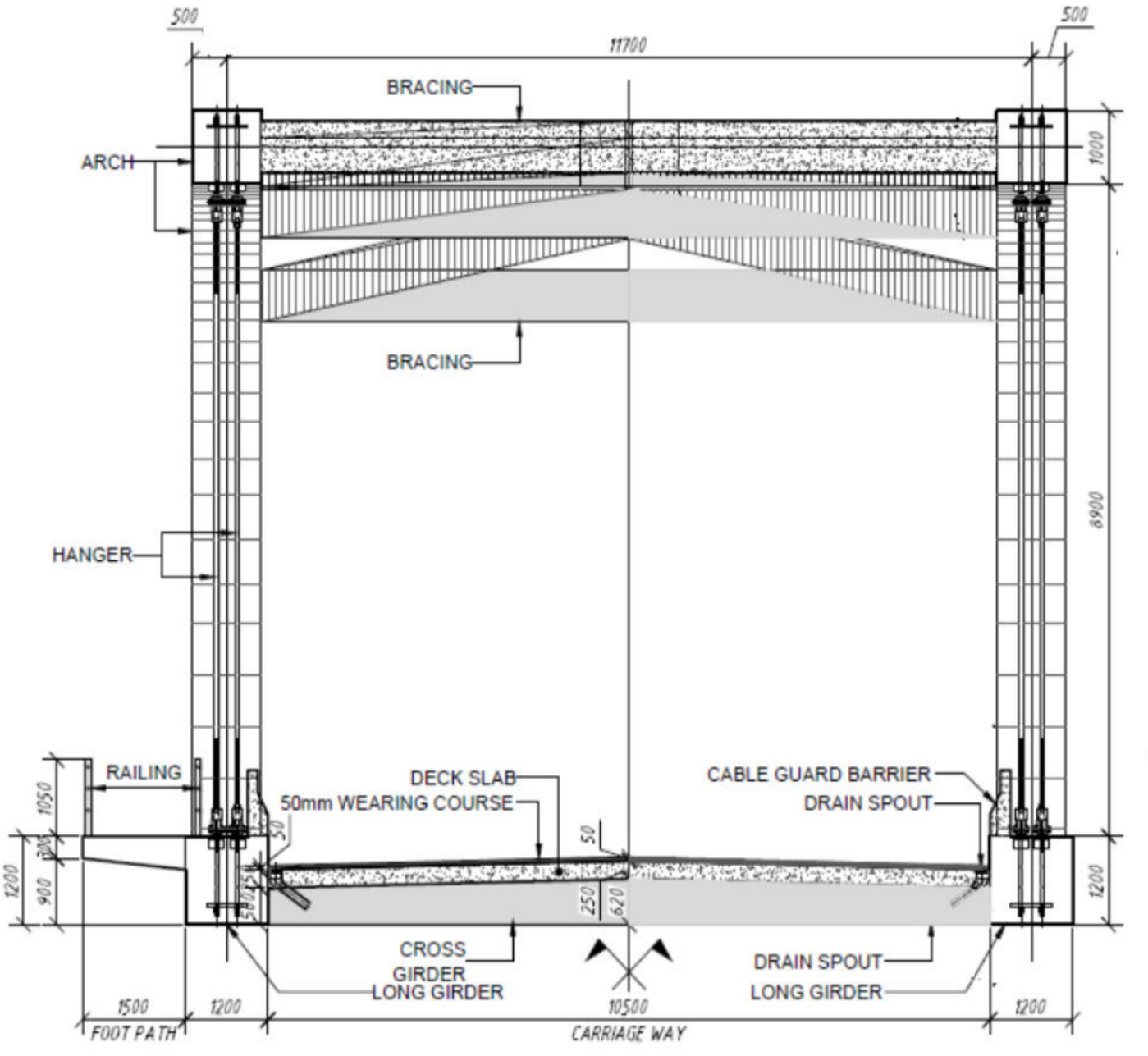



Fig. 4.2 : (b) Elevation of bridge
Cross section of Bridge (D/S)




Cross section of Bridge (U/S)

Fig. 4.2 : (c) Elevation of bridge

*Note: D/S and U/s means upstream and downstream respectively*

### *4.3 Design*

The bridge is designed as per IRC design specification. The main loads considered are (i) Dead load (ii) Moving load (iii) Braking load (iv) Wind load (v) Earthquake load (vi) Temperature load (vii) creep load (viii) Shrinkage loads (ix) Load due to elastic shortening etc. The main design steps are:

(a) Design of slab

(b) Design of cross girder (pre-stressed)

(c) Design of longitudinal girder (pre-stressed)

(d) Design of hanger

(e) Design of arch rib

(f) Design of bearing

(g) Design of substructure

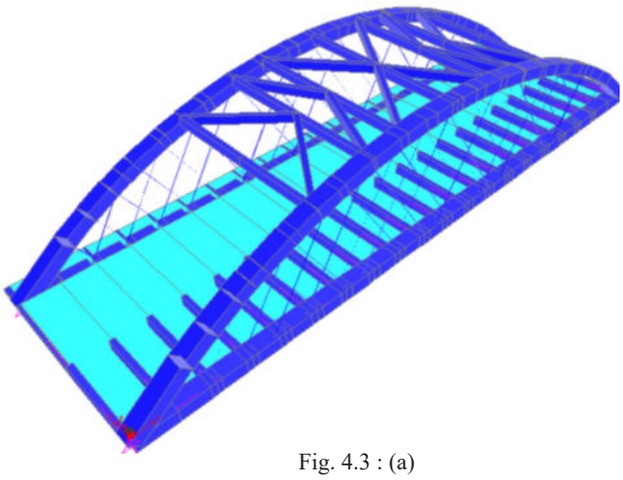


Fig. 4.3 : (a)

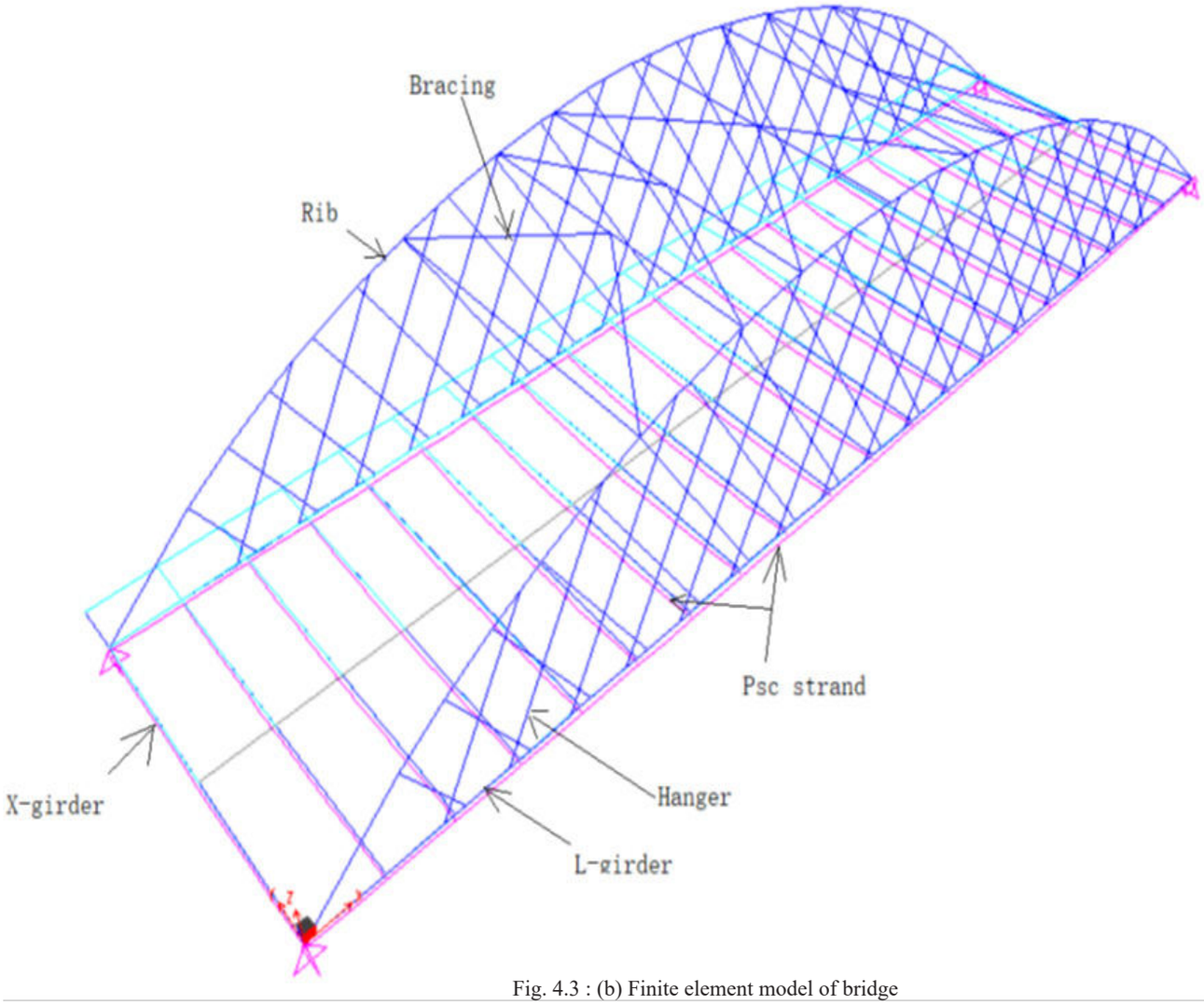



Fig. 4.3 : (b) Finite element model of bridge

The finite element model is developed in SAP2000 (Fig. 4.3) to find out the internal stresses in different elements. In FE modeling, slab has been modeled as shell element; cross girders, longitudinal girders, arch ribs are modeled as frame elements. Hanger is modeled as frame element with both end release (moment). Linear static analysis, non-linear static analysis, buckling analysis and response spectrum analysis has been carried out. The section design has been carried out for computed internal forces.

### *4.4 Construction Sequence*

Construction part is the most challenging in arch bridges compared to other types of bridges like suspension and cable stayed bridges. Although overall bridge cost is lesser in arch bridge, the associated construction issues make construction costlier.

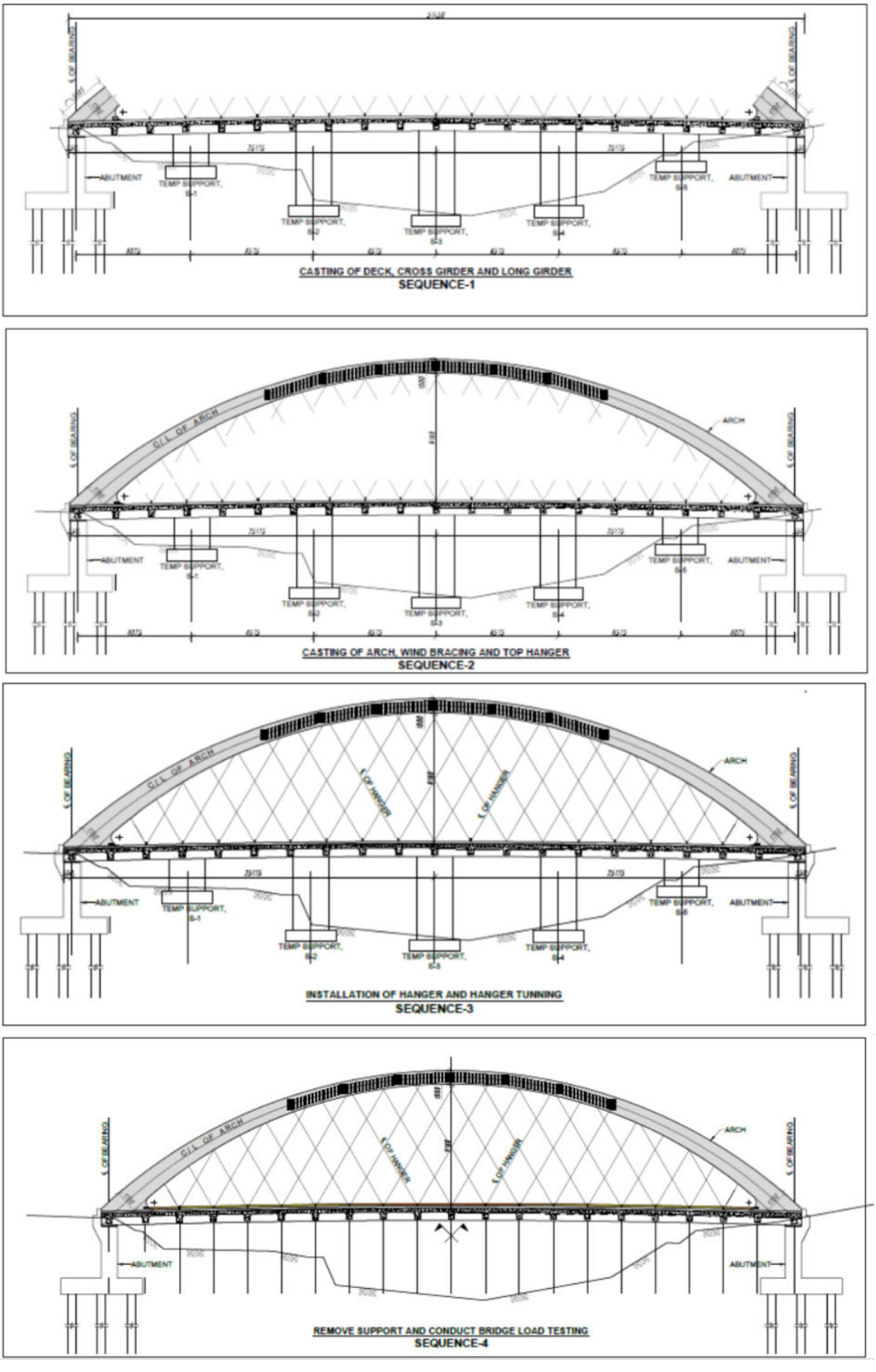
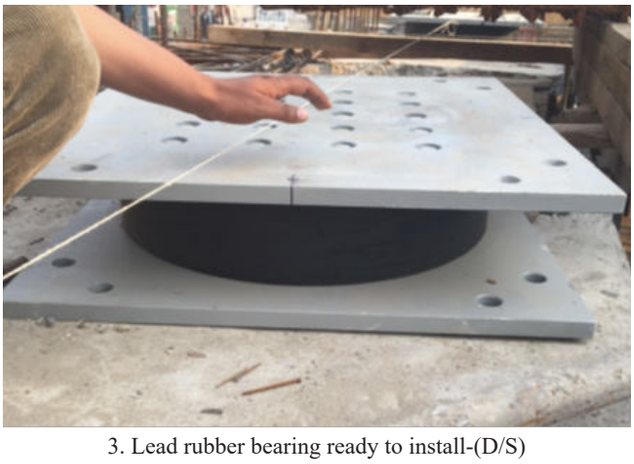



Fig. 4.4 : Construction sequence diagram (D/S-downstream, U/S-upstream)

1. Construction of substructure -(D/S)

2. Temporary staging for construction of superstructure- (D/S)



3. Lead rubber bearing ready to install-(D/S)

4. Construction of L and X girder-(D/S)

5. Details of hanger anchorage system and prestressing duct in longitudinal girder- (U/S)

6. Duct for prestressing (post tensioning) of cross girder-(D/S)

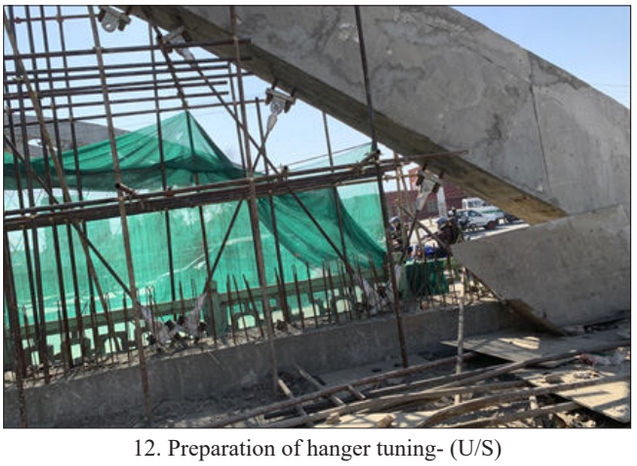
7. Details of hanger anchorage system in arch rib- (U/S)

8. Preparation of concreting work of arch rib and bracing-(D/S)

9- Concreting work of arch rib and bracing-(D/S)

10- Arch rib and bracing after concreting (U/S)

11. Hanger anchorage system –D/S



12. Preparation of hanger tuning- (U/S)

13. Landmark twin bridges in the heart of Kathmandu

Fig. 4.5 : Construction sequence photographs

**The construction sequence is presented as follows:**

(a) Arch foundation construction (pile, pile cap and abutment)
(b) Construction of temporary staging for construction of L girder, cross girder, slab
(c) Construction of lead rubber bearing
(d) Construction of L girder (with duct), cross girder(with duct), slab
(e) Construction of temporary staging for construction of arch rib and bracing
(f) Construction of arch rib
(g) Installation and tuning of hangers
(h) Construction of expansion joints and appurtenances

The construction sequences are shown in Fig.4.4 and Fig. 4.5. The bridge has become land mark structure in the heart of Kathmandu (Fig. 4.6).


Fig. 4.6 : Live telecast of famous program in Sagarmatha TV (in frame of the bridge)

***4.5 Conclusion***

Successful completion of this bridge is the milestone for construction of network arch bridge in Nepal. Nepalese Engineers have gained a lot of knowledge and confidence after constructing this bridge. The replication of construction of such type of bridge in other locations in Nepal is highly recommended where the site demands. Such bridge has advantage in Nepalese topography since such design doesn't involve the construction of a pier in the middle, construction work could be carried out in all seasons and flood has less effect on the bridge.

## 5. Landslide Stabilization Works in Improvement of Narayanghat-Mugling Road

***-Kiran Karki, S.D.E***
***- Deepika Ghorasaini, Engineer***
***(Mugling Narayanghat Road Project)***

***5.1 Introduction***

The road widening works along Narayanghat-Mugling Highway is under Nepal India Regional Trade and Transportation Program (NIRTTP) through the joint funding of Government of Nepal (GoN) and World Bank (WB). Because of the weak and fragile geological condition many slope failures have risen along this highway section and stabilization works are being performed along the highway. The stabilization at Ch 17+025 km is a peculiar example of landslide stabilization and the methodology used in this section can be performed along many road projects in Nepal.

The site is amongst the most critical highway sections in Narayanghat-Mugling highway. In 2003 AD, the landslide was mitigated using soil nailed walls and soil nailed blocks, which served well for thirteen years. Commendably and much to a surprise, the slope remained stable during the Gorkha Earthquake 2015. However, the activation of landslide was observed at the time of road expansion during 2016 to 2018 AD. The road subsided up to 1.5m at the end of first monsoon when it was noticed. The consultants for this use is ITELO/ ICGS JV Kathmandu and contractor is Bajraguru/Rayamajhi JV Kathmandu.

***5.2 Reason of failure***

A survey was performed in 2003 during low flow season which led to the conclusion that the toe cutting by the Trishuli River is also one of the major reasons for activation of slope. A large debris was deposited in the opposite bank, causing scouring at the left bank. A bathymetric survey was carried out to determine the depth of Trishuli River at the location of the slide and the dry season flow was found to be 6m to 8.5m deep.

The soil nailed treatment worked well from 2005 to 2018 but road widening works led to the reactivation of the landslide from 2016 to 2018. The wall had excessively moved along with the loss of nuts and head plates. The geometry of subsidence of the valley side lane indicates that the current failure is limited to depth of about 5m and few couplers have failed. Without the soil nailing done in 2005, the slide would have developed as deep as 11m as of 2003.

***5.3 Site specific activity during design period***

The site specific activities are as follows (shown in fig. 5.1)

1. Detail topographical survey using SW DTM and SW Road with 1m contour interval
2. Movement monitoring of all activities during study period
3. Engineering geological mapping for four hectares in 1:1000 scale
4. Multi-Channel Analysis of Surface Waves (MASW) at three points to determine geotechnical data such as shear wave velocity, directly SPT N value, cohesion, friction angle, bearing capacity etc.
5. Slope stability analysis using software like RS2, Rock fall, Rock Plane, DIPS etc. for various design options. Factor of safety (FoS) taken 1 for seismic and 1.4 for static waves along with seismic coefficient 0.18g.
6. Bathymetric survey to determine the bed profile level


Fig. 5.1 : Geotechnical Investigations performed at Chainage 17+025 km, Chitwan.

### *5.4 Slope Stability Analysis*

The preliminary slope stability analysis was carried out using Phase 2 software. The soil/rock strata were generalized into layers indicated by the shear wave profiles obtained from MASW investigation and laboratory investigation. Back analysis for factor of safety was also performed assuming factor of safety 1 at dry condition, varying water table and seismic condition. Three various options were analyzed; among the three, considering ease of construction, time of construction, effect of traffic, construction during monsoon and traffic management, Piled and Anchor wall option was preferred.

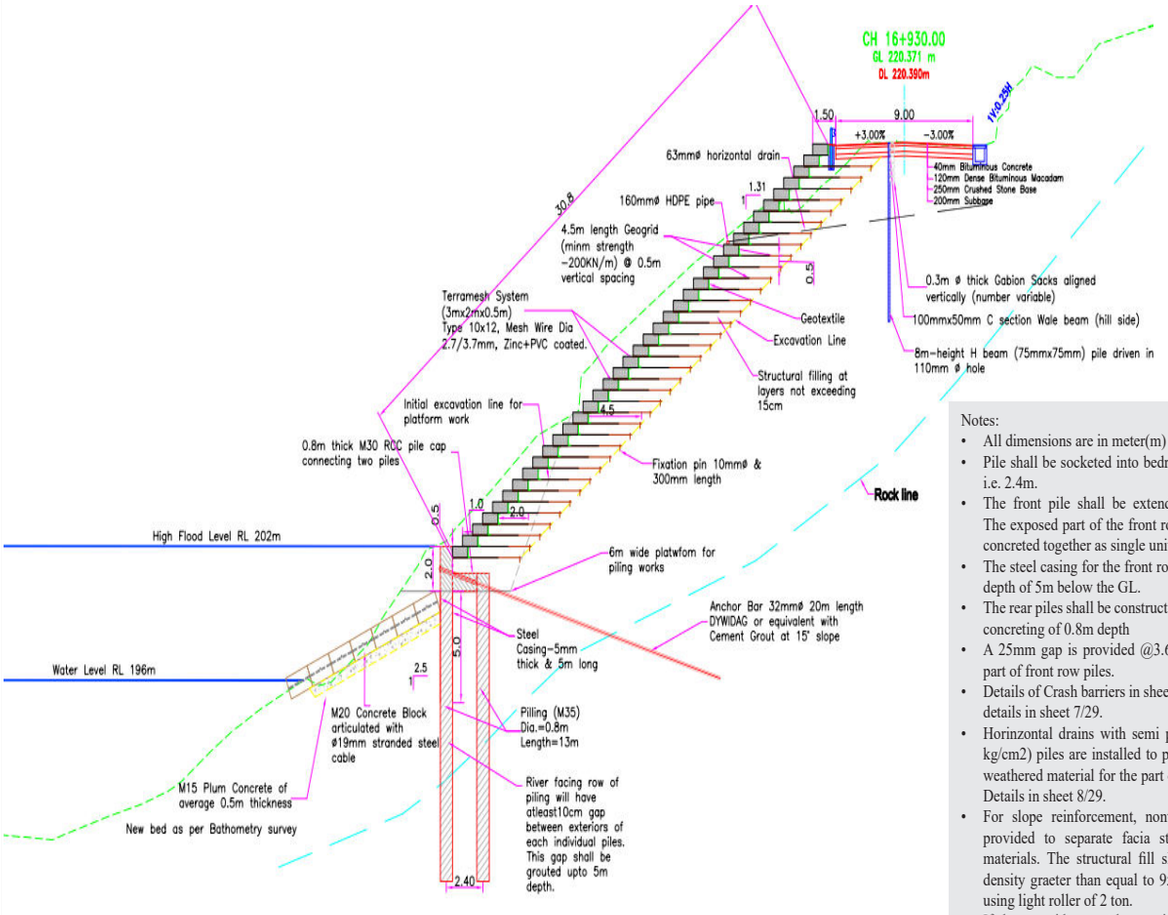
### *5.5 Salient Features of Pile and Anchor wall solution*

The site features of the pile and anchor wall are as follows:

1. Placing of articulated (with 16mm stranded steel cable) precast concrete blocks (1.5×1.5×1) m at the river bank in four rows from the present water line and gabion mattress till the High Flood Level (HFL).
2. Installation of two rows of tangential piles of diameter 0.8m and depth 13m, total 80 nos and total length of structure 52.1 m.
3. Pile cap of depth 1.3m, length 10.6m and breadth 3.2 m.
4. Pile Integrity Test
5. Construction of french drain
6. Construction of plum concrete
7. Installation of 32 nos. of soil nail each 20 m long along with semi flexible 3D galvanized steel mat for slope stabilization.
8. Soil nails with yield strength of at least 500 MPa with nominal diameter of 32mm and should be double corrosion protection.
9. Anchor end plate minimum dimension 250×250×25 mm.
10. Anchor be tightened using bedding pressure of about 25% of working load i.e. 62.5KN.
11. Drainage pipe for horizontal drain HDP pipe of diameter 63 mm and minimum thickness of 3mm, which is to be perforated by drilling minimum 50 holes per meter length on upper half with minimum diameter 5 mm and drain pipe is covered using geotextile.
12. Laying of flexible geogrids as primary reinforcement for composite soil reinforcement system, made of polyester core with polyethylene coating including secondary reinforcement of Terramesh system (TMS) with Zinc and PVC coated facing material.
13. Construction of compacted embankment to reinstate full width of embankment.
14. Construction of road pavement
15. Surface protection using bio-engineering measure
16. Installing piezometers, inclinometer and extensometer for the study of fluctuations in water table with regular monitoring at weekly intervals during monsoon period and monthly during dry season and depth of water recorded with respect to the reduced level.
17. Setting up DGPS or total station at the desired locations to study the surface movement in horizontal and vertical directions at frequency of weekly during monsoon period, and monthly during dry season.

### *5.6 Typical design and drawing*

The typical design and drawing of the pile anchor wall is as shown in Fig. 5.2 - Fig. 5.5




Notes:

- All dimensions are in meter(m) unless mentioned.
- Pile shall be socketed into bedrock by min. 3*dia. Of pile. i.e. 2.4m.
- The front pile shall be extended 2m above the ground. The exposed part of the front row piles (riverside) shall be concreted together as single unit.
- The steel casing for the front row piles are left behind for a depth of 5m below the GL.
- The rear piles shall be constructed to the front piles by RCC concreting of 0.8m depth
- A 25mm gap is provided @3.6m spacing on 2m exposed part of front row piles.
- Details of Crash barriers in sheet 25/29; and piling &anchor details in sheet 7/29.
- Horinzontal drains with semi perforated 63mm HDPE (6 kg/cm2) piles are installed to prevent the saturation of the weathered material for the part of the slope below the road. Details in sheet 8/29.
- For slope reinforcement, nonwoven geotextile shall be provided to separate facia structure and structural fill materials. The structural fill shall be well compacted to density graeter than equal to 95% Modified Proctor Value using light roller of 2 ton.
- If the geogridcan not be provided for full length of 4.5m due to presence of rock 25mm dia dowel bars shall be installed as directed by the engineer. No separate payment shall provided for the supply and use of dowel bars and the cost of the dowel bars shall deemed to be included by the contractor in other activities of this item.
- For any specified and change in words, proceed as directed by site engineer.

Fig. 5.2 Cross section of the protected structure

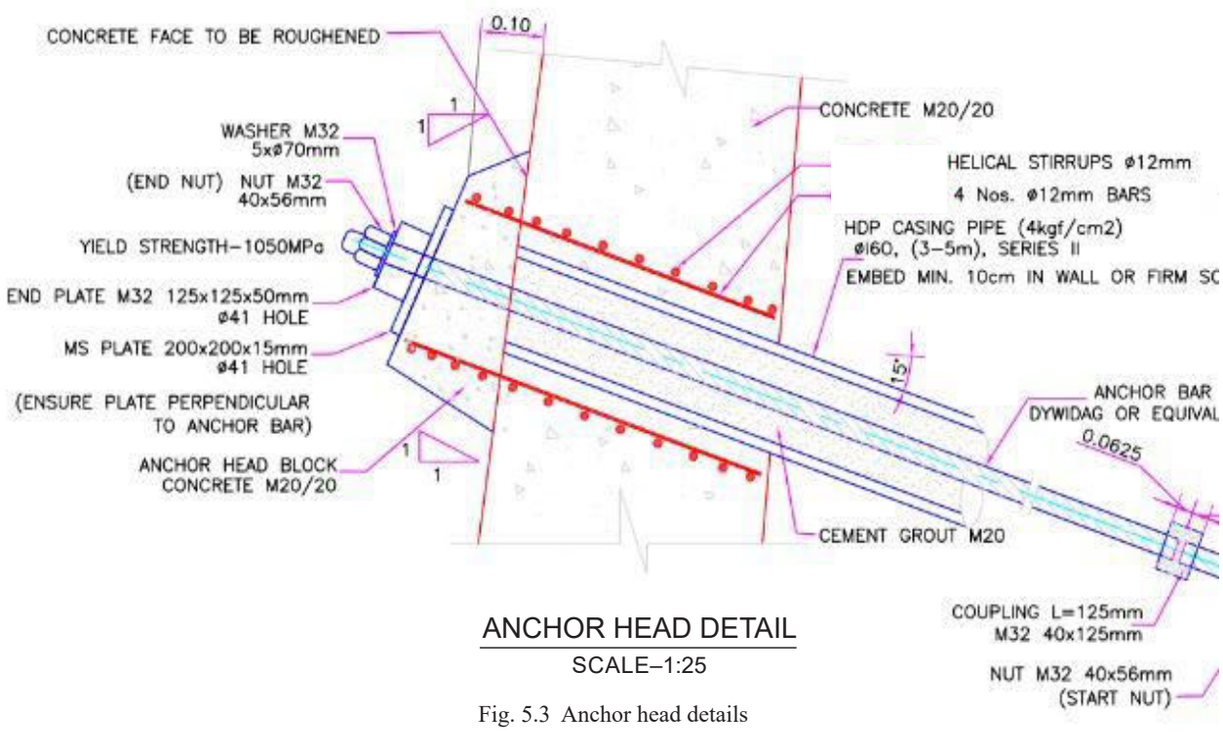
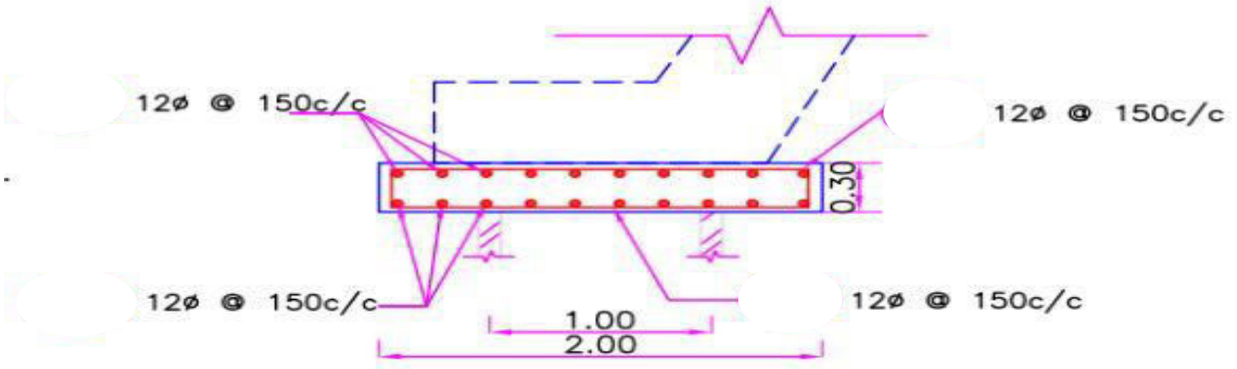
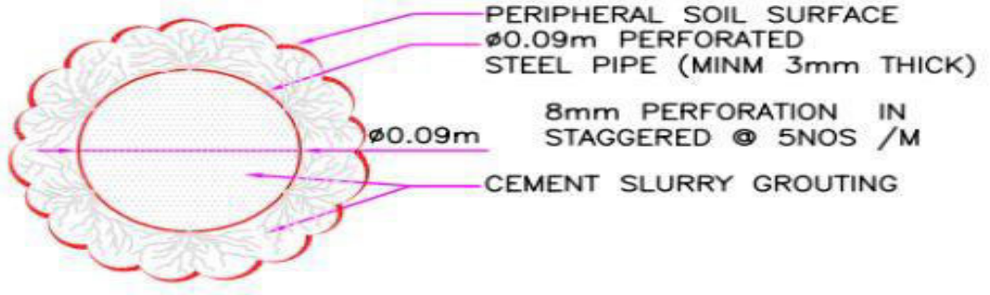



Fig. 5.3 Anchor head details




PLAN ELEVATION

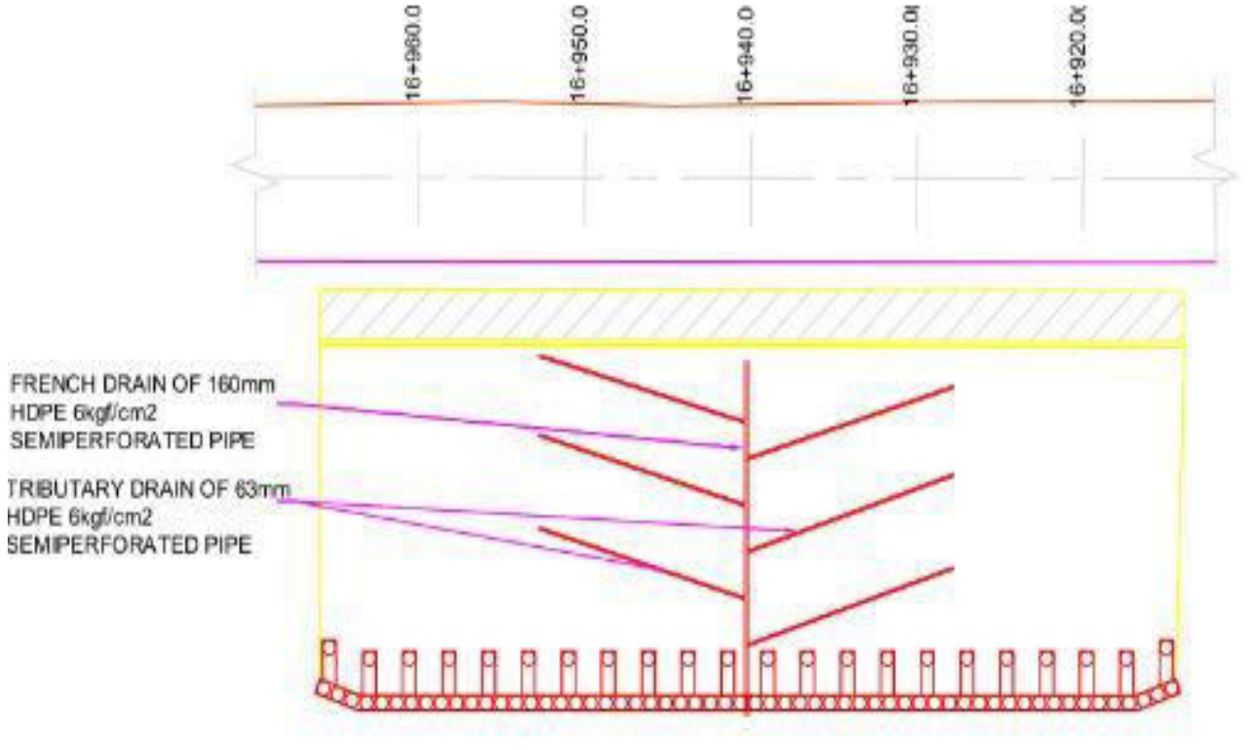
SCALE–1:50




PLAN VIEW OF MICRO PILE

SCALE–1:5

Fig. 5.4. Elevation and Plan of Pile and pile cap




FRENCH AND TRIBUTARY DRAIN PILE

SCALE–1:500

Fig. 5.5. Plan view of French and Tributaries Drain

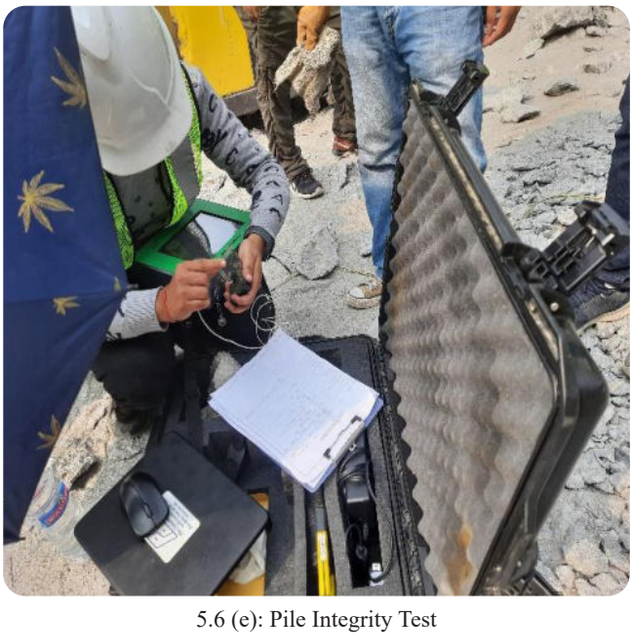
***5.7 Some site photographs of the site.***

5.6 (a): Chainage 17+025 km before commencement of work

5.6 (b) : Construction of Launching Apron

5.6 (C): Pile construction at site

5.6 (d): Construction of Pile Cap



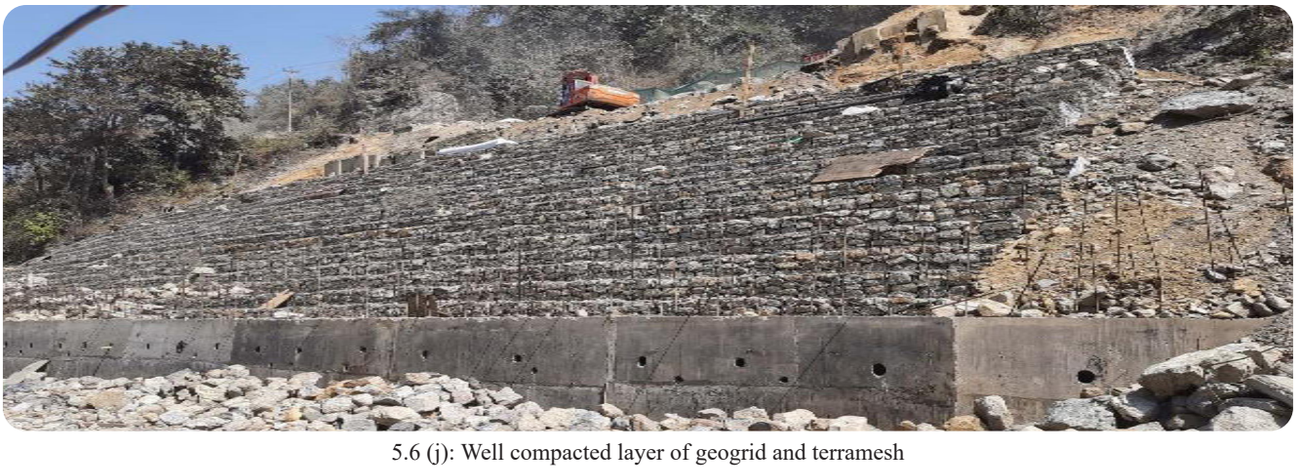
5.6 (e): Pile Integrity Test

5.6 (f): Laying and placing of geogrid

5.6 (g): Compaction test using Sand Replacement Method

5.6 (h): Casing for piezometer

5.6 (i): State of launching apron after flood of 2021



5.6 (j): Well compacted layer of geogrid and terramesh

## 6. Proposed Pavement Distress Index for Asphalt Pavement Management

***- Prabhat Kumar Jha, Joint Secretary, MoPIT***

### *6.1 Introduction*

Today's increasing budget constraints demand optimization and higher performance efficiency i.e., more volume of work with lesser investment. Thus the preservation of existing road asset plays great significance in management of scarce resources. Historically, the emphasis of the departments was given towards building new roads. After the establishment of Roads Board Nepal under Roads Board Act 2058 BS, the concept of maintaining and preserving existing pavement surfaces has been focused. This was a positive shift and it has resulted in three types of pavement maintenance operations under a Planned Maintenance Approach:

Preventive Maintenance (Routine, Recurrent and Periodic): Performed to improve or extend the functional life of a pavement. It is a strategy of surface treatments and operations intended to retard progressive failures and reduce the need for corrective maintenance works.

Corrective Maintenance (Rehabilitation): Performed after a deficiency occurs in the pavement, such as loss of friction, moderate to severe rutting, or extensive cracking. May also be referred to as "reactive" maintenance.

Emergency Maintenance: Performed during an emergency situation, such as a blowout or severe pothole that needs repair immediately. This also describes temporary treatments designed to hold the surface together until more permanent repairs can be performed.

All types of maintenance are needed in a comprehensive pavement maintenance program. However, emphasizing preventive maintenance may prevent a pavement from requiring corrective maintenance. Preventive maintenance is completing the right treatment option on the right road at the right time.
Many pavement treatments can be used for preventive, corrective, or emergency maintenance. Fig. 6.1 illustrates the differences among these three types of maintenance. As indicated on the graph, the main difference is the condition of the pavement when the treatment is applied. There are no clear boundaries between when a treatment is preventive versus corrective, or corrective versus emergency.

The prioritization and choice of candidate road section for periodic maintenance works has been done on the basis of three main criteria i.e., Surface Distress Index (SDI), traffic volume and age of surfacing. This article defines the pavement distress index and presents the possible merits of using proposed 'Pavement Distress Index' over SDI.

### *6.2 DoR System for Scoring Surface Distress Index (SDI)*

The pavement condition survey is evaluated from six rating score from 0 to 5. The 0 score indicated the pavement surface without any defects and score 5 indicate the maximum possible deterioration. A shoulder condition survey is also carried out at the same time using a rating in the range of 0 to 4. The following table shows the value of SDI and pavement condition indicated by the value.

| Surface Distress Index (SDI) Value | Pavement Condition |
|---|---|
| 0 – 1.7 | Good |
| 1.8 – 3.0 | Fair |
| 3.1 – 5.0 | Poor |

SDI score classification and corresponding criteria use to adopt for surface are shown Table 6.1 below:

| Scores | Incidence of minor defects (refer Table 6.2) | Incidence of major defects (refer Table 6.3) |
|---|---|---|
| | None | None |
| 0 | None | None |
| 1 | 1 to 200 sq.m. per 1000 m. | 1 Occurrence |
| 2 | <50% of the area | 2 to 4 occurrence |
| 3 | >= 50% | < 30% of area |
| 4 | | >=30% of area or potholes and base exposed <20% of the area |
| 5 | | Potholes and exposed base = or > 20% of the area |

Table 6.1 : SDI Scores

The distress elements are divided into two groups; major defects and minor defects. Among the different defect types, cracking, raveling and potholes are generally characterized by extent and severity while for rut depth, being continuous in nature, only severity of the deformation is noted. The following sections (Table 6.2 and Table 6.3) consist of definitions and interpretations considered during survey and score assignment.

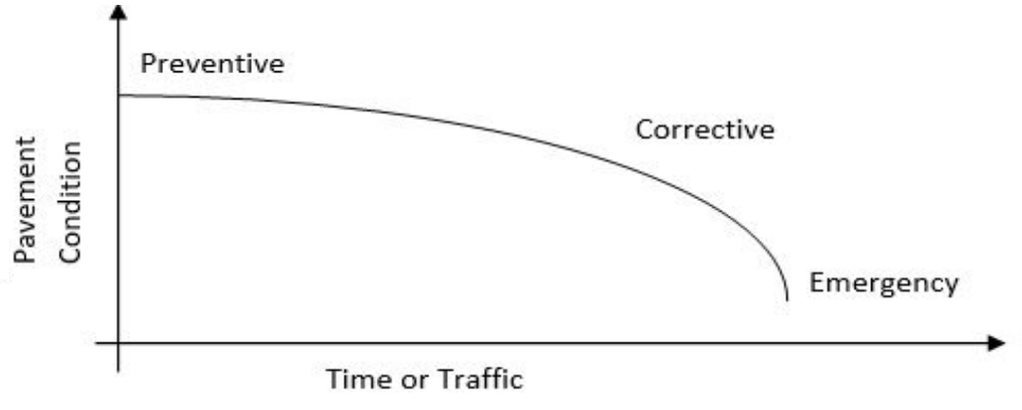



Fig. 6.1 Pavement condition versus time or traffic

| S.N. | Types | Sub Type Definition |
|---|---|---|
| a) | Cracking | Narrow interconnected cracks (1-3 mm width) |
| | | Line cracks (longitudinal or transverse) |
| | | Sealed cracks |
| b) | Maintenance Patches | Distinct localized patchwork has been applied |
| c) | Texture | Shallow raveling or scabbing (<20 mm) |
| | | Slickness (texture depth, 1 mm) |
| | | Bleeding |
| d) | Short Edge Break | Short edge break (> 100 mm < 5 m length) |

Table 6.2 : Definition of Minor Defects for Bituminous Roads

| S.N. | Types | Sub-Type Definition |
|---|---|---|
| (a) | Cracking | Wide interconnected cracks (>3 mm) |
| (b) | Texture | Scabbing (>20 mm depth) |
| (c) | Rutting | Rut depth >15 mm |
| (d) | Pothole | Pothole (>30 mm depth, >150 mm dia/length) |
| (e) | Exposed base | Exposed base or sub base or gravel |
| (f) | Edge Break | Long edge break (>100 mm, >5 m Length) |
| (g) | Depression/ humps | Corrugations of any type and extent |

Table 6.3 : Definition of Major Defects for Bituminous Roads

SDI is averaged over each road link or section under consideration and is used to provide an objective assessment of pavement condition and to indicate the need for periodic maintenance, rehabilitation or reconstruction. The DoR assesses the pavement condition and rates in the terms “good”, “fair” and “poor” on the basis of averaged SDI for a particular road link.

### *6.3 Drawbacks of the Present SDI System:*

- There is no relationship between the severity level of defects and their density. The same rating might indicate different severity levels.
- Just averaging the different SDI values, cannot give a true picture of pavement distress. Example: SDI score 4 for cracking and that of the pothole shall not be same and just averaging the individual defect SDI values may mislead the condition assessment.
- It may fail to measure the transverse undulations or consider the sections with poor IRI.
- Visual assessment may differ from person to person and degree of reliability may be lesser.

### *6.4 Pavement Distress Index*

- Pavement distresses contribute to pavement failure in different ways. If the distresses identified in a pavement are related to structural deficiencies, the pavement section is most likely not a candidate for preventive maintenance treatment, and should instead be scheduled for renewal or rehabilitation or reconstruction.
- Other distresses can be corrected with preventive, corrective, or emergency treatments. To be effective, an engineering approach should be taken to select and construct the treatment. It is critical that the proper maintenance treatment be done at the right time for the pavement to function as designed and for the maintenance program to be effective.
- Based on the DoR maintenance practices and worldwide best practices, the following indices and formula have been developed for practical application:

| IRI Scale (m/Km) | Ride Index | Remarks |
|---|---|---|
| <= 1.5 | 0 | Superior |
| > 1.5 - < 3.5 | 0.20 | Desirable |
| >3.5 - <6 | 0.50 | Undesirable |
| >6 | 1.00 | Unsatisfactory |

Table 6.4 : Ride Index

| Severity Level (SL) | $SL_{Value}$ | Density Level (DL) | $DL_{Value}$ | Aggregated Density Level of ‘i’ distress of a Road Section ($DL_i$) |
|---|---|---|---|---|
| Low | 10 | 0 | 0 | $D_i = \frac{Segment\_Area}{Road\_Section\_Area} \times \frac{\sum value}{100} \times D_{value}$ |
| Moderate | 50 | 1 | 1 | |
| High | 100 | 2 | 2 | |
| | | 3 | 3 | Segment Area means Observed area (Observed length x carriageway width) including the defective area. |
| | | 4 | 4 | |
| | | 5 | 5 | Maximum Road Section length shall not be more than 5Km. |

Table 6.5 : Aggregated Density Level Determination

*Pavement Distress Index = 0.30 x Ride Index + 0.30 x Rut (DLi of C1) + 0.15 x Functional Index (Sum of DLi of A2,A3,A4,A6,B2,C2,D1,D3) + 0.25 x Structural Index (DLi of A1)*

| ***Pavement Distress Index*** | **Remarks** | **Choice of Maintenance** |
|---|---|---|
| <= 0.15 | Superior | Routine and Recurrent |
| > 0.15 - < 0.45 | Desirable | Routine and Recurrent followed by Overlay |
| >0.45 - <0.75 | Undesirable | Rehabilitation (Part or Full) |
| >0.75 | Unsatisfactory | Reconstruction (Part or Full) |

Table 6.6 : Maintenance Type Selection

***Example :***
Road Section 5 Km
Road Width 7.5 m
Road Section Area 37,500 Sqm
Ride Index 0.2

| Index Category | Defect Type | Segment Area, Sqm | Severity Level | SL Value | Density Level | DL Value | DLi | PDIi |
|---|---|---|---|---|---|---|---|---|
| Rut | C1 | 2000 | L | 10 | 2 | 2 | 0.011 | 0.003 |
| | C1 | 1000 | M | 50 | 4 | 4 | 0.053 | 0.016 |
| | C2 | 790 | H | 100 | 5 | 5 | 0.105 | 0.032 |
| Functional | A2 | 5000 | M | 50 | 1 | 1 | 0.067 | 0.010 |
| | A2 | 2400 | H | 100 | 2 | 2 | 0.128 | 0.019 |
| | A4 | 4500 | M | 50 | 4 | 4 | 0.240 | 0.036 |
| | A6 | 4200 | M | 50 | 3 | 3 | 0.168 | 0.025 |
| | B2 | 2500 | H | 100 | 5 | 5 | 0.333 | 0.050 |
| | C2 | 5000 | M | 50 | 4 | 4 | 0.267 | 0.040 |
| | D1 | 7000 | L | 10 | 2 | 2 | 0.037 | 0.006 |
| | D3 | 8000 | L | 10 | 2 | 2 | 0.043 | 0.006 |
| Structural | A1 | 9000 | H | 100 | 5 | 5 | 1.200 | 0.300 |
| Ride | | | | | | | | 0.060 |
| **Pavement Distress Index (PDI)** | | | | | | | | **0.6032** |
| **Rehabilitation is necessary (Table 6)** | | | | | | | | |

Table 6.7 : Calculation matrix of the defects

## 7. Road safety initiatives in Nepal: An overview

***Dr. Tulasi Sitaula, Ph. D., P.Eng.***

### *7.1 Background:*

Road safety is a critical issue for developing nations. Road safety being a shared responsibility, it is very difficult to assign responsibility to various stakeholders, to coordinate and monitor programs. Precious lives and huge GDP are lost in Road Traffic Accidents every year. 90% of these accidents are clustered around developing economies with only 60% share of world vehicle fleet. Developed nations could contain the rate of accidents over the last ten years and brought forward the zero-accident vision to their safety planning. They have backed the programs with necessary commitments, funding, and actions. On the other hand, developing nations including Nepal are deficient in all three components.

Road safety has become a chronic problem in the road management business. Globally 1.3 million people lose their precious lives and 50 million get injured in road traffic accidents every year. There is an increase in accidents and associated casualties every year which translate up to 1.5% of GDP loss. Nepal has one of the highest death rates caused by road accidents in the world. There were a total of 46,712 road accidents in the last five years, which killed 11,945 people. In 2019, there were nearly 13,000 highway and road accidents in which 2,736 people lost their lives and 10,731 people were seriously injured. Those who survive often have traumatic brain and spinal cord injuries requiring long-term or life-long rehabilitative care.

Nepal has a trend of increase in road length by 6.9% and growth of vehicles by about 10% annually. Accidents are growing every year and the fatality is 10 per one lakh people. Nepal implemented Road safety Action Plan 2013-2020 which helped to contain the road accidents, though the target of halving it could not be achieved. Nepal participated in the third ministerial conference in Sweden and reiterated its commitment towards road safety. Nepal has prepared the action plan for 2021-2030

and initiated its implementation. Nepal has involved itself in road safety initiatives from early 90's when a dedicated unit named Traffic Engineering and Safety Unit, TESU worked towards it, made useful publications and started implementation in Naubise -Mugling road section as a demonstration program. Nepal was also a signatory of Busan agreement 2006 and Stockholm resolution 2020.

### *7.2 The Issues and challenges:*

Number of Road Traffic accidents and associated deaths in Nepal is quite high compared to global figures. The UN mentions that there is under-reporting of accidents in underdeveloped countries including Nepal due to errors and omissions in data collection. Driver negligence is the main cause of accidents in Nepal followed by Overspeed, poor vehicle condition, Haphazard overtaking, overload and poor road condition. There is lack of proper training and commercial licensing to drivers of public vehicles. The fund is a severe constraint as well.

Nepal is the participant and signatory of many of the global road safety conventions. Commitments are expressed by Nepal to reduce road traffic accidents as recommended by the United Nations. The UN has prepared and circulated guidelines for Decade of action of road safety 2021-2030 with an objective of reducing the RTA by half. In order to achieve this goal, it was agreed during Ministerial conference in Sweden 2020 that i) improve all the existing highways that carries 75% traffic to a minimum of three-star safety standard for all traffic including pedestrians, and ii) develop all the new roads with a minimum of three-star safety rating for all types of road users. These goals are in line with SDG 2030 targets of reducing deaths due to road traffic accidents by 2030 by half. The planned target are shown Fig. 7.1.


Target: By 2030, all new roads achieve technical standards for all road users that take into account road safety, or meet a three star rating or better.


Target: By 2030, more than 75% of travel on existing roads is on roads that meet technical standards for all road users that take into account road safety.

Fig. 7.1 :. Planned Target

The road safety management in Nepal is running in an ad-hoc manner. Few years back, there was no lead agency to lead and coordinate the road safety initiatives. Transport ministry is now designated as lead agency and DoTM is given adequate power and responsibilities to enforce road safety related rules and regulations. There is a critical need to have an institutional arrangement like Road safety council and to equip it with budgets and human resources.

The current state of road traffic accident in Nepal is presented in table 7.1 below

| Fiscal Year | Death | Serious Injury | Minor Injury | No of accidents | No of vehicles involved |
|---|---|---|---|---|---|
| 2016/17 | 2384 | 4250 | 8290 | 10178 | 16515 |
| 2017/18 | 2541 | 4144 | 8247 | 10965 | 18034 |
| 2018/19 | 2789 | 4376 | 10360 | 13366 | 22087 |
| 2019/20 | 2251 | 4615 | 11219 | 15559 | 25788 |
| 2020/21 | 2500 | 6448 | 18600 | 20640 | 33135 |
| 2021/22* | 1638 | 4037 | 14197 | 13709 | 22050 |

Table 7.1 :. National RTA trend of Nepal

*2021/22 data are for seven months only. Data source Nepal Police HSPTD

All the five pillars for road safety as agreed jointly at UN conventions are weak in Nepal, both in terms of infrastructure and implementation. The implementation of Decade of Action Nepal 2013-2020 was not successful despite a reasonably good plan of action. As a result, the rate of accidents is increasing regardless of the commitment to halve it. Lack of Awareness programs for critical road users, lack of adequate funding for infrastructure and monitoring and Lack of coordination among stakeholders could be mentioned as three leading issues for not achieving road safety goals. Progress of action plan implementation, as per Ojha 2022 is not satisfactory. The overall progress is 58% whereas some activities have quite a low progress rate of about 25%.

The implementation of the action plan was partially successful leading to completion of 43% activities only, where out of the 94 planned activities 40 of them were completed. The details of activities implemented in each of the 5 pillars are presented below in table-7.2.

| S. No. | Activities | Actions planned | Actions completed | Percentage action Completed |
|---|---|---|---|---|
| 1 | Road Safety Management | 19 | 9 | 47 |
| 2 | Safer Roads and Mobility | 26 | 11 | 42 |
| 3 | Safer Vehicles | 22 | 6 | 27 |
| 4 | Safer Road User | 16 | 9 | 56 |
| 5 | Post-Crash Recovery | 11 | 5 | 46 |
| | Total | 94 | 40 | 42.55 |

Table 7.2 : Implementation of RS Action Plan 2013-2020

The first pillar namely Road safety Management is ad hoc till date. Though the Road safety Strategy was passed long back, Road safety Bill could not be enacted till now. This is hampering the formation of Road Safety Council which will have a mandate to spearhead road safety activities including funding, stakeholder coordination and monitoring. The bill proposes minister of MoPIT as chair of RSC and there is representation from key stakeholders in the committee. The provisional road safety council formed in the year 2017 could not function as envisaged, for lack of authority and fund.

The second pillar, namely Safer vehicles is progressing at a very slow rate. Vehicle maintenance could not be implemented at the desired rate. Though the new vehicles are of high safety standards, twenty-year-old vehicles could not be taken out of the roads as planned. The body building that takes place locally for public vehicles like bus, mini-bus, and trucks are not designed at a reasonable safety standard. As a result, there is a huge loss of life and property in the event of accidents.

The Third pillar, namely safer roads and mobility is being implemented in a progressive way. All the programs supported by development partners are duly emphasizing on road safety. Thus, newly built and recently upgraded roads are relatively safer and some of them meet 3-star safety conditions as per our commitment. However, there is no program to enhance the safety of many of the existing roads while the UN decade of action 2021-2030 pledges for improving 75% of existing road network to 3 star or better conditions to all types of road users. The road safety audit function is weak both during design and implementation.

Implementation of fourth pillar namely safer road users, has not been successful so far. This is directly associated with lack of awareness among road users including drivers, lapses in licensing and its monitoring and weak enforcement. Provision of footpaths and proper road crossing facilities at level and at grades are vital, but they are lacking on most of the Nepal roads contributing to accidents. A higher level of risk taking from concerned road users expedites the road accidents and associated fatality/injuries. Inclusion of road safety materials in the school level curriculum is not happening as well.

The fifth pillar called post-crash response and recovery is not very prompt as well. There is issue of coordination to implement this activity. UN has appointed Ministry of Health as focal point for this pillar, but this organization is overloaded with general health issues and hence less focused on this activity. In a recent survey by Tulasi Sitaula, 2022 majority of key informants proposed that the responsibility should go to Road safety council and the Ministry of health should represent there as a member. There is issue with regards to who should reach to the crash site first. The study suggested that Local representative supported by Police are the appropriate authorities to handle the accident sites at the first instance. Prompt rescue from accident site and safely carrying the crash victims to nearby health facilities holds paramount importance from safety point of view. Trained manpower for safe transport of crash victims is equally important. Lack of Trauma centers are hampering the treatment of victims of the crashes. Expedited programs are required to construct and operate trauma centers as per the international standards.

The huge fleet of motorbikes and lack of cycle lanes in Nepal urban roads are pertinent issues to ponder seriously and to obtain unique solutions. Lack of reliable and efficient mass transport system is further crippled by absence of public vehicles in this area. Government jointly with private sector actors should develop a dependable mass transport system for which JICA master plan and Kathmandu Sustainable Urban Transport Project, KSUTP has created a very good groundwork and a sound theoretical base for it, which includes route allocations for different vehicle types and dedicated routes for mass transport. Many of the activities related to road safety are the mandate of the Department of Transport Management, DoTM. The current organization of this department is not enough for undertaking these activities. A serious thought and proper action are warranted either to shift this responsibility to other capable agencies or to strengthen the DoTM to carry out these activities in an efficient manner.

Recent study in the USA by Michigan University Transport Research Institute has shown that the following (Table 7.3) are the top ten countries in the world ranked on the basis of car crashes per 100,000 population. The irony is that all of them belong to the underdeveloped and developing part of the globe .

## Ongoing activities

There are a number of activities going on to reinforce road safety. The first and foremost one is the Road safety Act submitted to parliament for approval. The other activities include:

- Action Plan for 2021-2030
- Ad-hoc Road safety Council
- Road safety Audit
- Study and monitoring of black spots
- Road safety awareness programs
- Dedicated budget head for road safety
- Strict action against drink and drive
- Increasing donor support
- Studies and star ratings by ADB and iRAP
- Installment of 700 km of steel road safety barrier in critical highways
- Systematizing Road accident data collection and its management
- Proper road safety measures in the roads being upgraded

### *7.3 Way forward*

Road accident database creation and information management, Research and Development in road safety are two critical areas demanding the attention of policy makers. Nepal also needs to invest in safe system-based interventions. This includes designing safer roads, improving vehicle standards, deterrence-based traffic enforcement and encouraging positive road user behavior. This will require bringing together different agencies responsible for road safety, including transport, infrastructure, traffic police, health and emergency care, and education. However, the road safety battle cannot be won alone. Addressing these challenges will take the collective action of all stakeholders, including the government, international

| Rank | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Countries | Namibia | Thailand | Iran | Sudan | Swaziland | Venezuela | Congo | Malawi | Dominican Republic | Iraq |

Table 7.3: Road accident Running

development partners, private sector, civil society and the road users themselves. As Nepal embraces federalism, it will also be essential to coordinate with local governments to ensure road safety as a shared priority. With the necessary investments, strong political commitment, coordinated interventions and collective actions, we can build, upgrade and maintain safer roads in Nepal and save countless lives getting lost in road traffic accidents.

The Road Safety Act is prepared and submitted to the parliament for approval. Once this Act is in place, ministry of transport as lead agency and Transport minister as chair of Road safety council will have more responsibility and authority for road safety. Collaboration with all the stakeholders, including private sector actors would be easy and effective. With the formation of Road Safety Council, and allocation of adequate budget to implement the Road safety action plan, Nepal expects to perform better in the field of Road Safety in this decade.

## 8. Road Asset Management System in Nepal

***Er. Prem Prakash Khatri, SE. FRSMO, Damak***

### *8.1 Introduction*

An asset refers to the resource with economic value to a person or an organization. An asset is something that provides beneficial returns. Asset possesses either service value or financial value or both. The asset provides service to users, owners and communities and possesses service value. If an asset requires money to acquire, it possesses financial value. Road infrastructure delivers public service, requires finance to acquire that comes from taxpayers and reduces transportation cost. Thus Road is a Public Asset. A typical double lane hill road in Nepal costs around Nrs. 50 to 60 million per km to acquire based upon the current cost estimates of Mid-hill and Madan Bhandari Road Projects. The intermediate lane BP highway nearly cost NRs. 200 million per km length. The current 4 lane under-construction projects along Mahendra highway are going to cost around 150 millions per km. The average unit cost in plain areas or Terai of Nepal for similar standards is similar as well. The basic components of hill road are Earthworks, drainage structures, retaining structures, pavement structure and road furniture. The cost of acquisition depends on choice of design and available resources. This article briefly introduces the Road Asset Management System, its important components and its present status in Nepal.

### *8.2 Approaches to Road Asset Valuation*

There are basically two approaches on Road Asset Valuation i.e., Depreciated book value method and Replacement cost method. The first method considers the original asset cost reducing it by the value that is depreciated over the economic life of the asset. The latter one considers the estimated cost to replace the asset with one that meets current codes and standards. In 2000 AD, the Road Asset value of Nepal was estimated to be around NRs. 85 billion (source: www.rbn.org.np). Currently, the total road length of national highways is 11,178 kms. This excludes planned and underconstruction highway of around 3,000 kms. Around 7,000 kms or more than 60% of it is blacktopped. More than 1,000 kms or around 10% of total road length is gravel standard and remaining 3,178 kms or around 30% is earthen. (Source: http://ssrn.aviyaan.com/road_network)

Based upon the replacement cost method, the national highway asset value could be estimated to be roughly NRs. 500 billion excluding bridges considering the above mentioned unit costs. Referring to Bridge Management System (BMS) available in DoR website (source: http://bms.softavi.com/dashboard/guest_report_bi/), the total number of bridges along Highways and Feeder roads (previously known as SRN) is 2022, their total length being 94,722 meters. Assuming per meter cost of a double lane bridge as NRs. 2 million, the replacement cost of 2022 bridges would be close to NRs. 200 billion. Thus, the total highway asset would sum up to be approximately NRs. 700 billion. It should be noted that such approximations shall not undermine the fact that the calculations based on rigorously identified road inventory using appropriate economic/financial models are needed.

### *8.3 Road Asset Management System (RAMS)*

Road Asset management refers to the coordinated series of activities that monitor and maintain road asset. The effective road asset management realizes the value of road asset over the design life span. It demands increased attention, commitment and resources. In simple words, Road Asset Management is about knowing road asset value, their specific location, their present condition or health, the trend of deterioration, processing these information in order to estimate the approximate cost of maintenance, prioritize the schedule of maintenance, identify the right time to maintain and implement timely maintenance works for continuous service delivery to road users. The application of latest modern technology such as Geographic Information System (GIS), Global Positioning System (GPS), smart phones, drones, softwares etc. for increasing effectiveness and efficiency of Road Asset Management could establish a robust Road Asset Management System (RAMS).

### *8.4 Prerequisites of effective RAMS*

Basically, there are two prerequisites for effective Road Asset Management. Firstly, the relevant legislation provisions are necessary. Realizing the significance of Road Asset preservation for saving imminent reconstruction costs and catching the train of sustainable development, there should be appropriate Road Asset Management Policy and legal provisions for institutionalization of RAMS. Secondly, the quality management and assurance in Road Projects is must. If the quality of design, construction and maintenance are up to the mark, the acquired road asset is easier to manage and maintain until the design life span or beyond.

### *8.5 Components of RAMS*

The several components of RAMS are presented as follows:

*1. Road Asset Inventory System*

The details of road elements such as spatial location, dimensions, age of maintenance or acquisition, material types or qualities etc. are recorded. The latest technology using GIS software, GPS technologies, mobile applications etc. are used for efficiency in data management. The continuous updating system makes the inventory system really effective and useful. The user-friendly web based information system with GIS interface that is accessible to concerned planners and policy makers helps in qualitative and informed decision making.

*2. Condition Monitoring System*

This involves the periodic monitoring of health of road asset elements. The data history regarding condition or health of road elements are useful for planning right treatment options. It is also useful for performance rating and modeling. The condition monitoring of roads could be done in several ways. The road pavement condition could be monitored by visual inspection for SDI or with the help of modern equipment for measurement of IRI or Pavement Distress Index (PDI), advanced equipment like Falling Weight Deflectometer (FWD) for pavement evaluation etc. The other road elements could be monitored by visual inspection or using technological tools like drones, mobile applications, leveling equipment for measuring levels, sensors for measuring vibrations of structures, bridge inspection vehicles for bridge monitoring etc.

*3. Performance Modeling*

Performance modeling is done for nothing but to project or forecast the condition or health of road elements in due course of time utilizing the historic data of the same. It utilizes mathematical tools such as polynomial equations of favorable degrees in order to project the performance of road elements.

*4. Economic Models*

Economic models are required for valuation of road assets or estimation of cost of road maintenance and reconstruction or rehabilitation. The use of software like the HDM- series is common by transportation economists.

*5. Road Maintenance Planning*

This involves the prioritization of road sections for maintenance or repair or rehabilitation. This also involves the allocation of available budget after rational prioritization. The rational prioritization is done with the help of data and information available from inventory system, condition monitoring system and performance modeling. The quality of prioritization decision is the function of quality of data acquired in above mentioned systems.

*6. Institution for timely maintenance or quick response*

The Pavement deterioration curve (Fig 8.1) implies that 'Stitch in time saves NINE". The relevant research publications highlight that the timely maintenance of road could result in savings up to 20 times. Realizing the importance of quick response and timely maintenance, the procurement system needs to be specific with quicker processes than the one for asset building

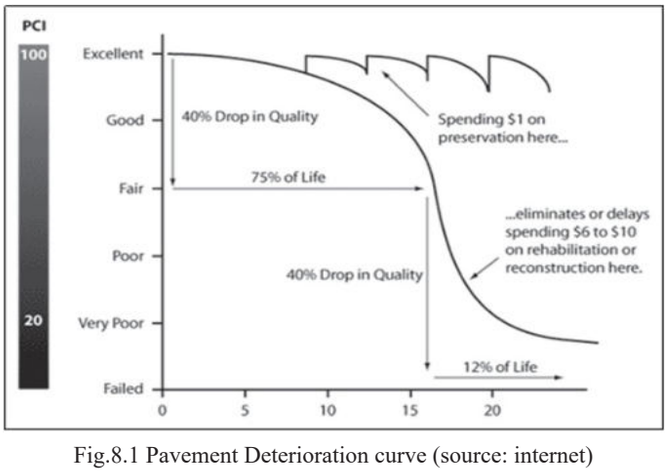



Fig.8.1 Pavement Deterioration curve (source: internet)

purposes. The international best practices could be followed for institutionalizing the system for timely maintenance. This is one of the most important components of RAMS since the effectiveness of the whole system is realized if implementation is sound and effective.

*7. Climate resiliency, Risk analysis*

The effective road asset management will require the provisions for ability to rebound from the impacts of natural disasters. The probable associated risks such as slope instability and probability of failures, flooding etc. need to be assessed and analyzed well along the road. The disaster preparedness is needed in order to respond quickly after the disaster and recover quickly.

*8. Monitoring & Evaluation*

This is the inseparable part of RAMS where the implementation process is closely monitored either live participation in the field or with the help of advanced information systems. At the end of implementation, the overall process is evaluated to find out the outcome or impact of implementation. This helps to measure the overall effectiveness of the system.

*9. Road Users Satisfaction Survey, GRM etc.*

It is the responsibility of government road agency to satisfy the road users. Road users are the ones who collectively put their contributions for investment in road infrastructure through the government. Road users deserve to demand the level of service they desire to experience. The road users' satisfaction survey could be done in multiple ways using live primary surveying or with the use of social media or online Grievance Redress Mechanism or use of mobile applications etc.

***8.6 Road Maintenance cost***

The road maintenance activities are categorized into Routine, Recurrent, Periodic, Specific and Emergency maintenance. Rehabilitation or Reconstruction are opted if the maintenance activities are not enough to manage the road operation. The cost of these road maintenance activities are presented in table 8.1 below. These figures are average figures of actual expenditure by DoR in recent fiscal years.

| S.No | Type of Maintenance | Approximate Cost, NRs. (per km per year) | Remarks |
|---|---|---|---|
| 1 | Routine | 1 lakhs | 2 lane |
| 2 | Recurrent | 2 lakhs | 2 lane |
| 3 | Periodic | 6 lakhs | Nrs. 36 lakhs in every 6 years |
| 4 | Specific | Variable, ~ 1 lakhs | Specific locations |
| 5 | Emergency | 20 thousands | |
| | Total | ~ 10 lakhs | |
| # | Construction Cost approximately NRs. 50 – 60 million/ km for 2 lane hill road | | |

Table 8.1: Road Maintenance cost

Assuming the road design life of 15 years, the total maintenance cost will be NRs. 15 million in 15 years constituting around 30% of construction cost. If maintenance options are ignored, the same road may have to be re-constructed at least thrice in 15 years incurring more than Nrs. 150 to 180 million. Moreover, the additional vehicle operation cost at the time of no maintenance could be 11 to 22 times more than the unit cost expended on road maintenance. (Source: Robinson and Roberts, 1982)

### *8.7 Road Maintenance Vs. Road Repair*

Road Maintenance and Road Repair (Table 8.2) are often misunderstood as similar things. However, they carry quite different meanings.

| S.N. | Road Maintenance | Road Repair |
|---|---|---|
| 1 | Road Maintenance are routine activities meant to prevent damages and prolong the life of road infrastructure. | Road repairs are restoration works when road gets broken, damaged or stops performing desired level of service. |
| 2 | Maintenance is about making sure repair never needs to happen. | Road Repair is about minimizing damages and returning everything to normal. |
| 3 | For example, clearing drain and culverts, crack sealing, wearing course patchworks, slurry seal, resealing etc. | For example, Major Pothole repairs along with replacement of base course, rehabilitation of sections etc. |

Table 8.2: Difference between Road Maintenance and Road Repair

### *8.8 Road Asset Management Philosophy*

For economic sustainability, the Road Asset Management cost should be covered well by the savings in vehicle operation cost raised due to Road Asset Management and maintenance works.

$$\text{RAM cost} << (\text{VOC1} - \text{VOC2})$$

where, VOC1 = Vehicle Operating Cost (VOC) without road maintenance works

VOC2 = VOC after road maintenance works

### *8.9 Status of RAMS in Nepal*

The above sections already mentioned the different components of RAMS. This section presents how Nepal is managing its highway asset referring to those components. The components of RAMS are italicized in the following paragraph.

In order to arrange and allocate funds for road maintenance, Roads Board Nepal (RBN) was established in 2059 BS followed by the enactment of Roads Board Act 2058 BS. As per clause 14 of RBN act 2058, DoR has been preparing Integrated Annual Road Maintenance Plan (IARMP) every year and RBN has been approving it to allocate maintenance budget with respect to available funds. IARMP is nothing but the integration of Annual Road Maintenance Plan (ARMP) of highways (previously SRN) prepared by road division offices. They refer to approved norms for estimating probable cost for Routine and Recurrent Maintenance. The periodic maintenance need is rationally identified with the help of traffic volume date, age of surfacing, Surface Distress Index (SDI) and specific requirements. The International Roughness Index (IRI) is measured using bump integrators though IRI data are not utilized for planning or prioritization purposes. The road register consisting of road link information such as road link length, road width and age of construction or surfacing etc. are updated every year in the ARMP software. This is the important component i.e., Road Maintenance Planning. The modern Road Inventory Management System (RIMS) with GIS interface is recently developed by Planning Branch, MIS unit, DOR. However, some technical issues associated with it demand for its further upgradation or reconstruction. Owing to the technical issues, it hasn't been yet linked to the maintenance planning. The road register and traffic volume survey are parts of a minimum 'Road Inventory System'. The SDI and IRI measurements are parts of 'Condition Monitoring'. The rating of road links on the basis of this data is kind of 'Performance Rating'. The unit rates are calculated and entered by individual division offices. The need for maintenance volume is identified by field survey and approved norms. Thus the total cost estimate is calculated which is part of a simple 'Economic Model'. The IARMP presents the total highway maintenance budget demand for next fiscal year. RBN approves Integrated Annual Program (IAP) and allocates the budget to DoR. The maintenance intervention works are implemented by Road Division offices throughout the country who are responsible for 'timely maintenance or quick response'. The Heavy Equipment Divisions (HED) provide heavy equipments to Road Division offices for emergency maintenance works. The Road Division offices urgently perform minor construction works by departmental or direct contracting in emergency situations that could be called as a minimum effort towards Climate resiliency. The 'Monitoring and Evaluation' are done by Superintending Engineers of Federal Highway Supervision and Monitoring offices and RBN. There are online GRM provisions and RBN has developed Mero Sadak app for addressing road users' grievances. Thus it could be inferred that the minimum concept of RAMS is being followed by DoR but that needs to be upgraded in order to preserve road asset, maximize service value of road asset and improve service delivery.

Although DoR is following minimum concepts of RAMS, the implementation part has been evaluated to be weaker in terms of both quality and quantity. There are issues reported regarding quality of materials and quality of workmanship that could be discussed in separate heading. The scenario of quantity is presented as follows. In the past 20 years, the scarcity of resources has led to low allocation of highway maintenance budget i.e., less than 40 percent of the yearly demand. The picture of demand vs allocation of maintenance budget including rehabilitation in past five years is presented in Fig. 8.2 below. As presented in fig. 8.2, the allocation in past 5 years were 30%, 33%, 34%, 32% and 44% respectively. The total allocation was 34% of total demand summed up in the past 5 years.

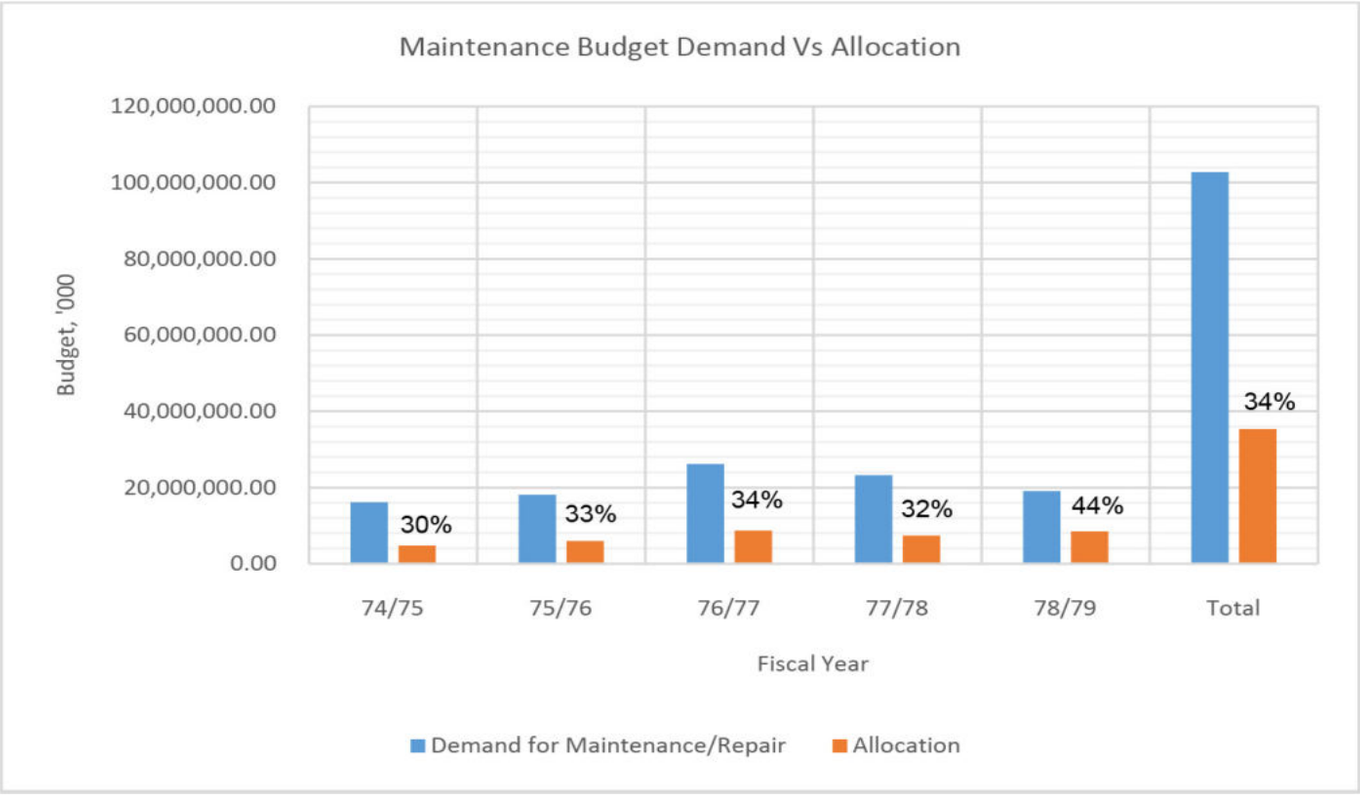



Fig. 8.2 : Scenario of demand and allocation of highway maintenance (including rehab) budget in past five years

The total figure of last five years is also presented because of the fact that the road maintenance liability is function of time and the maintenance backlog has been a serious issue in Nepal needing urgent intervention.

The absorption capacity hasn't been exciting either. The scenario of allocation and expenditure of highway maintenance budget in the past five years is presented in the table below. The average figure of five years is shown deliberately instead of the total figure owing to the fact that the budget was not freezed and the liability was transferred to the next fiscal year.

| S.No. | Fiscal Year | Maintenance Budget Allocation, NRs. | Expenditure, NRs. | Absorption capacity, % |
|---|---|---|---|---|
| 1 | 73-74 (2016/17) | 7,427,898,267.00 | 4,278,929,614.00 | 57.60 |
| 2 | 74-75 (2017/18) | 4,986,163,710.00 | 3,465,769,049.00 | 69.50 |
| 3 | 75-76 (2018/19) | 4,731,104,145.00 | 3,357,922,702.00 | 70.97 |
| 4 | 76-77 (2019/20) | 6,751,875,080.00 | 3,504,522,491.00 | 51.90 |
| 5 | 77-78 (2020/21) | 13,444,669,000.00 | 6,687,655,215.00 | 49.74 |
| | **Average** | **7,468,342,040.40** | **4,258,959,814.20** | **57.02** |

Table 8.3 : Budget allocation and actual expenditure

Considering the average absorption capacity (Table 8.3) of 57% and average allocation of 34% with respect to demand, the actual highway maintenance intervention is calculated to be 19.4% [hint: 57% of 34% of demand] with respect to demand presented in Integrated Annual Road Maintenance Program (IARMP) for highways. It should be noted that the allocation for routine and recurrent maintenance has been 100% of the demand for past several years and the allocation lag was confined to demands in periodic, specific maintenance and rehabilitation. It should also be noted that the expenditure in last two fiscal years was further lowered due to COVID-19 pandemic.

### *8.10 Conclusion and Way Forward*

In brief, RAMS is needed for maximizing financial and service value of Road Asset. The main objective of RAMS is just not to protect Road Asset by repairing and rehabilitating it but to emphasize on maintaining it so that the road would sustain until the end of design service life. Although a minimum concept of RAMS is followed for planning and implementing highway maintenance works, we haven't been successful in establishing fully effective RAMS in Nepal yet. The reasons could be greater focus on road asset building, little awareness regarding significance of maintenance, legal inadequacies, allocation deficit, cumulative maintenance backlog, low absorption capacity, overloading of traffic, enforcement issues etc. In a developing country like Nepal, where demand for asset building is astronomically higher than the capacity, the establishment of robust RAMS and quick response mechanism is necessary in order to preserve expensive Road Asset, reduce cost of vehicle operation and service delivery, save financial resources for further asset building and ensure sustainable development. The political, administrative and social awareness is needed to establish a robust RAMS and strong commitment for institutionalizing it is needed to implement it.

### *References:*

1. Managing Infrastructure Asset for Sustainable Development, UNDESA & UNCDF, 2021
2. Department of Roads, Nepal, www.dor.gov.np
3. Roads Board Nepal, www.rbn.gov.np

## 9. Seismic Retrofitting of Babar Mahal (DoR Building)

*Dr. Purushotam Dangol (ERTech)*
*Er. Suraj Malla (ERTech)*
*(Consultant:A not & ERTech Consultancy Pvt. Ltd. JV)*

### *9.1 Introduction:*

Babar Mahal is one of the many historical buildings that were hit by Gorkha Earthquake 2015. Babar Mahal (Fig. 9.1) used to be one of the Rana palaces in Kathmandu. Building is located north of Bagmati river incorporated in an impressive and vast array of courtyards and gardens. Palace was under Junga Bahadur Rana's Thapathali Durbar but later was separated and rebuilt in Neo-classical style by Chandra Shumsher Junga Bahadur Rana in BS 1966/1967 and gifted to Babar Shamsher Junga Bahadur Rana, since then palace was named after him as Babar Mahal. Average floor height of 3 storey Babar Mahal is 3.7 m. It occupies 5 courtyards and 113.26 m x 85.27 m of area. After the fall of Rana regime, Babar Mahal was occupied and owned by Babar Shamsher Junga Bahadur Rana but later he sold it to the Government of Nepal. Before the April 2015 Gorkha earthquake, Department of Roads, Office of Auditor General of Nepal and Nepal Oil Corporation occupied the palace.

An expert engineer team visited the building site in order to make a seismic conditional assessment and retrofit design of the existing building. To evaluate the strength of existing building elements, NDT, foundation exploration has been done.

### *9.2 Contract Details:*

| | |
|---|---|
| Employer | : Central Level Project Implementation Unit - Department of Urban Development and Building Construction (CLPIU-DUDBC) |
| Construction Company | : Samanantar Nirman Sewa Pvt. Ltd. |
| Consulting company | : A not & ERTech Consultancy Pvt. Ltd. JV |
| Contract Amount | : NRs. 86,02,52,754.36 without VAT |
| Contract Date | : 2076-03-25 (July 10 , 2019) |
| Contract Period | : 24 months |
| Extended Date of Completion | : 2079-06-30 |

### *9.3 Damage Assessment:*

Structure of Babar Mahal was built in Neo-classic style, constructed as brick masonry in mud mortar. Building has 5 courtyards within the premises of Babar Mahal. Complex was divided into 5 different blocks for damage assessment purposes (Fig. 9.2).


Fig. 9.1: Babar Mahal Complex before Earthquake
(a) West elevation

(b) South elevation

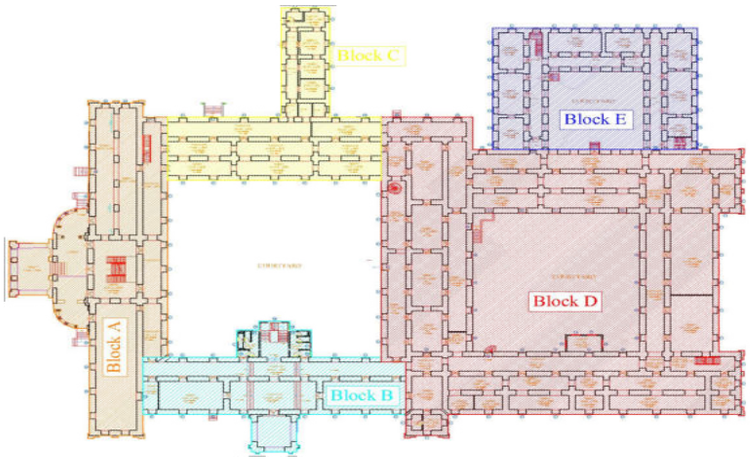



Fig. 9.2 : (a) Block separation

(b) Google image

During the site visit after earthquake (Gorkha Earthquake 2015), various damages were observed such as diagonal cracks in wall, deterioration of timbers, damage in masonry arch, diagonal and horizontal cracks, crushing and separation of masonry units etc shown in fig. 9.3.

Fig. 9.3: Typical damage observed: (a) Masonry unit separation, (b) Diagonal Cracks of masonry unit.(c) Timber cracks

### *9.4 Non-destructive test (NDT):Non-destructive test (NDT) was perform at the building such as:*

1. In-situ Shear Strength Test
2. In-Situ Compressive Strength Test (Single flat jack Test)
3. Pocket Penetrometer Test
4. Compressive Strength Test of Brick
5. Foundation Exploration
6. Timber Test (Resistograph)

From the test minimum value obtained for masonry are 0.08 MPa (shear strength), 3.39 MPa (Compressive strength). Mortar compressive strength from pocket penetrometer test was determined to be 1.37 MPa. Brick strength was determined to be 7.5 MPa from brick test. Timber test was performed to determine data of the existing timber as shown in fig. 9.4.

Fig. 9.4 : Typical NDT performed (a) In-situ Shear test, (b) In-situ compressive test, (c) Pocket penetrometer test, (d) Brick compressive strength test

### *9.5 Structural Analytical model:*

Three dimensional solid models were created for walls and line element for timber section and shell element for slab using SAP 2000 to represent structure's spatial distribution of the mass and stiffness. Default sign convention of local axis for solid element was accepted as in SAP 2000 for design purpose as shown in fig. 9.5.

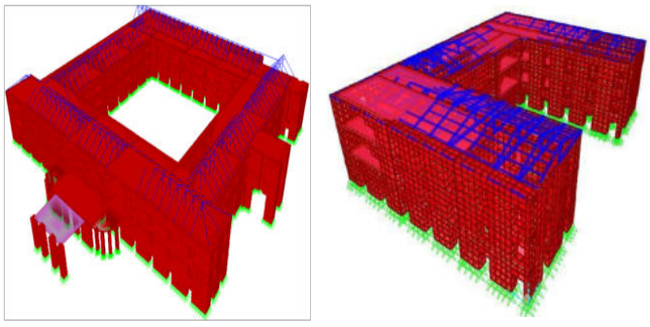


Fig. 9. 5 : Typical Analytical model (a) Block A (b) Block C

### *9.6 Verification of the Analysis and Structural Adequacy:*

The results of the computer model showed that the existing structure was adequate in almost all places for gravity loads but was highly inadequate to take the code specified lateral seismic forces. In some areas, the overstress ratio exceeded the permissible value. Hence, different retrofitting techniques are adopted for retrofitting the buildings with separation of blocks introducing the seismic gaps.

### *9.7 Seismic Retrofit Technique:*

Basic techniques adopted for retrofitting are listed below.

*9.7.1 Introducing Rigid Diaphragm Action of floor:*

For improved seismic performance, a rigid diaphragm was required to be put in place at both the floor levels. The diaphragm action was proposed to be developed by means of introducing diagonal bracing and anchoring to masonry wall by steel angles on the underside of the floor level (Fig. 9.6). The brace elements were connected to the steel joists for lateral support.

*9.7.2 Strengthening of Arches*

The arches suffered three types of failures: dislocation of keystone, severe cracking of arches and movement of supports. Two retrofit details for arch strengthening have been recommended based on the type of damage. Where there is movement of support and the arches are internal, a stainless steel tie with a turnbuckle is proposed. Glass fibre wrapping is used for strengthening the arch and jack arch floor (Fig. 9.6)

Fig. 9.6 : Jack Arch Strengthening with glass fiber

### *9.7.3 Carbon laminate & Glass fibre:*

Improves structure integrity by providing horizontal seismic bands on outer side of wall at lintel, sill, in between lintel and sill, springing levels etc with Glass fiber polymer sheet with carbon laminate (Fig 9.7).

through finite element modeling. Study was done in two stages: i) Damage assessment was carried out to determine damage in every structure element, ii) Analytical assessment after Non-destructive test (NDT) to determine material properties required for numerical analysis. The significant damage was observed

Fig. 9.7 : Outside wall Strengthening with Carbon Laminate and fiber

### *9.7.4 Steel Jacketing:*

Improves out-of-plane, shear and In-plane flexural ductility with vertical /horizontal steel plate jacketing are used and wall and floor are connected by MS angle (Fig. 9.8)

### *9.7.5 Conclusion*

This study presents the results of detailed damage assessment and retrofit techniques adopted for Babar Mahal analyzed in Babar Mahal due to earthquake event that occurred at April 25, 2015, and following aftershocks. Observed damages are compared with numerical simulation results and the different repair, retrofitting techniques were adopted with justification from finite element model. Strengthening of foundation is done by introducing micro piling.

Fig. 9.8 : Inside wall Strengthening with Steel Jacketing inside wall & MS Angle for connection (a) Block A (b) Block C

## 10 Ready Made Premix (RMP): "A Rapid Response Solution for Pot-hole Repair"

***– Krishna Raj Adhikari, SDE, Bridge Branch***

The major role of the Department of Roads (DoR) is to deliver service through highway maintenance. There are many types of maintenance activities on road surface according to the scope and extent of defects. Among them, recurrent maintenance has high significance in order to keep roads free of potholes and patches. In current practice, DoR with maintenance divisions and projects are using Hot Mix Premix, Hot mixed Asphalt, EAM (Emulsion Aggregate Mix) for pot hole repair and patch works. DoR also introduced a cold mixed patch almost 10 years ago, namely "Patch Master". Considering the importance of cold patch, DoR, Maintenance Branch, Roads Board Nepal and Road Division Bharatpur and experts agreed for initiating production of Ready-Made Premix and perform trials. In 2019 AD, a team of Road Division Bharatpur lead by author of this critical started to produce, store and apply Ready Made Premix as a Rapid Response solution for pothole repair (Fig. 10.1). This is a simple, effective, durable and time saving technique for road surface pothole and patch repair technique.

### *10.1 Benefits*

- Easy to warm and mix asphalt and aggregates
- Packed mix can be stored for long time (upto six months)
- Locally available materials for road works
- Rapid Response solution for patch hole repair
- Effective for small scale recurrent maintenance
- Early repair of potholes stops propagation and saves cost of future maintenance

Fig. 10.1 : Management group of Bharat Division

### *10.2 Materials (Fig. 10.2)*

- Surface Dry Chips / Aggregates
- Medium Cutback Bitumen (MC 800)
- Anti-Stripping agent (optional)
- Plastic Laminated bags / Plastic-Lined Sturdy Bags of capacity 40 to 50 kg

| Sieve Size, mm | Percent Passing |
|---|---|
| 9.5 | 100 |
| 4.75 | 40-100 |
| 2.36 | 10-40 |
| 1.18 | 0-10 |
| 0.075 | 0-2 |

Fig. 10.2 : Material storage at plant

### *10.3 Tools and Equipment*

- Asphalt mixture or warm mix set of bitumen and chips below 100°c
- Temperature reading device (Fig. 10.3)
- Safety gears (Gloves, Helmet, PPE, Mask, boots for worker and Supervisor)
- Fire safety Extinguisher
- Wire brush, road brush, air blower
- Weighing machine upto 100 kg capacity
- Hand hammer (Dhurmus)/ Rand Roller (Optional)

### *10.4 Preparation /Production*

- Heating MC 800 to temperature 70°c to 95°c add anti stripping if necessary
- Drying aggregate 25°c to 65°c
- Mixing Aggregates and bitumen MC 800 well in drum mixture. Conventional hot mix plant is also useful.
- Assure uniform coating of bitumen around aggregates. Approximately 100 to 110 bags (40 kg each) Ready made Premix Can be produced with a 200 litre (one drum) of MC 800 bitumen. Refer Norms for Rate analysis.
- Packing in laminated bag when the temperature of mixture downs below 40°c.
- Fill the bag with mix and weight in weighing machine (40 kg)
- Sealing it properly, marking batch, date and weight in each package.
- Storing or stockpiling in cool, dry and open place and keeping records.
- Arranging necessary fire control accessories (eg. fire extinguisher) in the premises of production and place of store.


Fig. 10.3 : Testing at Site

### *10.5 Method of application (Fig. 10.4 and Fig. 10.5)*

- Collecting data and location information of pothole site e.g. Nos., sizes, depth of pothole.
- Transport to site (supervision vehicle itself can be used for small amount of repair work). Supervisor and Length worker of concerning road section can be mobilized)
- Cleaning pothole with road brushes, wire brushes or air blower and making pothole dry.
- laying RMP in moisture-free pot hole from bag as per requirements and size of pothole. (no need of tack coat)
- Leveling the mix properly and compacting with hand hammer (dhurmus) or use hand roller. In some cases supervision vehicle over it.
- Sprinkle some sand on the compacted patch so that traffic bitumen of mix do not stick in tyre. [or spread plant leaves on the patch to achieve the same purpose.]
- Open for traffic
- Keep records.

The packed and properly stored RMP (Ready-made Premix) can be used within six months of production.

Fig. 10.4 : Photographs of materials preparation at site and laying

Fig. 10.5 : Photographs of materials laying at site

## 11. Accelerating Transport and Trade Connectivity in Eastern South Asia (ACCESS) –Nepal Phase 1 Development Cooperation Implementation Division (DCID)

### *11.1 Introduction*

The Ministry of Physical Infrastructure and Transport, Department of Roads has received financing from the World Bank, International Development Association (IDA) toward the cost of the Accelerating Transport and Trade Connectivity in Eastern South Asia (ACCESS) –Nepal Phase 1 (P177902), to increase the efficiency and resilience of trade and transport along selected corridors in Nepal. The Project comprises four components: (1) Digital Systems for Trade; (2) Green and Resilient Transport and Trade Infrastructure; (3) Institutional and Policy Strengthening for Transport and Trade; and (4) Contingency Emergency Response.

The total project cost is US$ 305 million of which US$ 275 million will be IDA credit and the balance to be financed by the Government of Nepal (GoN).

### *11.2 Components of the Project*

The ACCESS MPA Phase 1 have mainly four components; they are

**Component 1:** Digital Systems for Trade (US$ 6.15 million; IDA financing of US$ 4.1 million) will support the adoption and implementation of IT-enabled services for trade.

**Component 2:** Green and Resilient Transport and Trade Infrastructure (US$ 285.85 million; IDA financing of US$ 261.15 million) will support the development of green, climate-resilient, and inclusive transport and trade-enabling infrastructure along Nepal's primary trade corridor connecting Nepal with Bangladesh, India, and Bhutan, namely, the East-West Highway (EWH).

The project under Department of Roads (DoR) will include the following sub-components:

Subcomponent 2(a) – Upgrading works and construction supervision for the Butwal—Gorusinghe— Chandrauta (BGC) road section (69 kilometers) from a two-lane single carriageway to a climate-resilient four-lane dual carriageway with new market areas, and including safety features such as service lanes for lower speed vehicles along the road section running through dense urban settlements, rural and forest zones (to significantly improve road safety, promote the use of non-motorized transport, and protect wildlife where needed).

Subcomponent 2(b) – Detailed design, construction, and construction supervision of a green resilient urban bridge, including the construction of a green climate-resilient four-lane bridge (on the EWH) and regeneration of its surrounding urban environment through green, climate-resilient, and inclusive urban design (to support low-carbon urban development, enhanced mobility of non-motorized transport, and enhance the economic potential of the area).

The urban bridge will be built in one of the major urban locations identified and approved by the MoPIT under the ongoing bridges program (BIMP-II) along the EWH. Its location will be finalized based on ongoing pre-feasibility studies being conducted on the existing two-lane bridges in Butwal and Bharatpur, which are today—in the absence of adequate urban development planning—not only a bottleneck for trade, but also vulnerable to disasters and climate change, subject to environmental degradation of riverbanks and watersheds, and unsafe for its users and nearby communities. Both urban areas are fast-growing metropolises and important commercial hubs with potential for tourism and enhanced local economic activity.

Subcomponent 2(c) – Development and implementation of a green resilient highway corridor concept and strategy to support the development, approval, and implementation of an integrated strategy (and action plan for priority civil works) that balances equitable transportation functionality, climate resilience and sustainability of the highway corridor at the landscape level

**Component 3:** Institutional and Policy Strengthening for Transport and Trade (US$ 13 million; IDA financing of US$ 9.75 million) will support the strengthening of policies, institutions, and technical capacities

**Component 4:** Contingency Emergency Response (Estimated Cost US$ 0 million; IDA financing of US$ 0 million). This component will provide immediate response to an eligible crisis or emergency, as needed. In the event of an eligible crisis or emergency, the World Bank to re-allocate project funds to support emergency response and recovery.

### *11.3 Project Status and Activity for FY 079/80*

The negotiation between GoN and WB regarding financing agreement for this project took place in 20 May 2022 at World Bank Kathmandu Office and Financing Agreement will take place very soon. The period of this project will be for 7 years. The current status of the project and the activities for this fiscal year 079/80 will be as follows;

| S.N. | Components/Sub -Activity | Current Situation | FY 079/80 Activities |
|---|---|---|---|
| 2 | Green and Resilient Transport and Trade Infrastructure | | |
| 2a | Butwal — Gorusinghe — Chandrauta (BGC) road section (69 kilometers) | The detailed design of Butwal - Gorusinghe section (50Km) is currently being done by DoR ADB Project Directorate and Draft Design will be completed by September 2022. | |
| | Supervision Consultant | ToR is under Preparation | Hiring process completed |
| | Selection of Contractors for Improvement in 3 packages | | Selection of contractor will be completed |
| 2b | Detailed design, construction, and construction supervision of a green resilient urban bridge | Preliminary concept and bridge type selection done by World Bank Technical Team | Feasibility study including preliminary design will be completed |

Table 11.1: Project status

## 12. Short Term Restoration of Traffic through Bhapsi Bridge, Bardibas along EW-Highway.

***Er. Sanjay Mishra, SDE, DRO Janakpur.***

### *12.1 Introduction:*

Bhapsi Bridge is located on the East-West highway (EWH) which is the backbone of the national transportation system of the country. The google coordinate of the Bhapsi Bridge is 26°59'36.68"N, 85°52'57.51"E. Most of the bridges constructed under USSR support during EWH construction in 1974 AD, have served the nation since then. At that time more than 60 bridges were constructed with precast concrete sections (Fig. 12.1). In 2017, Ratu Bridge at E-W highway lying around 2 kms east of Bardibas was damaged due to flooding of a similar situation. The flood event that occurred in June 2019 washed away two middle spans of Bhapsi Bridge (Fig. 12.2) forcing people to travel through a 40Km longer alternative of lower standard road. The area is characterized as a flash flood zone in the rainy season. Hence bridge restoration was targeted to finalize before the rainy season.

Fig. 12.1: Bridge Before collapse

Fig. 12.2: Bridge after collapse

The bridge flooded at mid-night causing disruption of highway service & a number of vehicles were stuck without possibility to move ahead. A team of DRO engineers inspected the situation and visited the site early in the morning, trying to diagnose the causes and find out immediate alternative options. The waterway was blocked by transported trees from upstream forest areas cut on the north-west side promoting excessive scouring of the middle pier foundation. Immediately after, the technical team decided to put a Modular Panel Bridge (Fig. 12.3) for traffic movement. An experienced team was assigned for the task and the bridge element was brought from emergency stock kept at DRO Lahan. Finally, the network was restored in a week with load restriction.

The next level problem began when the modular bridge members were showing signs of crack and frequent pullout of the nut-bolts and bracing members. DRO team at that time considered the case as usual and tightened the bolts of loose member's number of times and replaced the minor bracing members. It was operated in a similar situation till the end of April 2021.

Fig. 12.3: Installed Bailey Bridge after old bridge collapse

### *12.2 Re Diagnosis and Treatment for modular bridge*

In the beginning of Jan 2021, it was reported that there was a crack in the bottom chord of the middle modular panel at four corners around quarter span & was immediately repaired again. The problem repeated with major cracks on one side and crack progressed on 3 of 4 corners before the field verification. It was finally decided to weld the breakage with gusset plates. After detailed examination, the problem was identified to repeat due to overloaded trucks, especially when they applied brakes on the middle span of the bridge. Since the modular bridge was rested at caps placed at a certain distance from the damaged edge, the bridge deflection was restrained at quarter span by Kerb stones of remaining existing parts. There was a heavy impact on the edge of the quarter span. The modular bridge should have been raised enough to allow deflection. The bottom member of the middle panel was resting directly on the kerb of the old bridge, causing severe repeated impact to break the members. After understanding the failure mechanism, there were three options i.e. dismantling remaining old span, raising the entire bridge or removal of parts at point of impact to allow deflection. The members were jacked with a hydraulic jack and dismantled all side Kerb blocks touching the bottom chord. Later on the impact sound diminished totally and was finished by tightening nut-bolts, welding broken members and correction of approach to reduce impact. It was observed for a month, the belly bridge was performing well and no additional symptoms appeared.

### *12.3 Construction of new bridge*

There were heavy traffic jams during peak hours even after the installation of a modular bridge and there were frequent complaints by engineering colleagues and VIP's traveling through the bridge regarding reduction in LoS at the national highway. Province Ministers, DAO, Bardibas Municipality & DIG office requested to resolve the issue as soon as possible for security response issue. After instruction from DG DoR, different options were explored & found it rational to prepare for new bridge construction. The option of one bridge and two bridges on either side of the median was discussed in a team. The constraints were, for that it needs to shift the existing modular bridge on one side having worthless expense till the time required to rebuild the bridge i.e., about 2 years. This was the most economic current scenario adopted with compromise to LoS and load restriction over the bridge. Relocation of the diversion could be included in the new bridge construction contract.

The old bridge was constructed with precast sections. The deck of the old bridge had inverted C-Sections. It was good to be reused with some strengthening techniques like Jacketing or using Carbon Fiber or Grouting for exposed reinforcement and minor cracks (Fig.12.4). In fact, there are similar old sections of Barhadi bridge at Dhalkebar camp. The problem was with piers. One new pier was required and others were bent enough requiring proper jacketing to restore its situation. The major concern of this option was the possibility of short time restoration.

Serious consultation was carried out with bridge design consultants, bridge branch team and FRSMO seniors regarding reuse possibility and foundation issue for immediate economical solution. The precast members were not suggested being aged and having cracks on it. Else if the selected similar sections of Barhadi Bridge stored at Dhalkebar camp was recommended to use as a replacement of sections requiring major strengthening techniques if adopted.The bridge foundation in BMS were Pile but at in-situ situation it was open foundation with nominal foundation depth. It was the major cause of foundation scouring during the flood. After discussion in the team it was decided to provide an open foundation below calculated scouring depth

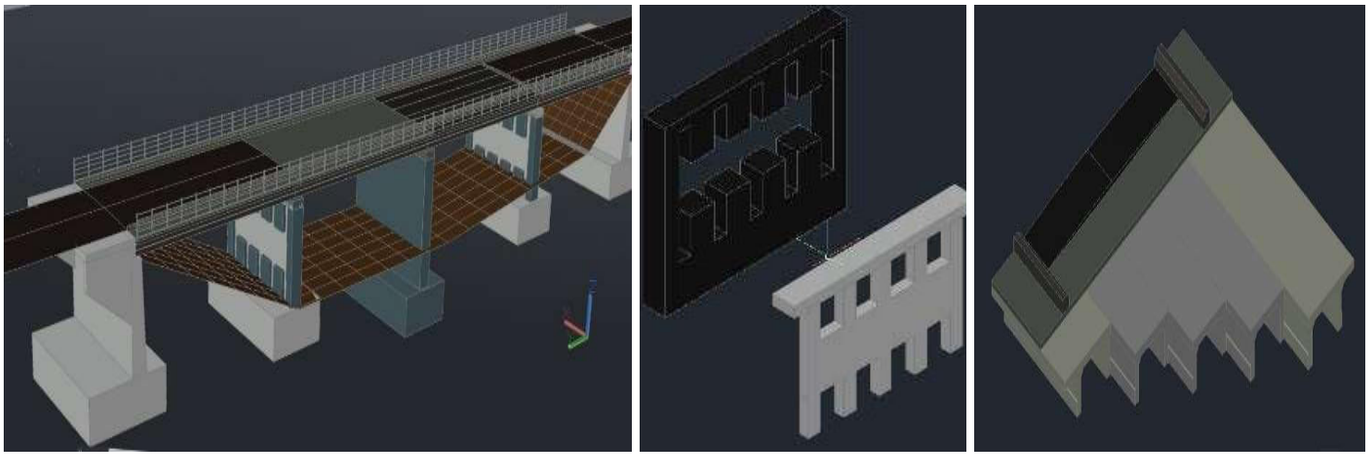


Fig.12.4: Some exercise for use of existing precast members and strengthening by Jacketing.

with minimum embedment for economy. After exploring all information it was recommended to use Standard Drawing of 15m intermediate lane as a deck, construction of new piers with nominal reinforcement details and existing abutment. Also allowed to use special provisions in the bidding process to attract the possible capable bidders with competency to finish before next flood season. Before actual bidding,the following exercises were carried out:

- Exercised in team, shortest possible crash period for the project.
- Invited all possible competent and local bidders for open discussion about possibility of completion in this duration. They were also notified about non-financial consideration due to crash project duration.
- Their response was positive, so requested them to not bid if they can't make it happen and spread the information among the contractor community.
- The strict provision was proposed in the bidding document: 'If the contractor wouldn't complete it before next rainy season, they shall re-install the modular bridge at their own cost'. They were informed about the relocation cost of the modular bridge.
- The cost of the project was estimated assuming the normal construction duration of 2 years. It had been explored that it was possible to finish it by next 8 months by rearranging the parallel activities but did not consider the associated cost due to lack of proper norms.

### *12.4 Project Details*

| | |
|---|---|
| Name of Work | : Maintenance of Flood Collapsed Bhapsi Bridge along EW |
| Highway, Ch. | : 268+270. |
| Location | : Bardibas, Mahottari. |
| Span of the Bridge | : 12.50m |
| Length of the Bridge | : 50m |
| Number of Span | : 4 |
| Type of Superstructure | : RCC Symply supported |
| Estimated Amount | : NRs. 3,99,14,345.95 (Incl. PS & VAT) |
| Contractor | : M/S Sugam Nirman Sewa Pvt. Ltd., Mahendranagar, Dhanusha. |
| Contract Amount | : NRs. 2,57,85,233.88 (Incl. PS & VAT with VO-1) |
| Start Date | : 2077/07/11 |
| Traffic Open Date for New Bridge | : 2078/02/15 |

### *12.5 Construction Management & Site Issue:*

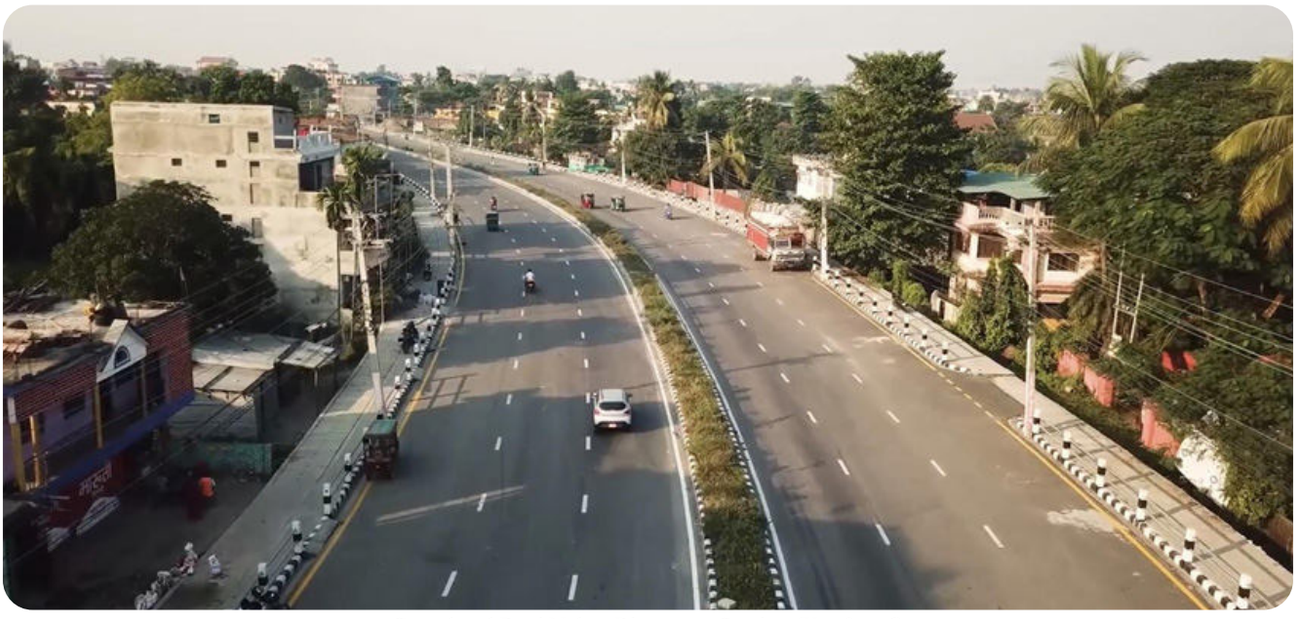
The Contractor, set up his camp, managed diversion, disassembled modular bridge, dismantled the old concrete elements other than abutment and formally initiated the actual work by the end of Jan 2022. While excavating for foundation, no piles were found as indicated in BMS drawing. Also the open foundation was laid just 2.5m below the low bed level. The abutment was protected by inserting a series of pipes. All three pier foundations were cast in sequence. The contractor brought his own set of equipment, and had good contacts for RMC concrete. By the mid of Falgun, all piers were completed and abutments were strengthened. Unfortunately, it took a long time to allocate a budget. The completed bridge is shown in Fig. 12.5.

### *12.6 Conclusion*

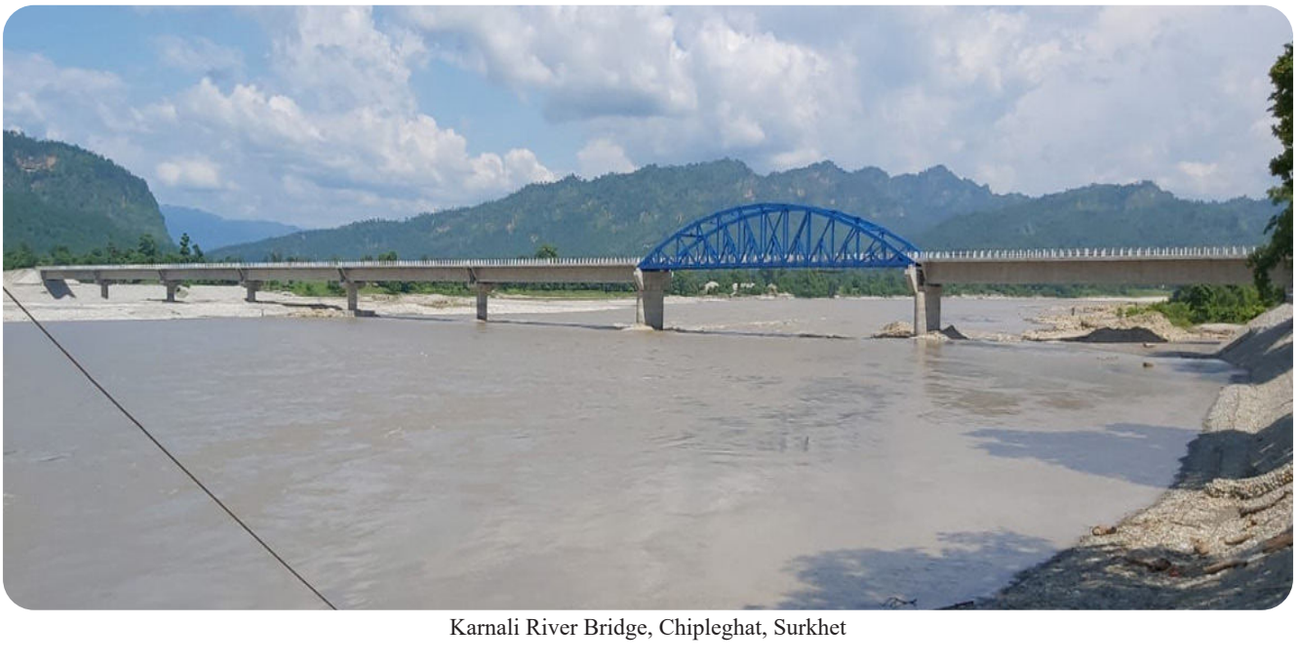
DRO-Janakpur team adds confidence of appraisal from multispectral well-wisher on success of project within timeline. Our special appreciation goes for direction on conception and convenience on success to, Director General, Er. Arjun Jung Thapa. We should not forget to appraise Mr. Shyam Sah, representing Sugam Nirman Sewa Pvt. Ltd. Many more people from upper agency and lateral professionals were supporting the day to day quarry. Lastly, it is learnt that when there is such a schedule crash on a project, must important is budgetary assurance.

Fig. 12.5: Completed bridge

## 13. Photographs of some major works in FY 2078/79



Completed Rani Nahar-Biratnagar Section (Km 3 to 6)



Karnali River Bridge, Chipleghat, Surkhet

Karnali River Bridge, Kachalighat, Kuine, Surkhet

Bheri River Bridge, Khusineghat, Surkhet

Kandra Khola Bridge, Kailali

Sunkoshi River Bridge, Foxingtar

Debris flow on Narayanghat-Muglin Road at Mauri Khola Bridge

Steel-Wire-Rope-Cable-Barrier (Flexible-Guard-Rails-System) in Narayanghat-Mungling Road

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