NEWSLETTER

Department of Roads (DoR)

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Asia Pacific Road Safety Observatory; A Knowledge Sharing Platform on Road Safety

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I. Introduction

The Asia Pacific Road Safety Observatory (APRSO) is a regional forum on road safety data, policies and practices to ensure the protection of human life on the roads across Asia and the Pacific.

The establishment of the Asia-Pacific Road Safety Observatory was announced in February 2020 on the eve of the Global Ministerial Conference on Road Safety in Stockholm, Sweden. APRSO was established by a group of international development organizations – the Asian Development Bank (ADB), The World Bank Group, Fédération Internationale de l'Automobile (FIA), the International Transport Forum (ITF) and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), with support from the World Health Organization and UK Aid through the Global Road Safety Facility (GRSF). ADB serves as the secretariat for APRSO.

It is a concerted effort by the development community and road safety stakeholders to better support countries in Asia and the Pacific in their efforts to drastically reduce road traffic fatalities and serious injuries. The objectives of APRSO are to:

- Collect, manage and analyse an Asia and Pacific regional database for road crashes in Member countries, facilitating on-going applied research and data-driven interventions.
- Provide research and technical assistance for Members on road crash data collection systems, standards and norms.

- Share research, evidence and technical material, software and necessary tools for collecting and analysing road crash data.
- Share evidence and foster dialogue on road safety within Asia and the Pacific.
- Support the creation of a governing body and a lead agency for road safety in every Member state, as well as strengthen existing ones.
- Provide capacity building on technical issues and evidence-based guidelines related to road safety.
- Establish cooperation agreements for implementing and evaluating road safety action plans among Members.
- Monitor the progress on road safety of each Member.
- Promote good practice on national and regional road safety policies and strategies.
- Informed by research and evidence help assess how to reduce factors that lead to serious road injuries in Member states.

APRSO commits to support Members through pursuit of these objectives. APRSO Members commit to support APRSO through participation in the APRSO through the General Assembly, Steering Committee and relevant Task Forces, and also to provide data and information of road crashes and road safety to the APRSO.

II. APRSO Membership and Member Countries

Members of the APRSO are Governments in Asia and the Pacific and supporting donor organizations. Non-voting members are relevant stakeholders comprising private sector firms, non-government organizations, the academe, and individuals interested in promoting and achieving better road safety outcomes.

The highest national public governing authority with competence or responsibility for road safety in an Asia Pacific country may become a member of APRSO by expressing interest in writing to the Chair of the Steering Committee.

Relevant stakeholders may request, in writing, to the Secretariat to become a member of APRSO. Following review of the applications the Secretariat will recommend appropriate response to the Steering Committee which will consider applications and set the terms of the proposed membership.

The responsibility of members shall be to collect data, submit data to APRSO, share road safety related information and work with APRSO to address and promote road safety.

Following 27 are the APRSO member countries till November 2023.

1. Australia	2. Afghanistan
3.Armenia	4. Azerbaijan
5. Bangladesh	6. Bhutan
7. Cambodia	8. Cook Islands
9. Fiji	10. Iran
11. Kazakhstan	12. Kyrgyz Republic
13. Lao PDR	14. Maldives
15. Marshall Islands	16. Mongolia
17. Nepal	18. New Zealand
19. Pakistan	20. Papua New Guinea
21. Philippines	22. Samoa
23. Solomon Islands	24. Sri Lanka
25. Tajikistan	26. Turkey
27. Turkmenistan	

Observer Status

- Myanmar

APRSO is supported by the its Governance Statute. This document sets out the governance structure and the functions of the Asia Pacific Road Safety Observatory (APRSO) as agreed by its member countries.

The APRSO is made up of the following bodies:

i. General Assembly

The General Assembly comprises both the voting and non-voting Members of APRSO.

The General Assembly is the decision-making body of APRSO and remains validly constituted if at least half of the APRSO member countries are present. The General Assembly sessions shall be chaired by the Chair of the Steering Committee[1].

1 Mr. Sushil Babu Dhakal, Director General, Department of Roads Nepal is the Chair of the APRSO steering committee since October 2022.

Agreements shall be adopted by a majority vote of the countries present at the Assembly.

The General Assembly is responsible for:

- Ensuring APRSO meets its mission and objectives
- Electing members of the Steering Committee
- Maintaining the development and applicability of this statute
- Approving APRSO's Annual Work Plan

ii. Steering Committee

The Steering Committee ensures implementation of the decisions made by the General Assembly. Its members will carry out their duties impartially, and in conformity with ethical standards, principles, and values, as well as with the mission and vision of the APRSO.

The Steering Committee has the following functions:

- Carry out all the necessary actions in order to fulfill the Assembly's mandate.
- Prepare and implement the APRSO workplan, which may include: Encourage the harmonization of procedures for uniform standards of road crash data collection, analysis, monitoring, and reporting among Members.
- Collate FSI road crash data and prepare the annual report on road crash data of Members.
- Support technical cooperation on road crash data among Members
- Approve the date and agenda of the annual General Assembly.
- Prepare all documentation, reports, and proposals to the General Assembly.
- Approve the required guidelines for the functioning of the APRSO.
- Approve new Members.
- Consider, validate, and endorse reports, proposals, and communications submitted by the Secretariat.
- Appoint Task Forces.

iii. Organization of the Steering Committee

The Steering Committee consists of seven members, five of whom should represent member countries and two represent supporting donor organizations who are elected by the General Assembly. Out of those members, a Chair shall be elected by simple majority for a two-year term which can be renewed for up to a further two terms. The Chair should represent a member country. Currently there are only five members in the steering committee including the Chair.

Country	Steering Committee Member	Position
Nepal	Sushil Babu Dhakal	Chair
Australia	Adam Stankevicius	
Bangladesh	Makhjanul Islam Tauhid	
New Zealand	Matthew Skinner	
Cambodia		

The APRSO Secretariat shall be a non-voting member of the Steering Committee.

iv. Task Forces

The General Assembly may establish Task Forces covering specific areas of interest as agreed by the members at the General Assembly.

The Task Forces will be led by members of the APRSO. At least two members should lead a Task Force, one acting as the Task Force lead and the other acting as the Task Force co-lead. The Task Forces shall report their activities to the Steering Committee through a monthly report and present their respective work findings and conclusions at Steering Committee meetings.

The Task Forces shall submit their work, findings, and conclusions to the General Assembly during the annual meeting.

v. Data Expert Group

The Data Expert Group is primarily responsible for coordinating, collecting and agreeing the regional crash data. It comprises individual National Data Coordinators who are nominated by their countries to liaise and coordinate between the different national and local agencies that collect road crash and other road safety data such as the traffic police, transport and highway departments, health departments and agencies, insurance companies and other agencies and organizations as might be warranted. The primary outcome is expected to be an improved national road crash data base that reflects all road related fatalities and serious injuries at the country level as well as at the regional level following agglomeration of the national data. The

Data Expert Group is expected to meet at least once a year to discuss progress in collecting improved crash data.

vi. Secretariat.

The Secretariat will be hosted within the Asian Development Bank for at least the first three years of the APRSO. Beyond three years the General Assembly will decide the location of the Secretariat.

III. APRSO: Current and Future Activities

a. APRSO Knowledge and Innovation Hub

The APRSO Knowledge and Innovation Hub, which will be hosted on the APRSO website, will maintain regular mass-communications with Observatory stakeholders, bring opportunities for innovative action to the observatory and its members, and support hosting of the APRSO events.

- Provide a clearing house of relevant and up-to-date road safety knowledge for use by practitioners
- Facilitate dialogue aimed at catalyzing action and investment in road safety
- Host road safety technical knowledge and training events
- Support communities of interest on key road safety topics for the region
- Promote adoption of the Safe System approach
- Encourage and support innovative activities that aim to accelerate road safety performance
- Extend the capacity of the APRSO Secretariat in meeting the knowledge and innovation needs of members.

b. Country road safety management improvement

The APRSO will contribute to the improvement in road safety management at a regional and country level by supporting capacity building towards greater application of evidence-based knowledge to road safety decision-making.

- Assessment of road safety management maturity for member countries using ADB's framework for Assessing the Maturity of National Road Safety Management Systems.
- Completed country road safety profiles including but not limited to comparative information on road use, road safety performance, legislation, governance, policy, funding, and road safety interventions being implemented.
- Country road safety data improvement plans covering data collection, analysis, use and the supporting systems for these activities.

c. Data collection and reporting enhancement

The APRSO will contribute to the enhancement of jurisdictional road safety data collection and reporting to support road safety decision-making.

- Generation and/or collation of new road safety data sets.
- Generation of comparative data to support reporting against the World Health Organization's 12 Voluntary Safety Performance indicators as set out in the Global Plan.
- Participation in the ESRA survey of road user attitudes.
- Visualization and machine assisted querying of road safety datasets.

d. Knowledge products

The APRSO will contribute to the availability of leading thinking on road safety best practice through the publication of specific themed knowledge products. These knowledge products will address an Asia and Pacific audience on themes of high relevant to road safety decision-making.

Possible themes include:

- Production of Asia and Pacific Road Safety Progress and Projections Report.
- Production of a road safety and climate action alignment guide.
- Production of powered two-wheeler safety design guidance.

As stipulated in the APRSO governance statute, several activities have been carried out in Asia Pacific region. As an example, ADB has provided technical assistance through TA-6763 REG for accelerating innovation in Transport Crash Data Management in Nepal. A study was done in Kathmandu with the objective to determine the effectiveness of

crash data collection, analysis, reporting and use by police, road authorities, hospitals and other stakeholders influencing road safety in Nepal. The TA has submitted a study report in May 2023 with some critical findings and has recommended the necessity of capacity building regarding Road crash analysis and investigation in Nepal.

IV. Summary

In order to protect human life on roadways throughout Asia and the Pacific, the Asia Pacific Road Safety Observatory (APRSO) serves as a regional platform for information on road safety statistics, policies, and practices.

There are 27 member countries in the APRSO. APRSO steering committee is a powerful bogy of APRSO among five bodies in its organization. Nepal focal is holding a position of "Steering Committee Chair" since October 2022.

APRSO is undertaking numbers of activities working with the government agencies within the member countries to achieve its own objectives.

Nepal, being a member country has a great opportunity to use this regional forum to manage road safety data, policies and practices to ensure the protection of human life on the roads. As we are still striving for getting a dedicated Road Safety Act and full phase Nepal Road Safety Council, we can use this forum to learn from the experience of the member countries about the policy and legislation on Road safety they are adopting, role of their National Road safety Council and to learn how to increase overall effectiveness of our road safety management system.

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On-going construction Work along Mugling-Pokhara Road

Design and Construction of Simply Supported Post Tensioned Slab Bridges

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1.1 Introduction

Solid or voided prestressed concrete slabs are used for short spans and where good access is available for their construction. Using slabs simplifies the formwork and concreting operations, although the decks are relatively heavy. Solid slabs are used only for short spans. With spans above 15m, the deck is likely to be voided to reduce the deck section and dead load. Solid slab in situ concrete decks are cast on full-height falsework with a simple formwork, reinforcement, and prestress layout. The slabs are post-tensioned with multi-strand tendons that are installed after the concrete has attained sufficient strength. This arrangement is used for short spans where good access is available. The advantage includes straightforward construction and simple formwork layout, while the disadvantage is that prestressing a solid concrete element is inefficient, and dead load becomes excessive as the span length gets longer. In situ, voided slab decks are commonly used within the span range of 25m to 35m. The voids usually extend over only the center portion of the span with a solid section used over the supports. In this way, the dead load moments are reduced while the full shear capacity is maintained at each end of the span. Thus,

The positive aspects of slab bridges are;

- It increases clearance above the afflux due to the shallow depth of the slab
- It gives a clean attractive appearance
- It has good lateral load distribution characteristics due to its good torsional stiffness
- It requires a low maintenance cost

The negative aspects are;

- It has heavy self-weight for a larger span
- It is economically not effective for a large span of the bridge
- It can cover a small span.

Many prestressed slab bridges have been constructed and some have been under construction in recent years in DoR. The details of a few bridges that were constructed in DoR are shown in Table 1.

Table 1.- Details of post-tension slab bridges recently constructed in Nepal

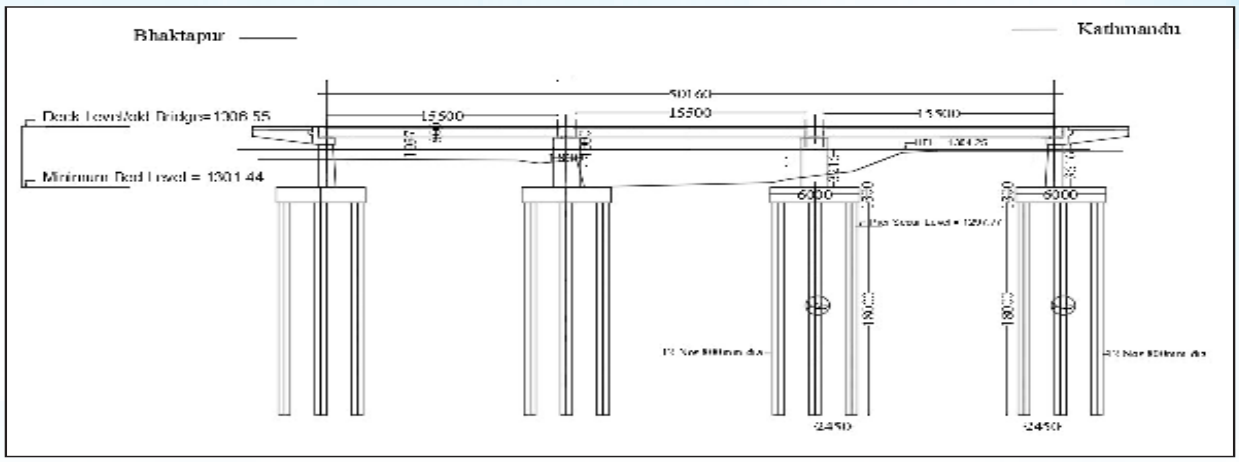
S.No.	Bridge Name	Span (m)	Overall depth (mm)	Strand	Concrete grade	Remarks
1.	Geruwa (Galchi)	10	500	7T13	M45	Two end
2.	Manohara	14.8	800	12T13	M45	One end
3.	Hanumante	15.5	800	12T13	M45	One end
4.	Thulo Khola (Galchi)	18	950	12T13	M45	Two end
5.	Mankhola	20	1000	15T13	M45	One end

In this paper, the design and construction aspect of the twin Hanumante Bridge is explained in detail. The bridge site is located in Arniko Highway. The old bridge is of total length 51m with 3-span RCC and pile foundation. The Google co-ordinate of the bridge site is 27.6742^0N, 85.3995^0E. This is the bridge in the service lane on both sides of the old bridge. To match the level of the existing bridge, the prestressed post tension slab bridge prestressing from one side is adopted in the new design. The advantage of one-side prestressing is that the width of the pile cap is small since no space is needed for the prestressing operation. The contract for the construction of this bridge was awarded in 2015 AD as a design-build contract. The contractor was Nilgiri Lokbir JV. The construction has already completed and opened to traffic. This bridge is the first post-tensioned slab bridge that was prestressed from one end with dead-end anchorage in Nepal.

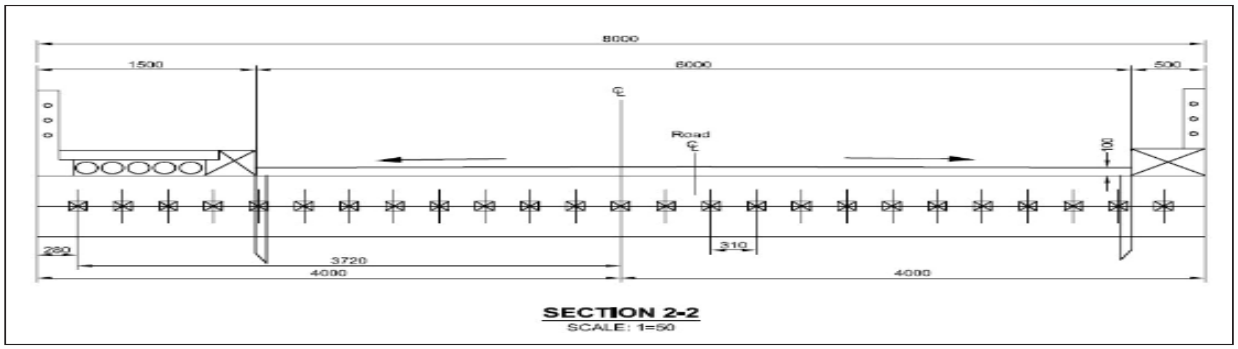
1.2 Salient feature:

The elevation and cross-section of the bridge are shown in Fig.1. The salient feature of the bridge is presented below:

Total length of bridge=50.16m
Span (L) =15.5 m
Overall depth = 0.8 m
Type of foundation = Pile foundation
Total width of bridge= 8.0 m
Carriageway= 6.0 m
Footpath width= 1.5 m (single side)
Dimension of pier cap =1.8m x 9m
No. and diameter of piles =12 Nos. 800mm dia
Type of prestressing= one side prestressing



(a) Elevation of Bridge



(b)- Bridge cross-section

Fig.1- Elevation and cross-section of Hanuman River Bridge

1.3 Design

The bridge is designed as per IRC design specifications. 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 load (ix) Load due to elastic shortening etc. The main design steps are:

1. Design of precast footpath slab and road kerb
2. Computation of BM and SF (Table 2, 3)
3. Calculation of prestressing force, elongation, and slip
4. Thermal stress computation
5. Flexural stress summary table (Table 4)
6. Ultimate moment of resistance
7. Analysis and design of transverse vertical shear
8. Design of end block
9. Design of bearing, expansion joint, and mesh above/below bearing
10. Design of substructure and foundation

Table 2.- Bending Moment due to different agents (tm)

(+ve) ; Hogg BM

Bending Moment due to

S.No	Distance from CL of bearing (m)	DL of Slab (tm)	SIDL (tm)	Long cantilever	Live Load,FP and utility loading (Governing)	Total BM (tm)
1	Support	0	0	1.47	0	1.47
2		-11.96	-2.31		-7.70	-21.97
3	L/8	-28.61	-5.53	1.47	-12.69	-45.36
4	1/4 th span section	-49.70	-9.61	1.47	-20.64	-78.48
5	3/8 th span section	-63.28	-12.24	1.47	-30.44	-104.49
6	Mid span	-69.36	-13.41	1.47	-33.56	-114.86

Table 3.- Shear force due to different agents (t)

					(+ve) SF;	
		Shear Force due to				
S.No	Distance from CL of bearing (m)	DL of Slab	SIDL	Long cantilever	Live Load and footpath loading (Governing)	Total SF
		(t)	(t)			(tm)
1	Support	16.70	3.23	1.44	5.48	25.41
2		14.00	14.00		5.42	33.42
3	L/8	11.62	2.48	0.00	5.34	19.44
4	1/4 th span section	7.75	1.73	0.00	5.17	14.65
5	3/8 th span section	3.88	0.98	0.00	5.02	9.88
6	Mid span	0.00	0.23	0.00	0.04	0.27

Table 4.- Basic stress summary table (kg/cm2)

Grade of concrete = M45			450 kg/cm2										
Permissible flexural stress for it:													
Temporary	7 days	28days		**Permanent**			28days						
Maximum compressive stress=	180	225		Maximum compressive stress=			148.5						
Maximum tensile stress=	-18	-22.5		Maximum tensile stress=			0						
			Stresses: kg/cm2										
	L/8 (L)			L/2			3L/8(R)			L/8 (R)			
AGENCY	fb	ft		fb	ft		fb	ft		fb	ft		
1. Girder DL	-26.74	26.74	-	-64.82	64.82	-	-59.14	59.14	-	-26.74	26.74	-	
2. PS -II (Applied at 28 days)	113.75	0.34	-	165.95	-50.28	-	168.38	-55.42	-	106.75	0.27	-	
R3=	87.01	27.08	-	101.13	14.54	-	109.24	3.72	-	80.01	27.01	-	
R4=	87.01	27.08		101.13	14.54		109.24	3.72		80.01	27.01		
3. Lossess in PS-II from 28 days	-23.32	-0.07		-34.02	10.31		-34.52	11.36		-21.88	-0.06		
R5=	63.69	27.01		67.11	24.85		74.72	15.08		58.13	26.95		
4. SIDL	-3.79	3.79		-11.16	11.16		-10.07	10.07		-3.79	3.79		Tem
Unloaded deck, R6=	59.90	30.80		55.95	36.01		64.65	25.15		54.34	30.74		
5. MLmax	-11.86	11.86		-31.36	31.36		-28.45	28.45		-11.86	11.86		Per
6-Deck loaded to max, R7	48.04	42.66		24.59	67.37		36.20	53.60		42.48	42.60		

1.4 Construction Sequence

The construction sequence is:

(a) Construction of pile foundation
(b) Construction of pile cap, stem, and abutment pier cap
(c) Placement of bearing
(d) Falsework and formwork construction for superstructure construction
(e) Reinforcement placement and duct profiling
(f) Deck concreting, prestressing strand placement
(g) Prestressing (Fig.2) and grouting
(h) Construction of bearings, expansion joints and appurtenances

The construction sequences are shown in Fig.3.

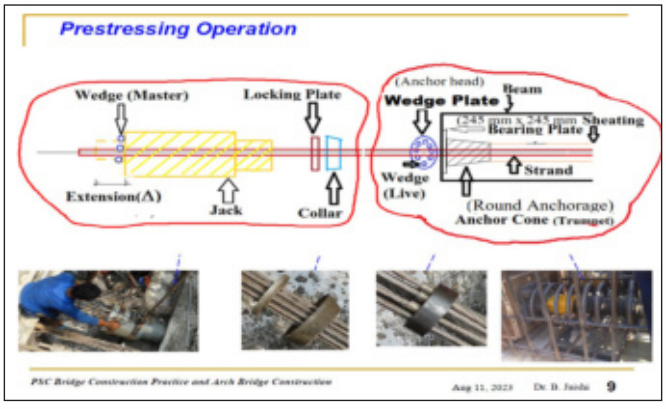


Fig.2- Prestressing operation

Fig.2- Prestressing operation

(a) Bridge site before construction begins

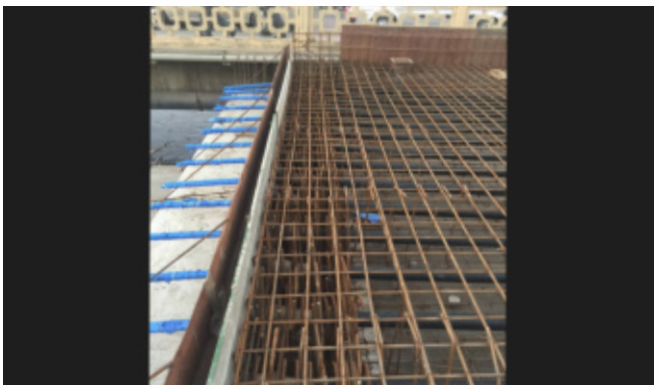
(b) Construction of pile foundation

(c) Existing Bridge foundation exposed

(d) Construction of substructure

(e) Scaffolding work for deck construction

(f) Reinforcement placing and duct profiling



(g) Dead-end anchorage details

(h) Deck concreting and prestressing cable placement

(i) prestressing operation

(j) Completed Bridge (Elevation)

(k) Dead-end anchorage details

Fig.3- Photographs of construction sequence of Bridge

2.5 Conclusion

The design and construction aspect of the twin Hanumante Bridge is explained. The prestressed post tension slab bridge prestressing from one side is adopted in this design. The advantage of one-side prestressing is that the width of the pile cap is small since no space is needed for the prestressing operation. This type of post-tension Slab Bridge is suitable for many locations where there is a height restriction and less freeboard is available, especially for urban areas. The span can be increased and economy can be achieved using a hollow slab configuration. The 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 urban locations in Nepal is highly recommended to get the above advantages.

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The Case Study of Bridge Information Modelling (BrIM) Project in Nepal

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A. Background

In Nepal, the Department of Roads (DoR) and the Department of Local Infrastructure (DoLI) have been actively involved in the planning, designing, and construction of bridges, crucial for enhancing transportation connectivity and infrastructure development across the country. In Nepal, the recent approach to design and construction has long relied on a fragmented and isolated process that lacks multidisciplinary collaboration. Individual stakeholders involved in a project often work within their silos, with limited communication and collaboration until the later stages of a project. This approach has led to a series of significant challenges plaguing the industry, including cost overruns, schedule delays, inefficiencies, design flaws, and a lack of comprehensive project documentation.

Fig . 1: Rendering of the bridge BIM Model along with topographic details.

B. Bridge Information Modelling

Bridge Information Modelling (BrIM) represents a model-based workflow that has gained prominence in the Architecture, Engineering, and Construction (AEC) industry worldwide. In Nepal, the adoption of BrIM practices is in a very beginning phase and has the potential to mitigate many of the issues that currently occur in a bridge project. BrIM is a digital representation of the physical characteristics of a bridge and its related infrastructure throughout its lifecycle. Contrary to popular misconceptions, BrIM is more of a process than a tool that helps to perform structural analysis and drafting

of the structure with ease. The tools used for various deliverables may be the same or different depending on the project's scale and requirements. Similar to Building Information Modelling (BIM) for buildings, BrIM for bridges involves creating and managing digital models of bridges, including their design, construction, operation, maintenance, and renovation phases. BrIM not only helps in producing higher quality documentation; it also produces an accurate quantity, cost estimates with detailed reinforcement modeling, and better visualization of issues that might occur during the construction phase as shown in Fig. 1 & 2. It is a better project management process rather than the traditional approach where a 3D-based process is utilized.

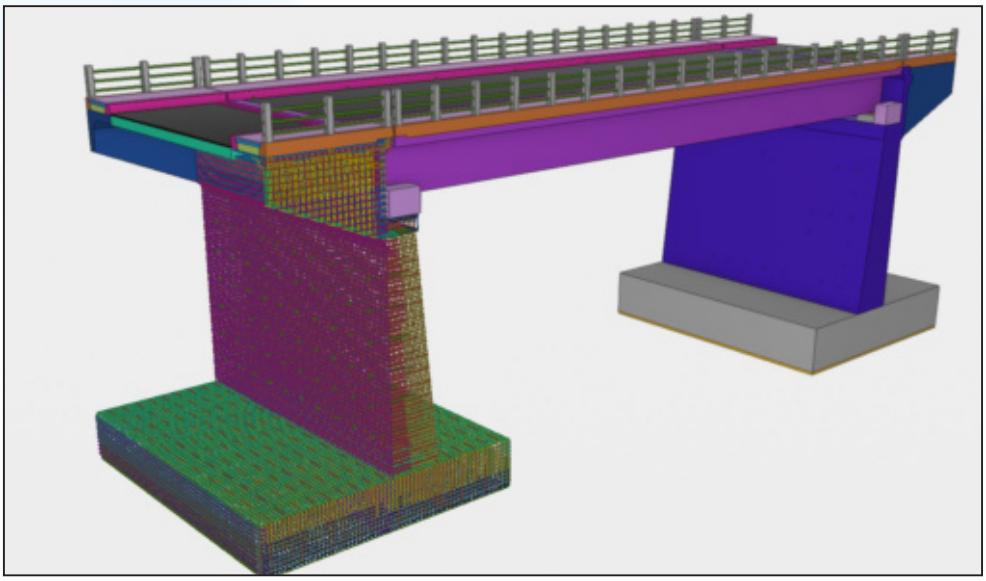

Fig. 2 : The Bridge Information Modelling (BrIM) view showcasing reinforcement details of the wing wall and Abutment

The first instance of implementing BrIM took place during the design of the pilot Bridge situated in the Arghakhanchi district in Nepal with research support from Nepal BIM Forum (NBIMF) and DoR. This pioneering effort aimed to evaluate and demonstrate the effectiveness of BrIM in enhancing the overall bridge design processes. The Wakle Khola Bridge project is RCC T-girder and the span of the bridge is 25m long which serves as a case study that showcases the potential benefits and challenges associated with embracing BrIM in Nepal's infrastructure development.

Fig. 3: Accurate Point Cloud Plan View showing the X, Y, and Z data and Topographic Visualization

In present surveying practices, the primary method for data collection often involves the utilization of a Total Station (TS) which only captures the data of a given point. This data forms the basis for creating topographic maps, which represent the contours of the site as shown in Fig. 4. However, the data collected at specific points may not have enough data points to accurately represent the entire site. This would result in interpolation and assumption, potentially leading to inaccuracies in design and construction.

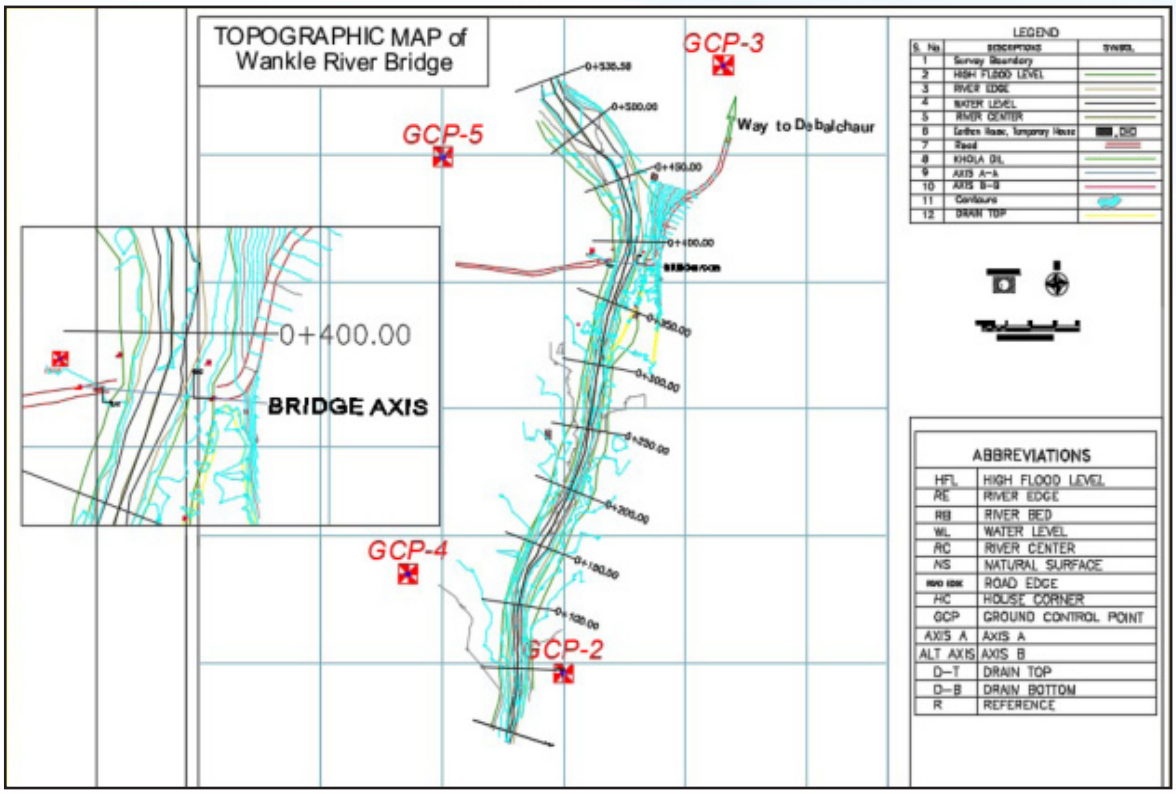

Fig. 4 : Various site details such as contour, chainage, and bridge axis shown on the survey data captured from Total Station

Fig. 5: Topographic details, generated from a drone survey

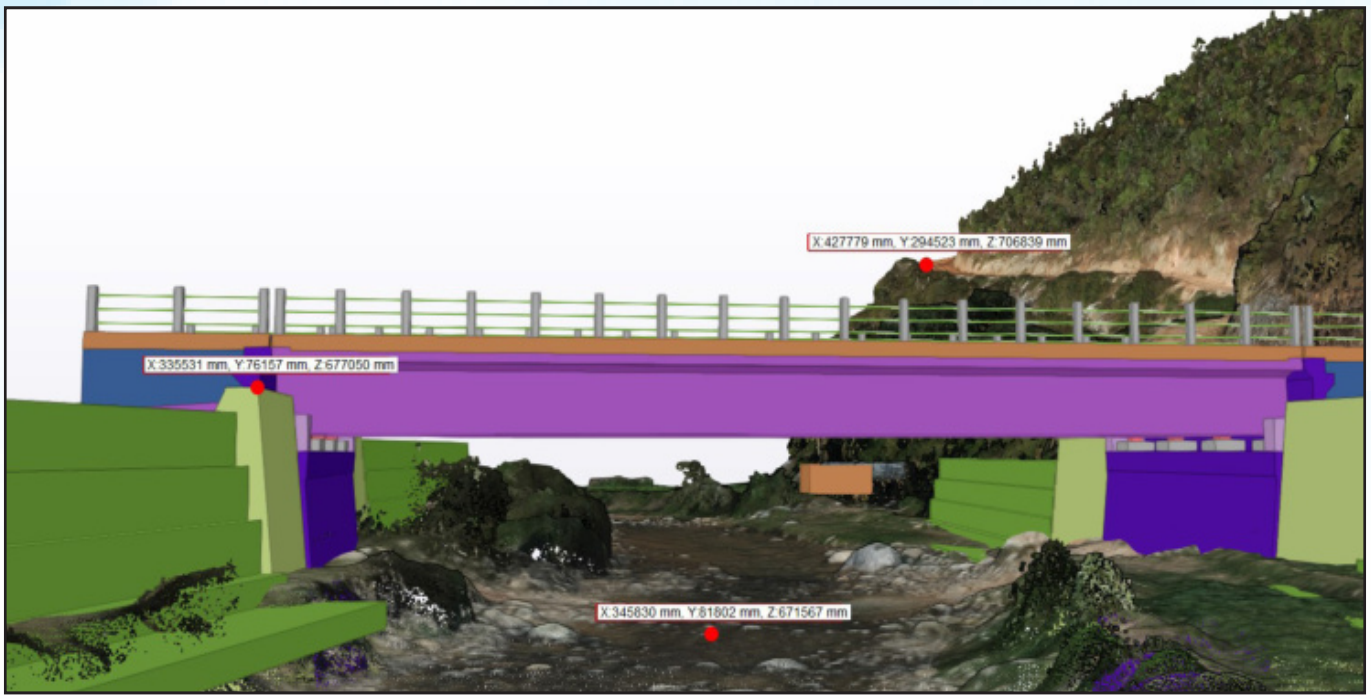

Fig. 6: Cross-Section View: BrIM and Point Cloud Revealing River Bedrock, Topographic Details, and local X, Y, and Z coordinates of the site

There are several limitations of the data collection approach in the current practices which lack various details of the site. The terrain features such as dense vegetation can be challenging to capture accurately using the total station as well. To address these limitations, modern data collection practices along with Differential Global Positioning Systems (DGPS), Unmanned Arial Vehicles (UAVs), and LiDAR (Light Detection and Ranging) should be integrated depending on the project necessity. For a particular pilot project, the drone was used to verify the data gathered from the Total Station and provide additional topographic information for the bridge site and the results can be seen in Fig. 3, 5, and 6 which show the accurate visualization of topographical information along with X, Y & Z positioning data of given point of the site.

The generation of a point cloud model for the site was accomplished through the application of the photogrammetry process which is discussed further. To capture the necessary data, a DJI Phantom 4 Pro drone was employed which captured the data of area approx. 0.352km^2 and took around 5 hours. To improve the accuracy of the data collected, five ground control points were also used. A total of 641 photographs, each with dimensions of 5472 pixels in width and 3648 pixels in height, were precisely collected, amounting to a substantial dataset of 7.00 gigabytes of photos and 6 gigabytes of videos. The conversion of this dataset into the desired point cloud model took around 4 days which required a high-end PC. Various data such as Orthomosaic, Digital elevation model (DEM), and Contours after post-processing of collected data was extracted.

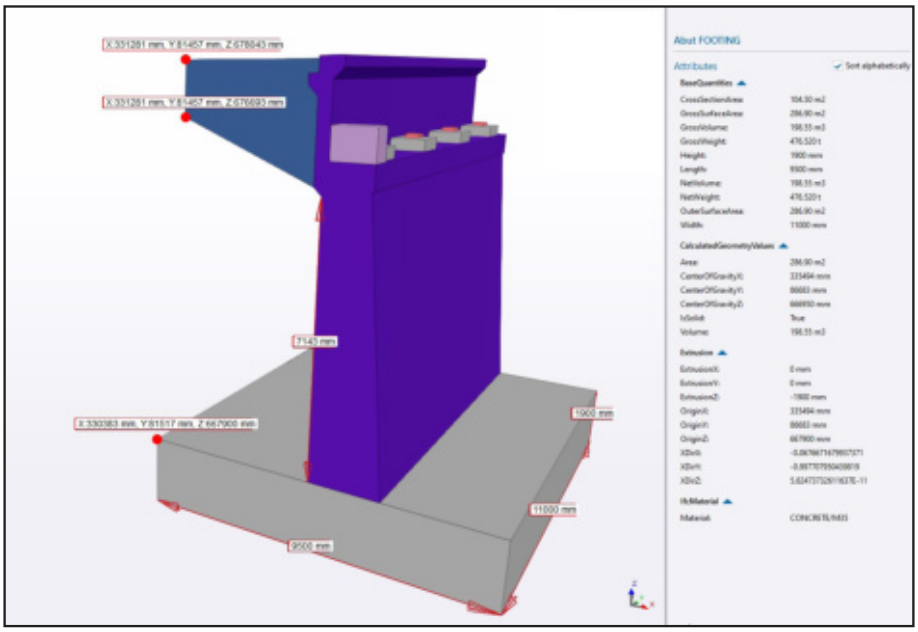

Fig. 7: BrIM model of bridge elements showing Abutment, Wing wall, and Foundation along with various data

The use of the BrIM process in the project enhanced the constructability of the structure by providing additional detailed information about the structure as shown in Fig. 8. The BrIM model not only showed how things look but also had information about the size of every part and the specific material details (Technical Specification) required to build each component of the structure. These details are very valuable to the contractor as they can meticulously plan the resources essential for the project's successful execution. The detailed visualization of each bridge element increased the understanding of the structure and communication among the team members and stakeholders, providing a clear and unified understanding of the project's intricacies. With precise BrIM models, the generation of 2D drawings and cross-sections becomes more efficient and less error-prone. This ensured that the construction team received accurate and easily interpretable drawings, reducing the likelihood of misunderstanding during the construction phase and avoiding costly reworks. These produced BrIM models could also be easily extracted and used for other various application purposes. The BrIM model could also be used by the technicians, supervisors, and site workers as using the BrIM is a relatively easy process.

In this pilot project, the Division Road Office provided the design and documents developed by the bridge consultant to create a BrIM model of the bridge using Tekla Structure. Trimble Connect was used as a common data environment which served as a single point of truth and team members could easily share and access information. A combined effort from three key resources, the BIM Manager, the BIM Engineer, and the Bridge Structural Engineer resulted in a total of 350 hours dedicated to the completion of the project. Their responsibilities included bridge structural modeling, rebar modeling, and the preparation of drawings. Creating the BrIM model for the bridge involved several key steps. Initially, the data provided in the design report are utilized as shown in Fig. 8 to develop the structural model of the bridge. Once this structural model was finalized, the detailing of reinforcement elements were processed as shown in Fig. 2 and 9. This included ensuring the proper placement and specifications of all reinforcing materials. Afterward, the essential task of comprehensive project documentation was untertaken to capture all the necessary information for the projects.

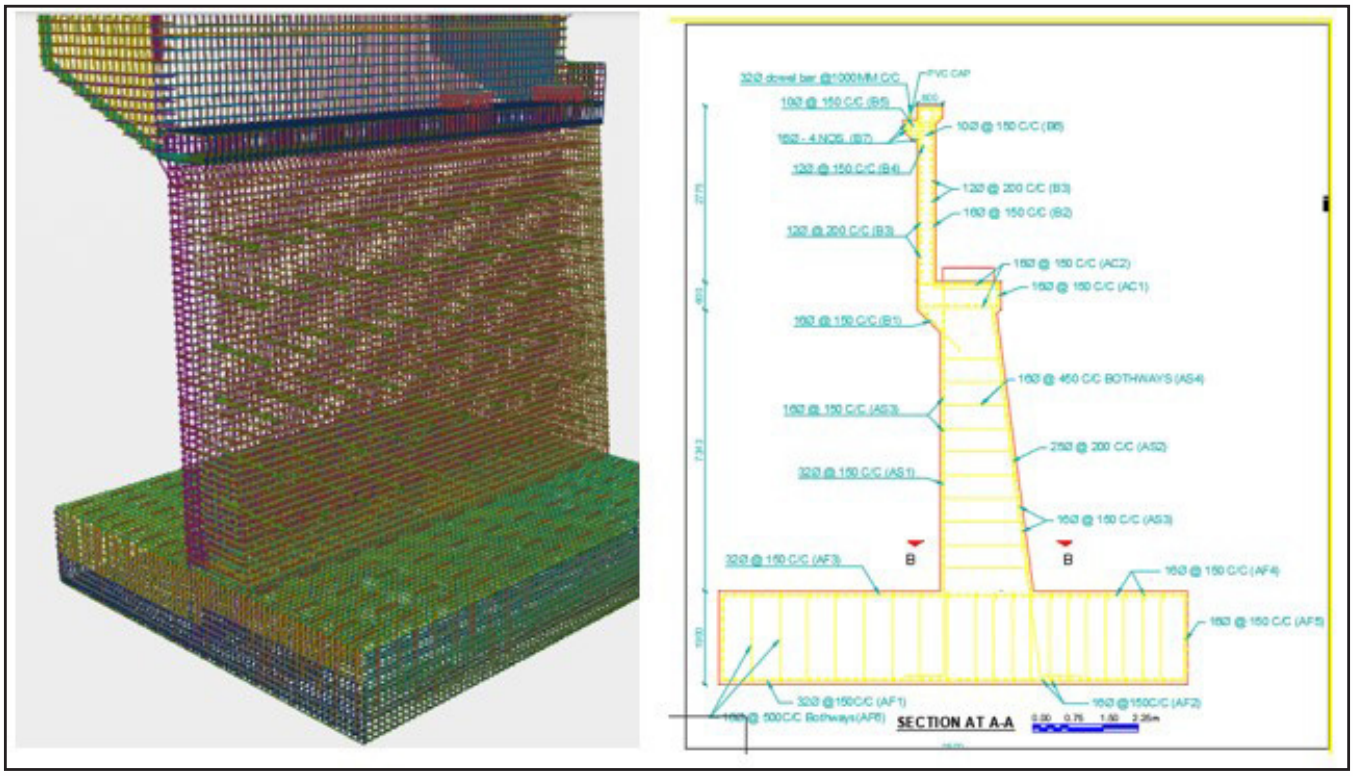

Fig. 8 : Comparing Bridge Reinforcement Modeling to 2D Reinforcement Drawings

The present process of rebar drawings and preparation of rebar schedules as shown in Fig. 12 is very cumbersome which can lead to various errors. It is also very common in the 2D drawing process that the rebars are also left out of the plans accidentally which can impact the quality and accuracy of quantity take-off and rebar schedule. On the contrary, BrIM rebar modeling provides rebar details that not only specify the size, shape, and placement of rebar elements but also account for factors such as openings, reinforcement cover, and development lengths. The rebar model of the structure enables technicians, supervisors, and site workers to visualize the rebar schedule easily. This means on site they can spot the problems with other parts of the structure much earlier which enables them to foresee the problems early on and fix them before the project gets built. This helps to save time, use less material, and spend fewer resources on the construction site.

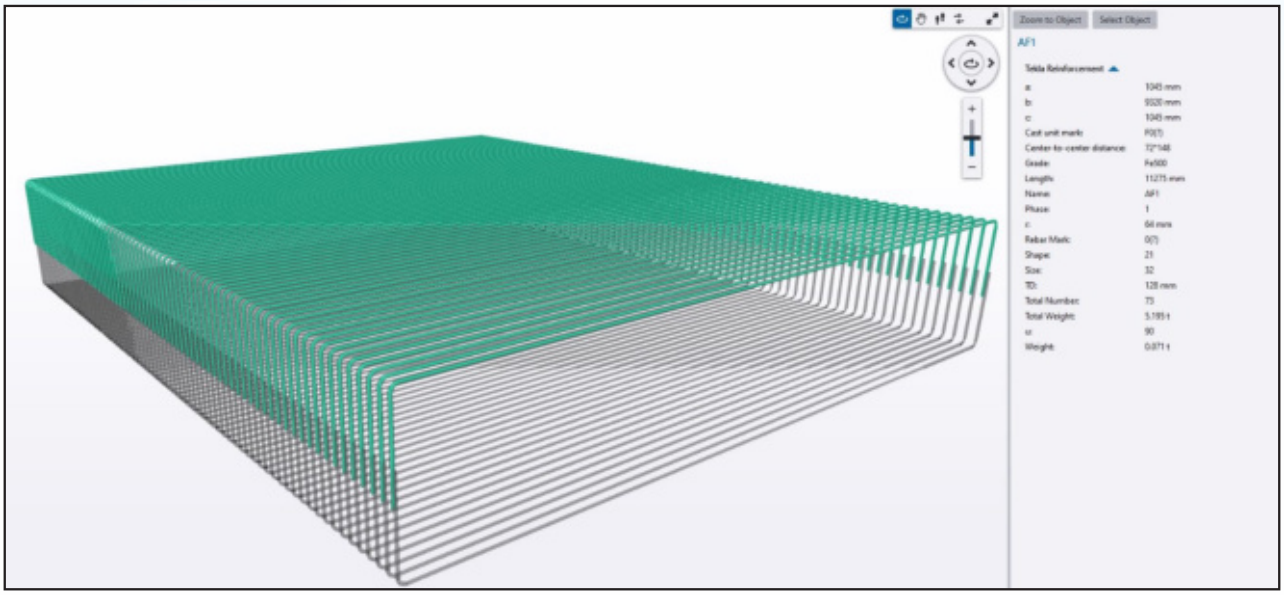

Fig. 9: Rebar Modelling and Schedule of AF1 & AF3 with AF1 technical details

The conventional method for estimating quantities for bridge elements and reinforcement bars shows minor variations in the calculated quantity when compared to the quantity takeoff based on Building Information Modeling (BrIM). Therefore, it is recommended to review the rebar quantity. This is primarily due to the inherent limitations and shortcomings associated with the traditional process of design and documentation. Traditional documentation often lacks intricate details about the structure and its components, including the complex geometries and topographical details associated with it. Subsequently, when estimators calculate the quantity take-offs using these 2D drawings, they make assumptions or interpolate the missing information which increases the likelihood of errors.

C. Conclusion and Discussion

As observed in the pilot project the BrIM process offers several benefits. However, the process faces several implementation issues in the Nepalese context. One of the primary concerns during the pilot project was the high cost of the software and the lack of experts who had enough knowledge of the BrIM process. Even though buying specialized software can be expensive, it's essential to understand that the benefits it brings to a project outweigh the initial costs. This is especially true when it comes to designing and constructing special bridges. As for the pilot project in approx. Rs. 20,000/m was the manpower cost to develop the BrIM model for the project which doesn't include the software cost, drone surveying, and DPR cost of the project.

Studies have consistently shown that construction projects in Nepal often face significant cost variations and delays which could be minimized using the BrIM process. To tackle these challenges effectively, it's a good idea for DoR and DoLI to use an innovative approach in construction design and construction workflow. This includes using

advanced processes and tools like BIM, BrIM, UAVs, LiDAR, and others throughout their project planning and construction phases. These digital technologies can help make projects more precise, improve communication, and reduce costly mistakes and delays.

To make this transition successful, the DoR and DoLI should provide training for their staff, teaching them how to use innovative tools and processes effectively. The Bridge Branch and Quality Research and Development Center of the department should play an active role in conducting the research and developing norms for design and project management utilizing the BrIM process. The department can also collaborate with organizations like the Nepal BIM Forum and BrIM experts, which focuses on bringing digital technology to the Nepalese consulting and construction industry, to get valuable guidance and support.

♦

Longest Motorable Bridge of Nepal

The longest motorable bridge in Nepal is Karnali (Geruwa) Bridge located at Kothiyaghat, Bardiya along the Postal Highway. The total length of the bridge is 1015 m and span arrangement is 18x55m PSC box girder plus 1x25m RC T-girder. The construction of bridge was completed in 2071 BS. The Contract for the construction of this bridge was made under the "Design and Build" contract with total funding from GoN. At that time, both the contract type (Design and Build) and construction technology (pre-stress concrete box girder) was new and less practiced in Nepal.

Karnali (Geruwa) Bridge, Kothiyaghat, Bardiya

Restoration of the Mechi Highway: Building a Modular Bridge to Replace the Washed Hewa Khola Bridge

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-Er. Hari Ram Rimal, Engineer, DoR

A. Introduction

Due to the catastrophic flood of Asar 3, 2080, the Hewa Khola Bridge at 27.151861°N and 87.719383°E in Panchthar District on Mechi highway (NH07) was swept away (Fig. 1). This disrupted the vehicular movement across the highway, leaving thousands of people without any means of travel and cutting off the road network to Taplejung district and a part of Panchthar district, particularly, Hilihang, Falelung, and Yangbarak Rural Municipalities.

Hewa Khola is an intermittent stream with a catchment area of 355.5 sq. km. The flow in this stream is primarily driven by the four monsoon months. During the early monsoon season, specifically on Asar 2 and 3, a flood event led to the transportation of large quantities of debris and floating materials from the upstream. This caused temporary damming at u/s and a sudden outburst, ultimately resulting in the washout of the bridge.

The dire situation required urgent action from the Department of Roads (DOR). In this column, we have discussed how we restored a new modular bridge on the site, after conducting hydrological and hydraulic analysis.

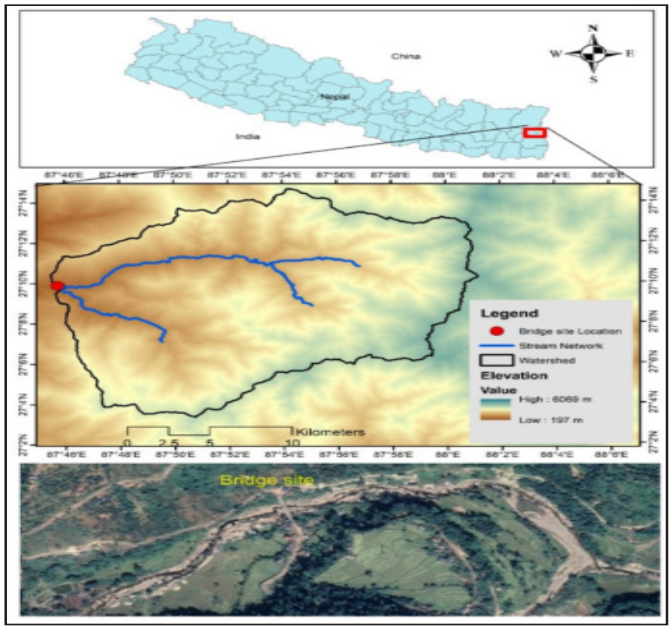

Fig. 1: Location map of Hewa Khola Bridge

B. Hydrological Analysis

For this study, to convert point precipitation to aerial precipitation, the Thiessen polygon method was adopted. Nearby stations of the Department of Hydrology and Meteorology were used. The station locations and the influencing areas can be seen in Fig. 2. The weightage of each station is shown in Table 1.

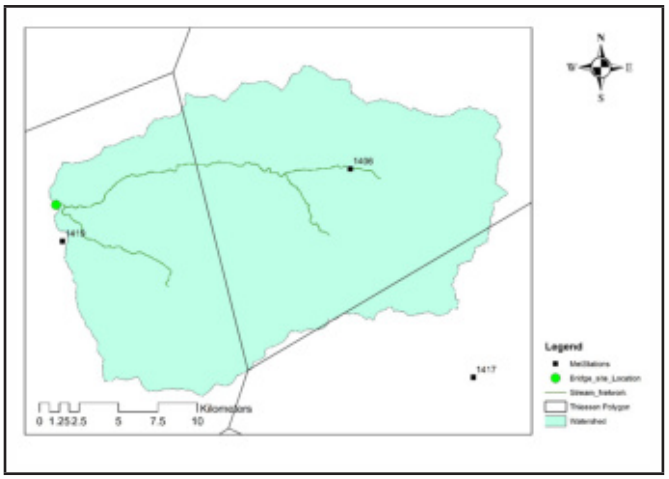

Fig. 2: Thiessen Polygon for Mean Aerial Precipitation Computation

Table 1: Contribution of each rainfall station for the basin

SN	Station Number	Area Contributed	% contribution	Weightage
1	1419	129.167	36.34	0.3634
2	1406	210.739	59.29	0.5929
3	1417	15.559	43.77	0.4377

Using precipitation data from DHM, precipitation of different return periods was computed using various methods. To identify the most suitable method for the given region, the Kolmogorov-Smirnov (KS) test was carried out. The outcomes of the KS test indicated that the Pearson Type III method was the best suited. Considering this, the precipitation of a 100-year return period using Pearson type III distribution was utilized for flood forecasting.

The Intensity Duration Frequency (IDF) curve for

the region was computed using precipitation data for different return periods from the Pearson III distribution. The IDF curve (Fig. 3), along with the computed time of concentration and return periods, was utilized to identify the corresponding rainfall intensity for the computation of peak floods in the location.

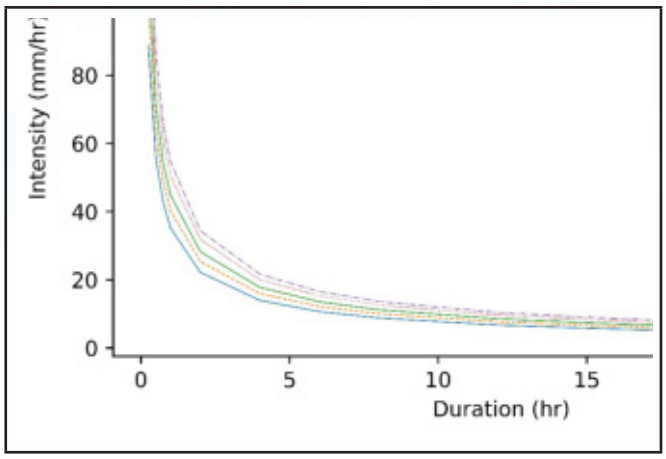

Fig. 3: Intensity Duration Frequency Curve for the Region

Different available methods were adopted for the computation of floods for various return periods. The summary of floods from different methods can be seen in Table 2. The table illustrates that different methods have produced varying flood values for the same return period. Consequently, there is uncertainty regarding flood forecasting in ungauged basins. In this scenario, a method with the highest flood value has been adopted for modular bridge design.

Table 2: Flood forecasting from different methods floods in m^3/s unit

Method/ Return Period	5	10	25	50	100
WECS	420.23	636.55	768.54	950.32	1094.42
Modified Dicken	534.24	664.71	795.17	967.64	1098.11
Rational	735.16	840.09	936.11	1054.73	1139.89
MHSP	749.39		1093.42	1343.20	1548.94

C. Hydraulic modeling

Flood data from the hydrological analysis were used for the hydraulic design of the modular bridge, ensuring that the bridge has sufficient freeboard during similar catastrophic events. The summary report of the hydraulic modeling for the bridge is provided below. Initial longitudinal and cross-sectional data were collected and utilized to conduct the hydraulic modeling of the bridge. Fig. 4 depicts the river flow path, bank lines, and cross sections used for the study.

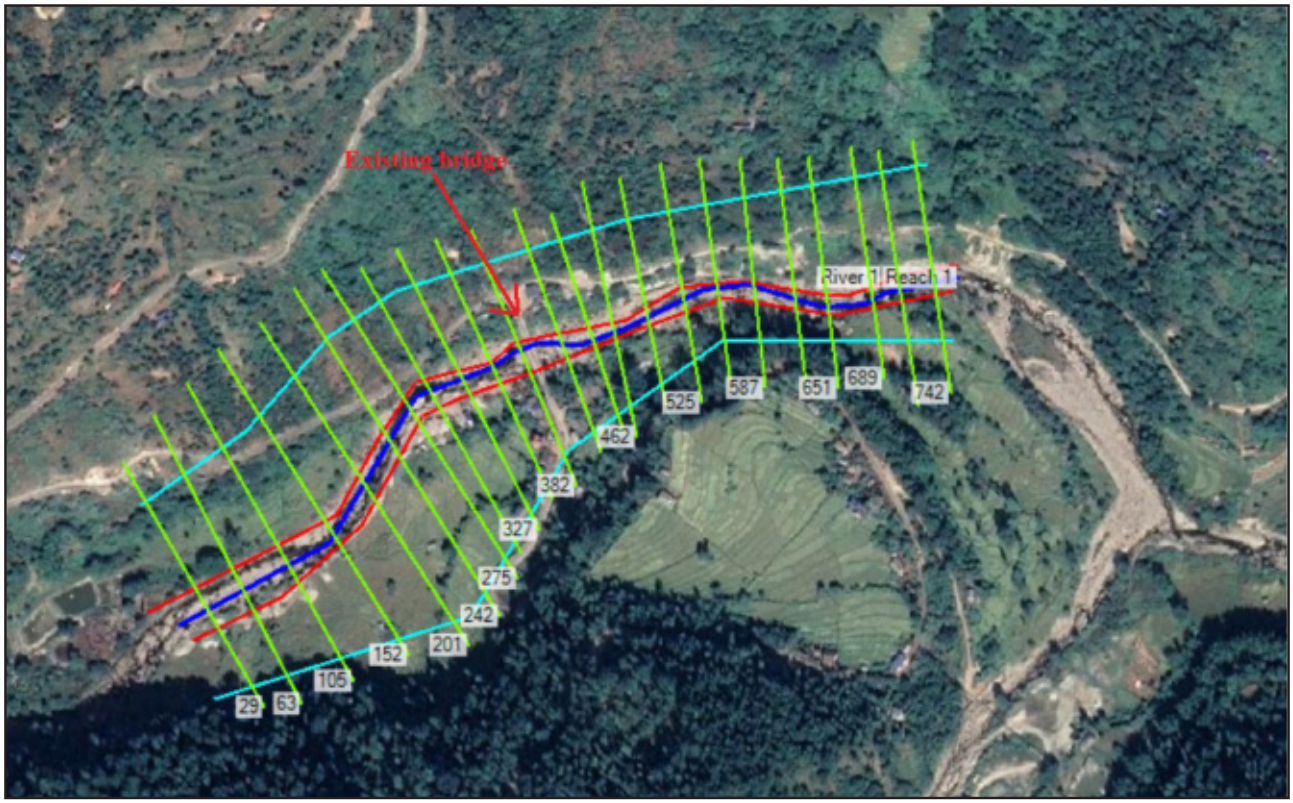

Fig. 4: River section used for 1D flow modeling of the bridge.

To ensure an adequate freeboard, 100-year return period flood was applied to the model, and computations were conducted [1]. A depth of 7.45 meters from the soffit level was observed for the 100-year return period in the model. Fig. 5 displays the cross-section and longitudinal section of the bridge, along with the water surface profile.

Taking care of the unusual recent flood, 2mt. freeboard was kept.

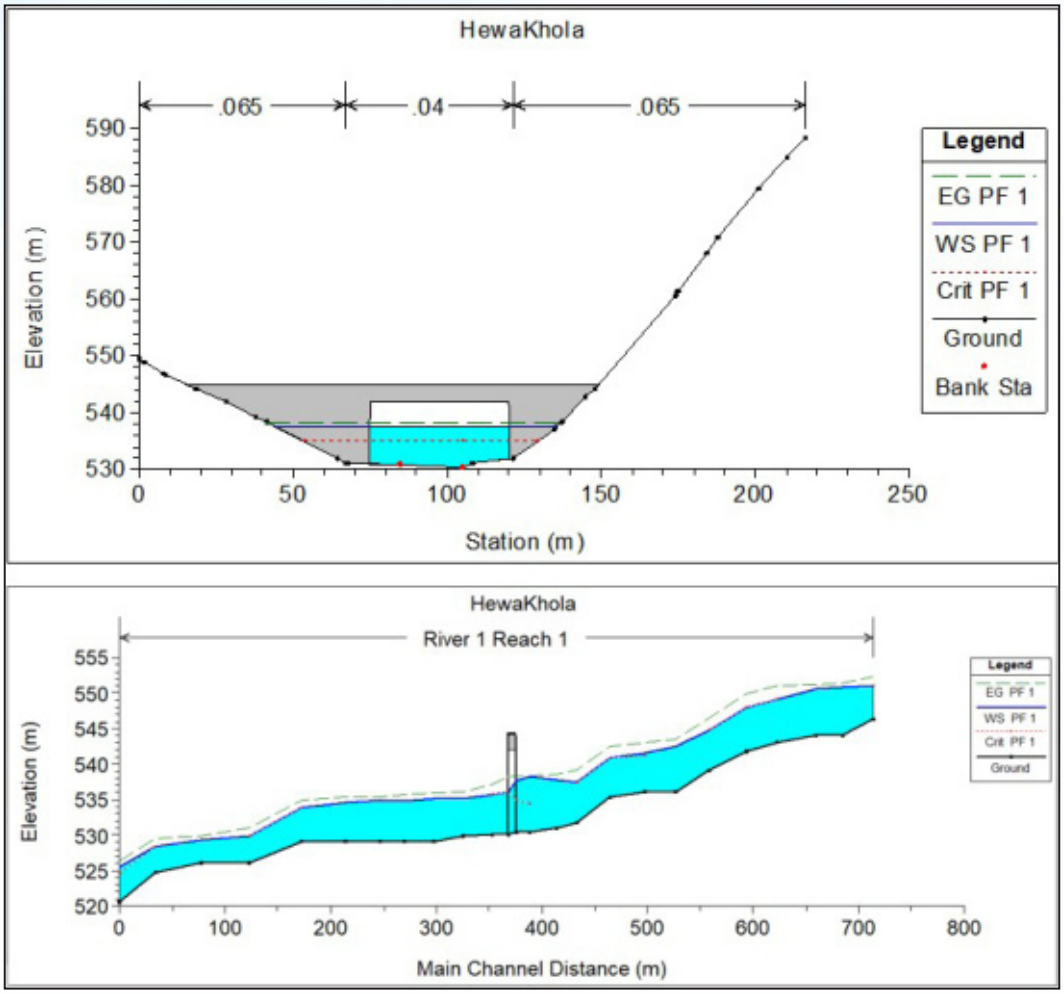

Fig. 5: Cross section and profile of 1D hydraulic modeling for modular bridge.

D. Selection of Abutment Structure and Size

For such type of emergency, time is the most essential thing. The use of plum concrete with temperature bar, Gabion only and Gabion cum RCC are the options for the abutment structure. The plum concrete with temperature bar requires some setting and hardening time and overall abutment construction time would elongate. The use of gabion only is faster in construction but due to its flexible nature, it might be susceptible to differential and total settlement. The previous study shows the use of RCC slab in Gabion wall, performs better for reducing wall top movement, and differential, and total settlement. DOR radially practices the use of Gabion cum RCC slab for abutment of bailey bridges. The time required for construction is also reduced due to the use of the Gabion structure. Hence, we have selected the Gabion cum RCC structure for abutment construction.

E. Construction Sequences

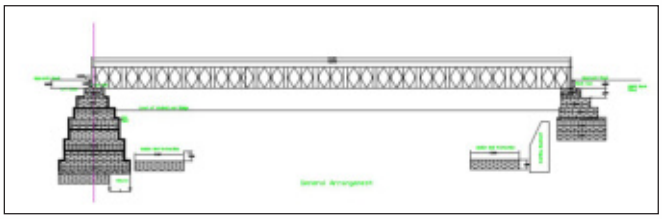

Fig. 6: General Arragement Drawing of Bridge

Soon after the catastrophic flood event, a site visit was done by the DOR Ilam team. The old bridge was completely washed away with left abutment. The

modular bridge was constructed with Gabion cum orginal RCC abutments on the left and right banks respectively. Design and prevailing construction practices provide an RCC slab band after every two layers of gabion wall, which is much more beneficiary for controlling differential and overall settlement of abutment. The provision of 12 mm dia. re-bar in a grid of 0.5m x 0.5m, which has a grip length of 15 cm in the lower and upper gabion layer controls the horizontal sliding between each slab-gabion interface. At least 10 hours was given for the final setting of the slab band before placing another gabion layer. The overall construction sequence was managed in such a way that everyday work was started with the gabion wall. During the process, the modular bridge assembling work and construction of the right abutment were parallelly done.

Launching operation of the modular bridge requires a horizontal embankment platform in the level of abutment cap of around 6m x 40m at the left bank. The overall construction sequences are shown in Table 3.

Table 3: Construction sequences for the various tasks performed in the field

S. No.	Construction Sequences	Time in days	Summary of activities and duration	Event no
1	Excavation of Foundation for left abutment and construction of gabion leveling course	1.5	Construction of left abutment (A) = 8 days	1-2
2	Re-Bar preparation and RCC work for base slab	1		
3	Construction of two layers of gabion and one RCC slab band	1.5		
4	Construction of the next two layers of gabion and one RCC slab band	1		
5	Construction of the next two layers of gabion and one RCC slab band	1		
6	Construction of top layer gabion, re-bar preparation, and RCC work for left abutment cap	2		
7	Backfilling work behind left abutment and approach road in cap level to make platform for assembling operation	2	Backfilling behind left abutment (B) = 2 days	2-3
8	Assembling and positioning of modular bridge	7	Assembling and positioning of the modular bridge (C) = 7 days	3-5
9	Excavation of foundation for right abutment and construction of two layers of gabion wall	2	Construction of right abutment (D) = 6 days	3-4
10	Re-Bar preparation and RCC work for base slab	1.5		
11	Construction of two layers of gabion, re-bar preparation, and RCC work for the right abutment cap	2.5		
12	Rebar preparation and RCC work for both back walls	1	Construction of back walls (E) = 1 day	5-6
13	River training work on the left abutment	5	Construction of left abutment wing wall (F) = 5 days	6-7
14	Construction of left approach	5	Construction of left approach (G) = 5 days	7-9
15	River training work on the right abutment	4	River training work on right abutment (H) = 4 days	6-8
16	Construction of the right approach	4	Construction of right approach (I)= 4 days	8-9

Event 1 = start of work, Event 9 = opening of traffic

Total days for traffic opening = 28 days

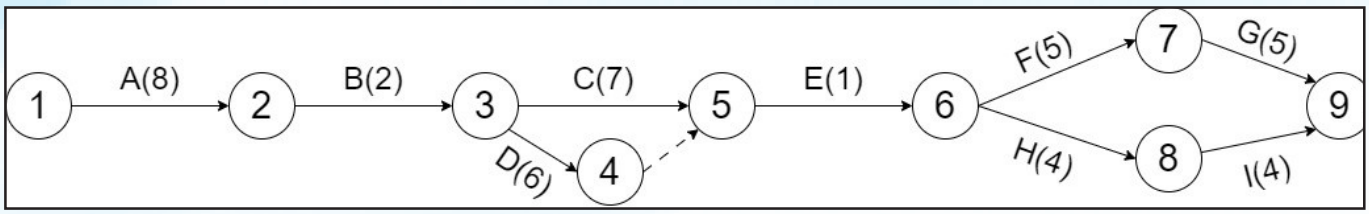

Fig. 7: CPM Network for scheduled project activities.

From the CPM Network (Fig. 7), the critical path is 1-2-3-5-6-7-9 and has the longest duration of 28 days.

Salient Features of the Installed Modular Bridge:

Total Length of the bridge = 48.80m

Width of the carriageway = 4.2 m

Area of left abutment footing = 8.0m x 7.0m

Area of right abutment footing = 8.0m x 5.0m

Number of span = 1

Raise of height above previous road level (hydrological requirement) = 2.8 m

Type of abutment structure = Gabion cum RCC

Capacity of the bridge (permissible) = 25 Ton (One vehicle at a time)

The construction photographs are shown in Fig.8.

Fig. 8: Some pictures of the bridge site are included, showing the site before the damage, after it was damaged, and during the installation of the modular bridge.

F. Conclusion:

Past experiences have shown that even modular bridges are not immune to flooding events. Therefore, hydrological and hydraulic analyses are essential prior to the installation of such structures. After conducting hydrological and hydraulic analyses, the modular bridge was successfully installed at the site, restoring vehicular movement and ensuring safe passage for the Northern region of the site.

Reference:

[1] Shakya, N. M. Guidelines on Hydrological and Hydraulic Analysis and River Training Works for Bridge Design. Government of Nepal, Ministry of Physical Infrastructure and Transport, DOR.

SOME FACTS ABOUT EAST-WEST HIGHWAY THAT YOU MAY NOT KNOW!!!

- Makawanpur and Arghakhanchi are the two hilly districts that are connected by the East-West Highway.
- Parsa is the only terai district of Nepal that is not connected by the East-West Highway.
- The foundation stone of the East-West Highway was laid at Gaindakot, Nawalparasi in 1 Baishakh 2019 by King Mahendra.

Historical Background of the Road Development in Nepal

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The development of roads has played a pivotal role in human civilization by enabling trade, transportation, and communication. The demand for durable surfaces arose with the advent of the wheel, facilitating the movement of people, animals, military forces, and goods. The initiation of large-scale road construction is believed to trace back to the Roman periods. After the Roman Roads, notable techniques in road construction include Tresaguet, Metcalf, Telford, Asian, Medieval, Macadam, Asphalt, and contemporary modern techniques.

The construction of hard surfaces for the movement of people and goods in Nepal began in ancient times, leveraging locally available knowledge, skills, and resources. Historical evidence indicates that road construction in the nation commenced only after the 1930's AD (1980-90 BS), during the Rana regime. The first motor car, a 1938 model Mercedes Benz arrived in the capital city around 1940 AD (1998 BS), transported by a group of approximately 64 people shown in Figure 1.

Fig. 1: People carrying the first vehicle (1938 model Mercedes Benz car) to Kathmandu Valley (around 1940 AD)

The initial road construction took place within the Kathmandu Valley, and the first road outside the capital city was the Amlekhgang-Bhimphedi road spanning 42 km. By the end of the Rana regime in 1950 AD (2007 BS), total road length in the country reached 376 km, categorized as 5 km blacktop (BT), 83 km gravel road (GR), and 288 km earthen road (ER) [1]. Earthen Track connecting the Singhadurbar, Bhadrakali Temple and Shahid Gate during 1950 AD shown in Figure 2. The first significant road, Kathmandu Bhaise (also known as Trivuwan Rajpath, TRP), was completed in 1953 AD (2010 BS), connecting Kathmandu to India at the South Border (Sirsiya, Birgunj). During the Rana Period, the public institutions "Bato Kaj Goshwara" and "Chhambhadel Adda" undertook responsibility for constructing and maintaining roads within the capital city, overseeing the construction of a total of 376 km of roads. Towards the end of the Rana era, these entities underwent a division into "Nayabato Kaj Goshwara" and "Puranobato Kaj Goshwara," tasked with constructing new roads and maintaining existing ones, respectively.

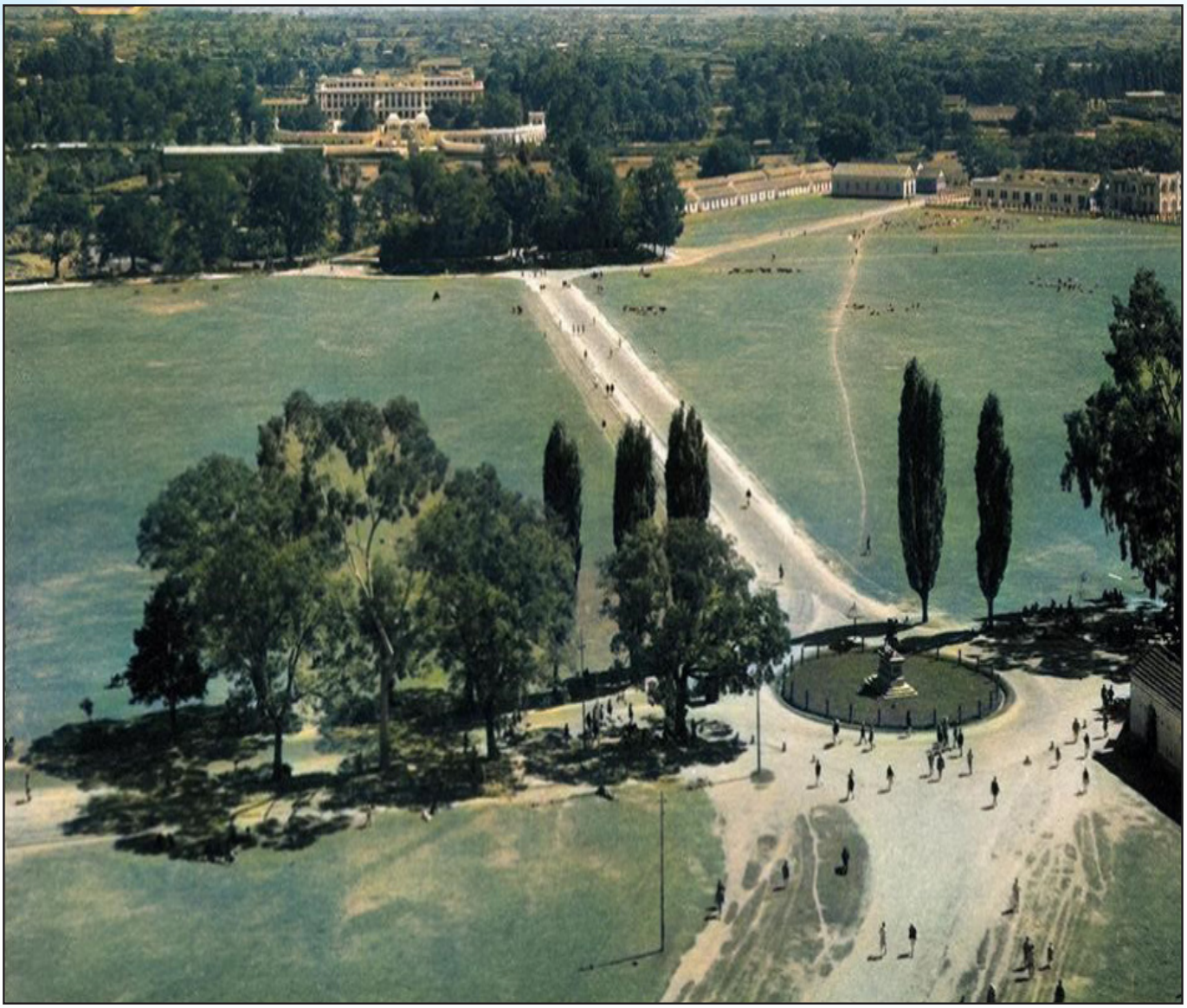

Figure 2: Earthen Track connecting the Singhadurbar, Bhadrakali Temple and Shahid Gate during 1950 AD.

A notice published on April 7, 1952 AD (26th Chaitra 2008 BS) in the Nepal Gazette by the Department of Transport and Communication (Yatayat Tatha Sanchar Bibhag) serves as evidence of the built roads intended to facilitate public transportation in Kathmandu, Lalitpur, Bhaktapur, and extending up to Banepa, Kavrepalanchowk [2]. Following the establishment of democracy in 1950 AD (2007 BS), these institutions underwent a merger and were renamed the Public Works Department (PWD), tasked with executing civil works. PWD comprised two divisions: the Road Division, responsible for road construction and maintenance, and the Building Division, handling building-related projects.

The army unit "Samarjung" was established to carry out routine maintenance under "Purano Bato Kaj Goshwara." In 1954 AD (2011 BS), the "Bagmati Valley Road Project" was instituted, during which the Royal Nepal Army conducted a detailed survey. By 1960 AD (2017 BS), the Rajdal Army Battalion had completed the construction of 70 km out of the planned 91 km Kanti Rajpath [3].

The Royal Nepal Army initiated the survey and construction of the Kanti Rajpath in 1954 AD, but due to insufficient resources, the project had to be abandoned. Similarly, the construction of an all-weather gravel road connecting Hetauda and Narayanghat commenced in 1956 AD (2013 BS) and was completed around 1959 AD. In 1956 AD (2013 BS), the Development Committee Act (Bikash Samiti Ain 2013) was enacted, leading to the establishment of a separate organization called the Road Transport Organization (RTO) in 1958

AD (2014 BS). The RTO was tasked with policy decisions, land acquisition, resource management, and road construction activities [4] [5].

The Public Works Department (PWD) underwent reform, and the Road Division was further divided into three Sub-Divisions: Construction, Planning, and Maintenance, each overseen by a distinct Chief Engineer. Mr. Gyan Prasad Sharma, Mr. Birendra Bahadur Karki, and Mr. Birendra Keshari Pokharel served as Chief Engineers for Planning, Construction, and Maintenance, respectively. Technical consultants were also appointed to enhance road transport capacity which included Mr. F. J. Chaudeley (CTA), Mr. Sorber (Design), Mr. Glaister (Planning), Mr. Zegnate (Maintenance), and Mr. Bell (Mechanical). The exact date of the DoR's establishment remains unconfirmed and some evidence suggests it occurred before Magh, 2017 BS [6]. During this period, the First Five Year Plan (FFYP, 2013/14 – 2017/18 BS) was nearing completion. Subsequently, the Road Transport Organization (RTO) was dissolved in 1962 AD (2018 BS) because of the various constraints [7].

King Mahendra laid the foundation stone of the East West Highway, also known as the Mahendra Highway, on the 1st of Baishakh 2019 BS (April 13, 1962). It took approximately four decades to blacktop the entire length of 1028 km. In the same year, the construction of the Kathmandu Kodari Highway commenced and completed its track opening during the Second Three Year Periodic Plan Period (2019 – 2022 BS), connecting the landlocked country to its northern border at Miteripul, Kodari. Initially, the Kathmandu Kodari Highway was named Mahendra Highway, but it was later renamed as Arniko Highway [1]. Similarly, the earthen track of Prithvi Highway (Naubise Mugling Pokhara Highway) was completed during the Third Three Year Periodic Plan (2023 -2026 BS) [7]. The Fourth Five Year Periodic Plan (2027- 2032 BS) witnessed significant progress in both road construction and the strengthening of the department's institutional capacity. During this period, roads were classified as Highway (Rajmarg), Arterial Road (Mukhya Marga), and Regional Road (Kshetriya Marg) [8]. The issuance of the first Nepal Road Standards in 2027 BS aimed at standardizing road alignment and cross-section elements.

Figure 3: Mahendra Highway Inauguration Pillar (2019-01-01 BS)

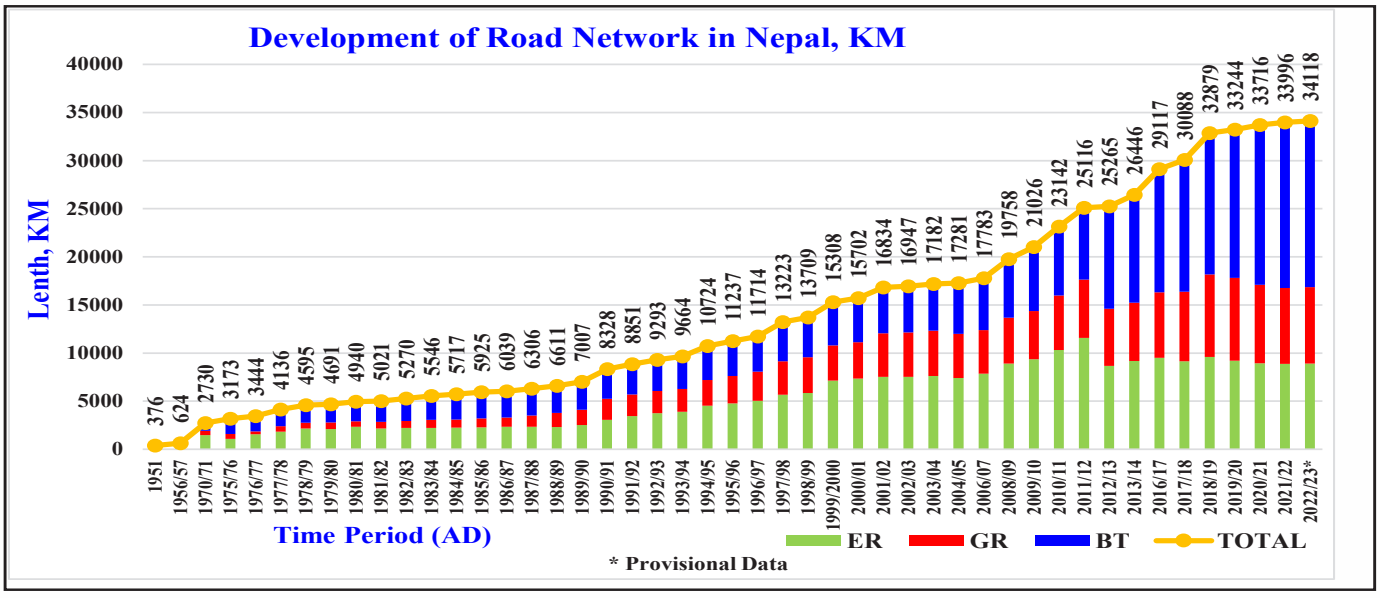

Figure 4: Development of the Road Network in Nepal [under DoR only]

The development of road length over time is presented in the Figure 4. The road network experienced a rapid development after the reestablishment of democracy in 2047 BS (1991 AD), with the exception of a slowdown during the insurgency period (2001-2004 AD). This could be attributed to an increase in the number of involved agencies, and still there remains a possibility of potential underreporting of the data. It is believed that the total road length in Kilometers has currently surpassed six digits figure. Simultaneously, concerted efforts have been made to enhance both organizational and institutional capacity within the same timeframe. Significant milestones during the Fourth Five Year Periodic Plan include the issuance of the Nepal Road Standard 2027, the enactment of the Public Road Act 2031, and the classification of roads as Highway (Rajmarg), Arterial Road (Mukhya Marga), and Regional Road (Kshetriya Marg) etc.

During the Fifth Five Year Periodic Plan (2032–2037 BS), roads underwent classification into distinct categories. These included Highways, serving as vital national routes connecting the east-west and north-south regions; Feeder Roads, connecting Zonal and District Headquarters, primary commercial areas, as well as religious and touristic sites to Highways; Main Urban Roads, encompassing routes within the Kathmandu Valley, Regional and Zonal Headquarters, and District Headquarters; and Local Roads, covering the remaining road network. The emphasis on the road construction process was particularly evident in the categorization of the North-South Highway and Mid-Hill Highway. Key segments of North-South Highway were Mahendra Highway connecting Surkhet, also known as Ratna Rajmarg, Dhangadi-Dadeldhura Road, and the Dharan-Dhankuta Road. Additionally, focus extended to the Mid-Hill East-West Highway, with specific attention given to routes like Pokhara–Surkhet Road and Kathmandu–Dhankuta Road [9] [10].

Later Roads Board Nepal (RBN), an autonomous body, was founded in 2002 AD under the Roads Board Act enacted on 2002 AD (2059-03-24 BS). Its primary objectives include ensuring safe, reliable, comfortable, and cost-effective road services, as well as generating funds for the repair and maintenance of roads. Meanwhile, numerous policies were formulated to attain the connectivity targets set by the Government of Nepal, such as the National Transport Policy (2001 AD), Nepal 20 Year Road Plan (2001 AD), Sector Wide Road Program and Priority Investment Plan (1997 and 2007 AD), DoR Strategy (1995 AD), Environment and Social Management Framework (2007 AD) etc.

The insurgency period had a significant impact on the development process, including the growth of transport infrastructure, leading to a slowdown in progress. However, following the establishment of peace, there was a notable resurgence in the road development process, marked by a substantial and rapid increase in momentum. The initiation of strategically and economically significant highways marked a pivotal moment in Nepal's transportation development. The Pushpalal (Mid-Hill) Highway, spanning approximately 1879 km, commenced in the fiscal year 2064/65 BS. Subsequently, the construction of the Postal Highway, covering an estimated 975 km, began in 2071/72 BS. Another noteworthy project was the Madan Bhandari Highway, spanning about 1250 km, which commenced on 2075-02-06 BS. These initiatives reflected a dedicated commitment to improving connectivity and promoting economic growth through the expansion of the national highway network. Similarly, in 2064 BS, the government of Nepal prioritized the Koshi Highway; 162 km stretch from Khandbari to Kimathanka, 435 km Kaligandaki Corridor spanning Gaidakot - Maldhunga - Korolla and about 290 km the Karnali Corridor, from Khulalu to Simikot to Hilsa. Notably, these projects were accorded special significance by being enlisted as national pride projects, with the exception of the Madan Bhandari Highway, which received this status in 2066 BS onwards. This underscored the government's determination to elevate these infrastructural developments to national priority status [11] [12] [13] [14] [15].

As of the approved organizational structure in the year 2000 AD (2058 BS) under the Department of Roads (DoR), there were five regional road directorates, twenty-five divisional road offices, six heavy equipment divisions, eleven mechanical offices, one central laboratory, and one mechanical training center. Additionally, various road projects were being implemented in accordance with requirements, with a total of 2,611 employees under its jurisdiction. As of December

29, 2021 (2078-09-14 BS), the Government of Nepal approved a new organizational structure, including four Federal Road Supervision and Monitoring Offices (FRSMO), thirty-three Road Divisions (RD), nine Heavy Equipment Divisions (HED), eight Mechanical Offices (MO), one Quality Research and Development Center (QRDC), one Mechanical Training Center (MTC), and a Project Implementation Unit (PIU). Consequently, the total number of employees within the organizations currently stands at 2,505 [16].

Following the implementation of federalism, there have been changes in the department's scope of work. Previously, the department was responsible for managing both national highways and feeder roads, collectively referred to as the strategic road network (SRN). According to Schedule 5 (20) of the Constitution of Nepal 2072 BS, the management of federal highways now falls under the sole authority of the federal government. Additionally, based on the decision of the Nepal Government (Council of Ministers) dated May 20, 2019 (2076-02-06 BS), a list of 80 national highways has been identified, and a decision has been made to limit the department's main responsibility to the construction, maintenance, expansion, upgrading, and repair of these national highways, totaling 14,913 km in length. The DoR is now primarily focuses on the construction, improvement, expansion, upgrading, and maintenance of those 80 national highways.

Major Achievement in the Road Construction (within DoR)

Districts connected by the SRN	:	76 districts (excluding Humla, connected from the China border)
Districts connected by the blacktopped roads	:	73 districts (Except Manang, Mustang, Humla and Dolpa)
Total length of roads in the national highways	:	14,913 Km
Length of blacktopped Highways	:	7,000 kilometers.
Length of the Multilane Highways (>2 lane)	:	200 km completed (500 km Ongoing)
Roads under regular maintenance (SRN)	:	7,872 km
Total Strategic Network managed (SRN)	:	18,164 km [17]

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Emergency Public Procurement Management (Goods , Service & Works)

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1. Defining Emergency Procurement

An 'emergency' is a sudden unforseen event. It can result in injury, loss of life or critical damage to property or infrastructure. Emergency situations can include:

- natural or manmade disasters: such as earthquakes, cyclones, flooding, fires or contamination
- failures of critical infrastructure or equipment: such as failure of a prison security system or critical hospital infrastructure
- critical health or environmental emergencies: such as a pandemic or food safety incident
- unanticipated events that make it impossible for an Public Entity to perform a statutory or critical function in the necessary timeframe: for example the destruction of critical election supplies immediately prior to an election would be an emergency for the Electoral Commission

In a emergency, Public Entities will need to be flexible in how they procure the goods and services or works that are required for their response. Public Entities are permitted to forgo routine procurement procedures. In adopting a more flexible procurement process Public Entities should consider what is reasonable and justifiable given all of the facts and circumstances they have to handle. Public Entities are permitted to purchase directly from a supplier if delay is involved in conducting a routine procurement (i.e. which involves open bidding and competitive tendering) will prevent them delivering the goods or services or works in time to bring effective relief.

Public Entities are to balance the need to act without delay (for example to save or preserve life, or safeguard buildings or repair critical infrastructure) against meeting their overarching public sector obligations (act lawfully, reasonably and with integrity).

Urgent situations that are created by a Public Entity through a lack of planning or risk mitigation do not constitute an emergency. Public Entities should consider contingency planning where appropriate to allow for the provision of goods and services or works if an emergency, supply shortage or other unforeseen event arises. The level of forward planning should reflect the strategic importance of the good or service or works, the risk of an emergency and the cost of any contingency measures. The approach taken by the Public Entity should be balanced, practical and fiscally responsible and may be part of their wider risk management strategy.

2. Key Considerations

The following key considerations may help your Public Entity respond in an emergency:

- clarify that the situation meets the criteria for treatment as an 'emergency' and that a flexible approach to procurement can be fully justified
- identify, specify and prioritise the immediate procurement activities that will bring relief
- consider the operating environment and conditions 'on the ground'
- find out what other government Public Entities and NGOs are doing and, where possible, collaborate
- consider the duty of care to suppliers or contractor and take appropriate measures to ensure their safety.

3. Legal Provisions in Nepal

Public Procurement Act 2063, Clause 66 has provision concerning procurement to be made in special circumstances, where the occurrence of special circumstance has created a situation in which, if a procurement is not made immediately, the public entity will sustain further loss, the Public Entity may procure or cause to be procured immediately. The chief of the Public Entity shall have to give information of the circumstances

and the detailed description concerning the procurement to be made immediately to one level higher authority.

Public Procurement Regulation 2064, Rule 145 has provision, where a Public Entity shall, in making a procurement pursuant to Section 66 of the Act, have to prepare written details of the procurement requirements, quality, quantity, conditions and period of completion of work and shall procure only the quantity and for the period required to face the contingent circumstances by having a competition made so far as practicable or by concluding negotiations for fair and proper price after receiving written quotation or proposal from a single construction entrepreneur, supplier, consultant or service provider, as the case may be.

4. Maintaining Accountability

- once the situation has been stabilised and there is no immediate risk to human life, the environment or critical infrastructure, consider establishing a governance and management structure to coordinate and authorise necessary procurement activities
- in emergencies there is a higher risk inflated prices ,fraud, bribery and corruption may also be a concern. Be aware of these possibilities and take action to guard against them
- be aware of the possibility of conflicts of interest and manage them appropriately
- document the emergency procurements during or as soon as possible after the event
- clearly state in the records that the purchase was an emergency procurement and record the facts and circumstances justifying this approach.
- whatever procurement process has been adopted it is still subject to audit

5. Ensuring Procurement Principles Value for money

Value for money involves a balanced judgment of financial and non-financial factors and takes into account the total cost of procurement from initiation to end of contract or disposal. Further guidance can be found in the Achieving value for money – Goods and services or works procurement guide.

Value for money may be more challenging to determine in a response to an emergency. There may be:

» urgency that requires streamlining invitation, offer and evaluation processes

» increased risks (for example risk to fitness for purpose, quantities, timeliness, probity, due diligence, contractual terms, waste)

» significant changes in demand (for example performance, quantities, delivery timings or locations)

» significant market disruptions (for example raw materials and production, transport and distribution, new goods or services, start-ups or pivoting suppliers)

» unfamiliar goods and services, and their markets, with limited time for buyers to conduct market analysis and due diligence

» a lack of standards or testing available for new goods and services

When determining value for money in an emergency response, urgency places a heightened emphasis on timeliness and reliability of delivery relative to the value of other factors. This is not a reduction in value for money, but rather a rebalancing of factors – urgent and reliable supply has value too.

Accountability

Accountable Officers remain accountable for their Public Entity's procurement decisions during an emergency. The Public Entity should consider if its existing accountability framework meets its needs in an emergency or if changes to accountabilities and governance structures are required. For accountability to be effective, the plan needs to be clear about who is authorised to make what decisions and in what circumstances. When decisions are made, record who made the decisions, state the decisions, and why.

Public Entities should consider how procurement support will be provided and governed during an emergency. This will be influenced by how the Public Entity commands its response. For example, will the Public Entity response be centralised or decentralised?

The emergency procurement plan should identify responsible officers and applicable reporting and communication lines. It should also determine appropriate levels of financial, sourcing and contract approvals delegations for responsible officers.

Probity

When doing urgent procurement there is an increased risk in relation to maintaining integrity, non-corruptibility, and impartiality of procurement decisions. Normal probity considerations apply, with a heightened emphasis on managing conflicts of interest to mitigate this risk.

The urgency of a procurement in an emergency may preclude competitive market approaches or restrict competition. Consequently, some suppliers may perceive that the market was not given fair opportunity. Recording the basis for procurement decisions is important to address such concerns.

Scalability

Scalability is about adapting the procurement processes to the risk, complexity, and urgency of a procurement. In routine procurement, processes can be simplified for procurement activities of low risk and complexity or accelerated to respond to urgent business needs. In response to an emergency, scalability can be used to abbreviate processes for procurement activities of higher risk and complexity to achieve the necessary urgency.

Consider which processes in the procurement lifecycle can be abbreviated and detail how they will be applied in the emergency procurement plan.

6. Manage procurement risk

» An increase in procurement risk should only be considered if it reduces risk to life, property, environment, and services.

» Identify and manage risk to information asset security since any vulnerabilities arising in an emergency could be exploited, and vulnerabilities may continue beyond the emergency event.

» Reduce risk in emergency procurement activities while increasing speed by:

» leveraging existing contracts

» dealing with proven suppliers

» referring to the Public Entity's past market research and evaluations

» collaborating across Public Entities to gain information about the market, particular suppliers or unfamiliar goods or services or works.

» Plan to purchase from the Public Entity's existing contracts wherever possible. If contracts are due to expire during the urgent response stage, the Public Entity may consider extending them until both the Public Entity and prospective suppliers are able to undertake a routine procurement process.

» The emergency procurement plan should give guidance on how to identify and manage procurement risk in emergencies.

» Where unfamiliar emergency needs are common across several Public Entities, expertise in one or more Public Entities could be utilised or developed to provide a whole of government response.

7. Prepare for Foreseeable types of Emergencies

» Prior preparation prevents poor performance: analyse the Public Entity's emergency response and business continuity plans and prepare to provide procurement support accordingly.

» The emergency procurement plan should include the procurement support needed for foreseeable emergencies. Preparation should be proportionate to the risk of foreseeable emergencies.

» Prepare for procurement support activities prior to an emergency event by:

- considering likely activities in category planning
- conducting market analysis and preparing the market approach for new goods and services that may be needed
- varying relevant existing contracts to ensure they can be leveraged in an emergency
- establishing new contracts specifically for emergencies

» Response to previous emergencies could identify some urgent goods and services likely to be needed in similar emergencies in the future.

» Conduct a complexity and capability assessment in preparation for likely procurement support activities to be undertaken during an emergency. The urgency of these procurement activities is likely to increase risk and may require more capability than they would as routine procurement. If more capability may be needed, this should be reflected in the Public Entity's capability development plan.

» Communicate the emergency procurement plan to those who need to know before an emergency so that they can prepare, which may include some suppliers.

» In the event of an unforeseen emergency or impact, it is likely that the preparation for foreseeable situations will be of use, with or without modifications.

In Department of Roads,Nepal, Annual Integrated Emergency plan is prepared for deployment of emergency equipment with possible locations for each highway to overcome the emergency situation caused by flood and landslide.

8. Types of Emergencies Public Procurement

Emergency responsiveness can be viewed at three different levels with regard to the immediacy of the threat or danger and the degree of harm if relief is delayed.

- Level 1 – Immediate response: reactive procurement
- Level 2 – Disaster relief: emergency procurement
- Level 3 – Post-disaster reconstruction: accelerated procurement

Level 1 - Immediate reaction phase

When an emergency occurs, lives, property, environment, and services are at risk, and people may get stressed, even panicked. In emergency procedures, immediate reaction, such as evacuation from a building to a designated assembly area, is a drill – everyone knows what to do immediately, both individually and collectively. Similarly, the procurement response should allow immediate reaction within predetermined constraints as necessary.

At this point in an emergency, procurement activity is reactive, and likely to be of limited scale. Procurement activities need to follow an urgent, reasonable and defensible procurement process.

Level 2 – Disaster relief: emergency procurement

The urgent response phase commences once the impact of the emergency is assessed. An Public Entity will determine how to direct and control its emergency response and when to activate its business continuity plan. The procurement response becomes less reactive and progressively more controlled.

Procurement risk in this phase is amplified due to the urgency, and increased scale and complexity of procurement. Control of procurement in this stage is critical to timely and effective procurement support, whether the Public Entity's procurement function is centralised or decentralised.

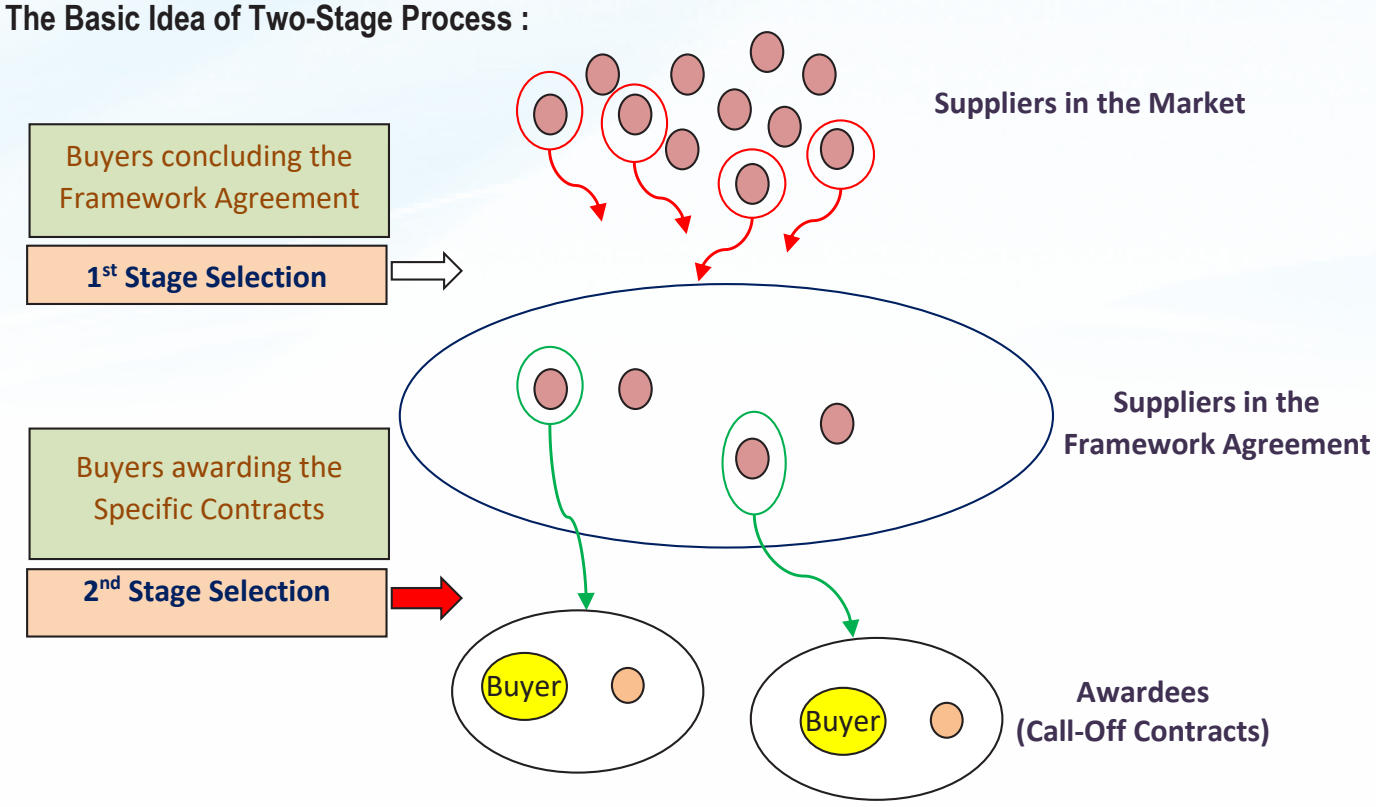
Consider how the emergency event may affect the operating environment. There may be a need to collaborate with other government Public Entities, non-government Public Entities, and local communities. For example, when arranging delivery of goods and services the Public Entity, the response should not compete with affected communities for limited local resources such as fuel, food and water.

Level 3 – Post-disaster reconstruction: accelerated procurement

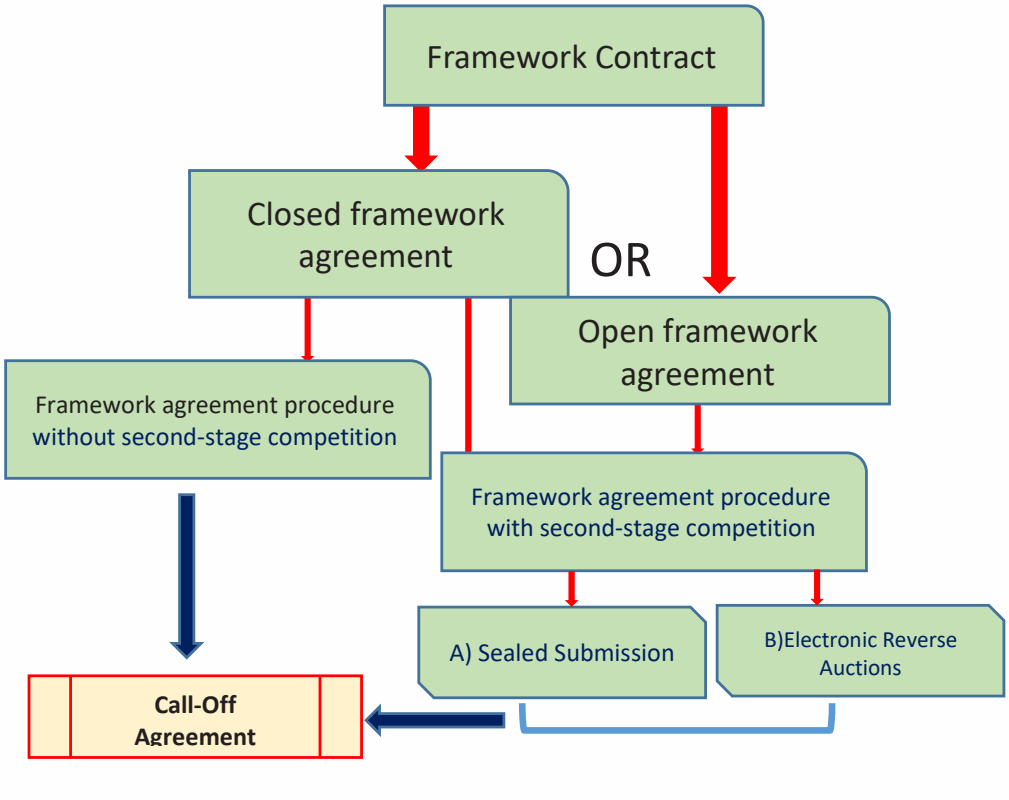
The recovery phase occurs when life, property, environment, essential services or key Public Entity services are no longer endangered or threatened. The focus shifts from urgent response to rebuilding and restoring business-as-usual.

In the recovery phase, routine procurement policy and processes should resume for all procurement. Some procurement activities may be accelerated under routine procurement policy and processes that comply with all mandatory supply and works policies' requirements. Contracts awarded earlier in the response to an emergency should be reviewed. It may be appropriate to terminate or renegotiate these contracts.

The Basic Idea of Two-Stage Process :



definite-quantity indefinite-delivery framework contracts, requirements framework contracts, and indefinite-quantity framework contracts.



9. Application of Framework Agreement for Emergencies Public Procurement

A framework is an agreement with suppliers to establish terms governing contracts that may be awarded during the life of the agreement. In the conventional method of the procurement, time of delivery, location of delivery and quantity of delivery are well defined at the time of procurement, but in case of the Framework Agreement; all or any of one may not be mentioned at the time of the Framework agreement and only defined in Call Off Contract. Such procurement model is useful for recurring and emergency purchase.

It is an agreement between one or more supplier, "the purpose of which is to establish the terms governing contracts to be awarded during a given period, in particular with regard to price and, where appropriate, the quantity envisaged". Also, It is an agreement between the procuring entity and the selected supplier (or suppliers) concluded upon completion of the first stage of the framework agreement procedure.

Framework agreement procedure is conducted in **two stages**: a first stage to select a supplier (or suppliers) to be a party (or parties) to a framework agreement with a procuring entity, and a second stage to award a procurement contract under the framework agreement to a supplier party to the framework agreement : Call- Off Agreement.

Overview of Framework Agreement

Some key features of frameworks agreements are:

- can be placed by an individual contracting authority, a group of contracting authorities or a central purchasing authority
- can be with a single supplier or multiple suppliers
- if with multiple suppliers, the minimum number must be three (provided there are at least this number of qualified candidates)
- "mini – competitions" may be held between participants as needs arise
- the maximum duration is three years (unless in exceptional circumstances justified by the subject of the framework)
- the terms and criteria for awarding contracts must be published at outset and not substantially changed

"Closed framework agreement" means a framework agreement to which no supplier that is not initially a party to the framework agreement may subsequently become a party;

"Open framework agreement" means a framework agreement to which a supplier (or suppliers) in addition to the initial parties may subsequently become a party or parties;

Suppliers may apply to become a party or parties to the framework agreement at any time during its operation by presenting indicative submissions to the procuring entity in compliance with the requirements of the invitation to become a party to the open framework agreement.

There are three types of **indefinite-delivery framework contracts:**

- definite-quantity indefinite-delivery framework contracts,
- requirements framework contracts, and
- indefinite-quantity framework contracts.

"Definite-quantity framework contract": a contract to provide for delivery of a definite quantity of specific goods, services for a fixed period, with deliveries or performance to be scheduled at designated locations upon order. Example: Uniform for Police Officer Purchase

"Requirements framework contract": recurring requirements but cannot predetermine the precise quantities of goods, services that the procuring entity's activities will need during a definite period. The procuring entity state a realistic estimated total quantity in the bid and resulting contract. This estimate is not a representation to a bidder that the estimated quantity will be required or ordered.

The contract provides that all purchases by the procuring entity for the specified goods, services will be made under the contract. Entity has not purchased by any another way or suppliers, all actual purchases under the contract only). The contract states, if feasible, the maximum limit of the supplier's obligation to deliver or perform and the procuring entity's obligation to order. The contract may also specify maximum or minimum quantities that the procuring entity may order under each individual order and the maximum that it may order during a specified period of time. Example : Office Printing Papers, Toner Purchase

"Indefinite-quantity framework contract": a contract to provide an indefinite quantity, within stated limits, of goods, services during a fixed period, when the procuring entity cannot predetermine, above a specified minimum, the precise quantities of goods, services that will be required during the contract period. It is not advisable for the procuring entity to commit itself for more than a minimum quantity. The procuring entity should use an indefinite-quantity framework contract only when a recurring need is anticipated.

If Demand is fixed and Place to deliver / perform is fixed: definite-quantity indefinite-delivery framework contracts is good options of Procurement under the Framework Agreement,

If Demand is recurring but demand cannot be predetermined, specifying demand in terms of minimum and maximum quality and Entity commitment to all actual purchase only under one contract : requirements framework contracts, is good options of Procurement under the Framework Agreement

If Demand is recurring but demand cannot be predetermined, specifying demand in term of minimum and maximum quality, but minimum. quantity must be procured in indefinite-quantity framework contracts. This is good option of Procurement under the Framework Agreement.

Second stage of a framework agreement procedure (Call Off Contract)

A procurement contract under a framework agreement may be awarded only to a supplier that is a party to the framework agreement, by sending the Order Form Template electronically/ written letter.

On receipt of an order form a Procuring entity or Other Procuring entitys, the Supplier shall accept the Call- Off Proposal and returning electronically the order form to the Procuring entity concerned within the defined Working Days; to deliver the goods/service/works at agreed rates at the time or Framework Agreement(FWA) or quote the rates for mini-competition or participate in electronic reverse auction.

Least Order Or Call-Off Contract Price is one of the option to set Awarding Criteria for Call-Off Contract. A Call-Off Contract can also be awarded on the basis of most economically advantageous Offer ("MEAO") from the point of view of the Procuring entity. The criteria shall be related to Quality(Which consists of the Added Value / Innovation, Social Value, Approach to Delivery of the Services, Mobilization, Use of Supply Chain /Partners), Cost effectiveness, Technical merit, Technical assistance, After sales service, Price, Aesthetic and functional characteristics, Running costs, Environmental characteristics, Delivery date and delivery period, Period of completion.

The model also best suits for the procurement of relief logistic in case of disaster such as flood and landslides

i.e emergency situation. But, e-portal for the implementation of the procurement model is still awaiting to be developed in Nepal.

10. Legal Options available for Emergencies Public Procurement

There are multiple legal options to manage the emergency public procurement management to the public entities.

Existing Legel Options	Recommended Procedure
Option 1: Public Procurement Act 2063, Clause 66 Provision Concerning Procurement to be Made in Special Circumstances & Public Procurement Regulation 2064, Rule 145 Provision Concerning Procurement in Special Circumstances	• No limit of procurement amount • If need to act within hrs or 3-5 days, direct negotiation with a single construction entrepreneur, supplier, consultant or service provider • If need to act more than 7 days, One Envelop 1-3 days – Tender Notice, 1-2 days EoI and 3 days for agreement
Option 2: Public Procurement Act 2063, Clause 41. Provision for Direct Procurement & Public Procurement Regulation 2064, Rule 85 Provision Concerning Direct Procurement	• Limit of procurement amount as per clauses/ rules • By getting quotation from minimum 3 construction entrepreneur, supplier, consultant or service provider • negotiation and action

Option 3: Public Procurement Act 2063, Clause 9. Procurement to be Made by Inviting Open Bid & Public Procurement Regulation 2064, Chapter 5 Provision Relating to Bidding	• For Level 3–Post-disaster reconstruction: accelerated procurement • If need to act within few months, 2-3 weeks – Tender Notice, 3-5 days EoI and 7 days for agreement after • departmental approval for time line
Option 4: Public Procurement Regulation 2064, Rule 98. To Carry out Construction Work Through Force Account	• No limit of procurement amount • Material procurement as per relevant procurement provisions • Labour components under Muster roll
Option 5: Public Procurement Regulation 2064, Schedule-3 (Relating to Sub-rule (1) of Rule 21), Procurement contract of goods or other services, b) Framework Agreement	· No limit of procurement amount · But, need separate e-procurement system with Reverse Auction for mini-competitions

11. Keep adequate records & Public Disclosure

Record emergency procurement activities during or as soon as practicable after the event. Mark the record as an emergency procurement and outline the facts and circumstances justifying this approach.

Documents containing the following matters shall have to keep in the records under Rule 149, which shall be , but not limited to:

- description relating to special circumstances
- the procurer(s), financial delegate
- conflict of interest declarations
- the business needs, the crisis to be occurred in public security, interest and community health, if procurement is not made immediately,
- justification for conducting an emergency procurement, and not adopting the other methods of procurement.
- the market analysis
- the market approach and why (including consideration of state purchase contracts)
- supplier/contractor(s) and key offer(s) details
- evaluation outcome and value for money of selected offer(s)
- financial approval amount (including options to extend and contingency funds)
- details required by procurement-related policies
- copy of the contract or key contract details:
    - supplier/contractor (s)
    - scope (type and quantity of goods or services or works)
    - delivery date for one-off supply or term
    - value (initial term)

Where a Public Entity has made a procurement exceeding one million Rupees under Public Procurement Act 2063, Clause 66 Provision Concerning Procurement to be Made in Special Circumstances & Public Procurement Regulation 2064, Rule 145 Provision Concerning Procurement in Special Circumstances; it shall have to publish a public notice of the details of the procurement so made and send information thereof to the Public Procurement Monitoring Office.

12. Conclusions

In Nepal, there are clear legal provisions in order to manage the emergency or special circumstances procurement. The situations that are turned urgent due to lack of planning or risk mitigation do not constitute an emergency. Also, Emergency procurement shall not apply, where goods or services or works fall under common procurement arrangement; or where specific event was anticipated or planned.

Guidance on performance security, insurance, variation order, time extension and similar issues need to be detailed by Public Procurement Monitoring Office.

After the emergency response is completed, performance review under emergency procurement shall be done to identify improvements. This may be part of, or in addition to, an annual review of the emergency procurement plan as part of the annual procurement planning cycle.

We should consider applying learnings from conducting emergency procurement that may be relevant to improving routine procurement

process and plans. For example, if processes were abbreviated without increasing risk, that may indicate that those abbreviated processes are suitable for use by the Public Entity in routine procurement.

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On-going construction Work along Narayanghat-Butwal Road

Road Traffic Accidents in Kathmandu Valley

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A. Background

For an occurrence involving one or more vehicles in an event that results in damage to property, people, or the environment, "accident" is the commonly accepted word. The term accident implies a random event that occurs for no apparent reason other than "it just happened". The National Highway Traffic Safety Administration [1] has suggested replacing the word 'accident' with the word 'crash' because a crash could have been prevented or its effect can be minimized by modifying driver behavior, vehicle design, roadway geometry, or the traveling environment. However, going through different literature, universally accepted terminology is "accident" or "crash" and they are used interchangeably in this article/study.

The road transport system is composed of three components namely road users, vehicles, and road environment. Human factors, vehicle factors, and the road itself might be the major causes of road crashes [2]. Contributing factors to highway crashes may be related to the driver (inattention, illness, or fatigue), the vehicle (brake, steering, or throttle failures), or the road itself (lack of sight distance, poor roadside clear zones, changing weather, etc.). Interventions may seek to reduce or compensate for these factors or reduce the severity of crashes. Heavy traffic volume, speeding, narrow lane width, larger number of lanes, different urban roadway sections, narrow shoulder width, and reduced median width increase the likelihood of accident involvement [3].

In reality, most crashes cannot be related to a singular causal event. A direct relationship between individual contributing factors and particular strategies to reduce crashes does not exist. Instead, crashes are the result of a convergence of a series of events that are influenced by a number of contributing factors (time of day, driver attentiveness, speed, vehicle condition, road design, etc.). According to the HSM [4], crashes have the following three general categories of contributing factors:

- **Human** – including age, judgment, driver skill, attention, fatigue, experience and sobriety;
- **Vehicle** – including design, manufacture and maintenance;
- **Roadway/Environment** – including geometric alignment, cross-section, traffic control devices, surface friction, grade, signage, weather, visibility.

Research by Treat et al. [5] about the relative proportion of contributing factors for the crash is summarized in Fig. 1. The figure shows that the main contributing factor to the accident is the driver's factors; whose contribution is 93% in combination with other two factors (roadway factors, vehicle factors), 57% alone and 27% in conjunction with roadway factors.

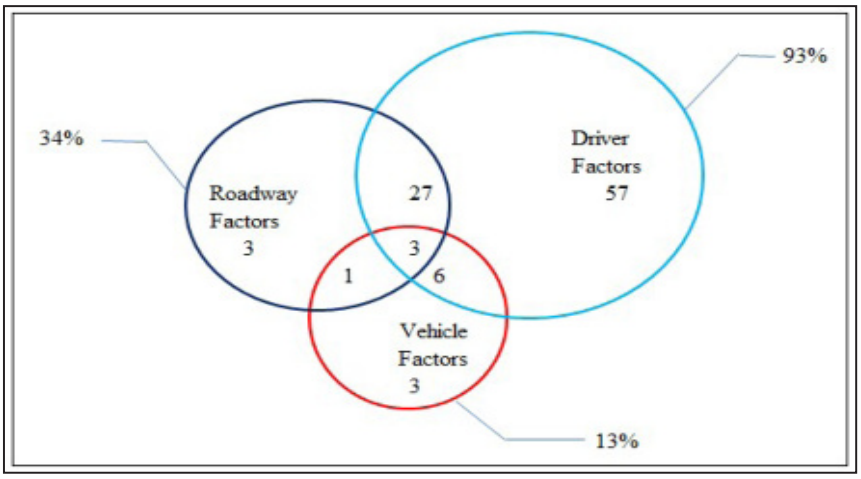

Fig. 1: Factors Contributing to Road Accidents

A framework for relating the series of events in a crash to the categories of crash contributing factors is the Haddon Matrix. The Haddon Matrix helps to create an order for determining which contributing factors influence a crash and which period of the crash the factors influence. Table 1 provides an example of the Haddon Matrix; the factors listed are not intended to be comprehensive; they are examples only.

Table 1: Example of Haddon Matrix

Period	Human Factors	Vehicle Factors	Roadway/Environment Factors
Before Crash Factors contributing to increased risk of crash	distraction, fatigue, inattention, poor judgment, age, cell phone use, deficient driving habits	worn tires, worn brakes	wet pavement, polished aggregate, steep downgrade, poorly coordinated signal system
During Crash Factors contributing to crash severity	vulnerability to injury, age, failure to wear a seat belt, driving speed, sobriety	bumper heights and energy adsorption, headrest design, airbag operations	pavement friction, grade, roadside environment
After Crash Factors contributing to crash outcome	age, gender	ease of removal of injured passengers	the time and quality of the emergency response, subsequent medical treatment

B. Road Traffic Accidents in Kathmandu Valley

There are more traffic problems and crashes in Kathmandu Valley than in other cities in Nepal, since more than half of the total registered vehicles ply in the Valley and about one-third of the national population reside in the Valley. According to the Nepal Police Traffic Directorate (NPTD), about half of the road traffic accidents (RTA) nationwide occur in Kathmandu Valley only.

To explore the extent and factors contributing to road traffic accidents in Kathmandu Valley, descriptive methods in the form of tables, charts, and graphs are used. Accident data collected from Valley Traffic Police [6], Kathmandu for the period of 5 years (F/Y 2018/19 to F/Y 2022/23) is used. The data analysis explores the road traffic accident with the number of fatalities, number of injuries and property damage only (PDO), human involvement in an accident, types of vehicles involved in the accident, and factors contributing to the accident.

(i) Total Road Accidents

In the F/Y 2018/19, the total road traffic accident was 8,511 and it reached 10,675 in the year 2022/23. In 2018/19 the number of reported deaths resulting from road accidents is 254 reflecting an annual declination of about 2% compared to the previous year. Fig. 2 shows the number of road traffic accidents in Kathmandu Valley from 2018/19 to 2022/23. The accident trend line is sagged in the years 2019 and 2020. This may be due to the COVID-19 and its associated effect of less exposure on the road. The data on road traffic accidents shows that there is almost one person victimized and more than one vehicle has undergone some damage in each accident.

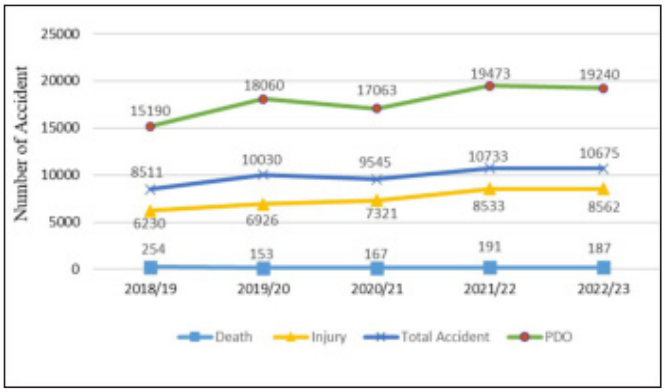

Fig. 2: Road Traffic Accidents in Kathmandu Valley

(ii) Driver's Involvement in Road Accident

When drivers' involvement in road traffic accidents is compared by their age category, those drivers with an age greater than 40 years old are found to be the less affected age category for the period of 5 years (F/Y 2018/19 to F/Y 2022/23). On the contrary, drivers with an age greater than 25 years, but less or equal to 40 years are the most affected driver's age group in road traffic accidents. The involvement of drivers in most of the accidents from the age group 25-40 years may be due to the impatient and recklessness nature of driving and also may be due to the large number of driving license holders for this age group.

Fig. 3 shows driver's involvement in road traffic accidents by age in Kathmandu Valley from 2018/19 to 2022/23. From the figure, it can be seen that aged drivers are more careful about traffic safety than youth below 40 years old, therefore their involvement in accidents is less. It is also

possible that aged drivers have more experience and probably much more responsibility than youths. In addition, it is also possible to say that youth behaviors towards traffic safety are poor due to peer groups' suggestions and influence on driving style and encourage taking risks within such age.

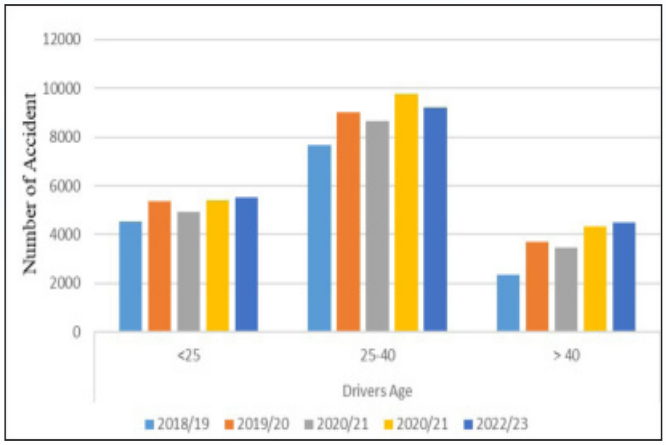

Fig. 3: Driver's Involvement in Road Accident in Kathmandu Valley

(iii) **Vehicle Involvement in Road Accident**

As the motorcycle number in Kathmandu Valley constitutes a great deal of the movement on the road, their involvement in accidents occurrence is also high. If a grouping of vehicle involvement in road traffic accidents in Kathmandu Valley is made, most of the accidents are caused by motorcycle and car/jeep/van groups followed by bus, truck/tipper, and micro-bus groups. The accident frequencies for the first group (motorcycle and car/jeep/van) were found to be about 4 times the accidents caused by the second group (truck, bus, and micro-bus) in Kathmandu Valley for the period of 5 years (F/Y 2018/19 to F/Y 2022/23). Fig. 4 shows vehicle involvement in road traffic accidents in Kathmandu Valley from 2018/19 to 2022/23.

The possibility of Motorbike riders having more causalities than other means of road transport is high and one accident may result in many causalities. This may be due to the high speed of two-wheelers as compared to the four-wheelers, not following the traffic rules and lane discipline by the riders of two-wheelers and the impatient and recklessness driving nature of the two-wheeler users. Motorbike riders are the most vulnerable road users because of their unprotected state and need for high attention to balance the vehicle. Therefore, it can be said that some interventions are very urgent to minimize the number of motorbike accidents, like compulsory helmet provision for each occupant, and awareness classes at some intervals (maybe during the license renewal time).

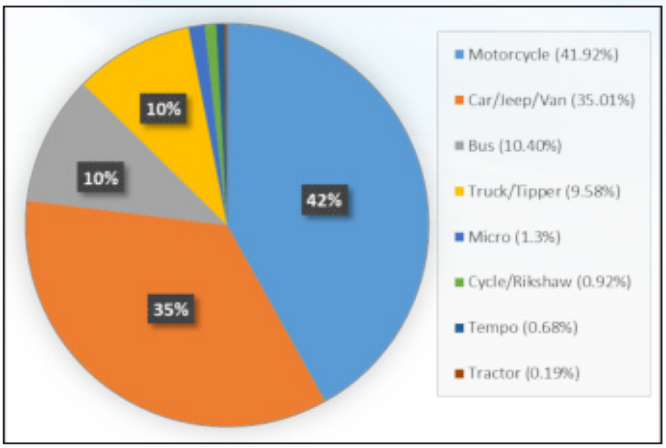

Fig. 4: Vehicle Involvement in Road Accident in Kathmandu Valley

(iv) Factors Contributing to Road Accident

For the period of 5 years (F/Y 2018/19 to F/Y 2022/23), the leading cause of road traffic accidents in Kathmandu Valley is found to be driver's carelessness. The occurrence of road traffic accidents due to the driver's carelessness is about 75% of total accidents. Other major causes of accidents including over speeding, drunk driving, and unsafe overtaking are also the negligence of drivers. The overloading case can also be attributed to the driver's negligence, but it is not always necessarily true. Therefore, driver behavior plays an important role in avoiding accidents or minimizing the severity of accidents in case of accident occurrence. Hence, enforcement of the law and awareness of the driver is the most important. Again, awareness is also necessary regarding the negligence of passengers, pedestrians, and cattle driving on the road.

Mechanical failure of vehicles is also one of the leading causes of accidents, which should be addressed properly. The poor physical condition of the road also plays a vital role in the traffic accident. Fig. 5 shows the causes of road accidents in Kathmandu Valley collectively from 2018/19 to 2022/23.

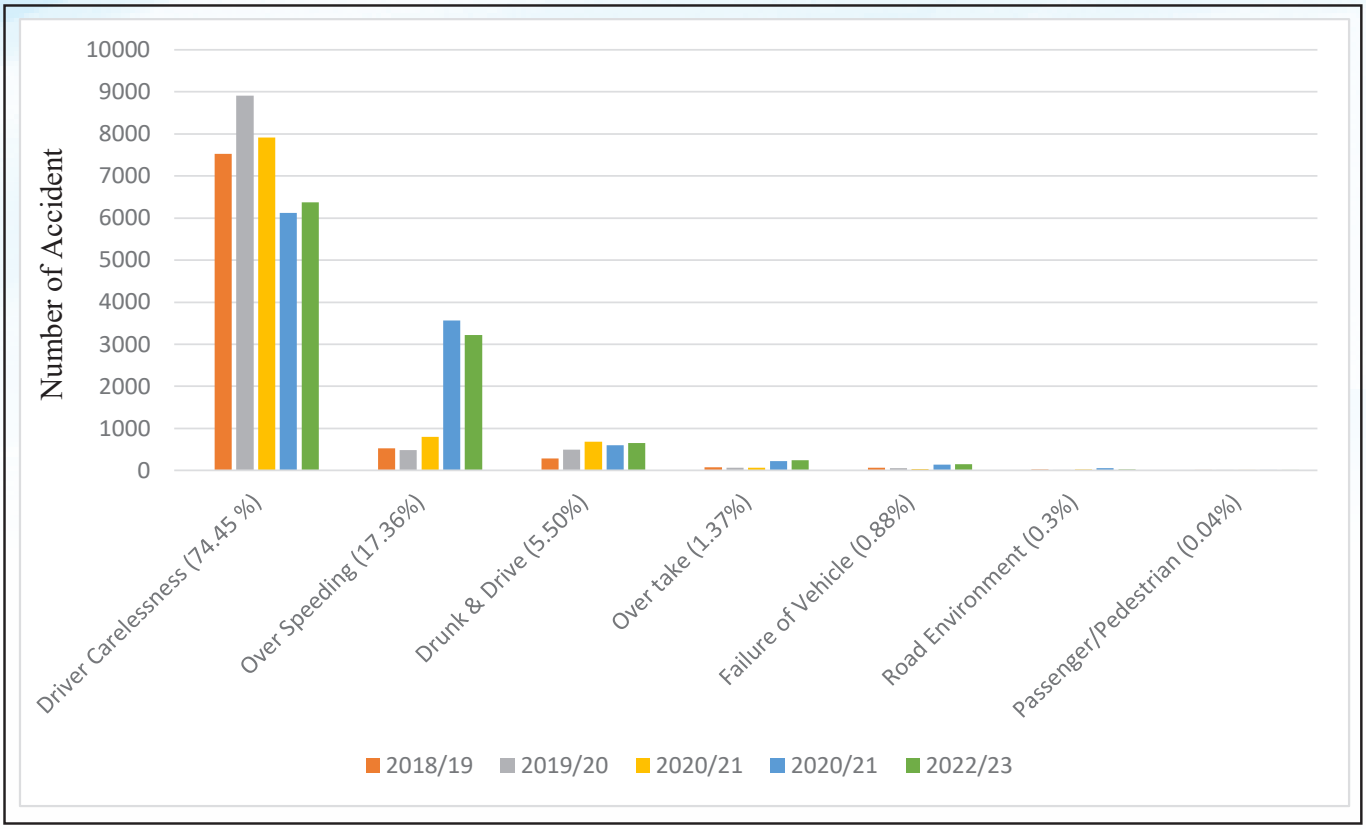

Fig. 5: Factors Contributing to Road Traffic Accidents in Kathmandu Valley

According to the road accident record provided by Valley Traffic Police, it is evident that the reasons for the majority of accidents in Kathmandu Valley are due to negligence by the driver including carelessness, speeding, drunk and driving, and unsafe overtaking which account for more than 98% in a total recorded accident for 5 years 2018/19 to 2022/23.

The data presented here shows that the most vulnerable age group to road traffic injuries and deaths is the young population. The young age is considered the most vulnerable road users because maximum of them from this age are bike riders, students, and early career makers and hence are in a rush always. They are the most energetic but aggressive so, they are more likely to get involved in road traffic crashes, injuries, and deaths. Therefore, it can be said that enforcement and awareness for young people are lacking somewhere.

C. Discussion and Conclusion

The data from the Nepal Police used in this study showed that the major cause of road traffic crashes was the negligence of drivers. It is often evident that the other factors are also equally contributory to the crashes but in the documentation; negligence of drivers is given the higher rank. That is why, a strong and direct investigation is required for identifying the real cause so that the government and concerned authorities can work effectively.

In-depth technical analysis for investigating the causes, linking them to the damage caused to property or injuries caused to occupants of the vehicle and other road users, is very difficult using the present set of data available in Nepal. The accident data collected from the accident sites, through the existing arrangements are insufficient because those are collected only for reporting as a crime record and meeting only the requirement of adjudication. Therefore, it is very crucial to modify the accident data collection system, incorporating collection of all the necessary data of accident occurrence. Besides this, a fairly large number of accidents are never reported to the police, mainly because the involved parties want to settle the matter between them.

A universal objective of road safety is to reduce the number and severity of crashes within the limits of available resources, science, technology, and legislatively mandated priorities. That is why, the right interventions through strong and effective road safety policies are key elements and can make

a significant positive impact to reduce road traffic crashes and injuries [7]. Many countries of the world including developed and developing have reduced or controlled road traffic crashes and injuries by the means of scientific and practical policies, strategies, guidance, intervention, and evaluation comprising of the *Golden 3 E's* viz. Education, Engineering, and Enforcement with the involvement of relevant stakeholders.

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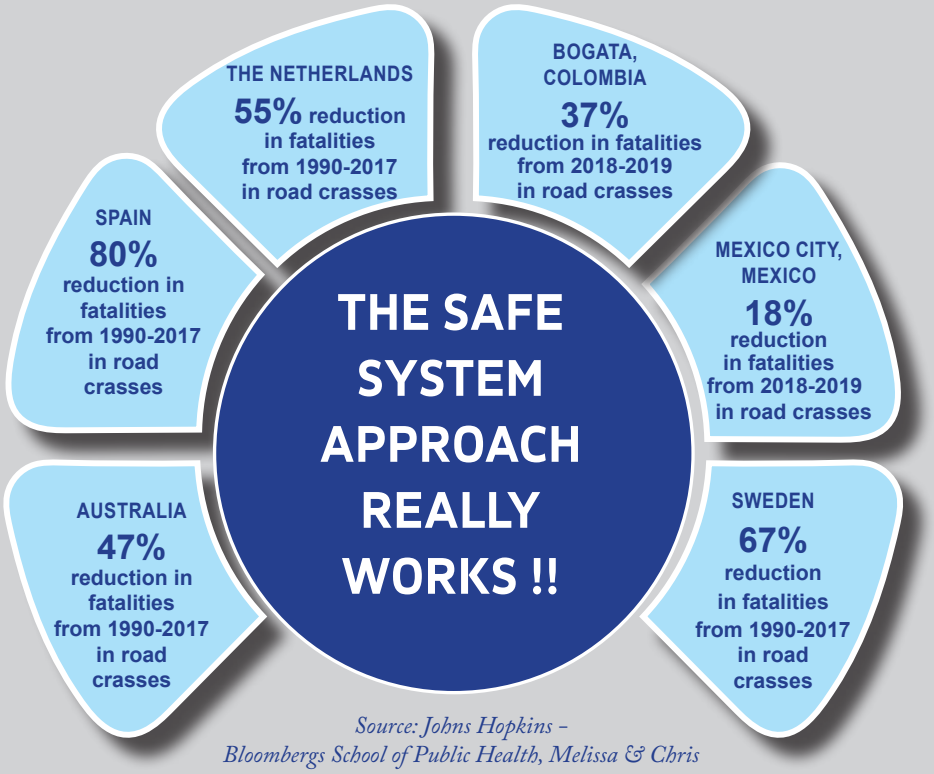
SAFE SYSTEM APPROACH FOR ROAD SAFETY

It is an integrated and comprehensive process to improve the safety performance of the transportation system that makes allowance of errors, and eliminates predictable and preventable serious injuries and fatalities.



Source: Johns Hopkins – Bloombergs School of Public Health, Melissa & Chris

Control and Management of Fugitive Dust Produced During Highway Construction and Upgrading

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1. Introduction:

The Constitution of Nepal has guaranteed the right to a clean and healthy environment as a fundamental right. The National Environmental Policy, 2019 has a provision for the polluter's pay principle adhered to by the constitution. The Environment Protection Act, 2019, and Environment Protection Regulations, 2020 are the regulatory legal instruments to achieve a clean and healthy environment. The control of environmental pollution and achievement of sustainable development through the assessment of environmental impacts before the implementation of development projects are abided by these legal frameworks.

Upgrading existing highways, at least in double lane standards, is one of the major activities of the Department of Roads (DoR). Upgrading of roads generates immense levels of dust and this dust creates havoc not only for the community and ecological health but also for the hindrance on technical and administrative workloads of DoR. Control and management of dust has become one of the major challenges and the adoption of suitable and cost-effective measures is a dire requirement to manage healthy construction practices in road upgrading works.

This study aims to assess the dust control and management practices adopted in selected road projects and proposes the best practices of dust control and management mechanisms to be adopted for future road upgrading projects under DoR.

2. Study Area

Project Directorate-Asian Development Bank (PD-ADB), is one of the major branches under DoR that looks after all the ADB-funded road projects. Currently, there are three running projects SASEC Highway Improvement Project (SHIP), SASEC Road Improvement Project (SRIP), and SASEC Mugling Pokhara Highway Improvement Project (SMPHIP); Phase-I under PD-ADB.

Under SMPHIP, the Mugling-Abukhaireni-Pokhara (81 Km) section (referred to as MAP road) lies in the Tanahu and Kaski districts of Gandaki Province (Fig. 1).

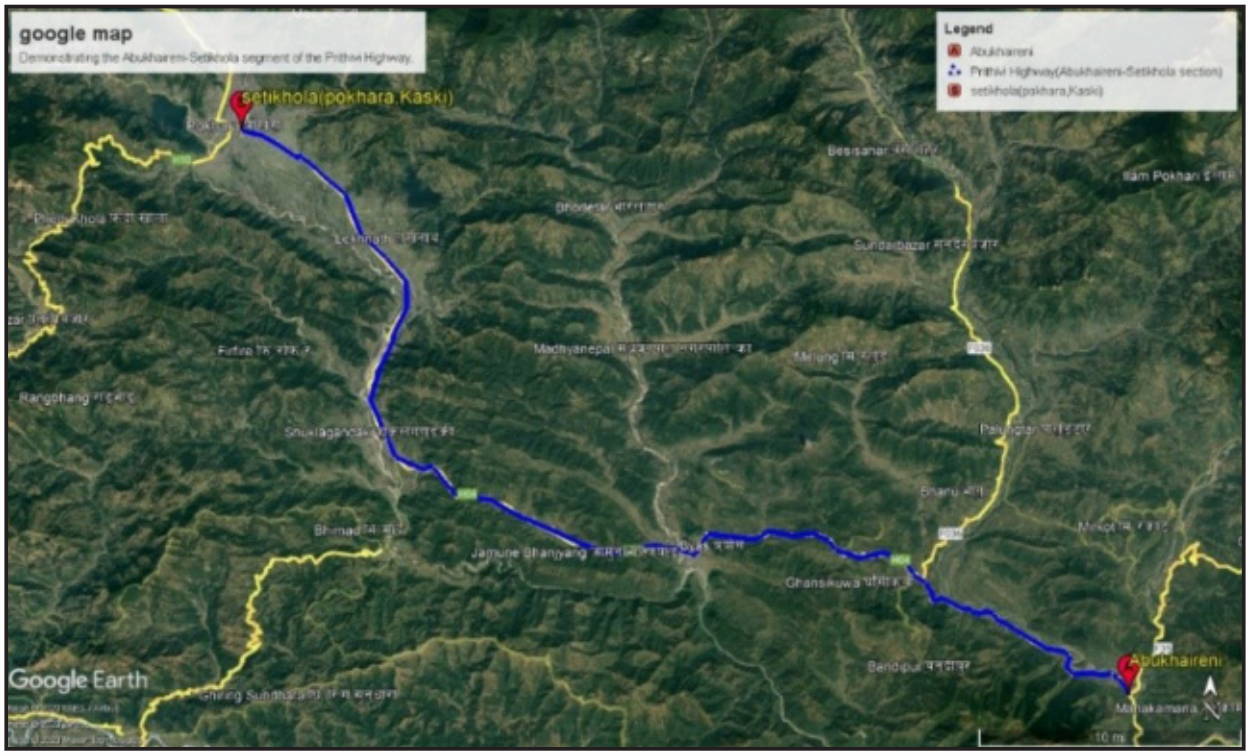

Fig. 1: MAP road alignment in Google Maps (Retrieved on August, 2023)

Under SHIP Kanchanpur-Kamala (87 Km) road section (referred to as KK road) in Siraha and Spatari district of Madesh Province.

Under SRIP, the Narayanghat-Butwal (115 Km) section (referred to as NB road) in Nawalparasi East, Nawalparasi-West, and Rupandehi districts of Gandaki and Lumbini Provinces.

3. Methods

Approved Environmental Management Action Plan (EMAP) of respective road sections and Periodic Environmental and Social Monitoring reports submitted by the Contract Supervision Consultant (CSC) were thoroughly reviewed before the field visit. Field visits on July 10-15 for the MAP road section, July 26-29 for the KK road section, and August 2-6 for the NB road were conducted. A checklist was prepared and used to enlist the sources of dust, control mechanisms, and management practices. During the field visit, highway traverse survey was done to observe the significant dust-prone sites. Sources of dust like quarry sites, storage yards, batching plants, and crusher plants were also assessed. The practices of dust control and management were assessed and recorded. The consultation meeting was conducted with the Team Leaders (TL), Residence Engineer (RE), Assistant Residence Engineer (ARE), Environmental Experts (EE), and Social Experts (SE) of respective CSCs, the environmental and social experts of the respective contractors and with the local persons during the visit.

A numerical value from 1 to 5 has been assigned to rate the dust control and management practice in the field. The rating of the management was assigned based on subjective expert judgment. The rating matrix in Table 1 has been used to access the dust management perspectives.

Table 1: Matrix for rating of dust control and management practices

S.N.	Rating	Condition	Description
1	1	Very Poor	The scenario is extremely poor, with no interventions done, and requires huge effort from management
2	2	Poor	The scenario is poor, with very few signs of interventions, and requires huge effort from management
3	3	Good	The scenario is good, with few signs of interventions but not adequate and requires huge effort from management
4	4	Fair	The scenario is good, with adequate signs of interventions but interventions are not integrated and require few more effort from management
5	5	Very Good	The scenario is good, with adequate integrated signs of interventions, and requires continuous effort from management

Interpretation of Control and Management Practices: For the interpretation of the management practices; the overall rating of control and management practice has been obtained and converted to a total percentage based on the number of practices and the maximum rating value. Based on the value obtained; the interpretation matrix in Table 2 has been used to evaluate the dust control and management practices in the respective projects.

Table 2: Matrix for evaluation of dust control and management practices

S.N.	Rating (%)	Evaluation	Description
1	More than 80	Significant	Dust control and management practices adopted are adequate and acceptable but continuation is required
2	50-80	Moderate	Dust control and management practices adopted are not adequate and few more intervention is required
3	Less than 50	Poor	Dust control and management practices adopted are not adequate, not acceptable, immediate and rigorous intervention is required

4. Sources of Dust

During the field visit and consultation with the environmental and social experts of CSC, the following reasons and sources of dust have been identified.

4.1 Construction Sites: The sites intensified with heavy construction equipment and vehicles for lane preparation, slope cutting/trimming, and scarified sites are found to produce dust.

4.2 Cross-Drainage Structures: Dismantling and site preparation of cross-drainage structures are major and frequent sources of dust. The management of exiting minor bridges/culverts and site preparation for minor bridges/culverts construction sites although very small in length generate a huge amount of dust during the vehicular movement. Since these sites are frequent

and are in large numbers, contractors are also found not sprinkling water regularly.

4.3 Diversion Roads: These roads are either graveled or earthen in most cases holding a huge amount of dust. The plying of vehicles generates huge amounts of dust from these roads.

4.4 Hot Mix Plant/Batching Plant: These sources generate dust during the refining of construction materials. The negligence of evacuation of the sedimentation ponds of the batching plants, mismanagement of the plant site premises, and the earthen surface of the sites with the ply of heavy vehicles generate dust at the site. Haphazard cement debagging in the plant sometimes produces dusty air.

4.5 Crusher Plants: These are confined sites generating dust during the crushing and purifying of construction materials. These sites are earthen with large amounts of dust which are triggered and magnified through the movement of vehicles.

4.6 Dismantling of the Public/Private Structures: The sites with the requirement of dismantling the public and private structures generate a significant amount of dust. Similarly, the removal of trees and relocation of public utilities are found to be the sources of dust.

4.7 Traffic: One of the reasons for dust generation is found to be the mismanagement of the traffic during the construction. Particularly, the vehicles plying in the permitted existing earthen roads that need to be maintained, the potholes developed in the permitted existing roads, use of earthen side lanes under interventions by vehicles frequently generate dust in the sites.

5. Dust Management Practices: These projects are regularly practiced and focus on the progressive management and control of dust at various sites of the road sections. Some of the mechanisms for dust control have been enlisted here:

5.1 Lane Management: The KK Road project has well-developed and well-adopted lane management practices. The construction activities have been confined in a particular lane (construction lane) and the permitted exiting lane (permitted lane) has been managed for vehicular movement. This has supported the vehicles to run on the maintained paved surface and forbidden the movement for the under construction/upgrading earthen and dusty lanes, which are supposed to be one of the most significant sources of dust in upgrading road projects (Picture 1). The NB and MAP projects have poor lane management practices because of which most of the permitted lanes are scarified. The permitted lanes are earthen with full of dust causing the eruption of dust during the vehicular movement. The construction/upgrading of side lanes in NB road, back cutting and slope trimming in MAP road and Daunne section of NB road have generated massive dust in these road sections (Picture 2).

5.2 Regular maintenance of the potholes in the permitted paved lane: The practice of maintaining the potholes regularly in the permitted lanes has reduced dust in the particular sites of the KK road section. Poor and frequent maintenance of permitted lanes at the NB road section and MAP road section has enhanced dust eruption during vehicular movement. However, the maintenance of permitted lanes of these road sections is not adequate to regulate dust management. The diversion roads are not regularly maintained so they support dust generation.

5.3 Barricades: The KK Road project has established a system of barricading the lanes under construction/upgrading that has well functioned not only for road safety but also for the reduction of dust generation. The model of barricades prepared with the help of locally available materials like bamboo, soil/sand sacks, barricading tapes/construction tapes, and signage posts have contributed to the reduction of dust eruption. Along the linear barricades in the permitted lanes, the barricades were also established vertically to prohibit traffic movement in the construction/upgrading lanes and have supported dust control and management (Picture 3). The barricading at NB and MAP is poor which has triggered not only the road safety management but also enhanced dust generation. The free movement of vehicles on both permitted and non-permitted lanes has supported the eruption of dust (Picture 4).

5.4 Sprinkling of water: These all projects have sprinkled water at construction sites, permitted lanes, and the sites of cross drainage structures to reduce the dust eruption. They have been sprinkling the water at the sites at least three times a day (Picture 5).

5.5 Community Consultation: The contractors and the consultant team are in regular consultation for the reduction and management of the dust particularly in the settlement areas. The consultation has always directed and alerted the contractors and consultants to reduce the dust eruption. The contractors and consultants are continuously coordinating with the office of the local rural municipalities and municipalities to facilitate the communities to reduce the generation of dust at settlement areas.

5.6 Management of Batching Plants/Crusher Plants/ Construction Materials: The established batching plant and crusher plants of all the road sections have adopted a wet system of purifying the construction materials. Regular use of water has reduced the dust generation. These batching plants and crusher plants have established sedimentation tanks where the sediment-laden water has been collected and the arrested dust by such water is stored in the collection tank for some time before releasing sediment-free water to the water bodies (Pictures 6 & 7).

The crusher established was found lacking high barricades and the construction materials at the batching plants and crusher sites were uncovered with a high risk of dust nuisance in the nearby areas except at one of the batching plants at MAP road (Picture 8).

The haphazard dumping and storage of construction materials adjacent to the roadsides has also created the nuisance of dust. The uncovered haulage, sometimes, of the construction materials has also generated dust in these road sections.

5.7 Rating and Interpretation of Dust Control and Management Practices: Based on the subjective expert judgment and the established rating matrix mentioned in the method section, the following rating and interpretation of the dust control and management practices have been assessed for these projects:

Table 3: Rating of control and management practices for MAP road section

S.N.	Control/ Management Practices	Rating	Percentage*	Remarks
1	Lane Management	2	40%	Poor
2	Barricades	2	40%	Poor
3	Traffic Management	3	60%	Moderate
4	Sprinkling of Water	4	80%	Moderate
5	Construction Material Management	3	60%	Moderate
6	Community Safety	3	60%	Moderate
7	Corporate Social Responsibility	2	40%	Poor
	Total (Overall Rating)	**19**		

*(*Calculation of percentage is done as observed rating/ Maximum rating value *100%)*

The lane management, barricading, and CSR for this road section are found to be poorly exercised. The management of the traffic, management of the construction materials, and provisions for community safety have been practiced moderately. There is regular sprinkling of water in the construction area, however the effectiveness of this sprinkling has been observed to be moderately effective.

Table 4: Rating of control and management practices for the KK road section

S.N.	Control/ Management Practices	Rating	Percentage*	Remarks
1	Lane Management	5	100%	Significant
2	Barricades	5	100%	Significant
3	Traffic Management	4	80%	Moderate
4	Sprinkling of Water	4	80%	Moderate
5	Construction Material Management	2	40%	Poor
6	Community Safety	3	60%	Moderate
7	Corporate Social Responsibility	2	40%	Poor
	Total (Overall Rating)	**25**		

*(*Calculation of percentage is done as observed rating/Maximum rating value *100%)*

The lane management practice for the permitted lane and construction lane in this project is observed excellent. Similarly, the placement of the barricades and effectiveness of such are observed in positions. The traffic management was good, the sprinkling of water was observed regularly and continuous efforts for community safety were observed as moderate. The management of the construction materials and enhancement of CSR for community safety is observed to be poor.

Table 5: Rating of control and management practices for the KK road section

S.N.	Control/Management Practices	Rating	Percentage*	Remarks
1	Lane Management	2	40%	Poor
2	Barricades	3	40%	Poor
3	Traffic Management	2	40%	Moderate
4	Sprinkling of Water	4	80%	Moderate
5	Construction Material Management	3	60%	Moderate
6	Community Safety	3	60%	Moderate
7	Corporate Social Responsibility	2	40%	Poor
	Total (Overall Rating)	**19**		

*(*Calculation of percentage is done as observed rating/ Maximum rating value *100%)*

The lane management, barricading, traffic management, and CSR for this road section are found to be poorly exercised. The management of construction materials and provisions for community safety have been practiced moderately. There is regular sprinkling of water in the construction area, however the effectiveness of this sprinkling has been observed as moderately effective.

5.8 Comparisons of Dust Control and Management Practices: The following table illustrates the adopted practices for dust control and management in the study area:

Table 6: Rating of overall control and management practices

S.N.	Road Sections	Rating (%)	Evaluation	Remarks
1	MAP	54.28	Moderate	Dust control and management practices adopted are not adequate and few more intervention is required.
2	KK	71.42	Moderate	
3	NB	54.28	Moderate	

The overall evaluation for the control and management of dust in these projects is found to be moderate. These road sections have considerably adopted dust control and management measures. The KK Road section has effective control and management measures compared to the other two road sections because this road section has adopted an integrated approach to mitigation measures. The major lack at NB and MAP roads is due to the preparation and implementation of a Lane Management Plan (LMP). These road sections had initiated the scarifying of most of the permitted sites where the plying of vehicles generated a significant amount of dust to enter the atmosphere. KK road section adopted the simplified model of barricades of bamboo poles and stretchers integrated through the LMP that significantly controlled the vehicular movement on construction/upgrading lanes and reduced dust generation. The barricading mechanism at NB and MAP road sections is comparatively poor and hence the dust eruption is higher in these roads. The sprinkling of water in dusty areas is regular as mentioned in the Environmental Management Action Plan (EMAP) of approved Environmental Assessment (EA) reports for all these roads however, the high sun and regular vehicular movement accelerated the rate of evaporation drying the water sprinkled sites within 10-15 minutes. Community consultations for the control and management of dust have been found in all of the road sections as an action of grievance redress mechanism rather than the participative approach. Lack of availability of adequate water sources at NB road section had been observed since most of the road section lies in dry and fragile Chure area. Regular maintenance of potholes, cross drainage construction sites and the diversion roads had not gained serious concern raising the dust control and management issues. The materials at batching plants, crusher yards, and stored near the permitted land were found uncovered creating the risk of dust nuisance.

6. Recommended Dust Control and Management Approach:

Following integrated dust control and management approach can be one of the best models for controlling and managing dust in road upgrading projects in Nepal:

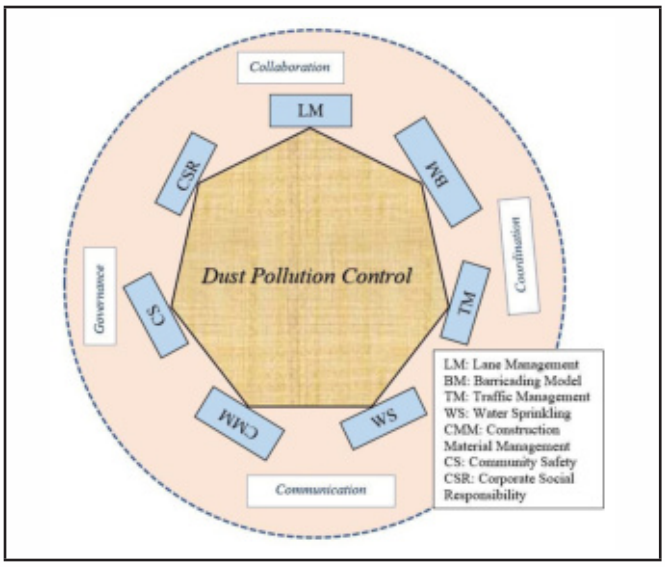

Fig. 4: Integrated Model of Dust control and management in Road upgrading projects in Nepal

6.1 Lane Management (LM): The movement of the vehicles and the earthen/dusty road surface of the lanes are directly proportional to the dust generation in road projects. Hence the management of the lanes through the Lane Management Plan (LMP) is significant for dust control and management. Upgrading of the road should always maintain a healthy permitted lane where the vehicles are permitted for movement. The plan should address the lanes to be upgraded and the time/schedule for construction/upgrading the particular sites. The plan should straightly guide the executing agency, CSC, and the contractors to provide the working lanes/sites only after the completion of the previous sites to minimize dust eruptions. The plan should integrate the regular maintenance of the permitted lane and prohibition of vehicular movement in the construction/upgrading lane.

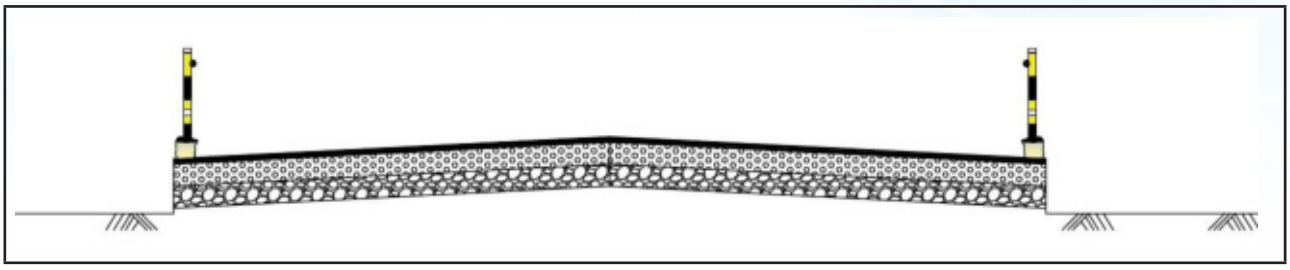

Fig. 5: Typical Cross-Section of Lane Management (Permitted Lane and Construction Lane)

6.2 Barricading Model: Barricading the permitted lane on both sides not only helps to maintain road safety but also prohibits the haphazard vehicular movement in the construction/upgrading lane and hence reduces the generation of dust. The simple barricading model practiced at KK Road has a significant contribution to the reduction of dust. The module consists of sand sacks/bags with about 10-15 kg of sand/soil where bamboo poles of about 1 meter are inserted. These bamboo poles are connected at the top with the bamboo stretcher that maintains the barricading model of about 20 meters. The bamboo poles are also interconnected with the help of barricading tapes so that the barricades are visible during the night. The 20-meter barricade model blocks are further connected with the same model blocks up to 100 meters in parallel to the permitted lane on both sides. It is required to keep the gaping of about 20 meters for the construction vehicles/access to the village/urban roads at an interval of 100 meters or as per required. The barricading model of 20 meters is also required to be placed vertically to the permitted lane to prohibit haphazard vehicular movement in the construction lanes/junctions. The benefit of this model is that it is made up of easily available local materials, and is cheap, reliable, cost-effective, portable, and easily replaceable when required.

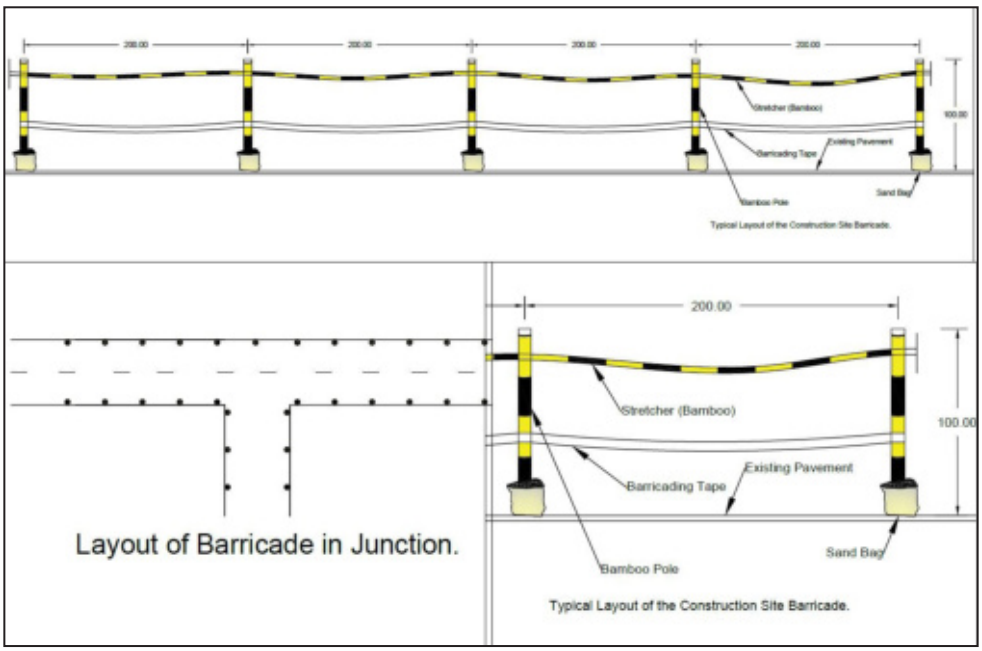

Fig. 6: Typical Layout for Barricade

The tentative costing of such a model based on the consultation with the CSC and Contractors of KK road has been as follows:

Table 7: Tentative cost estimate of barricading model for dust control and management

S.N.	Parameters	Unit	Rate (NRs)	Total (NRs)	Remarks
1	Number of Bamboo (6 meters) for Stretcher	1	350	350	This is an estimate for 20 meters block barricading model.
2	Number of Bamboo (6 meters) for rods	4	350	1400	
3	Sandbags (No.)	20	5	100	
4	Barricading Tape (m)	30	5	150	
5	Labor Charge	LS	500	500	
	Sub-total			**2500**	
6	Approach Side Management (5%)	LS		125	
7	Miscellaneous (15%)	LS		375	
	Total			**3000**	
	Estimation for 1 Km (both sides)			***300000***	

* The rate could vary as per conditions and district rate.
** Sand/Soil collected for construction or waste construction materials could be used in the sandbags.

6.3 Traffic Management: Traffic management is one of the tools to control and manage dust in upgrading projects. The plying of vehicles on the upgrading lane and diversion roads generates massive dust. The installation of traffic signs, deploying flag persons to maintain smooth traffic flow, timecards for the construction sites, maintaining overtaking spaces, penalties for overtaking from non-permitted lane/haphazard movement on the permitted lane, etc. could be some of the major action plans for traffic management.

6.4 Water Sprinkling: Water Sprinkling is the most common approach to suppress the dust eruption at construction sites. The construction/upgrading sites with high chances of dust generation need the regular sprinkling of water. The environmental and socially sensitive areas like the settlements, schools, hospitals, etc. require sprinkling of water regularly. The sprinkling of water on diversion roads and cross drainage structures sites also reduces dust eruption. The paved existing permitted lane requires frequent water sprinkling so that the dust carried by vehicles is washed out. The areas with no settlements and sensitive areas require frequent water sprinkling. The supply of water could be either by the use of tankers in the dry areas or could be with pipes in the areas with adequate availability of water sources. The construction of reserve ponds in the dry area will help the easy availability and accessibility of water regularly where possible. The sprinkling of the water at settlement areas could be managed by forming a water sprinkling committee representing the local government, local people from the settlement with dust nuisance, CSC, contractors, and the project office. This committee will be responsible for managing the dust in the settlement areas through water sprinkling regularly.

6.5 Management of Construction Materials: Management of sources of construction materials and processing of construction materials helps to reduce dust. The extraction and collection of construction materials shall follow the provisions as mentioned in the Environmental Management Plan (EMP) of not only the approved Environmental Assessment of road projects but also the local governments approved EA reports of sustainable collection of riverbed materials. The batching plants and crusher plants should be established at environmentally and socially acceptable sites and should have high, at least 6 meters, barricades to avoid the dust nuisance nearby. The processing activities shall follow a wet mechanism (use of water to the extent possible) to water trap the suspension dust. The processed water should be collected in a sedimentation tank. The water should be treated at least three times in the sedimentation tank i.e. at least three sedimentation tanks are required before the release of water to the nearby water bodies. The sedimentation tanks should be evacuated as soon as the tank is filled. The raw construction materials, to be treated and the stored treated construction materials, should be well covered with wind safety gear to avoid air-blown dust in the nearby community. The construction materials should be well covered during the transportation/haulage. The construction materials stored at construction lanes/sites should be utilized as soon as possible or should be barricaded and covered for the longer detention.

6.6 Community Safety: The safety of individual households in critical construction/upgrading sites can be covered with the help of a tarpaulin sheet for a shorter period. Before the dismantling of the private and public structures, proper barricade of such structures should be adopted.

The dismantling activities should be carried out during off hours without disturbance to the nearby communities.

6.7 Corporate Social Responsibility: The contractors and/or consultants involved in construction/upgrading are private entities liable for the overall safety of the community through Corporate Social Responsibility (CSR). A certain percentage of profits of such entities should go for environmental and social safeguards. A certain percentage of CSR should be allocated for dust management at certain settlements/communities by the contractors and/or CSC.

6.8Coordination,Collaboration,Communications, and Governance: There should be robust coordination, collaboration, and communication among DoR, Directorates, Projects/Division Offices, CSC, Contractors, Provincial and Local Governments, Communities, and other stakeholders for the synergistic effort to control and manage dust. Establishing result-oriented reporting mechanism by contractors/consultants to the Projects/Division Offices, Directorates, and DoR will timely address the dust issues. Environmental and social monitoring by central governmental authorities as per the Environment Protection Act (2019) and Environment Protection Regulations (2020), Provincial and Local Government will help to reduce dust issues in the construction/ upgrading of road projects.

6.9 For road expansion projects: The old two lane road if well maintained at the time of site possession can be utilized during construction stage for traffic operation. So, that the construction could be done at either sides and dust could be minimized by operating traffic in the maintained old land.

7. Conclusions

Control and management of dust is one of the major environmental problems to address during the upgrading of road projects in Nepal. Dust control and management need to adopt the integrated approach as the sources and reasons for the generation of dust are multiple. Lane management, barricading, traffic management, water sprinkling, construction material management, community safety, and corporate social responsibility are the seven pillars for the control and management of dust in road projects.

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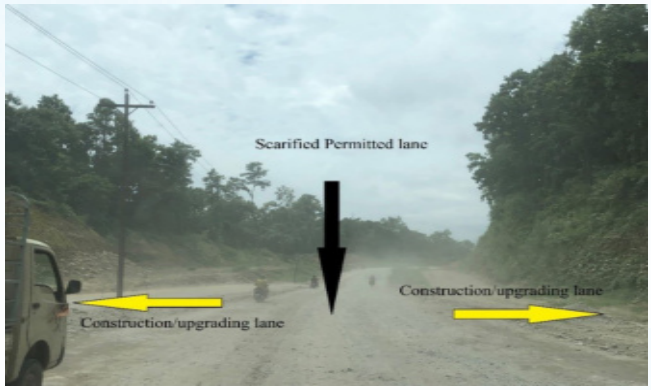
Few Pictures for Illustration

(a) Lane Management at KK Road



(b) Scarified permitted lane with poor maintenance at NB road

(c) Barricades for road safety and dust control at KK road

(d): Upgrading of side lane without barricading at NB road

(e) Water Sprinkling at settlement area at NB road section

(f) Crusher plant with sedimentation ponds at MAP road

(g) Batching plant with sedimentation pond at NB road

(g) Construction materials covered at MAP road

Selection of appropriate mitigation measures to reinstate the rockslide near Aabukhaireni along Mugling-Pokhara Road

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1. Introduction to the rockslide site

About 70m long section of the road at km 86+050 of Pokhara-Mugling section of Prithvi Highway was damaged on 10th June, 2022 after the heavy rainfall in the area. Due to the collapse of the road, one car and one motorcycle fell into the river and at least two persons were killed. One-way traffic was resumed after 24 hours by cutting the slope on the hillside, which is also vulnerable to slope failure.

Thereafter, on 21st June, the Department of Roads sent the geotechnical engineering expert to carry out the field visit, assess the rockslide and causes of failure, and suggest appropriate mitigation measures. After the site visit by the expert and preliminary assessment of the site, some additional information on the geology of the site and material properties were also gathered by conducting field and laboratory tests of rock samples. Based on all available information, the expert suggested different alternatives such as mitigation measures to reinstate the rockslide to open the two-way traffic. This paper highlights an overview of different options and describes the details of the best option.

2. General observation of the damaged section near Aabukhaireni

Fig. 1 and Fig. 2 show the damaged road section of road at km 86+050 of Pokhara-Mugling Road on the Mugling-Aabukhaireni section of Prithvi Highway. The damaged portion of the road is about 70 m long. The underneath material is highly fractured and jointed rock mass. The roadside slope is very steep, the slope angle varies from 60°-75°. There is the Marsyangdi River at the toe of the slope. Exposure of bedrock can be seen at the toe of the slope. There is no sign of toe cutting by the river at this location. The slope has rock exposure consisting of jointed and fractured rock mass with bluish-grey phyllitic rock (Fig 3).

Fig. 1: *Damaged Road section of Mugling-Aabukhaireni section of Road (Km 86+050)- Top View*

Fig. 2: *Damaged Road section of Mugling-Aabukhaireni section of Road (Km 86+050), Marsyangdi River on the right-hand side*

Fig. 3: Rock type, exposure, failed slope of damaged Road section of Mugling-Aabukhaireni section of Road (Km 86+050)

3. Possible solutions to the damaged road section

Since the failed section of the road is on the major highway linked to Pokhara from the capital, there is a high traffic flow. There is no possibility of constructing a diversion at this location and we cannot even close the road for construction works for a long time. As the slope uphill and downhill side is too steep, there are only a few options left to reinstate the slope in its original condition. To repair or reinstate this damaged road section, we can think of the following options:

A. Backcutting of the existing rock slope on the hillside and shifting the road centerline towards the hillside.

As a conventional solution, the road can be reinstated by cutting back the hill slope and the center line can be shifted towards the hillside. To keep the existing road width intact, the immediate protection of the rock slope on the valley side is also required, otherwise, it may topple further. For a double lane standard (7 m wide) road, it is required to cut about 2.0 m extra width on the rock slope which would go up to 20 m-30 m high on the slope. At least 7m width will be required to reinstate the two-way traffic on this section. A typical cross-section of the road cutting is shown in Fig. 4. If we need to make a standard double lane with drain and shoulder, we need at least 9.5 m road width, which means we need to cut at least 4.5 m extra width.

Advantages:

- It could be a conventional approach and could be an easy/difficult option depending on the nature of the rock slope above the road.

Disadvantages:

- This option will disrupt the regular traffic flow during rock cutting, and may be a threat to road traffic flow and for construction workers.
- It may cause the rockslide/rock to topple on the hillside and make the uphill slope more unstable.
- It may require blasting, which may be difficult or even not possible.
- The uphill slope may require rock bolting and anchoring and may need more time for construction.
- Although we cut the uphill slope for the required road width, the protection of the downhill rock slope with dowels, anchors, grouting, and shotcrete will be required.
- If we need a 9.5 m road width for a standard double lane, this option needs huge cutting, the cost will be higher, and the uphill slope could be unstable.

The tentative estimate for hard rock excavation on the side will be about 1000 m³ and it will require about 1500 sq m rock slope protection works on the uphill and about 2500 m² on a downhill slope. The rock slope protection works will include rock anchors/dowels and shotcrete concreting. The estimated cost of rock slope protection works without roadworks will be about NRs 3,00,00000.

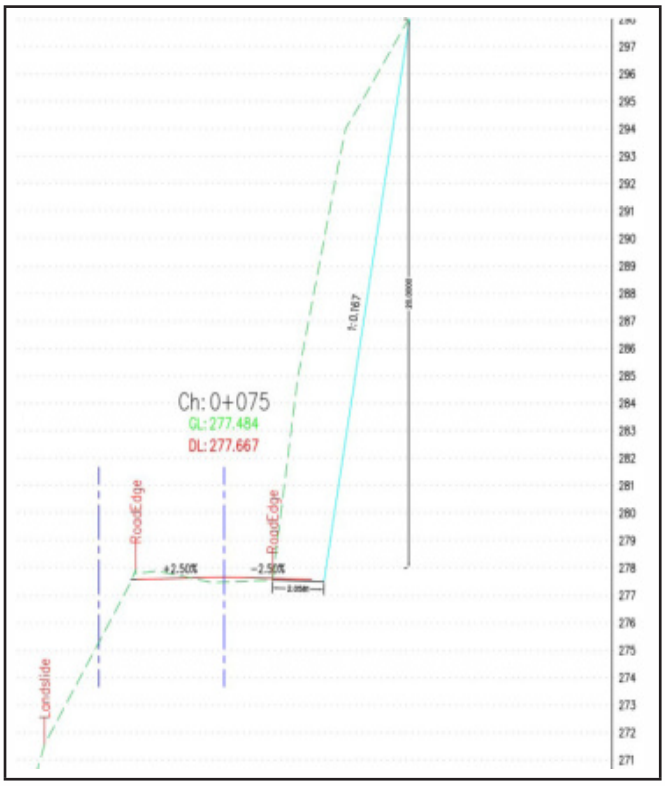

Fig. 4: For about 2 m extra width of road about 20 m high cutting is required in case of back cutting.

B. Reinstate the failed rock slope using rock anchors and RCC facing without backcutting

In this option, the failed slope will be reinstated by using a rock anchor, skin wall, and backfill (see Fig. 5 and Fig 6). Based on the field data obtained

from the division road office, a stability analysis of the slope section has been carried out. The result of the stability analysis of slope on a typical cross-section using a 40 cm thick RCC and self-drilling rock anchors (Fig. 6) at 1.5 m vertical spacing and minimum 5m bonding inside the bedrock is presented in Fig. 5 below. In this option, we can have about 9.5m road width with a downhill slope angle between 70°-80°. The details of the analysis and final design are presented in the next section.

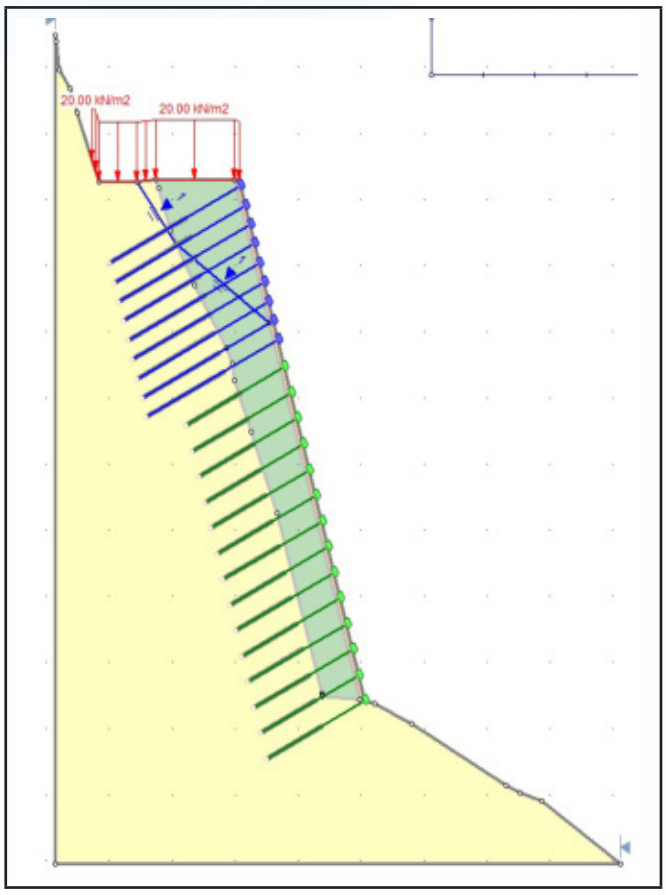

Fig. 5: A sample result of the stability analysis of failed rock slope with the use of rock anchors at 1.5 m spacings, 5-7 m embedment lengths, and with RCC facing wall.

Advantages:

- It could be a better engineering option to reinstate the road without restriction on regular traffic flow. In this option, the construction work will not hamper the regular traffic flow when we carry out the installation of rock anchors from bottom to top.
- No risk of instability on uphill as well as downhill slopes.
- Requires less time to repair the road compared to backcutting of uphill slope.
- Full road width of double lane standard (9.5 m) can be achieved easily.

Disadvantages:

- The drilling works on steep slopes will be much more difficult and will involve high risk to construction workers.
- It requires rock anchoring and drilling equipment which may not be available at the local contractor.
- It requires injection drilling and rock drilling bits which may not be available in the local market.

An estimated cost of slope protection without road works= NRs 4,75,00000

Fig. 6: An example of an anchored RCC wall using self-drilling anchors.

C. Reinstate the failed rock slope using rock nails with steel grid facing

This option is similar to option B, the only difference is instead of using rigid RCC facing, steel mesh facing will be used in this option. The use of steel mesh facing will ease the ground water movement and the growth of vegetation on the slope is possible which looks natural after some time. A typical section of steel mesh and anchor head connection used in this method is shown in Fig. 7.

Advantages:

- It could be an alternative and cheaper engineering option to RCC.
- The construction work will not hamper the regular traffic flow when we carry out the rock nails from bottom to top.
- No risk of instability on uphill and downhill slopes. No risk of blockage of groundwater.
- Requires less time to repair the road compared

to backcutting of slope or construction of RCC facing wall.

- It is possible to make a green surface by using bioengineering on the top of steel mesh facing.

Disadvantages:

- It requires rock anchoring/nailing and drilling equipment which may not be available at the local contractor/market.
- It requires injection drilling and rock drilling bits which may not be available in the local market.
- The steel mesh facing may be subjected to corrosion in the long run if we do not have quality galvanized steel in the construction.

***Fig. 7**: An option for protection works to reinstate the failed rock slope with the use of self-drilling rock anchors/nails (injection drilling) at 2m X 1.5m spacings, 2.0 m-3.0 m embedment length and with steel mesh/gabion wire mesh facing and backfilling with pervious materials.*

The slope construction will start from the bottom and layer-by-layer compaction of backfill should be done in each 0.5 m and self-drilling injection nail will be placed in every 1.5-2.0 m vertical height and at 1.5 m centers in horizontal direction. The connection of steel mesh and placement of the anchor head frame is shown in Fig. 8. The final slope will be as shown in Fig. 9.

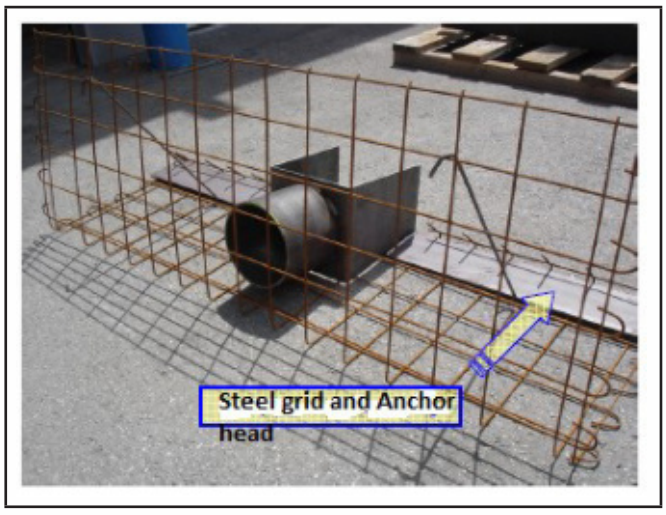

***Fig. 8**: Steel mesh and anchor/nail head frame placement in the proposed slope protection with steel mesh facing. All steel used in construction should be galvanized.*

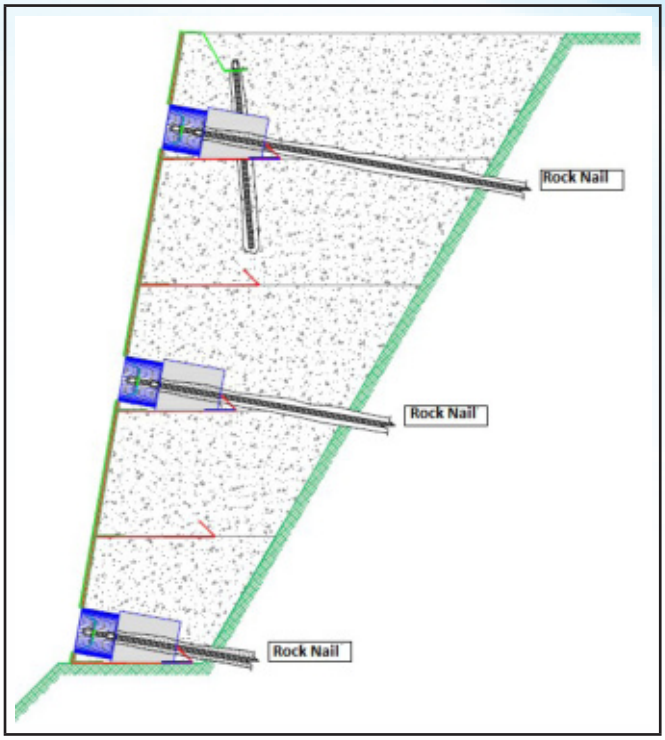

***Fig. 9:** Proposed protection works to reinstate the failed rock slope with the use of self-drilling anchors and steel mesh facing and backfilling. The rock nails should have at least 3 m embedment in the bedrock.*

An Estimated cost of slope protection without road works= NRs 3,25,00000

D. Reinstate the failed rock slope using piles, beams, and deck slab

The failed rock slope can be reinstated by using a combination of deck slab and beams supported by vertical and inclined piles. However, this solution will be expensive and as the rock slope has multiple sets of vertical joints, there is a high risk of global shear failure and toppling of rocks. This option also requires some anchors, dowels, and shotcrete on the downhill side. Traffic diversion may be required to implement this option; therefore, this option is not recommended.

E. Reinstate the failed rock slope using the steel bridge/bailey bridge

Another option to open the two-way traffic on this damaged section could be the installation of a single-lane bailey bridge of 60 m span. This option will be only for the short term. This option also requires some anchors, dowels, and shotcrete on the downhill side as the slope protection measures. In this option, traffic diversion for certain times may be required and downhill slope protection must be required.

4. Recommendations

Among all five options mentioned above, option B will be the most appropriate option considering the available material, technology, ease in construction, construction safety, traffic safety, and requirement of traffic diversion during construction. If there is a budget constraint, we could go for option C to save some costs. However, option C requires more quality control in the fabrication of the anchor head, galvanization of steel mesh, and compaction of backfill materials. Option C will take less time compared to option B because the setting time of RCC facing will be longer.

5. Detailed design of anchored wall

Anchored walls are needed in those locations where there is no sufficient space to construct foundation of the gravity or cantilever walls. Anchored walls derive their lateral capacity through anchors embedded in stable soil or rock behind all potential soil/rock failure surfaces. Anchored walls are similar to non-gravity cantilevered walls except that anchors embedded in the soil/rock are attached to the wall-facing structure to provide lateral resistance. Anchors typically consist of buried or grouted soil/rock anchors.

Since the failed slope height is more than 15m, a gravity wall needs about 9.00m wide space for the foundation. Therefore, on steep slopes and for high walls, if the slope is on the stable rock behind, an anchored wall will be beneficial and cost-effective. In the case of the present rockslide (Sakher rockslide), an anchored wall is designed, and the overall stability of the slope has been carried out.

5.1 Field survey and collection of field data

A field survey was conducted by the Damauli division and slope cross-sections were prepared for the model slope. The data on the groundwater condition and soil rock layers were obtained from the site visit and observation by the expert. The data related to the properties of soil and rocks are obtained by field tests (pull-out tests of test anchors, see Fig. 10) and laboratory tests. The values for cohesion and friction were estimated from the field test and lab test results.

Fig. 10: *Pull-out test of grouted rock anchors at the field.*

5.2 Preparation of slope model and stability analysis

A slope model of the critical section of the failed road slope was prepared in Slide 6.0. Soil /Rock layer information and properties are assigned to the respective rock, backfill, and reinforced concrete facing wall. Then rock anchors of varying lengths are inserted. After completion of the model, a traffic load of 20 KN/m² was also applied on the slope, and stability analysis was carried out. The result of stability analysis with consideration of surcharge load and earthquake force is shown in Fig. 11. The assumed parameters for rock and soils are also given in the table.

The use of 9 m and 12 m long anchors with bond lengths of 5m and 7 m considering the worst condition of the slope has resulted in a Factor of Safety of 2.75 which will be enough for this slope. The calculated forces in anchors and possible failure plane are shown in Fig.12. The final design of slope with rock anchors (38 mm dia. self-drilling) at 1.5m spacings on both sides with about 40 cm thick RCC facing wall is shown in Fig. 13.

The estimated total cost for the recommended design of anchor wall with all protection measures including road works is about NRs 6,45,00000.

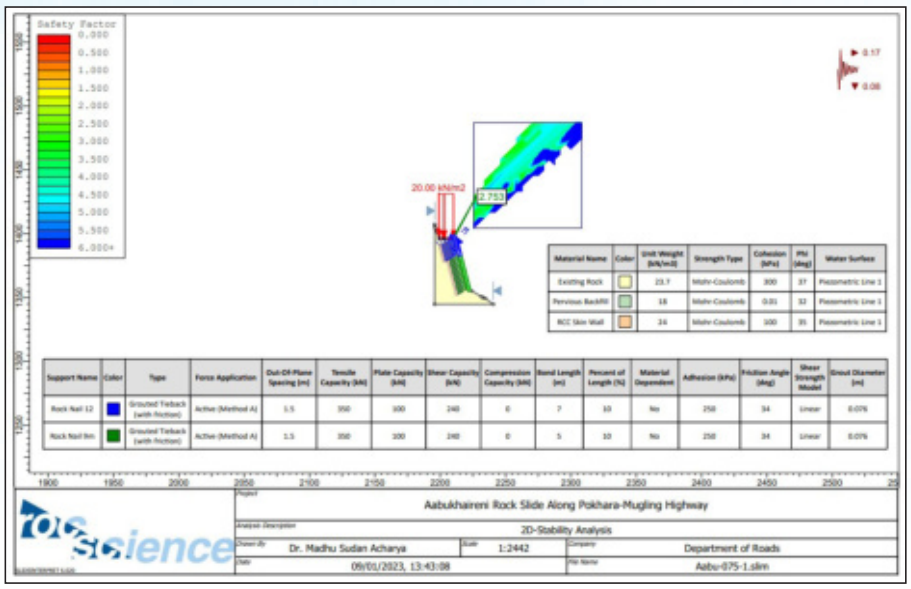

Fig. 11: *Result of slope stability analysis using SLIDE 6.0 software*

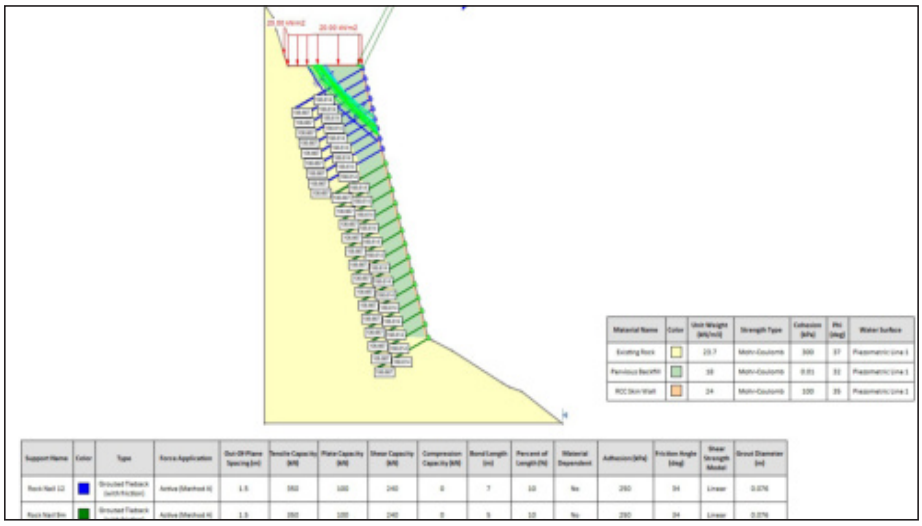

Fig. 12: *Calculated forces on anchor and possible slide plane, the result of slope stability analysis using SLIDE 6.0 software.*

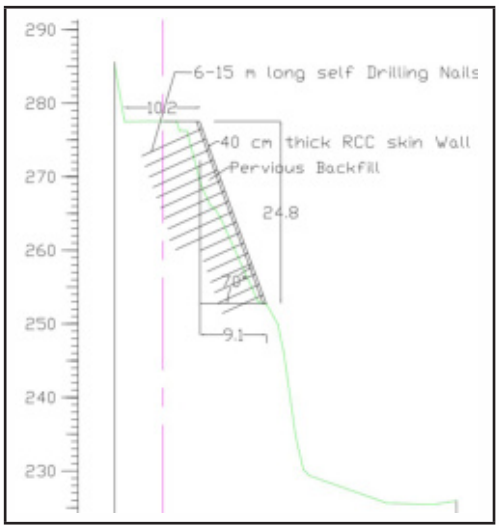

Fig. 13: *Final design of the slope with rock anchors (38 mm dia. self-drilling) at 1.5m spacings on both sides with about 40 cm thick RCC facing wall of about 25 m height.*

6. Proposed Construction Steps for nailing/ anchoring

a. First, it is required to install either a crane with a working platform on a stable area of the road or appropriately secured scaffolding and nail-driving equipment at an appropriate location which can be taken down the bottom of the failed slope.

b. From the working platform mounted on the crane or from the platform made by scaffolding, a few rows of self-driving nails (see Fig. 14) of designed length (at least 5-7 m embedment length inside rock) should be drilled, which should be projected outside up to the designed final slope line.

c. Then a reinforced cement concrete wall base should be prepared on the lower point of the rock slope by installing a few dowel bars as

required. Then concreting of the facing wall can be done up to the first layer of anchors which should be placed about 1m above the bottom of the RCC skin wall.

d. Then the 2nd layer of the anchor can be installed with a pre-designed slope angle (70°-75°) and backfill, and compaction of the first layer shall be done.

e. The whole backfilled slope will be stabilized by anchor and RCC facing working layer by layer until it reaches the road level.

f. It is suggested to use geo-membrane or geo composite in each 2m vertical as a separation layer and provide weep holes on the RCC facing at the same level to drain the groundwater/seepage water coming into the backfill materials.

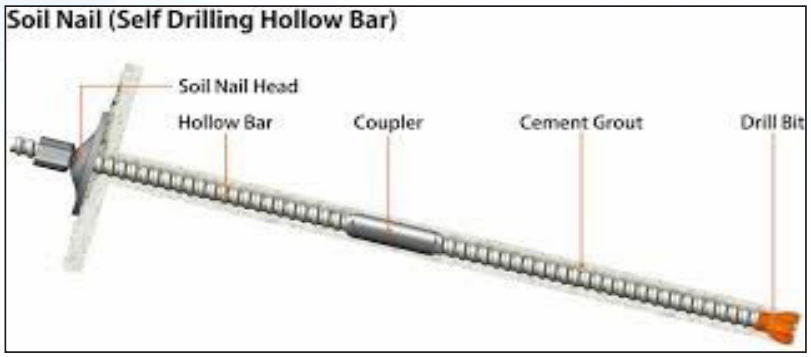

Fig. 14: *An example of self-drilling nail. It will be available both in solid and hollow sections of different diameters, for injection drilling hollow bar is used.*

Some photographs of the site are shown in figure 15 and 16.

Fig. 15: *Failed slope situation*

Fig. 16: *Preparation for wall base with dowel bars*

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