NEWSLETTER

Department of Roads (DoR)

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1. Appointment of new Director General

Er. Sushil Babu Dhakal was appointed as the new Director General (DG) of the Department of Roads on 2079-11-03. The department's employees warmly welcomed the new DG and bade farewell to the former DG, Er. Arjun Jung Thapa, who was transferred to the position of Joint Secretary in the Ministry of Physical Infrastructure and Transport (MoPIT).

After taking the leadership of the Department, the new Director General has prioritized following activities within the Department.

1) Improvement of laboratory facilities of department offices for quality control in construction works.
2) Increase the effectiveness of internal technical audit/ supervision by Federal Roads Supervision and Monitoring Offices.
3) Issue guidelines and directives for Dispute/ Claim Handling and Contract Termination/ Post Termination Mangaement
4) Use of Government Integrated Office Management System (GIOMS) for office automation among all DoR offices.
5) Timely amendment of known issues in Norms and Technical Specifications.
6) Use of innovative technologies in pavement maintenance.
7) Blackspot identification for reduction of road crashes.
8) Finalizing Employee job description.
9) Encouraging meetings on virtual platforms for monitoring and regular meetings.
10) Discouraging road encroachment and removal of properties within the right of way built without permission.
11) Initiate Training to Road Supervisors for axle load monitoring on National Highways.
12) Continuation of Bio-engineering and promotion of nature-based solutions.
13) Landslide mitigation, intervention based on rigorous investigations and historical evidence.

2. Major achievements during tenure of former DG Arjun Junga Thapa

1. Continued Bio-engineering more aggressively by establishing nurseries and implementing slope stabilization under Divisions and Project Offices.
2. Initiated Planning, designing and constructing modern office buildings in Federal Monitoring Offices and Road Divisions Offices.
3. Strengtheneded Laboratory facilities in Road Divisions and Projects Offices to enhance quality of construction and maintenance works.
4. Continued Publication of DoR Newsletter in regular basis.

5 Published different guidelines and manuals that are useful for design, construction, supervision and maintenance works.

6. Finalized O&M Survey and made necessary plans for strengthening human resources.

8. Focused on Road Assets Management works of DoR.

3. Budget Expenditure and Progress (3rd Trimester 2079/80)

S. No.	Description	Budget
	Annual Budget Allocation	129.32 Billion
	Total Expenditure up to 3rd Trimester	47.49 Billion
	Fiscal Progress compared to Annual Allocation	36.72%

S. No.	Description	Annual Target	Progress up to 3rd Trimester	Progress compared to Annual Target
	Blacktop, Km.	1300	264	20.31%
	Gravel, Km.	650	355	54.62%
	Earthen, Km.	400	110	27.50%
	Rehabilitation/ Reconstruction, Km.	600	177	29.50%
	Periodic Maintenance, Km.	761	278	36.53%
	Bridge Construction, Nos.	300	81	27.00%

4. Design and Construction of Three Span Continuous Open Spandrel Concrete Deck Arch Bridge

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4.1 Introduction

Fig. 4.1 Google map of bridge site

The bridge site is located at Kachalighat, Kuine, Surkhet along Chisapani-Babiyachaur-Badichaur-Surkhet Road. The left and right banks lie at Tatopani Taule-9, Surkhet and Sugarkhal, Kuine-9, Kailali respectively. The bridge lies about 10 kms upstream of existing famous Karnali Cable Stayed Bridge in East West Highway. The Google co-ordinates of bridge site is 28^{0}43'22.85"N, 81^{0}16'21.97"E (figure 4.1). The contract for construction of this arch bridge was awarded in AD 2015-07-13 as a design build contract. The contractor was ANK-Lumbini JV. The construction was completed completed and opened to traffic in AD 2023-01-9. This bridge has set up many records in the bridge construction history in Nepal and will be a milestone in the era of modern bridge construction. This is the first longest continuous open spandrel concrete deck arch bridge in Nepal. It is the second continuous arch bridge in Nepal as the first one is the Babai arch bridge along Nepalganj-Surkhet road. The complexity of false work and construction technology was significant being successfully handled by Nepalese contractor till now.

4.2 Salient features:

The General Arrangement of bridge is shown in figure 4.2. The salient features of the bridge are presented below:

Total length of bridge = 300 m

Arch Span (L) = 87.4 m (Span 1), 99.1m (Span 2),100.1m (Span 3)

Arch Rise = 18.2 m (Span 2)

Span Rise ratio = 5.5(Span 2)

Numbers of arch ribs = 3

Size of main arch rib = 0.9 m (B) x 1.5m (D)

Left arch block foundation = Open foundation on rock

Right arch block foundation size = Pile foundation with full scour protection

Total width of bridge = 11.0 m

Carriageway = 7.5m

Footpath width = 1.6m

Contract amount: NRs. 339,661,000.00 including VAT & PS.

Unit cost w.r.t contract amount: Nrs, 1,132,203 per running meter

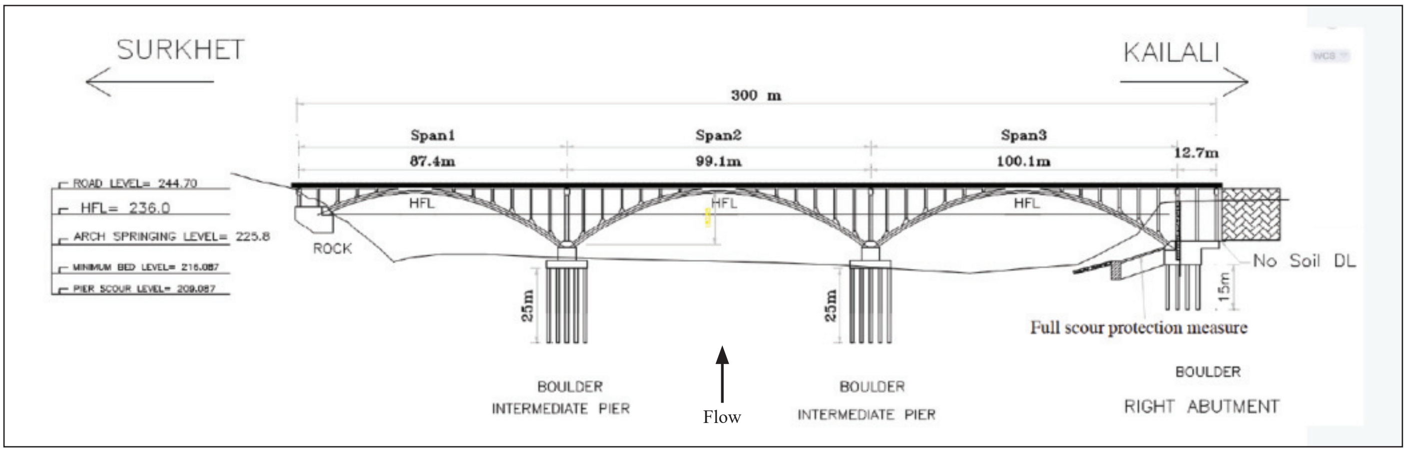

Fig. 4.2- General Arrangement of bridge

4.3 Design

The bridge is designed as per IRC design specification.

The main loads considered in this independent work are (i) Dead load (ii) Live/ Moving load (iii) Braking load (iv) Wind load (v) Earthquake load (vi) Temperature load (vii) creep load (viii) Shrinkage loads (ix) Load due to elastic shortening etc. The main design steps are:

(a) Design of slab

(b) Design of cross girder

(c) Design of longitudinal girder

(d) Design of spandrel column

(e) Design of arch rib

(f) Design of bracing connecting arch ribs

(g) Design of arch foundation block

(both abutment and pier)

The finite element model was developed in SAP2000 (figure 4.3) to find out the internal stresses in different elements which has been compared with manual analysis. In FE modeling, slab has been modeled as shell element; cross girders, longitudinal girders, spandrel columns, arch ribs and bracing connecting arch ribs are modeled as beam elements. Linear static analysis, non-linear static analysis, buckling analysis and response spectrum analysis has been carried out. The section design has been carried out for computed internal forces. The special design challenge for this bridge are due to different support level of arch springing in span1 and the bridge is of 3 span continuous structure.

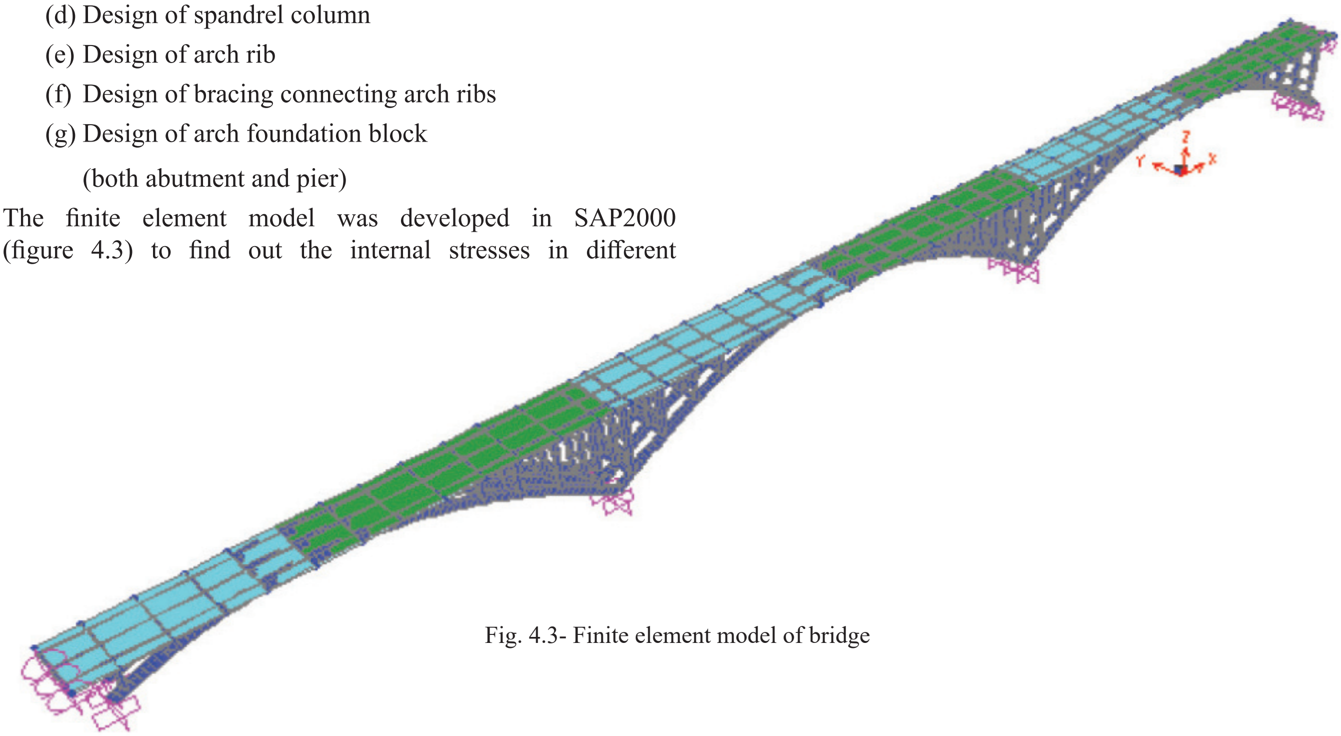

Fig. 4.3- Finite element model of bridge

4.4 Construction Sequence

Construction is the most challenging issue in arch bridge than other types of bridges like suspension and cable stay bridges. Although overall bridge cost is less in arch bridge, there is always construction issue. The construction sequence is:

a) Arch foundation block construction in abutment and piers (pile foundation)

b) Construction of spandrel column above arch foundation block

c) Construction of arch rib of span1 and span2 with scaffolding

d) Construction of arch rib of span3 with temporary truss

e) Construction of arch rib connecting bracing

f) Spandrel column construction

g) Construction of longitudinal girder and cross girder for deck

h) Construction of slab

i) Construction of bearings, expansion joints and appurtenances

The Construction Sequence are shown in figure 4.4(a).

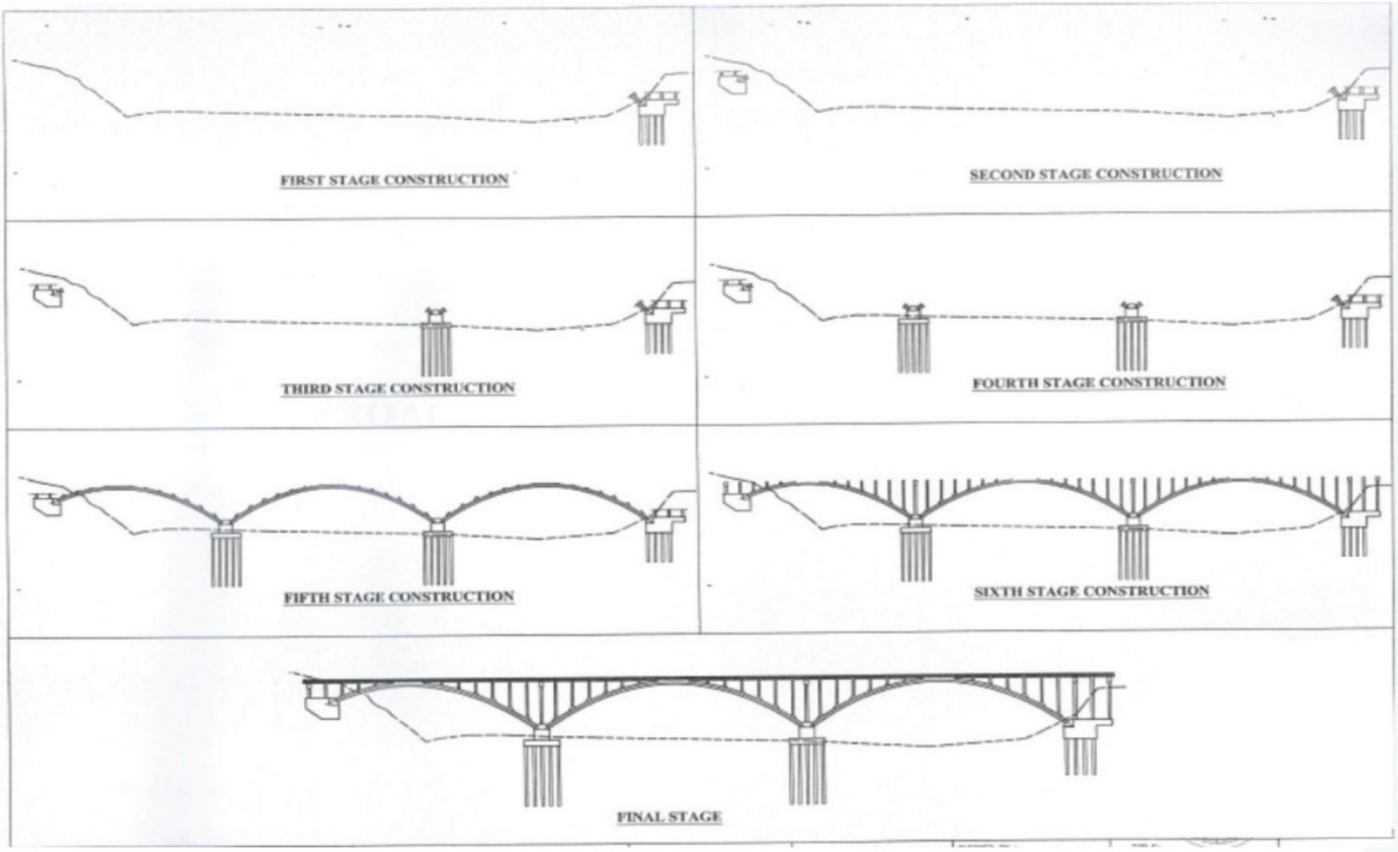

Fig. 4.4-(a) Construction sequence

4.5 Conclusion

This Kuine arch bridge is the first longest continuous open spandrel concrete deck arch bridge in Nepal. The special design and construction challenge for this bridge are due to different support level of arch springing in span1 and the bridge is of 3 span continuous structure. Successful construction of this bridge is the milestone for construction of motorable arch bridge in Nepal. Nepalese Engineers have gained a lot of knowledge and confidence after constructing this bridge. Replication of construction of such type of bridge in other location in Nepal is highly recommended due to its overall least cost and Nepal's favorable topography.

Fig. 4.4-(b) Bridge site before construction begins

Fig. 4.4-(c) Left abutment during construction

Fig. 4.4-(d) Right abutment during construction

Fig. 4.4-(e) Pier during construction

Fig. 4.4-(f) Construction of Span1 and Span2 using staging

Fig. 4.4-(g) Construction of Span3 using temporary truss

Fig. 4.5-(h) Longitudinal and cross girder reinforcement for Deck construction

Fig. 4.5-(i) MSE wall in right abutment

Fig. 4.5-(j) Completed Bridge

Fig.4- Construction sequence and photograph of Bridge Site

5. Shortest Distance Calculator: An implementation example at the DOR

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5.1 Introduction

The size of Nepal's road network has reached almost one hundred thousand kilometers. For traveling from one place to another there are a number of alternating routes available for choice. It is always logical to choose a route that is either the shortest in length or takes the shortest time for travel. In this article, we are examining only the route having the shortest length. It is not always straightforward to choose the best route for travel.

Many business entities including transport-related organizations, banks, and others frequently need to have knowledge of the length of the road travel between two places. To solve this problem an attempt was made by the author to create a computer program that may quickly give the desired route with the shortest length. The result of this attempt was published in the form of a web application on the DOR website in 2005.

Distance calculator is available in DoR website. It is a computer-based application that gives the shortest distance between various places in Nepal in a user-friendly way. In this article, the methodology adopted for the creation of the application and the theory behind it will be discussed. The task of this creation was done in several steps: the modeling of the physical routes in a logical way understandable by the computer and then analyzing the network for the optimum route.

5.2 Modeling the road network

A road network consists of a number of places connected by roads. This type of network can be modeled by a mathematical concept known as Graphs. A Graph is a mathematical structure that shows the relationship between various objects in a visible way. In a graph, objects are represented by their nodes or vertices. The name of the nodes is shown beside them. These nodes or vertices are connected together by lines called edges representing the relationship between the objects. These lines have some numerical values called weights that depict the 'amount' of the relationship between the objects they connect. These weights are usually shown beside the line denoting the edge.

When a road network is represented by Graph, its vertices represent the places and the edges represent the roads between these places. The weight of the edges represents the length of the roads to travel between these places.

The Graph representing the entire road network of the country might be a very large geometrical figure. For the simplicity of discussion, a small fraction of the entire road network is taken here. This sample road network represented as a Graph is depicted in figure 5.1.

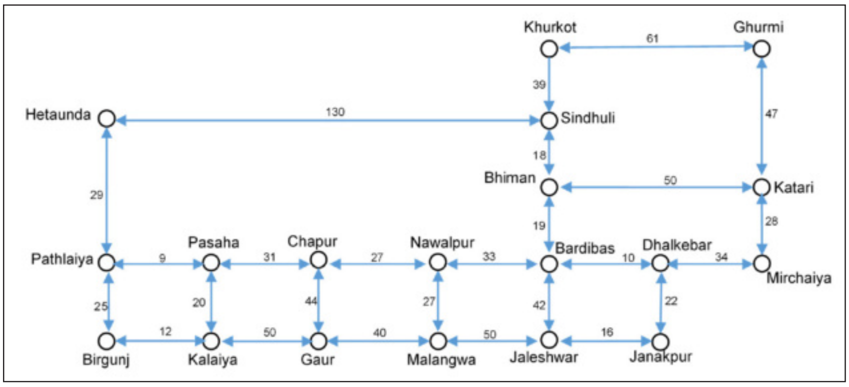

Fig. 5.1: Road Network Example

Although the graph in fig 5.1 clearly depicts the road network with the relationship between nodes, it is not suitable to input into the computer. It should be converted to a suitable data structure to be easily readable by the computer.

There are many types of data structures available to model the road network or Graph. We have adopted a comma-delimited text data structure. In this type of data model, each node is represented by a line of text with several fields separated by commas.

It consists of the name of the place followed by the name of the connected nodes and their distances separated by commas. If two nodes are interconnected by only a one-way road then the line of text consists of only the name of the source node.

For example, for the network shown above the place named Nawalpur is connected with Malangwa, Chapur, and Bardibas with roads of 27km, 27km, and 33km respectively. The information about this place is modeled as a line of text as follows:

Nawalpur, Malangwa,27, Chapur,27, Bardibas,33

Similarly, all nodes of the sample network are modeled and put as lines of text. It is advisable, but not necessary, to keep the lines of the text in alphabetical order. This greatly simplifies the addition, deletion, or alteration of the place information in the text file.

The whole road network represented by the graph shown in figure 5.1 is converted to several lines of text as shown below. As explained earlier each line of text represents one place or node of the network. The network consists of 19 nodes and there are 19 corresponding lines of text.

```
Bardibas,Bhiman,20,Dhalkebar,10,Jaleshwar,42,Nawalpur,33
Bhiman,Sindhuli,18,Katari,50,Bardibas,20
Birgunj,Kalaiya,12,Pathlaiya,25
Chapur,Gaur,44,Pasaha,31,Nawalpur,27
Dhalkebar,Bardibas,10,Janakpur,22,Mirchaiya,34
Gaur,Chapur,44,Malangwa,40,Kalaiya,50
Ghurmi,Khurkot,61,Katari,47
Hetaunda,Sindhuli,130,Pathlaiya,29
Jaleshwar,Bardibas,42,Janakpur,16,Malangwa,50
Janakpur,Dhalkebar,22,Jaleshwar,16
Kalaiya,Birgunj,12,Gaur,50,Pasaha,20
Katari,Mirchaiya,28,Bhiman,50,Ghurmi,47
Khurkot,Sindhuli,39,Ghurmi,61
Malangwa,Nawalpur,27,Jaleshwar,50,Gaur,40
Mirchaiya,Katari,28,Dhalkebar,34
Nawalpur,Malangwa,27,Chapur,27,Bardibas,33
Pasaha,Pathlaiya,9,Chapur,31,Kalaiya,20
Pathlaiya,Pasaha,9,Birgunj,25,Hetaunda,29
Sindhuli,Khurkot,39,Bhiman,18,Hetaunda,130
```

Fig. 5.2: Road Network text file

The fig. 5.2 lines of text are saved in the computer in the form of a file. This is implemented as a file called ' networkinfo.txt' in the Distance Calculator application.

5.3 Analysis of the network

After the road network is implemented as a file and kept in the computer memory, we have to create a program to interact with this file and provide the solution sought. The program takes the input of the places of the source and destination from the user, extracts the information about the road network, analyzes it, and gives out the shortest distance of travel from the Source to the destination as well as the route in the form of a sequence of places.

The algorithm used in the Distance Calculator is known as Dijkstra's Algorithm.

Dijkstra's algorithm is a popular shortest-path algorithm used to find the shortest path between two nodes in a graph with non-negative edge weights. The algorithm is named after its inventor, Edsger W. Dijkstra, a Dutch computer scientist.

Here is how the algorithm works:

1. Start by selecting a source node in the graph.
2. Assign distance value i.e distance from the source node to every node in the graph. For the source node, the initial distance value is set to 0, and for all other nodes, it is set to infinity.
3. Set the source node as the current node.
4. For the current node, consider all of its neighbors and calculate their tentative distance values by adding the weight of the edge between the current node and each neighbor to the current node's tentative distance value.
5. If the calculated tentative distance value of a neighbor is less than its current tentative distance value, update its tentative distance value to the new value.
6. When all the neighbors of the current node have been considered, mark the current node as settled. A settled node will never be checked again.
7. Select the unsettled node that has the smallest distance value, and set it as the new current node.
8. Repeat steps 4 through 7 until the destination node is settled.
9. At the end of the algorithm, the shortest path from the source node to the destination node can be found by following the path with the smallest sum of weights.

Flow Chart for the whole process is given below:

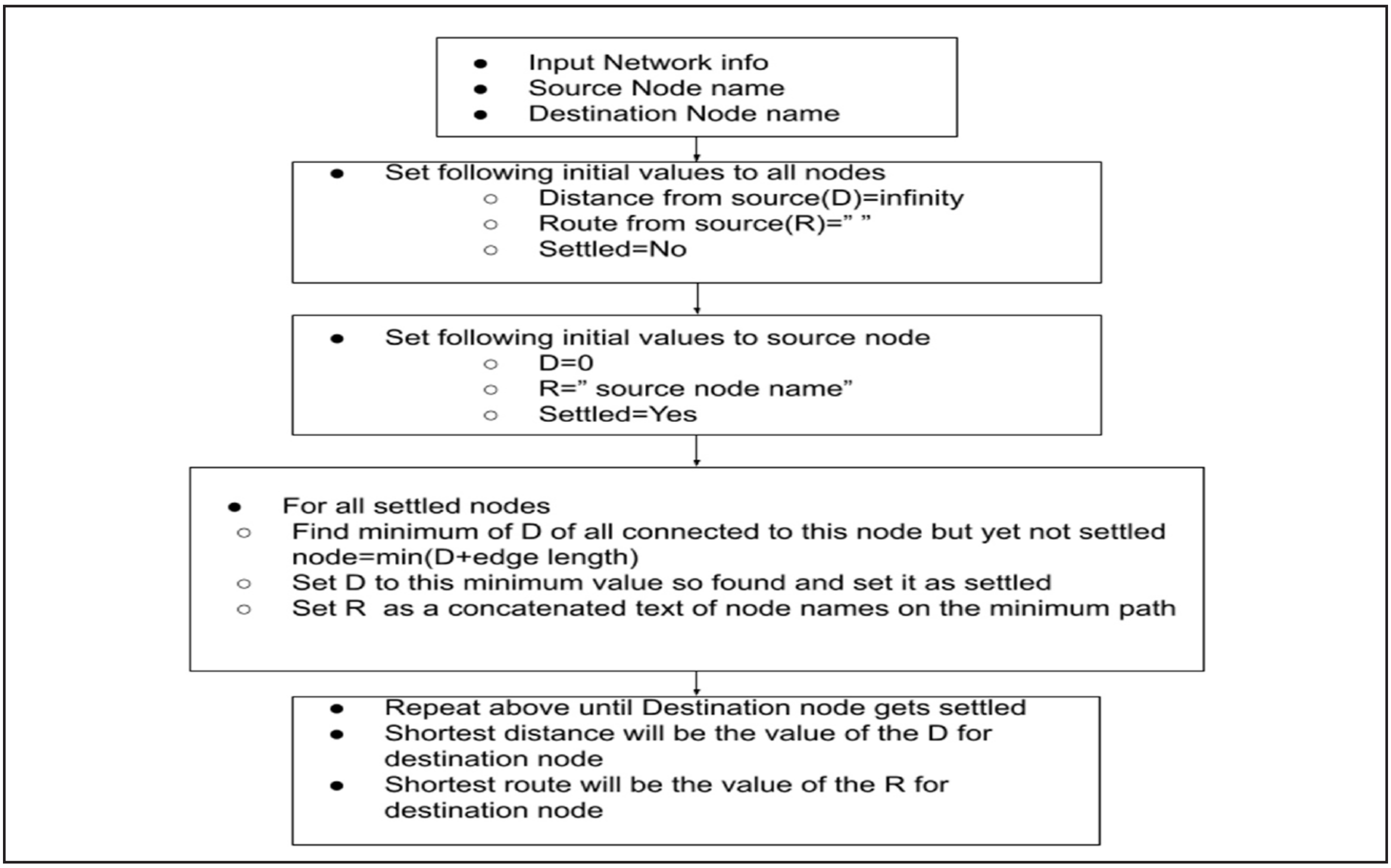

Fig. 5.3: Flowchart for Dijkstra's Algorithm

The working of the algorithm is explained in an example here. Suppose you have to travel from Hetauda to Janakpur. On the way, you have to attend an important function at Gaur. In this case, the network is analyzed in two stages: one from Hetauda to Gaur and another from Gaur to Janakpur.

In our example for the first leg of travel i.e while traveling from Hetaunda to Gaur:

Initialization

- Source node-Hetauda
- Destination-Gaur
- Distance of Hetaunda from source node=0
- Route to Hetaunda from source node= ”Hetaunda” is Hetaunda settled?

After the first step

- Current Node=Hetauda
- Distance of Pathlaiya from source node=min(0+29,infinity)=29
- Route to Pathlaiya from source node=” Hetauda-Pathlaiya”
- Distance of Sindhuli from source node=min(0+130,infinity)=130
- Route to Sindhuli from source node=”Hetaunda-Sindhuli” is Pathlaiya settled? yes

After the second step

- Current Node=Pathlaiya
- Distance of Birgunj from Hetaunda=min(29+25, infinity)=54
- Route to Birgunj from source node=”Hetaunda-Pathlaiya-Birgunj”
- Distance of Pasaha from source node=min(29+9,infinity)=38
- Route to Pasaha from source node=”Hetaunda-Pathlaiya-Pasaha” is Pasaha settled? yes

After the third step

- Current Node=Pasaha of Kalaiya from source node=min(38+20,infinity)=58
- Route to Kalaiya from source=”Hetaunda-Pathlaiya-Pasaha-Kalaiya”
- Distance of Chapur from source node=min(38+31,infinity)=69
- Roue to Chapur from source=”Hetaunda-Pathlaiya-Pasaha-Chapur” is Kalaiya settled? yes

After the fourth step

- Current Node=Kalaiya
- Distance of Gaur=min(58+50,infinity)=108
- Route to Gaur from source=”Hetaunda-Pathlaiya-Pasaha-Kalaiya-Gaur”
- Distance of Birgunj from source=min(58+12,54)=54
- Route to Birgunj from source=”Hetaunda-Pathlaiya-Birgunj”
- Is Gaur settled? yes
- Is Birgunj settled? yes

Thus we have found the shortest distance from Hetaunda to Gaur as 108 km on the route Hetaunda- Pathlaiya- Pasaha-Kalaiya- Gaur. In a similar way, we can find the distance from Gaur to Janakpur as 106km on the Gaur- Malangwa- Jaleshwar-Janakpur route. So finally we get our solution as shown in fig. 5.4. The final shortest route is highlighted in fig. 5.4 below.

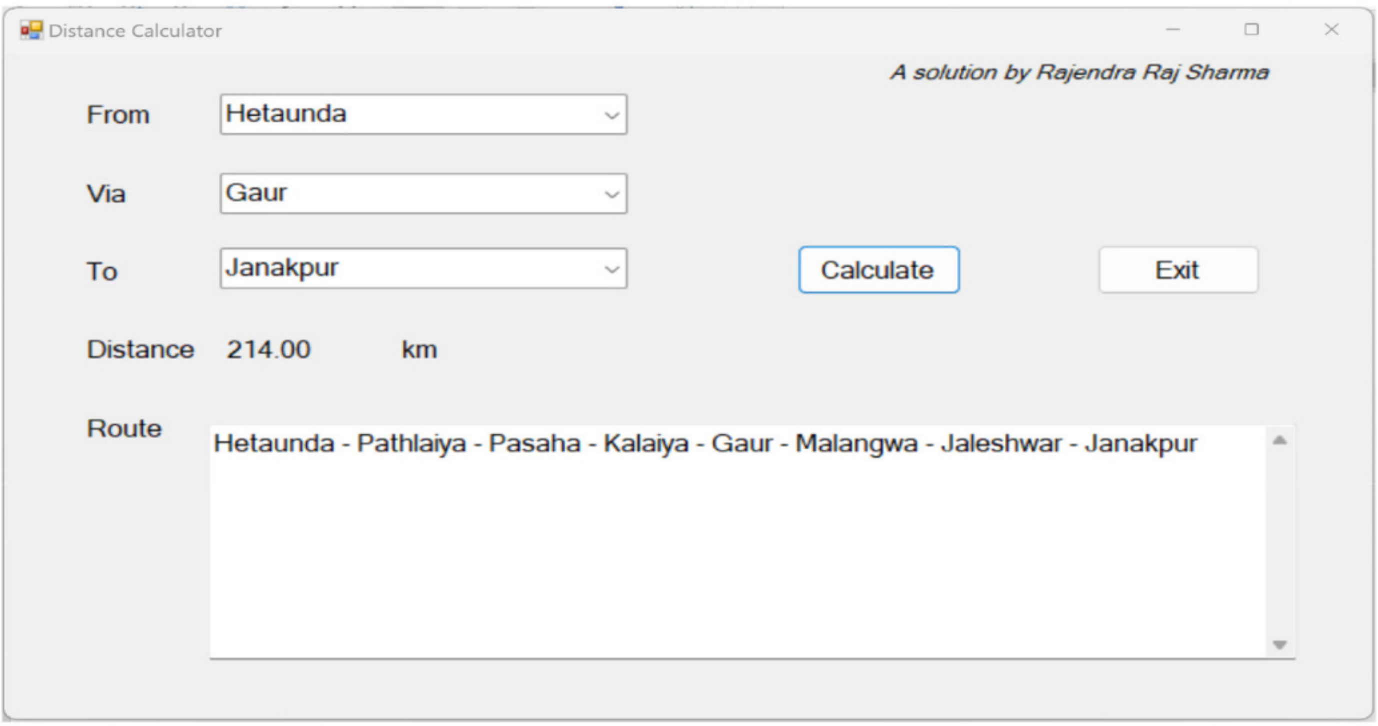

Fig. 5.4: Graphical User Interface

5.4 Implementation

The whole process of finding the shortest path as per the algorithm discussed above was implemented in a computer program with the code written in Visual Basic language and converted to a binary i.e. .exe format. A fragment of the code is given below:

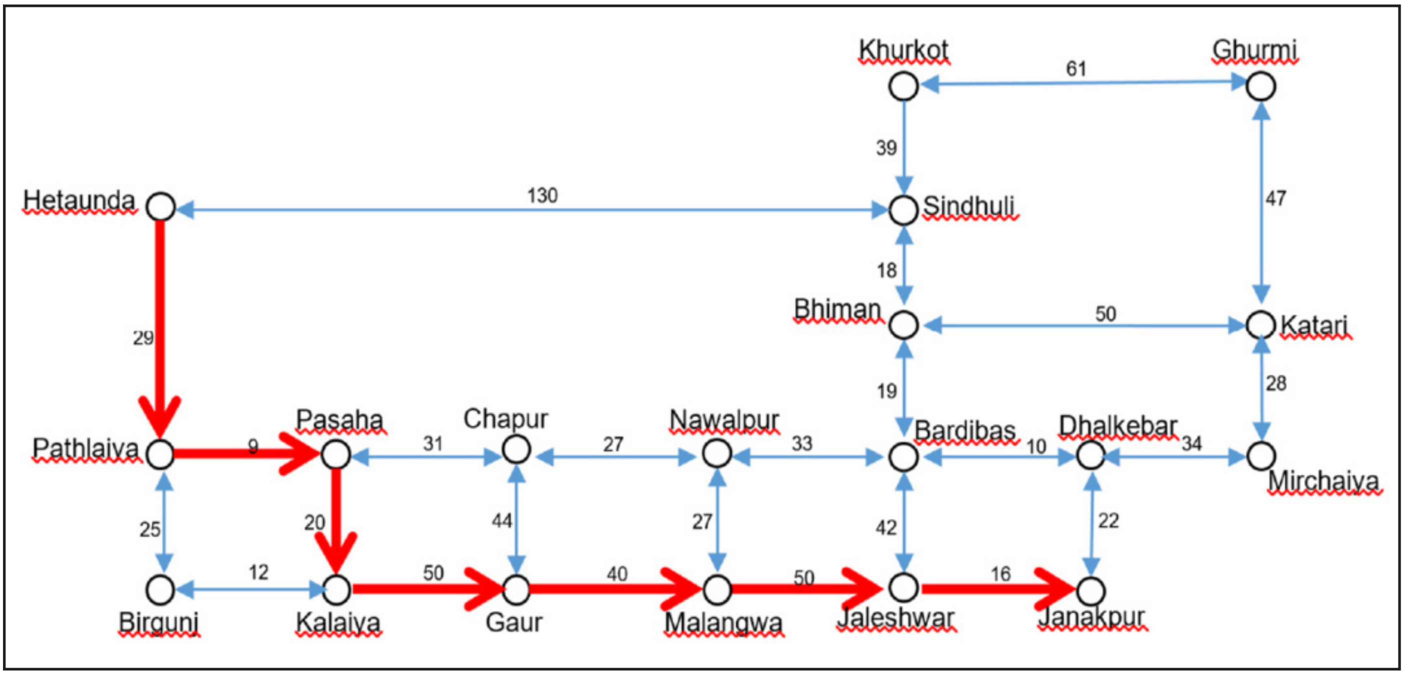

Fig. 5.5:Solved route

```
'Implementation of shortest path algorithm for the road network of Nepal by
'****RAJENDRA RAJ SHARMA***
Public Class frmMain
    Structure Vertex 'New type of variable for nodes information defined
        Public Name As String
        Public numofNextNodes As Integer
        Public NextNodeName() As String
        Public distToNextNode() As Single
        Public DistFromOrigin As Single
        Public RouteFromOrigin As String
        Public settled As Boolean
    End Structure
    Private Sub FindDistanceRoute(Origin As String,
                                  Destination As String,
                                  ByRef Distance As Single,
                                  ByRef Route As String)
        'This procedure takes the name of origin and destination routes and
        'gives Distance And Route between these nodes
        Dim Oindex As Integer, Dindex As Integer
        Dim i As Integer, j As Integer, m As Integer
        Dim d As Single, R As String
        Dim min As Double
        For i = 0 To numofnodes - 1 ' reset all changed values
            With node(i)
                .DistFromOrigin = infinity
                .RouteFromOrigin = ""
```

Fig. 5.6: Fragment of the code

5.5 Further Works

As a further development of this program or application, a geographical map showing the location of places can be added to this system. Furthermore, in addition to the length of the links average travel speed on that link can be added so that the shortest travel time can also be found. Since the first implementation of this application back in 2005 the road network has grown tremendously, the text file with network information should be completely updated to include the new links and nodes. If there is any query regarding this implementation one can contact me by email at razendra@live.com.

6. Field Verification of Asphalt Mixtures

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6.1 Introduction

A thorough understanding of the concepts regarding volumetric properties is essential in understanding variability that can occur when field-produced mixtures are compared to laboratory mix design results. Issues such as absorption, mixture conditioning and gradation have significant impact on the volumetric results of field-produced mixtures.

6.2 Laboratory design versus field production

Good performance of asphalt pavements is achieved by using high-quality materials, precise process control during mix production and best placement practices during construction. The life of a pavement and the cost of maintenance can be very sensitive to seemingly minor variations in materials properties, such as aggregate gradation, asphalt content, mixture volumetrics and compaction.

The goal of mix design is to establish mix formulation and process control targets known as the job mix formula (JMF). A JMF should contain the following criteria along with appropriate production tolerances:

- binder content;
- gradation of each specified sieve size;
- cold feed and/or hot bin proportions;
- aggregate properties including bulk specific gravities;
- bulk and maximum specific gravities of the mixture; and
- volumetric properties including P_a, VMA, VFA, and DP;
- stability, flow or other performance parameters specified.

Field verification of the asphalt mix involves testing and analyzing the field-produced mixture to ensure that the JMF criteria specified above are met. Significant differences exist between the small-scale operation of the laboratory mixing bowl and a 500-ton-per-hour HMA plant.

HMA produced in the field will often display different volumetric properties when compared to results in the lab. Laboratory mix and field-produced mix have different physical handling of the aggregate before and after blending of materials, varied use of particulate control and a differing environment in which absorption can occur. All of these, along with other variables, can produce changes in the VMA and air voids of the field-produced mixtures when compared to the laboratory mix design.

Mix Design Type: Asphalt Concrete Wearing Course By Marshall Design Method

1. Sieve analysis test results of the provided aggregates and filler materials :

Sleve size mm	% PASSING			
	19 mm down Agg size	10 mm down Agg size	4.75 mm down Agg size	Mineral Dust Filler
25	100.00	100.00	100.00	100.00
19	71.55	100.00	100.00	100.00
13.2	8.83	100.00	100.00	100.00
9.5	4.97	88.52	100.00	100.00
4.75	4.78	16.58	92.48	95.18
2.36	4.00	7.31	66.66	75.58
1.18	3.20	7.12	37.41	49.60
0.6	2.56	2.91	28.53	40.75
0.3	2.00	2.58	16.13	33.01
0.15	0.96	1.75	4.74	24.58
0.075	0.16	0.35	0.05	20.36

2. Proposed mix proportions of provided aggregates and dust filler:

19 mm aggregate	=	35	%
10 mm aggregate	=	30	%
4.75 mm aggregate	=	5	%
Mineral Dust filler	=	30	%

3. Sleve analysis of the mix aggregates after provided proposed mix proportions:

Sleve size mm	% passing Mix grading of agg, sand and dust	Specified Limit
25	100	100
19	90.04	90-100
13.2	68.09	50-79
9.5	63.30	52-72
4.75	39.83	35-55
2.36	29.60	28-44
1.18	20.01	20-34
0.6	15.42	15-27
0.3	12.18	10-20
0.15	8.47	5-13
0.07	6.27	2-8

4. Specific Gravity Test Results of provided aggregates, dust filler and bitumen :

a. 19 mm size aggregate	=	2.674
b. 10 mm size aggregate	=	2.668
c. 4.75 mm size aggregate	=	2.659
d. Mineral Dust Filler	=	2.654
e. Specific gravity of vitumen	=	1.043

5. Proposed Optimum Bitumen Content after Marshall Design Test results analysis :

Optimum Bitumen Content by weight of Total Agg. Mix = 5.56 %

6. A/C Mix Design Results at proposed Optimum Bitumen Content :

a. Stability at	5.54	%	Bitumen Content =	13.60	KN
b. Flow Value at	5.54	%	Bitumen Content =	2.16	mm
c. Bulk Density at	5.54	%	Bitumen Content =	2.378	gm/cc
d. Air Voids at	5.54	%	Bitumen Content =	3.10	%
e. Voids in Mineral Aggregates at	5.54	%	Bitumen Content =	15.55	%
f. Voids filled with bitumen	5.54	%	Bitumen Content =	80.00	%

Table 6.1: Sample Job Mix Formula

A mix design technician or engineer should account for anticipated differences between the lab and field when they have experience with the proposed materials, especially the aggregate, and the plant that will produce the mix.

Field verification of an asphalt mix is necessary to measure what differences exist and what corrective measures, if any, need to be made. Out- of-date mixture designs are often a source of production problems. If the mix design was performed some time (maybe months) ahead of paving, or the materials used during the design are not representative of the materials used on construction, there may be an unacceptable difference between the plant-produced mix and the JMF established in the mix design phase. Plant adjustments may bring the plant-produced mix within the gradation specifications, but may have a hard time complying with the volumetric and performance requirements.

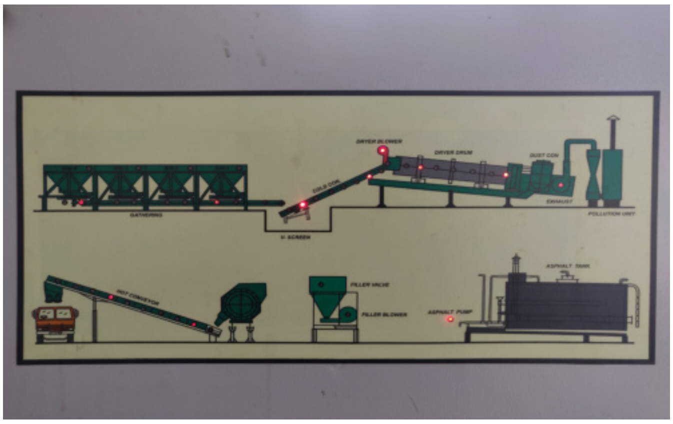

Fig. 6.1: Field Production of Mixture - 2

Fig. 6.2: Field Production of Mixture - 1

Fig. 6.3: Laboratory Production of Mixture - 1

Fig. 6.4: Laboratory Production of Mixture - 2

Reconciliation of the differences that are found between the JMF and field-produced materials should be approached from a systematic perspective. First, recognition of what can or cannot be readily changed to meet the project requirements during production needs to be established. An example of where changes may not be allowed without a complete redesign of the mix includes the failure of aggregate materials to meet source property requirements.

Many adjustments can be made during production to maintain adequate results. Aggregate proportions and asphalt content are two items that are often adjusted during production. Adjustment to only one item at a time is recommended. Multiple, concurrent adjustments can cancel each other out to produce a net result of no change or a drastic change to the mixture.

6.3 Quality control tests and calculations

6.3.1 Asphalt content

Several methods can be used to determine binder content. The most frequently used methods are the extraction test (AASHTO T 164 or ASTM D2172) and the ignition oven test (AASHTO T 308).

Picture 6.5: Binder Content Test

6.3.2 Aggregate gradation

Various methods also exist to determine aggregate gradation. Gradation results can vary depending on the sample location. Samples are often obtained from the cold feed belt or hot bins prior to the introduction of binder into the mixture. Extraction or ignition oven testing of the plant-mixed material is considered to be a more accurate measurement for the aggregate gradation of the final mixture. There can be a significant difference between a cold feed gradation and extracted gradation caused by the physical breakdown of the material as it is processed through the plant. Gradations should always be washed to ensure complete accuracy of the amount of minus No. 200 (75 µm) material.

6.3.3 Maximum specific gravity of the mix

The theoretical maximum specific gravity, G_{mm}, of the HMA paving mixture is a key measurement during both laboratory mix design and field verification. G_{mm} is the specific gravity of an asphalt mixture with air voids excluded. Using a vacuum procedure to remove entrapped air from the mixture, the test determines the volume of the asphalt mix in a voidless state. Multiplying G_{mm} by the density of water, ρw, will yield the theoretical maximum density of an asphalt mixture. This G_{mm} is used to determine the air voids of compacted mixtures as well as a reference typically used to determine the in-place density of the HMA. The following example demonstrates this process.

Maximum specific gravity = G_{mm} = 2.438

Density of water = ρw = 1,000 g/m^3

Maximum density = G_{mm} × ρw
= 2.438 × 1,000
= 2,438 kg/m^3

6.3.4 Bulk specific gravity of the mix

The bulk specific gravity of the mix (G_{mb}) can be determined on any compacted HMA. This includes material compacted in the lab or material compacted on the roadway. Laboratory compacted samples of plant-produced mix must be compacted using the same procedure used in the mix design (SGC, Hveem or Marshall).

Multiplying G_{mb} by the density of water will yield the bulk density of the compacted HMA sample. The following example demonstrates this process.

Bulk specific gravity, G_{mb} = 2.344
Density of water, ρw = 1,000 kg/m3

Bulk density = G_{mb} × ρw
= 2.344 × 1,000
= 2,344 kg/m3

When sampling field mix for bulk specific gravity determination, laboratory compaction without reheating is recommended. If reheating of cold or stored samples cannot be avoided, a correlation should be made to adjust the compactive effort on the reheated mix to match the volumetric properties (such as VMA and percent air voids) of field mix which was not reheated.

6.3.5 Air voids

Since G_{mb} is measured on a compacted sample, the measurement includes air contained in the mix. The percent air voids, P_a, of the compacted mixture is calculated using the bulk and theoretical maximum specific gravities in this equation.

$$P_a = 100 \times \frac{G_{mm} - G_{mb}}{G_{mm}}$$

The following is a demonstration of this equation in use.

G_{mm} = 2.438 G_{mb} = 2.344

$$P_a = 100 \times \frac{2.438 - 2.344}{2.438} = 3.9\%$$

6.3.6 Stability (Marshall and Hveem) and flow (Marshall)

These properties can be measured on the laboratory compacted samples of field-produced material. Some agencies include them in field verification tests. These tests have traditionally been utilized as a measure to indicate the rutting resistance and durability of an HMA. However, these values are affected by many different aggregate and asphalt properties and are less reliable than volumetric property tests for predicting pavement performance. If the volumetric properties (air voids, VMA, asphalt content) and the aggregate quality and gradation of the mixture are properly controlled, then the stability and flow will normally meet the appropriate specifications.

6.4 Job mix formula verification and daily overlag

Field verification involves two different levels of analysis performed on the HMA. The first involves analyzing the mixture on the first day of full production to compare the mixture to the Job Mix Formula (JMF). The second uses day-to-day field verification tests to determine if the mixture properties continue to meet specifications.

6.4.1 Job mix formula verification

Asphalt content, gradation, void analysis and other specified tests are performed to compare field-produced mixture properties with the JMF. These tests will indicate if the aggregate characteristics have varied since the mix design, and may indicate if problems exist from changes in the aggregate after processing through the asphalt mixing plant. Field verification results may show that changes are necessary to meet the JMF and specification's applied tolerances. For example, minor changes in the asphalt content may bring air voids back into compliance. Alternatively, if the mixture is meeting agency specifications but not the JMF and applied tolerances, the JMF can be adjusted to the average results of the plant-produced mix. Significant differences between the laboratory design and field-produced mixture may necessitate a new mix design using the actual production materials. Once the JMF has been verified or adjusted, the final JMF is established and payment is measured from these values. This final JMF is often referred to as the adjusted JMF or AJMF.

Adjusting the JMF at start-up is common to maintain mix volumetrics. However, continuous changes to the JMF are not acceptable and indicative of poor production processes.

6.4.2 Daily mix verification

Daily testing can provide an early warning by indicating if the mixture properties deviate from the specifications. This daily verification is part of plant process control that can identify potential acceptance problems before a large amount of mix is placed.

Daily field verification tests are typically performed on random samples taken from a set quantity of material called a lot. A lot is typically a day's production or a given tonnage of material. It is important to use random sampling techniques so an unbiased evaluation of the material can be made (see Asphalt Institute's MS-22, Principles of Construction of Hot Mix Asphalt Pavements, for further information).

Fig. 6.6: Aggregate Verification – 1

Fig. 6.7: Aggregate Verification – 2

Fig. 6.8: Plant Production Verification

Fig. 6.9: Bitumen Verification

Fig. 6.10: Plant Production Control Unit Verification

The details of the verifications are shown in figure 6.2 to 6.10.

6.5 Volumetric adjustments

The most common problem encountered in plant-produced mix is the failure to meet VMA and air voids volumetric parameters. These properties are related in that a failing air voids test is usually the result of a changing VMA—assuming the binder content is correct. The change in VMA is most often explained by inconsistent mixture curing during testing or a change in the gradation of the aggregate.

Mixture conditioning of samples is essential in providing accurate volumetric properties. Changes in air voids or VMA are often encountered and go unexplained. Careful observation of material conditioning times can often explain fluctuating volumetric test results. The time and temperature of mixture conditioning can greatly affect the amount of asphalt absorbed in the aggregate, thus changing the theoretical maximum specific gravity (Gmm) and, to a lesser extent, bulk specific gravity (Gmb) test results. For example,

Gmm samples taken from a truck at the plant and allowed to immediately cool can have significantly lower results (lowered absorbed asphalt) than if the same material were hauled to the roadway, sampled behind the paver, and returned to the plant lab in an insulated specimen container, and then allowed to cool. It is common for neither of these scenarios to match the curing time performed in the laboratory during the mix design process. In order for field-produced mixtures to match laboratory design values, mix samples should be cured at similar temperatures for a similar length of time. Highly absorptive aggregates will greatly magnify the importance of matching the curing time and temperature in the lab to that in the field.

It is important to remember that VMA measured on a lab-compacted specimen is the result of the amount of aggregate packing that occurs in the mold when placed in the compactor. Anything that changes the amount of aggregate that can be compacted into the specimen will affect the resulting VMA. A change on one aggregate sieve can alter the compaction characteristics of the mix and change the way the entire aggregate structure "fits" together. A common scenario when going from design in the lab to production in the field is that the aggregate experiences further "breakdown" in the plant relative to the mixing bowl. This breakdown can create a higher percentage of minus No. 200 material (dust) that will decrease air voids and decrease (collapse) VMA in a compacted sample.

When QC/QA plans only require the monitoring of the air voids in a mixture, and when VMA unknowingly decreases, it is a common adjustment to simply reduce the amount of binder being added to the mixture to restore the specified air voids level. Caution should be exercised here as the real reason for the lower air voids is the collapse of the available VMA in the mix or the binder coating the aggregate has not had sufficient time to be absorbed. Simply reducing the binder content may correct the air voids deviation but leave the mixture with an insufficient amount of binder to provide a durable, fatigue-resistant pavement. Other options exist to restore the VMA in a mixture, including but not limited to the following suggestions:

- Evaluate sampling and testing procedures to assure a standardization of curing parameters;
- Make gradation changes that generate additional VMA;
- Increase the fracture content of the aggregate;
- Reduce natural sand components and increase the usage of manufactured sand;
- Introduce highly fractured, durable, intermediate-sized "chips" into the aggregate structure;
- Reduce the dust in the mixture by increasing the fine aggregates that contain less material passing the No. 200 sieve, or by not returning all of the material from the dust collection system; and
- Wash the aggregates to reduce the dust.

Powerful, advanced techniques exist today that can be highly useful in guiding plant operators to the most efficient adjustment for their situation. Perhaps the most widely recognized and refined of these is the Bailey Method. With tools like the Bailey Method, mathematical predictions of how a proposed gradation change will affect VMA, and thus other volumetric properties, can be made.

A quality control manager can investigate various scenarios, typically via a spreadsheet, to determine which bin adjustments will likely best reconcile their mix to the correct volumetric properties. The Bailey Method explains why very small changes in gradation can have a dramatic effect on the resulting volumetric properties depending on the mixture. More information on the Bailey Method can be found on the Asphalt Institute's website.

Absent of Bailey Method-like tools, trial-and-error plant adjustments based on experience can be made to achieve compliance with the JMF. The complex dynamics of a mix does not allow for this literature to fully address the unique circumstances of individual situations. It must be emphasized that regardless of mixture adjustment techniques utilized, uniformity of stockpiled materials are essential in producing quality asphalt mix. It is very difficult, if not impossible, to predict the results of a change in bin proportions when dealing with highly variable stockpiles.

6.6 Density specifications

The goal of compaction is to achieve a smooth, uniform surface at optimum air voids content that ultimately determines whether the pavement will perform as expected. The in-place air voids of HMA after compaction is a very important factor that affects performance of the mixture throughout the life of the pavement. Achieving compliance with compaction specifications is the final step in the quality management of the HMA construction procedures and must be accomplished to produce a quality asphalt pavement. There are four primary methods for specifying the compaction of in-place HMA pavements:

- method specifications;
- control strip specified density;
- bulk specified density; and
- theoretical maximum specified density.

6.6.1 Method specifications

A "method" specification has no reference density against which the in-place density and air voids are compared. This type of specification lists such items as number, type and size of rollers to be used, number of passes each roller makes, use of temperature measurements, descriptions such as "surface is rolled until free of roller marks" and so forth. Judgment is the primary decision tool for determining optimum compaction when using this type of specification. Method specifications are generally only applicable for smaller projects with light traffic, or thin lift construction (1 inch or less), such as leveling courses and thin or non-uniform HMA overlays. In these cases, cost and the inability to obtain meaningful data may preclude the use of a reference density specification.

Specified density methods compare the in-place density of the pavement to a reference density. The pavement density is specified as a percentage of the reference density. One of the following three reference densities is typically used in density specifications.

6.6.2 Control strip specified density

This process calls for the construction of a pavement control strip of a minimum length or volume of mix at the start of each lift being constructed. After compaction is completed, a specified number of tests are measured from random locations within the control strip. The average density obtained is calculated and becomes the reference density.

The reference control strip density must then be compared to either the laboratory or theoretical maximum density of the field-produced HMA to determine if densification is adequate and accepted. Once an acceptable control strip has been obtained, the test strip density becomes the reference density typically specified during construction. Values over 102 percent indicate that something has changed and a new control strip should be considered.

Control strip specified density requirements are the least effective in assuring optimum pavement performance as control strip compaction conditions are highly variable. Temperature conditions, subgrade condition, roller ballast, tire pressure, operator inconsistencies, along with many other variables can significantly affect a reference control strip density.

6.6.3 Bulk specified density

This method compares in-place pavement density to a laboratory compacted sample of field-produced mix. Field-produced HMA is compacted using the same effort used during the mix design. The laboratory density is measured using the bulk specific gravity test.

In terms of specification compliance, an agency compares the in-place pavement density to the reference density in the form of a ratio:

$$\text{Percent of Bulk Density} = \frac{\text{In-Place Density} \times 100}{\text{Laboratory Bulk Density}}$$

When it has been verified that the field-produced mix matches the mix design properties, the laboratory compacted samples provide the same air voids content as determined in the mix design, typically 4 percent. If an in-place air voids content of 8 percent is desired, the in-place density should be 96 percent of the laboratory bulk density.

Minimum bulk density specifications typically range from 96 to 100 percent of the laboratory compacted bulk density. Values over 100 percent may be indicative of the following:

- The materials have changed.
- There are problems with the plant equipment.
- Poor sampling or testing techniques may have been used.
- There may have been problems with the laboratory equipment.
- Aggregate is being crushed under the roller.

6.6.4 Theoretical maximum specified density

Theoretical maximum density testing determines a void less unit weight of the mix, as if it were compacted to a zero air voids condition. Using the Rice test method, the theoretical maximum density of the field-produced mixture is determined as the reference density. The relative density of the in-place pavement is again calculated as the ratio of the in-place density to theoretical maximum density.

$$\text{Percent of Theoretical Maximum Density} = \frac{\text{In-Place Density} \times 100}{\text{Theoretical Max. Density}}$$

The theoretical maximum density represents a void less mixture. When the in-place air voids content is 8 percent, the in-place density is 92 percent of the reference theoretical maximum density. The theoretical maximum specified density is the most widely used method of specifying pavement compaction. Minimum compaction requirements typically range from 92 to 96 percent of the theoretical maximum density. Values over 97 percent may be indicative of problems in the following areas:

- The materials have changed.
- There are problems with the plant equipment.
- Poor sampling or testing techniques may have been used.
- There may have been problems with the laboratory equipment.

Test results over 100 percent of Gmm are theoretically impossible.

6.6.5 Summary of the different specified density methods

The relationship between the reference density measurements and air voids of the in-place pavement is shown in figure 6.11. Laboratory compacted and in-place air voids benchmarks equal to 4 and 8 percent are depicted against each type of reference density. It should be noted that, while the comparison between theoretical maximum density and in-place air voids content is constant, the relationship between the other two reference density types and in-place air voids will shift up or down depending on the actual mix design and compaction criteria used in this specification. For example, if the mix design air voids is at 5 percent, then 100 percent of laboratory density would be at 5 percent air voids. If the same compaction criteria of 96 percent of laboratory density were used, this would yield an in-place air voids content of 9 percent (96% × 0.95), not 8 percent.

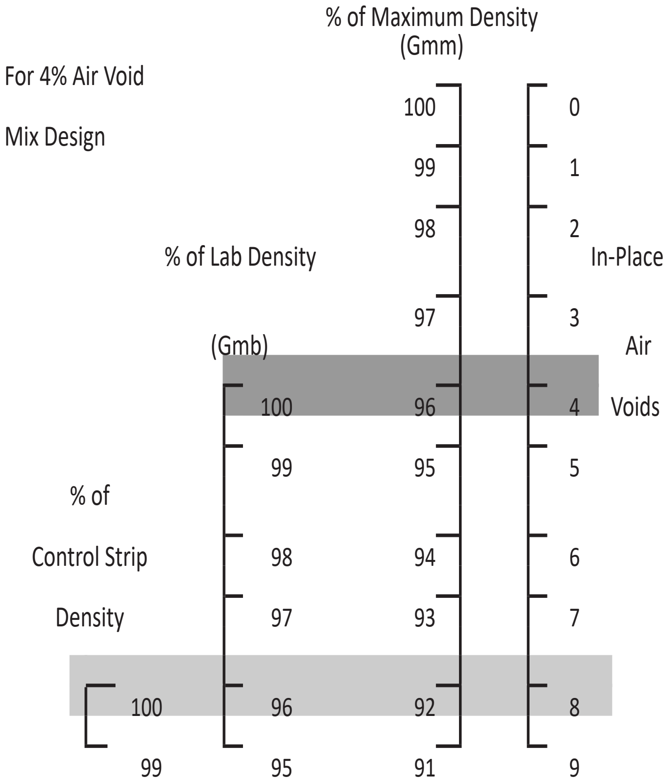

Fig. 6.11 Relationships between the reference density measurements and the air voids

Each of the reference density specification procedures has additional considerations that may make one more favorable than another on a particular project. These considerations include the traffic volume, subgrade support, size of the project, construction and testing schedules and any lift thickness variation.

A higher degree of compaction monitoring is recommended in the initial stages of the construction process, regardless of which density specification is used, to ensure optimum results from the compaction process.

In addition to maintaining minimum compaction, it is also necessary to investigate excessive compaction. There are many causes for this occurrence, including:

1. excessive moisture in the plant-produced mix;
2. improper bag house operations;
3. variable absorption rates of aggregate materials; and
4. poor quality aggregate that degrades during compaction, often associated with thin lifts.

Whenever abnormally high density (below 3 percent air voids) occurs in a compacted mix, the cause should be determined and corrected. This problem may also require that the mix be adjusted or redesigned. Flowchart of field verification is shown in figure in 6.12.

Receive the Mix Design from Contractor

(Job Mix Formula – JMF)

Check for criteria specified in Section 6.2 along with appropriate production tolerances in JMF

Inspection of Raw Materials to be used for producing the asphalt mix

Inspection of Production Plant and Verification of Calibration of Plant before production begins

Begin production and supervise mixing process (Temperature of Asphalt Binder, Temperature of Aggregate and Mixing Time)

Sampling during production – JMF Verification

Testing and Analysis

Adjustments to the mix as necessary to meet specifications

Documentation of the results of tests and any adjustments made

Monitoring the production process to ensure it is consistent and quality is maintained – Daily Mix Verification

Flow Chart for Supervision of
Asphalt Mix Production

Fig. 6.12 Flowchart of field Verification

(Extracted from MS-2, Asphalt Mix Design Methods, 7th Ed. – Asphalt Institute along with site photographs and other picture aids and a flow chart collected and created during supervision by Aashutosh Karna)

7. An Overview of Comparison between Marshall and Superpave Mix Design Methods

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7.1. Introduction

Nepal has placed a significant emphasis on infrastructure development to achieve its developmental goals, with roads being a crucial component. This article focuses on the mix design component of pavements and aims to provide DoR personnel, engineers, readers, and researchers with information on the two common flexible pavement (asphalt) mix design procedures.

It is important to note that the term "asphalt" has different meanings in different parts of the world. For example, in Europe, asphalt refers to Hot Mix Asphalt (HMA) or Asphalt Concrete (AC), whereas in the US, it is known as bitumen or asphalt binder. In the South Asian region, bitumen is considered a binder, while asphalt concrete is viewed as a mix of all constituents, including bitumen.

The goal of mix design is to determine the combination of bitumen and aggregate that will ensure long-lasting performance as part of the pavement structure. This involves laboratory procedures to establish the necessary material proportions for use in the asphalt mixture.

According to Asphalt institute Ms-27th edition 2014, there are three types of Asphalt mix design procedures for Hot Mix Asphalt (HMA): Marshall Method, Hveem Method, and Superpave Methods. The Marshall Method, which has been in use since 1930, is popular worldwide, including in Nepal. The Superpave method was introduced by the US Department of Transport's Federal Highway Administration (FHWA) in 1993 and has replaced the Marshall method in the USA, gaining popularity in other countries.

The advantage of the Marshall Mix Design method is that it provides an expectation of the mixes' performance for local materials and environmental impact. In contrast, the Superpave mix design method utilizes performance-based and performance-related criteria to design the proper asphalt mix, which enables a direct relationship between laboratory and field performance. This technology has tremendous potential and could be implemented in different countries, leading to higher performance and longer-lasting roads. Therefore, a comprehensive study comparing the design of bituminous mixes using both Superpave and the Marshall method of Mix Design is needed.

The main objective of this article is to understand the difference between the Marshall Design method and the Superpave system design method in Asphalt flexible pavements.

7.2. Marshall Mix Design

The Marshall method seeks to select the asphalt content at a desired air void 4% that satisfies minimum stability, range of flow values, Density with respect to Maximum Theoretical Density, Voids in Mineral Aggregate (VMA), Voids Fill with Asphalt(VFA) and Traffic condition (Low, Medium, High).

Typically, the Marshall Mix Design method consists of Four basic steps.

Aggregate Selection: Test requirements as specified, blending of aggregates.

Asphalt Binder election: Test requirement as specified, Viscosity Grade bitumen, Modified Bitumen.

Determination of Volumetric properties: Air voids, voids in the mineral aggregate (VMA), voids filled with asphalt (VFA), Density, Theoretical Density.

Optimum binder content determination: This step can be broken up into 5 sub steps:

i) Prepare a series of initial samples, each at different asphalt binder content and calculation of volumetric properties.
ii) Compact these trial mixes using the Marshall drop hammer. This hammer is specific to the Marshall mix design method. Conduct water sensitivity analysis.
iii) Test the samples in the Marshall testing machine for stability and flow. The testing machine is specific to the Marshall Mix Design method. Passing values of stability and flow depend upon the mix class being evaluated.
iv) Determine the density and other volumetric properties of the samples.
v) Select the optimum asphalt binder content. The asphalt binder content corresponding to 4 percent air void is selected.

7.3. Superpave Mix Design

The Superpave mix design method was designed to replace the Hveem and Marshall methods. The Superpave system ties asphalt binder and aggregate selection into the mix design process and consider traffic and climate as well. The compaction devices from the Hveem and Marshall procedures have been replaced by a gyratory compactor and the compaction effort in mix design is tied to expected traffic.

The Superpave Mix Design method consists of four basic steps:

Aggregate Selection: Test requirements as specified, restrictions on aggregate gradation are specified by using gradation specifications, Blending of Aggregate with proper gradation

Asphalt Binder Selection: Test requirement as specified, Superpave PG asphalt binders are selected based on the expected pavement temperature extremes in the area of their intended use.

Determination of Volumetric properties: Air voids, voids in the mineral aggregate (VMA), voids filled with asphalt (VFA), Density, Theoretical Density

Optimum asphalt binder content determination. This step can be broken up into 4 steps:

i) Prepare a series of initial samples, each at different asphalt binder content and calculation of volumetric properties.

ii) Compact these trial mixes in the Superpave Gyratory Compactor. This compacter is specific to the Superpave mix design method. Number of Gyrations (number of compactions) is main factor to consider which depends on Traffic Loads (ESALs). Conduct water sensitivity analysis.

iii) Determine the density and other volumetric properties of the samples.

iv) Select the optimum asphalt binder content. The asphalt binder content corresponding to 4 percent air voids and should be equal to Number of gyration that will achieve 96% compaction of Theoretical Density (G_{mm}).

7.4. Differences on Test Methods and Philosophy

Differences on test methods and philosophy are given as per table 7.1 and table 7.2 below:

Table 7.1. Difference on Test Methods

S.N.	Design steps	Resources	Marshall Mix Design	Superave mix design
1	Material Selection	Aggregate	As per specification requirement	Differ in gradation and control points
		Fine Aggregate	As per specification requirement	Differ in gradation and control points
		Filler	As per specification requirement	Same
		Binder	Bitumen VG grades	Bitumen Performance Grade
2	Material Blending	Job mix	Required	Required and should consider restricted zone in gradation
3	Compaction		Hammer compactor	Gyratory Compactor
4	Design binder content	From graph and data	At 4% air void from air void vs binder content graph	*N_d value at 4% air void = 96% of Gmm (from using two grahps, 1. Air void Vs Binder content 2. % G_{mm} @ Nd Vs Binder content
5	Moisture sensitivity	Laboratory Tests	Yes	Yes
6	Performance testing	Field Test	Recommended	Strongly Recommended

N_d = Number of Gyration at designed value

Table 7.2. Difference in Philosophy

S.N	Marshall Mix Design	Superpave Mix Design
1	It is Uni-directional unconfined test, but actual pavement material is subjected to Triaxial stress.	It is confined test. It considers Triaxial stress which is actual pavement behavior under load.
2	Its empirical test parameters are not related directly to the pavement performance such as permanent deformation and fatigue cracking behavior.	This method considers permanent deformation and fatigue cracking by selecting proper materials of aggregate and PG grade bitumen
3	It does not identify easily compactable mixes under traffic.	It identifies easily compactable mixes under traffic by considering number of gyration in three phase initial, design and final.
4	Impact compaction used in this method does not simulate the mixture densification as it occurs in a real pavement.	It simulate the mixture densification as in real pavement

7.5 Way forward

Various papers have been published in the literature regarding the comparison between Marshall and Superpave methods for design of asphalt mixtures. Recently, several studies have been conducted to evaluate the feasibility and performance of Superpave-designed mixtures. For Nepal superpave mix design is totally new.

Wang et al [1] in his study compared the volumetric and mechanical performance properties of Superpave mixtures and Typical Taiwan mixture (TTM) using the Marshall method. His results showed that the asphalt binder contents for the Superpave-designed mixtures are lower than TTM Marshall-designed mix and TTM mixtures exhibited low densification values.

Jasim [2] evaluated the volumetric, mechanical properties and moisture susceptibility for both Marshall and Superpave design methods. She found that the estimated asphalt content for the Superpave mix design is lower than that obtained by Marshall Mix Design. This indicates that the Superpave mix design is more economical.

A study in India by Swami et al. [3] was conducted to ascertain and evaluate how well Superpave designed mixtures performed compared to conventional Marshall mix with respect to permanent deformation (rutting) using local materials in Malaysia. The study results showed that the Superpave gyratory compactor (SGC) is capable of achieving lower air void contents than that could be achieved by the mechanical Marshall hammer compactor. Also they found that Superpave mixes have less asphalt binder contents than the Marshall mixes.

Asi and Khalayleh [4] who study the possibility of adopting the Superpave mix design procedure in Jordan to solve the bleeding problem and some of the distresses common in asphalt roads. They found that using local aggregate gradation for heavy traffic in the Superpave design method gave dust proportion higher than the maximum specified limit by the Superpave procedure. High dust proportion will usually lead to brittleness of the mixes. Therefore, they recommend shifting to the Superpave design procedure.

Hafez and Witczak [5] have stated that for identical traffic and climatic conditions, the Superpave Level 1 design for polymer modified mixtures, the binder was found to be about 0.5 to 0.8 percent less than the Marshall analysis. For Superpave mixes at traffic level less than 1 x 107 ESALs, simulating 75-blow Marshall Mixes the asphalt design contents were found to be almost equivalent. As the climatic region changes from worm to cool, super-pave required 1 percent higher binder content compared to Marshall procedure.

Magdi and Samir [6] from Sudan have concluded that Superpave mix design results in lesser binder compared to Marshall mix for hot climate and heavy traffic conditions, higher density in Superpave is due to Superpave Gyration Compactor compactive effort and also concluded that, performance-based Superpave mixes performed better than Marshall mixes.

Recently, Millennium Challenge Account (MCA) Nepal have introduced the Superpave design method to Nepal. The laboratory is estabilished in Quality, Research and Development center (QRDC) promises. Proper allocation of DoR personal to run superpave lab is another issue for DoR. QRDC, DoR must initialize the superpave design for asphalt mix for better quality of road pavement. But DoR shall analyize the availability of PG grade bitumen which is outside of country furthermore in case of proper run of superpave lab research can be done for the appropriate environment friendly binder instead of or along with PG grade binder.

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8. Road Safety Status in Nepal

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Some 3,700 people who left home today morning walking, biking or riding to school or work plying in street, or sitting out on a long trip will never return home. Another 137,000 people will be injured, some of whom will be disabled for life in the road accident. This represents the daily road accident scenario of the present conditions in the world. Road traffic accident is the 1st cause of death of children aged 5 –14 years and young adults of 15-29 years. Road traffic injuries are the 8th leading cause of death overall. Among the death from road traffic injuries, 54 percent of victims are vulnerable road users (pedestrians, cyclists, and motorcyclists). UN general assembly on 10 May 2010 declared the UN Decade of Action for Road Safety 2011-2020 for saving millions of lives (Orgainzation, 2011). The declared action should take place at local, national, regional, and global levels throughout the decade. The five pillars were set up for the implementation as mentioned in figure 8.1 (Nation, 011).

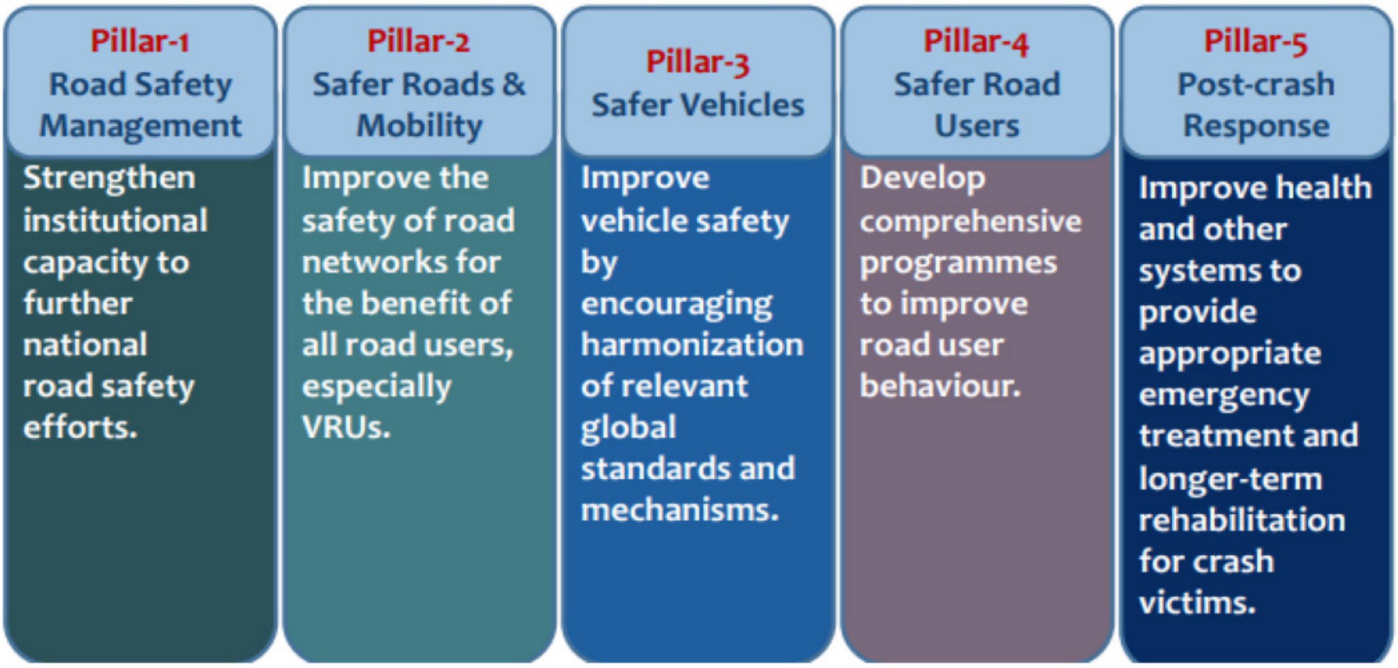
These mentioned actions can be implemented through Financing, Legal framework, Speed management, Capacity management, Ensuring a gender perspective in transport planning, Adopting technologies to the safe system, and focusing on low and middle-income countries. These safety targets are aimed to achieve through the shared responsibility among stakeholders, like government, academia, civil society and youth, the private sector, funder, and the United Nations.

The road safety scenario in Nepal

Nepal's road safety status in 2009-2010 was as follows.

Per 100000 population		In 10000 registered vehicle	
Death	Injured	Death	injured
9	58	17	113

(Source: The World Bank Group, 2021)



(Source: The World Bank Group, 2021) Fig. 8.1 Five Pillars of Road Safety

The implementation of the decade action could not be satisfactory enough and the next decade of action has been declared.

The 3rd Global Ministerial Conference on road safety was held in Stockholm, Sweden, in February 2020 which was the final year of the Decade of Action for Road Safety 2011 – 2020. It brought government ministers together to extend the 2020 target to reduce road deaths and serious injuries to 2030. UN General Assembly resolution 74/299 declared a decade of action of road safety 2021 – 2030 with the target to reduce road traffic death and injuries by at least 50 percent during this period (Organization, 2021). This decade of action for road safety calls for the action of the Safe Systems Approach:

- Multimodal transport and land use planning
- Safe road infrastructure
- Safe vehicle
- Safe road user
- Post-crash response

Being the signatory country in the Bussan meeting, Nepal has set the target to reduce road traffic accidents by 50 % till 2020. But the road safety status of Nepal in 2018/2019 is observed as following.

Per 100000 population		In 10000 registered vehicle	
Death	Injured	Death	injured
10	50	8	41

(Source: The World Bank Group, 2021)

Looking at the above data the target of the decade is not reachable.

In 2019 alone, there were nearly 13,000 highway and road accidents with more than 2,700 death and 10,000 serious injuries. Road crash deaths and injuries in Nepal have been on a sharp upward trajectory since the early 2000s, as the country invested in increased road connectivity and economic growth boosted vehicle ownership. The road safety crisis is a growing global epidemic and Nepal is no exception. A study by the World

Bank in Nepal showed that the economic cost of road traffic injuries has increased threefold since 2007 and the value of this is equivalent to 1.5 % of gross national products. Road crashes have a disproportionate and devastating impact on the poor. More than 70 % of road fatality victims in Nepal are vulnerable road users. They include motorcyclists, cyclists, and pedestrians. The loss of income and medical expenses can thrust a family into deep poor. Despite the Covid 19 lockdown in Nepal, the number of road-related accidents has not reduced noticeably. Road safety is not the only challenge to transportation but also strong impact on health, human capital, and economic growth.

In the case of the fatalities, 72 percentage of road crash fatalities and injuries are the productive age of 15- 64 year group (The World Bank Group, 2021). The ratio of male to female in fatalities with the 15- 49 year age group is 3:1 and affected disability from road crash injuries per 100,000 people is recorded as 1084 life years.

Road crash fatalities and injuries snapshots are presented below.

Country population 1016	28,982,772	Country reported fatalities 2016	2006
WHO estimated Fatalities 2016	4622	GBD estimated fatalities 2016	6765
WHO est. fatalities per 100,000 pop 2016	15.9	Estimated serious injuries 2016	69330
Cost of fatalities and serious injuries 2016	$1,194 million	Cost as % of country GDP, 2016	5.6 %

(Source: The World Bank Group, 2021)

Positioning of Country in Region

Country	2016 WHO Estimated road fatalities	2016 GBD Estimated road fatalities	2016 WHO Estimated fatalities rate/100,000 pop.	2016 GBD Estimated fatalities rate/100,000 pop.	% trend in fatalities rate/100,000 (2013-2016)	Motorization Registered Vehicle/100,000 pop
Nepal	4622	6765	15.9	22.88	-0.6 %	8071
Best Performing Countries in Region.						
Maldives	4	32	0.9	7.25	-4.0%	21737
Pakistan	27,582	52,807	14.3	25.16	-3.1%	9,499
Best Performing Countries Globally						
Switzerland	223	334	2.65	3.89	-5.4%	71,182
Norway	143	215	2.72	4.09	2.4%	75,544
Singapore	155	197	2.76	3.53	-4.9%	16,604
Sweden	278	390	2.83	3.88	-3.2%	62,037

(Source: The World Bank Group, 2021)

Nepal has revived the National Road Safety Council (NRSC) led by the Ministry of Physical Infrastructure and Transport as an apex body for road safety in the country. Going forward, the government needs to enact the road safety bill and fully empower the National Road Safety Council to have ownership of the road safety agenda (Schafer, 2021). It is the right time to invest in safe system-based intervention. This includes designing safer roads, improving vehicle standards, traffic enforcement, and encouraging positive road user behavior. It requires bringing different agencies responsible for road safety including transport infrastructure, traffic, police, health, emergency care, and education. The major achievements in road safety in Nepal in the last decade can be explained as the use of convenient free telephone service in road crash, operation of trauma centre, inclusion of work zone safety in contract, initiation of amendment of vehicle and transportation act. Different trainings for concerned authority are another achievement. The road safety audit accreditation training supported by World Bank is another achievement. From this training 10 persons are certified as valid auditors in road safety. It is hoped that this may work as a milestone in the improvement of road safety during road infrastructure development. There are some major gaps in the implementation of the Decade of Actions of Road Safety. Amendment of the Motor Vehicle and Transport Management Act, Strategy of National Road Safety Council, Safety Manual for Non-strategic Road Network, design guideline for safer roads, Standard for a safe vehicle, vehicle inspection procedure, establishment of safety unit in Ministry of health and population are major lapses in the implementation in road safety.

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Road safety status and some initiatives in Nepal, K. N. Ojha

9. Legal Requirements for Removal of Trees and Acquisition of Forest Area in Road Projects

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9.1 Introduction:

The Department of Roads (DoR) is a prime federal body, under Ministry of Physical Infrastructure and Transport (MoPIT), Government of Nepal (GoN) responsible for the development and maintenance of strategic roads, construction and maintenance of bridges, road tunnels and flyovers/via ducts on National Highway. There are defined legal requirements for acquiring the forest area and removal of trees during the construction and upgrading of these road infrastructures. This article aims to visualize the legal provisions and procedures for acquiring the forest area and removal of trees for various projects under DoR and also help to understand the removal of government trees from Right of Way (RoW) declared roads and office premises in simplified steps.

9.2 Legal Provisions:

Forest Act (FA) 2076 and Forest Regulations (FR) 2079 are the governing laws mainstreaming the process for removal of trees and acquisition of forest area for various projects. The Environment Protection Act (EPA) 2076 and the Environment Protection Regulations (EPR) 2077 are supportive laws that help make the process of such intact.

9.2.1 Forest Act 2076:

Section (42) of this Act has provisions related to the use of forest areas for development projects. Sub-section (1) states, if there is no alternative to use the forest area for National Priority Projects, projects approved for investment by the National Investment Board, National Pride Projects, and any project requires to use the forest area and has very insignificant negative environmental impacts as recommended by the environmental assessment reports as per prevailing laws, the Government of Nepal shall grant a permission for using such forest area. Section (45) of the Act mentions about the provision of Forest Development Fund (FDF) where required amount for compensation cost for removal of trees, cost required for compensatory plantation and care over for five years, the cost of acquiring forest area and the cost for plantation of trees of acquiring the forest area in the ratio of 1600 individual trees plantation per hector (Rule 93-6, FR), as estimated by Department of Forests and Soil Conservation (DoFSC), needs to be deposited.

9.2.2 Forest Regulations 2079:

The regulation mentions about the provisions related to the management of vulnerable trees, removal of government trees within the RoW of roads or canals, and the trees to be removed for new construction and upgrading projects.

a) Management of vulnerable trees/trees in office premises:

Rule (36) under the provisions related to the management of vulnerable trees, Sub-rule (1) states that the vulnerable trees from government offices, public institutions, other office premises those do not have the proof of land ownership and the vulnerable road side trees, trees of waiting sheds, trees near water resources/springs, trees near religious sites i.e. not from the forest area, which deemed disastrous to life and property if no immediate action performed can be removed by Divisional Forest Officer (DFO) as per the decision/recommendation of the committee coordinated by DFO. Rule (37) has provision of removing vulnerable trees from government offices, public institutions, other office premises that have the proof of land ownership as per the decision/recommendation of the committee coordinated by DFO. The committee comprises DFO as coordinator and representative officer of District Administration Office, representative officer of District Land Management Office, representative officer of District Survey Office, representative police officer of respective Police Office, ward chief of respective ward of Local Government as members. Sub-rule (4) of Rule (36) states that if a tree falls or swiped due to any natural causes and obstructs public roads, highways, electricity lines, drinking water, drainage, canals or rivers, the DFO can remove them in coordination with the respective agencies.

b) Provisions related to removal of trees from RoW:

Sub-rule (3) of Rule (102) has provision of removal of trees, for expansion/upgradation of the roads or canals, from RoW of any roads or canals, the RoW of which had been declared by GoN of Nepal prior to the promulgation of FA 2049. The concerned project can ask to DoFSC with the respective departmental recommendation (DoR for RoW declared roads) for the removal of such trees for the purpose of expansion or upgradation and DoFSC may grant the permission for the removal of such trees after the necessary technical assessment.

c) ***Provision of removal of trees from the National Forests:***

If trees are to be removed in new development projects/ projects with no declared RoW, there is a clear provision in Sub-rules (1) and (2) of Rule (102) of the FR 2079. After the agreement between the development project and DoFSC for removal of trees and acquisition of forest area, as per Rule (94), removal of trees will be done as per Sub-rules (1) and (2) of Rule (102).

d) ***Required documents to be attached with request letter for acquiring forest area:***

Rule (88) has the provision for requesting the GoN for the acquisition of forest area for development projects/RoW not declared road projects with following documents:

1. Feasibility Report/Report indicating the required data of forest area with the valid reasons and basis,
2. Permission Letter/ License from the concerned bodies if the project requires such letter,
3. Approved Environmental Assessment (EA) Report,
4. Information sheet regarding the forest area to be acquired and the number of trees to be cleared for the project,
5. Detailed Project Report, Detailed Engineering Report, Documents regarding approved program of such project,
6. Decision of National Planning Commission for National Priority Projects,
7. Project Development Agreement with the Decision of National Investment Board, if the project investment is through National Investment Board,
8. Legal Documents indicating National Pride Project for the National Pride Projects,
9. Letter regarding the assurance of budget and documents of budget assurance for the priority project being implemented by Provincial Government,
10. Letter regarding the assurance of budget and documents of budget assurance for the priority projects being implemented by Local Government.

e) Others:

Rule (92) has provision of Land Acquisition Facilitation Committee under the Coordination of Chief District Officer (CDO). The members of this committee shall be the Head of District Land Management Office, Head of District Survey Office, Head of District Treasury Controller Office, Chief of Ward of respective ward of respective Local Government, Respective DFO and Project Chief of respective project as Member Secretary.

9.3 EPA 2076 and EPR 2077:

These are supportive laws for removal of trees and acquisition of forest area for a particular project. These laws mandate to conduct and approve EA reports i.e. Brief Environmental Study (BES)/Initial Environmental Examination (IEE)/Environmental Impact Assessment (EIA) prior to the implementation of any projects. Section (3) of EPA and Rule (3) of EPR has defined the list of projects requiring BES, IEE and EIA in Annex-1, Annex-2 and Annex-3 of EPR respectively. Approved BES, IEE and EIA reports recommend for the total number of trees to be removed and total forest area to be acquired for the implementation of a particular project. Based on the recommendation of these approved EA reports, GoN grants permission of removal of trees and use of forest area for the project. If the data regarding removal of trees and forest area to be acquired varies with the data of DoFSC during verification, these laws also have provision to carry out and approve Supplementary EIA report/Updated IEE or BES report/Updated Environmental Management Plan (EMP) as per the requirement of the project and proceed for the removal of trees and acquisition of forest area. The provisions of FA 2076, FR 2079, EPA 2076 and EPR 2077 hence are interlinked for the removal of trees and acquisition of forest area for a particular project.

Process for Removal of trees and Acquisition of Forest Area:

The required process for removal of trees from the office premises of Road Division Office (RDO), RoW declared road projects before the commencement of FA 2049 and the removal of trees and acquisition of forest area for new road projects/ RoW not declared roads has been visualized in the figure 9.1, 9.2 and 9.3 respectively.

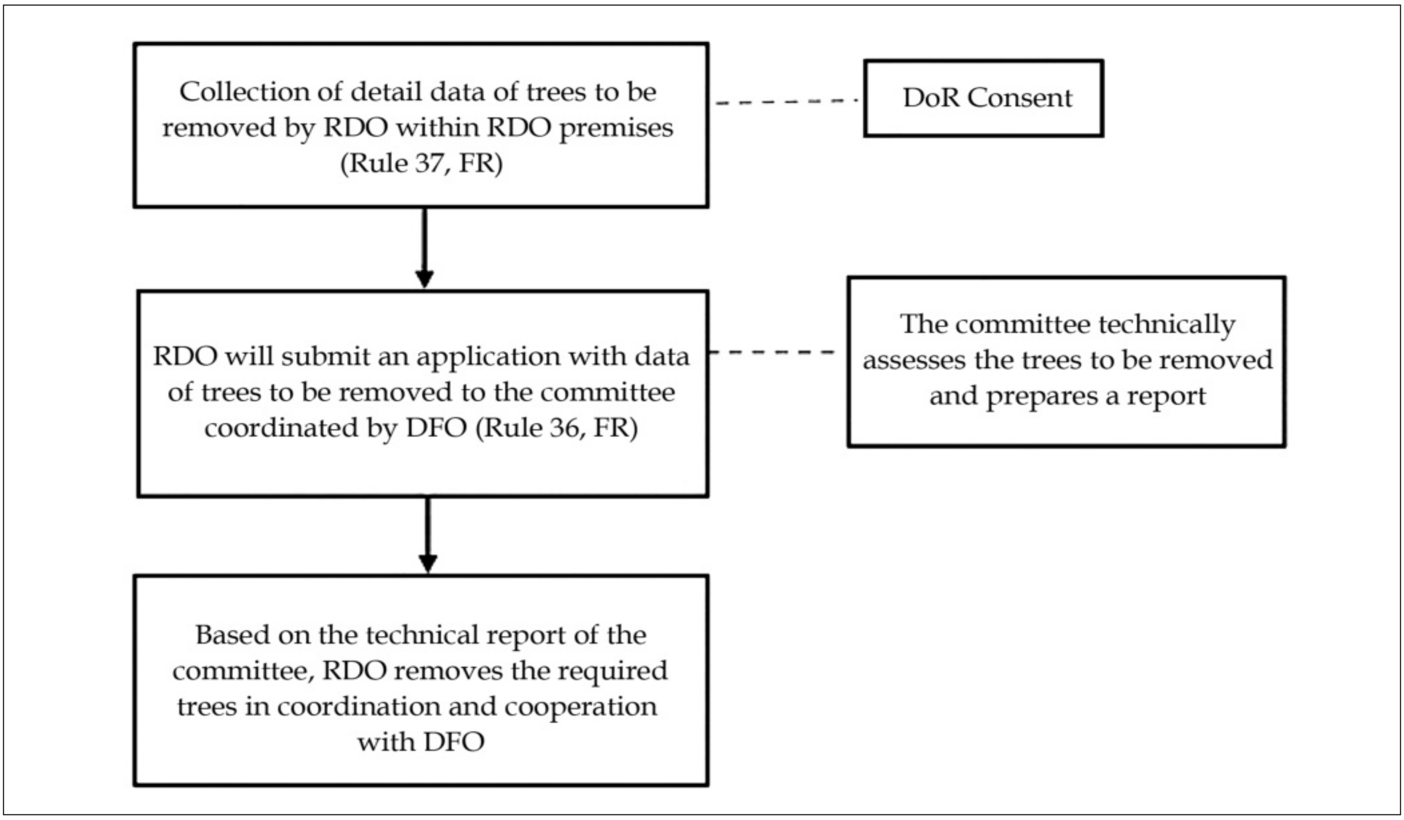


Fig. 9.1: Process for removal of trees from RDO premises

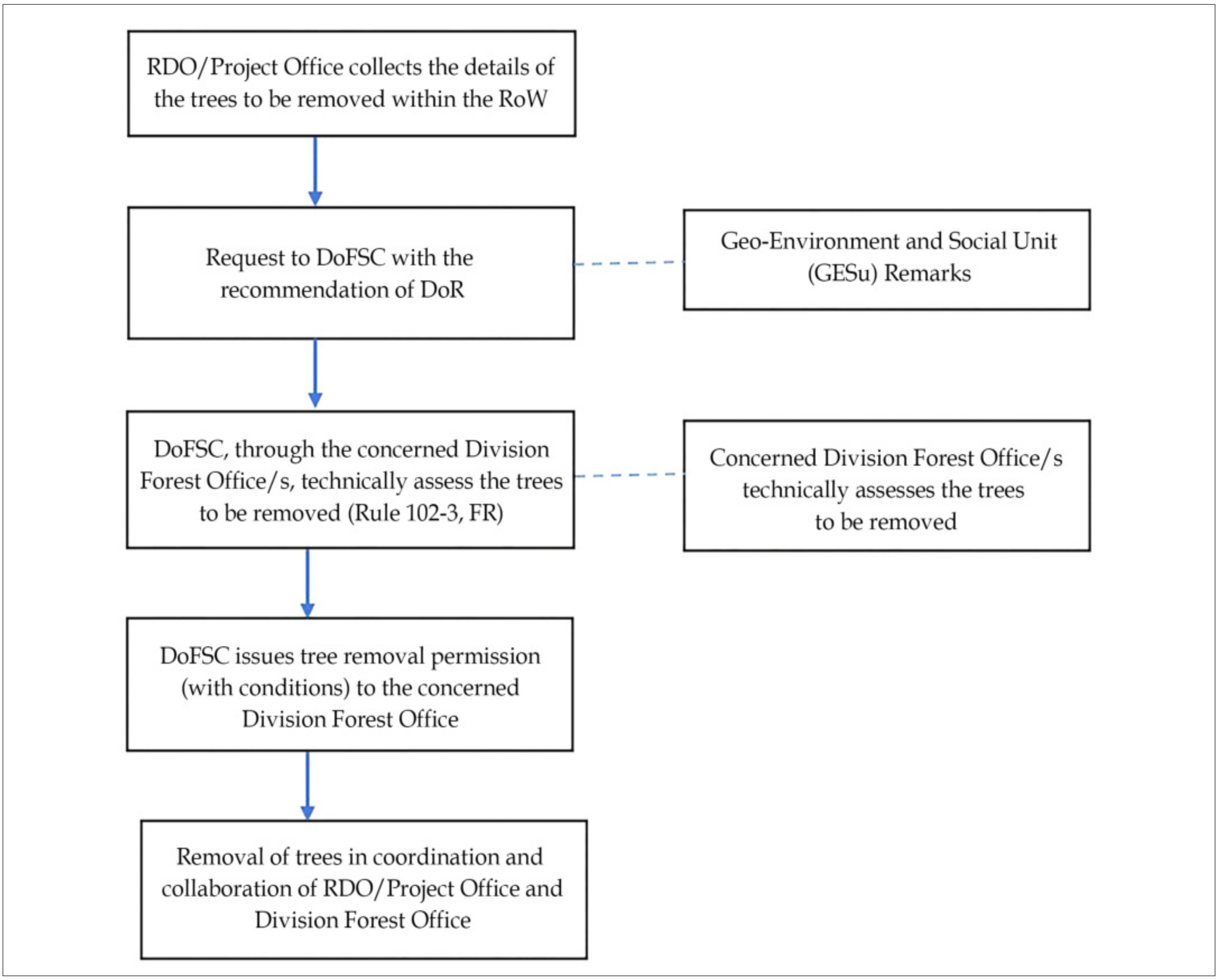


Fig. 9.2: Process for removal of trees from RoW declared roads

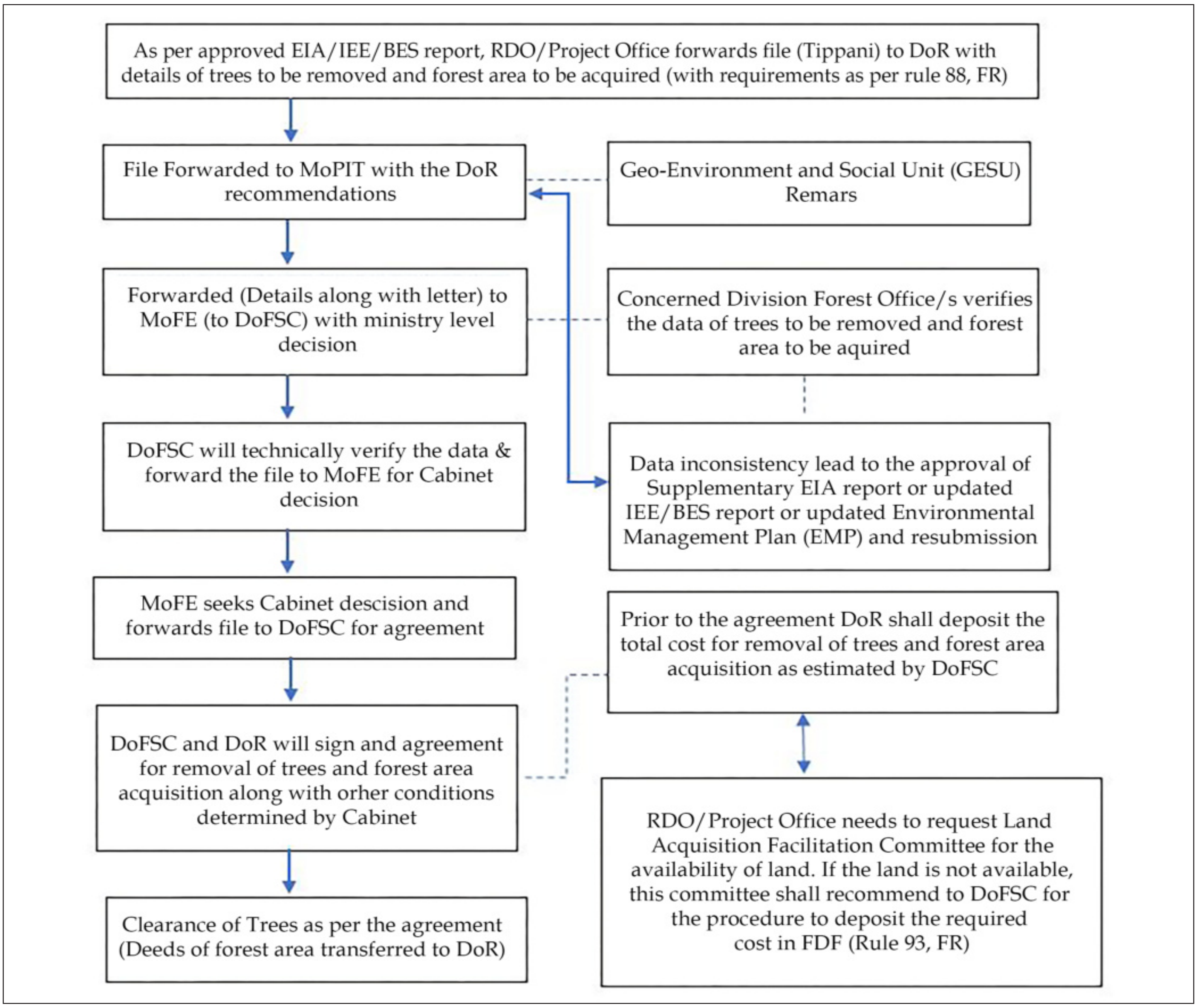


Fig. 9.3: Process for removal of trees and acquisition of forest area for new projects/ RoW not declared roads

9.4 Conclusion:

Legal requirements for the removal of trees and acquisition of forest area for the implementation of the development project are deemed process oriented as summarized above. The process is interconnected with the approval of EA reports and quality of such reports. The approval of such report traverses through technical assessments, legal and administrative requirements resulting in temporal stretching to a final product. The variation of data for removal of trees and acquisition of forest area in the approved EA report and verification by DoFSC generates the legal requirement for approval of supplementary EIA report, updated IEE/BES report or updated EMP, consequently hindering the projects through administrative and technical procedurals, incrimination of time and cost of the project. The development projects are also hindered due to the cost for removal of trees and acquisition of forest area that needs to be deposited in the FDF prior to the agreement with DoFSC. GoN has not yet devised the mechanism to ensure the cost to be deposited so as to smoothen the process for removal of trees and acquisition of forest area.

Formulation and implementation of shorten procedural set up for the approval of EA report is an utmost requi rement for the cost and time sensitive implementation of the development projects. Meanwhile, the quality control mechanism of such reports also needs to be highlighted through intensive knowledge enhancement practices not only of the consultants preparing such reports but also of the concerned stakeholders of the assessment procedures including individuals and institutions under GoN. Smooth, early and timely coordination between concerned stakeholders also can generate momentum for maintaining the quality of EA reports, early approval of EA reports and approval and implementation of removal of trees and acquisition of forest area for development projects.

9.5 Legal Documents Reviewed:

GoN (2076) Forest Act (FA) 2076, Government of Nepal.

GoN (2076) Environment Protection Act (EPA) 2076, Government of Nepal.

GoN (2077) Environment Protection Regulations (EPR) 2077, Government of Nepal.

GoN (2079) Forest Regulations (FR) 2079, Government of Nepal.

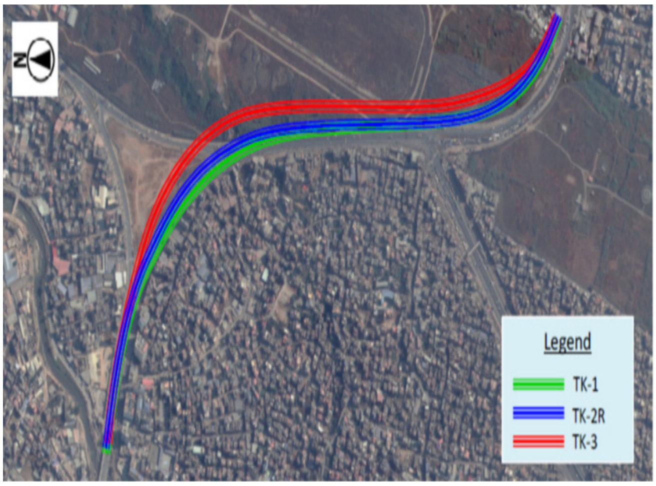
10. Photographs of the few works in Fiscal Year 2079-80

Before Improvement

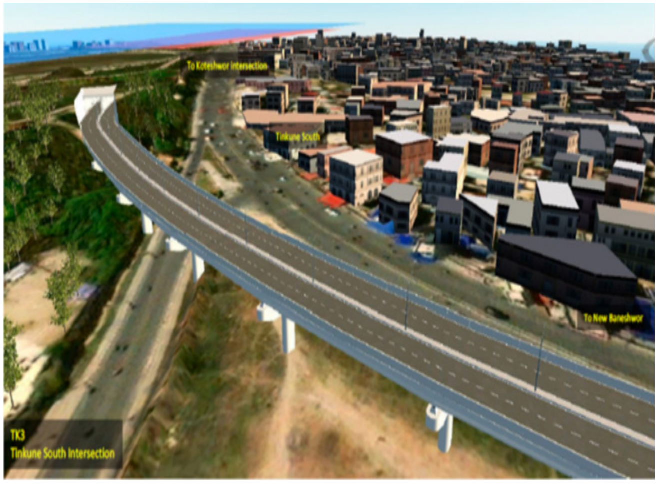
After Improvement

(a) Phogotraph of Jadibutti chowk before and after improvement

Proposed Alternatives for Koteshwor-Tinkune Intersection



Different alternatives



Flyover towards Tinkune Chowk

Flyover towards Jadibuti Chowk

(b) Schematic diagram of different alternatives of Intersection improvement plan for Tinkune Intersection 50 big (Flyover +Cut and cover tunnel + Flyover)

1- View of Rebar setting at Portal

2- View of Concrete Lining

3-Setting of Geotextile and Water Proofing Membrane

4- View of Invert Concrete

(c) Photographs of under-construction Naghdhunga Tunnel

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