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A Study of Quarry Sites for Second International Airport

by

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APPROVAL PAGE

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The undersigned certify that they have read and recommended to the Institute of Engineering for acceptance, a thesis entitled "**A Study of Quarry Site for Second International Airport**" submitted by Ashesh K. Yadav in partial fulfillment of the requirements for the degree of Master of Science in Transportation Engineering, Nepal is a record of works carried out by him under my supervision and guidance.

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ABSTRACT

Second International Airport is seen as alterative to relieve the flow of flights with higher capacity compared to TIA and enhance the air transport connectivity between Nepal and rest of the world as an international hub airport including transit facilities. The project site is located in the Bara district with Boundary as Bakaiya River in the east and Pasaha River in the west.

There are three quarries namely Bakaiya River, Bagmati River and Rapti River near to the project site with approximately 50 km distance with crusher plant established. These quarries have sufficient amount of raw material for the SIA project to be built. Raw materials collected from these quarries meet the standard specification of Department of Roads as well as Manual of Tribhwan International Project for the undergoing construction project of two bay in south of bay no: 1. Raw materials are tested for Gradation, Los Angeles Abrasion (LAA), Aggregate Crushing Value(ACV), Sodium Sulphate Soundness(SSS), Specific Gravity(G), California Bearing Ratio(CBR), Stripping Test, Alkali Reactivity Test and are found to meet the specifications.

Key words: Second International Airport, LAA, ACV, SSS, G, CBR

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LIST OF ABBREVIATIONS

CAAN	Civil Aviation Authority of Nepal
DoR	Department of Road
TIA	Tribhuwan International Airport
SIA	Second International Airport
EIA	Environment Impact Assessment
IEE	Initial Environmental Examination
CBR	California Bearing Ratio
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
FI	Flakiness Index
LAA	Los Angeles Abrasion
SSS	Sodium Sulphate Soundness
G	Specific gravity/Unit weight
Max.	Maximum
Mpax.	Million Passengers
Lt.	Liters
Mmole	milimoles
Kg	Kilograms
ASTM	American Society for Testing and Materials
AASHTO	American Association of State Highway and Transportation Officials
IS	Indian Standard

CHAPTER ONE:
INTRODUCTION

1.1 Background

Tribhuwan International Airport (TIA) has reached its saturation level and Second International Airport is seen as alterative to relieve the flow of flights with higher capacity compared to TIA and enhance the air transport connectivity between Nepal and rest of the world as an international hub airport including transit facilities. Second International Airport is the proposed Inetrnational Airport located at Kolhavi Municipality, Province 2, Nepal. Proposed Airport covers approximately about 80 sq. km. of area with east boundary as Bakaiya River and West boundary as Pasaha River respectively. Figure 1.1 shows the topomap of SIA.

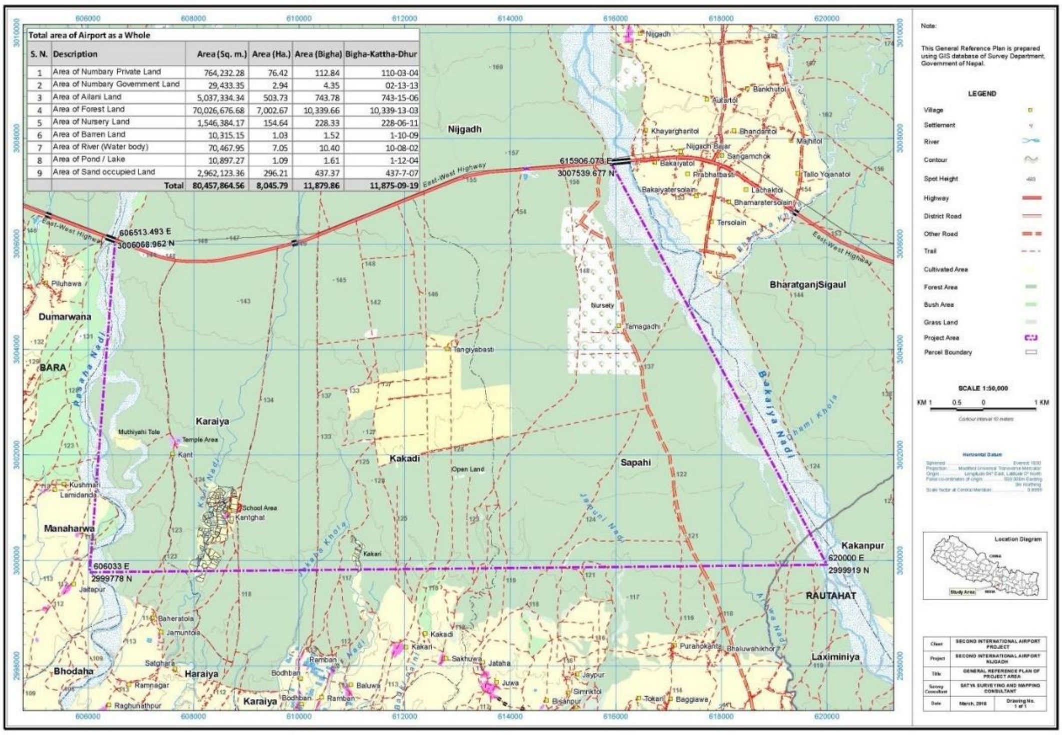

Figure 1.1:Location Map of Proposed Second International Airport

Location of Second International Airport provides free maneuvering airspace of minimum 20 km radius with 150 km distance from the capital which will be connected with Kathmandu-Terai Expressway. Second International Airport is expected to have two parallel run ways with capacity of 15 million passenger annually with as well as Airbus A380.

Building such a national pride project needs a lot of raw materials such as Aggregate, Sand, Boulders, cement, Bitumen, etc. Among these materials, raw materials such as Aggregate, Sand, Boulders, are used from locally available quarry nearest to the construction site. These construction materials should be strong enough to make durable infrastructures built for the designed category. There are different tests conducted to make sure the materials collected from these quarries meet the specification for the designed period and loading.

1.2 Statement of the Problem

Construction of such a huge project requires a lot of raw material. Inferior construction material which does not meet the standard design and specification will result in both serviceability and economy of the Project. Therefore, construction materials meeting the standard specification must be used and construction should be supervised. Thus, Identification of such quarry sites near to the project will not only provide the standard construction material but also make the project economical.

1.3 Research objectives

Objective of this study is to conduct tests of different materials from different quarries to meet the minimum standard as per specification in abundant quantity.

Specific objectives:

i. To conduct lab test of raw materials collected from the quarry sites investigated.
ii. To verify the results with standard specifications.
iii. To find out quarries investigated could yield enough material for the completion of project.

1.4 Scope of the Study

This study will help for the identification of quarry site for contractors as well as government agencies. This study also makes sure about the quantity required for the construction of SIA is sufficient from these quarries. After knowing the physical properties of these quarry, it can also be used for other infrastructure development project to make strong and durable infrastructure.

1.5 Assumptions and limitations

The assumptions of research works are listed below:

i. The sample collected represents the materials produced from all the crusher of that respective quarry.
ii. Quantities available in the EIA report of SIA is approximately equal to the quantities necessary for the completion of Project

The limitations of the research work are:

i. Quarry sites were selected from where materials are being extracted.
ii. Tests were conducted only for base course and Aggregates.

1.6 Study Location

Quarry sites selected are located near the site selected for the Second International Airport (SIA). There are three river basin near to the site from where materials has been collected for carrying tests. These quarry sites are:

i. Bakaiya River Basin (Bara District)

Figure 1.2: Crusher plant of Bakaiya River

ii. Bagmati District (Rautahat district)

Figure 1.3: Crusher plant of Bagmati River

iii. Rapti River (Makwanpur District)

Figure 1.4: Crusher Plant of Rapti River

Figure 1.5: Crusher producing crushed aggregate from natural aggregate

1.7 Organization of the Report

This report consists of total five chapters. First chapter includes introduction, scope, limitation and study area. Second chapter includes the significance of different tests and capacity of quarries as well as total quantity required for the construction. Third chapter includes methodology adopted for this research. Results and discussion are presented in chapter four whereas, chapter five includes conclusion of the research work.

CHAPTER TWO:
LITERATURE REVIEW

Newark airport, in New Jersey (USA) experienced asphalt shearing in the heavy aircraft braking zone associated with aircraft landings [27]. It was concluded that inadequate aggregate interlock resulted in a reduction in shear strength.

2.1 Quantity Required

Construction of such national pride project would require huge quantity of local and imported construction material. Local construction material shall be bought from nearest quarry sites.

An attempt is made to estimate the requirement of local construction materials for the single runway construction. These construction materials will be fill filled from local resources. Detail requirement of construction material for the full development phase will be made during the DPR preparation. There is large deposit of the local construction materials in the Pasaha Khola and Lal Bakeya River at the upstream which will be confirmed during the detail design phase. Table 2.1 gives the requirement of the construction materials in the Project.

Table 2.1: Requirement of Construction Material

SI	Key Construction Material	Unit	Tentative Quantity
1	Earth Fill	m^3	5,800,000.00
2	Sub Grade	m^3	330,000.00
3	Aggregates		
	Subbase	m^3	625,000.00
	CS Base	m^3	415,000.00
	Asphalt	m^3	275,000.00
	Concrete Pavement	m^3	120,000.00
	Structural Concrete	m^3	250,000.00
4	Sand	m^3	375,000.00
5	Boulders	m^3	150,000.00

(Source : EIA report of SIA; GEOCE consultants (P) Ltd.)

2.2 Capacity of Quarry Sites

Capacity of Quarry are calculated based on the length of the river, their corresponding width and depth of the raw material deposited. Furthermore, final capacity of quarries is calculated deducting the wastage of the crusher plant while converting raw material from quarry to standard materials. The capacity of quarries considered for study are:

2.2.1 Bakaiya River

Bakaiya river in the east boundary of the project site and located in Bara district. This quarry is the nearest quarry to the project site. Bakaiya river is 14900 m length with average width of 350 m and material deposition of 2 m. Raw material while processing in the crusher 25% waste materials are produced. With this data the capacity of this quarry after is shown in the table 2.2 :

Table 2.2: Capacity of Bakaiya River

SI	Key Construction Material	Unit	Tentative Quantity
1	Sand/Silt/Clay	m^3	2,346,750.00 (30 %)
2	Gravel	m^3	4,693,500.00 (60 %)
3	Gabion/Boulder	m^3	782,250 (10 %)
	Total (Deducting wastage)	m^3	7,8,225,00.00

2.2.2 Bagmati River

Bagmati River is 40 km east of the Project site in Rautahat district. Bagmati river is 21200 m length with average width of 350 m and material deposition of 2 m. Raw material while processing in the crusher 15% waste materials are produced. Capacity of the Quarry is shown in the table 2.3 :

Table 2.3 : Capacity of Bagmati River

SI	Key Construction Material	Unit	Tentative Quantity
1	Sand/Silt/Clay	m^3	5,045,600.00 (40 %)
2	Gravel	m^3	7,420,000.00 (50 %)
3	Gabion/Boulder	m^3	1,261,400.00 (10 %)
	Total (Deducting wastage)	m^3	112,614,000.00

2.2.3 Rapti River

Rapti River is 57 km west of the Project site in Makwanpur District.Rapti river is 13760 m length with average width of 250 m and material deposition of 0.5 m. Raw material while processing in the crusher 20% waste materials are produced. The capacity of Quarry is shown in the table 2.4 :

Table 2.4: Capacity of Rapti River

SI	Key Construction Material	Unit	Tentative Quantity
1	Sand/Silt/Clay	m^3	412,800.00 (30 %)
2	Gravel	m^3	825,600.00 (60 %)
3	Gabion/Boulder	m^3	137,600 (10 %)
	Total (Deducting wastage)	m^3	1,376,000.00

2.3 Material necessary for other Projects

Gravel necessary for the railway project is 3,534,017.65 cu.m.

(Source : Department of Railway, Bishalnagar, Kathmandu)

Quarry location and logging site are shown in the figure 2.1 :

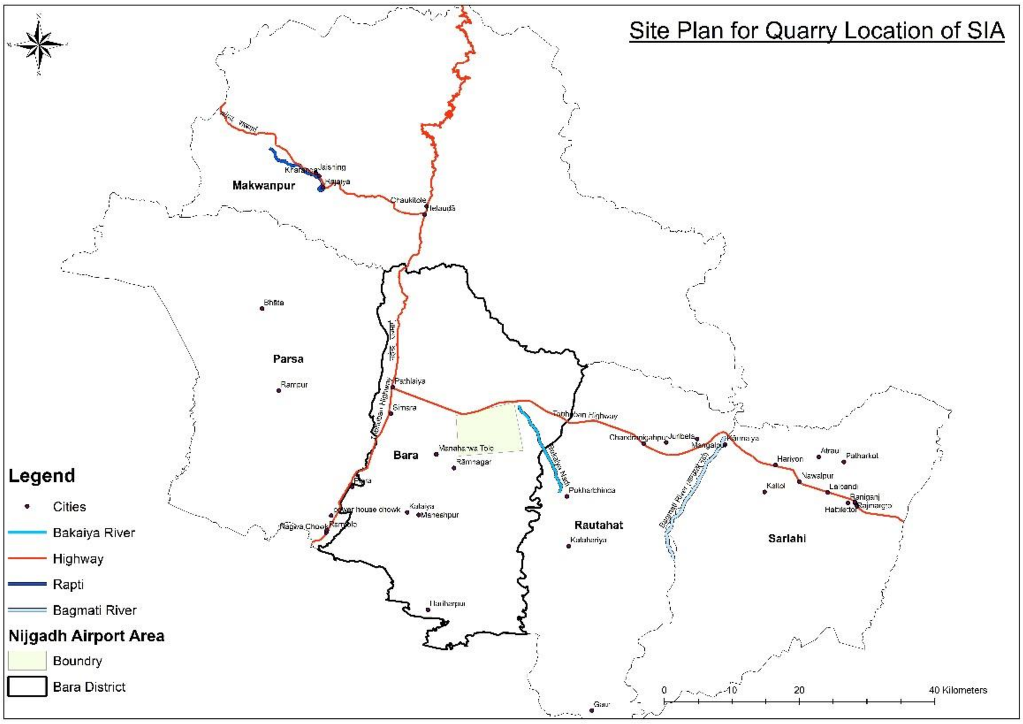

Figure 2.1: Site plan of Quarry for SIA

2.4 Standard Tests

Local material which we can obtain from quarry are aggregate, sand and boulder. There are different tests with respective significance of materials. These tests are:

2.4.1 Gradation Test

Gradation is the non-destructive qualitative test expressed in percentages by weight of the various particle size of which a sample of aggregate is composed. This test has direct influence in quality and cost of pavement component.

The results of indirect tensile strength show that the tensile strength of asphalt concrete increases along with the increment of gradation index, till reaches its peak and then decreases. (Arief SETIAWAN, Latif Budi SUPARMA, Agus Taufik MULYONO)

2.4.2 Flakiness Index

The flakiness index of aggregate is the percentage by weight of the aggregate particle whose least dimension or thickness is less than 3/6 times of their mean dimension. More flaky aggregate effects in workability of the concrete.

2.4.3 Specific Gravity

Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Specific gravity of an aggregate is considered to a measure of quality or strength.

2.4.4 Aggregate Impact Value (AIV)

Aggregate impact value is the value used to measure the impact resistance to the sudden load by the aggregate. This shows toughness of the aggregate by resisting disintegration when subjected to the standard loading.

2.4.5 Los Angeles Abrasion (LAA)

Los Angeles abrasion test is the test to check the resistance against wearing ability of the aggregate. This test signifies how hard aggregate to resist abrasion.

2.4.6 Soundness Test

This test is conducted to check the resistance of aggregate against weathering action by performing accelerated weathering test cycle. This test determines aggregate capacity to withstand alternate wet and dry conditions.

2.4.7 California Bearing Ratio (CBR) Test

CBR test is measure of resistance of sample material against penetration to the standard load against controlled condition. The load is expressed as standard load value to obtain specified deformation level and is said as CBR value.

2.4.8 Stripping Test

This test is conducted to check the effect of moisture upon the adhesion of bituminous film with surface of the aggregates. Bitumen is coated to the aggregated and subjected to the distilled water to determine the adhesion between aggregate and bitumen.

2.4.9 Alkali reactivity Test

This test is conducted to check the potential reactivity of an aggregates with alkalis in Portland cement and concrete. Aggregate which passes from 300 micron sieve and retains in 150 micron sieve is reacted with 1 N sodium hydroxide solution during 24 hour at 80 ºC.

2.5 Standard Specification

References for the standard specification for this study is Standard Specification for Road and Bridge works – 2073 & Specifications Section 20 000: Civil Works and Section 20 400 Structural concrete works of “Construction of Two Bay on southside of Bay No. 1 of International Apron, Tribhuwan International Airport “.

2.5.1 Standard Specification for Road and Bridge works – 2073

i. **Base Course**

Specification for base course is shown in table 2.5:

Table 2.5: Aggregate Grading Requirement for Base Course (DoR Specification)

Sieve Size	Percentage Passing by Weight
53	100
45	95-100
26.5	
22.4	60-80
4.75	25-40
2.36	15-30
0.6	8-22
0.075	0-5

Specification for Physical requirements for Wet mix macadam base (DoR Specification) is shown in table 2.6:

Table 2.6 : Physical requirements for Wet mix macadam base (DoR Specification)

S.N.	Test	Test Method	Requirements
1	Los Angeles Abrasion Value(LAA) or Aggregate Impact Value (AIV)	IS: 2386 – 4 IS: 5640	40 max. 30 max.
2	Combined Flakiness and Elongation index	IS: 2386 - 1	35 max.

ii. Asphalt Concrete

Specification of aggregate for asphalt concrete is shown in table 2.7:

Table 2.7: Composition Qty. Bituminous concrete Pavement Layers (DoR Specification)

Grading	
Nominal aggregate size	**19 mm**
Layer Thickness	**50 mm**
IS sieve (mm)	**Cumulative % by weight of total aggregate passing**
26.5	100
19	90-100
13.2	59-79
9.5	52-72
4.75	35-55
2.36	28-44
1.18	20-34
0.6	15-27
0.3	10-20
0.15	5-13
0.075	2-8

The physical requirements for coarse aggregate for is shown in table 2.8:

Table 2.8 : Physical Requirements for Coarse Aggregate for Bituminous Concrete (DoR Specification)

Property	**Test**	**Specification**	**Method of Test**
Particle Shape	Combined Flakiness and Elongation Indices	Max 35%	IS: 2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%	IS: 2386 Part IV
Durability	Soundness Sodium Sulphate	Max 12%	
Water Absorption	Water Absorption	Max 2%	IS: 2386 part III

2.5.2 Construction of Two Bay on southside of Bay No. 1 of International Apron, Tribhuwan International Airport

i. Base Course

Specification of Base course as per TIA Manual Division 20 300-Pavement Works is shown in table 2.9:

Table 2.9 : Gradation of Aggregate for Base course (TIA Manual)

Sieve Designation (Square Opening)	**Percentage by Weight passing Sieves**
50	100
37	90-100
25	70-95
19	55-85
4.75	30-60
0.6	12-30
0.075	0-8

The table 2.10 shows quality standard for Base course aggregate:

Table 2.10 : Quality Standard for Base course Aggregate (TIA Manual)

Work Item	Test Form	Test Method	Standard Value
Well Graded Crushed Aggregate Base Course	LAA	AASHTO T-96or equivalent	Max. 35%
	AIV		Max. 25%
	FI	By the Engineer's Instruction	Max 25
	SSS	AASHTO T-104 or equivalent	Max. 12%
	Moisture Content	ASTM D-2216 or equivalent	2%

ii. **Asphalt Concrete**

Specification of Asphalt Concrete as per TIA Manual Division 20 300-Pavement Works is mentioned in table 2.11 and quality standard is shown in table 2.12 respectively.

Table 2.11 : Gradation of Aggregate for Asphalt Concrete (TIA Manual)

Sieve Designation (Square Openings)	**Percentage by Weight Passing Sieves (%)**	
	Type 1 (Asphalt Binder Course)	**Type 2 (Asphalt Surface Course)**
25	100	
19	90-100	100
12.5	70-90	90-100
9.5	68-82	-
4.75	35-55	55-70
2.36	20-35	35-50

1.18	-	-
0.6	11-23	18-30
0.3	5-16	11-21
0.15	4-12	6-16
0.075	2-7	4-8

Table 2.12 : Quality Standard for Asphalt Concrete (TIA Manual)

Work Item	**Test Form**	**Test Method**	**Standard Value**
Asphalt Concrete Surface Course and Binder Course	LAA	AASHTO T-96 or equivalent	Max. 30%
	FI	By the Engineer's Instruction	Max 25
	SSS	AASHTO T-104 or equivalent	Max. 5%
	Moisture Content	ASTM D-2216 or equivalent	3%

2.6 Necessity of Standard Materials

"Newark airport, in New Jersey (USA) experienced asphalt shearing in the heavy aircraft braking zone associated with aircraft landings. It was concluded that inadequate aggregate interlock resulted in a reduction in shear strength." **C.J. Bognacki, A. Frisvold, T. Bennert.**

"The gradation and mechanical properties of aggregates impressively affect the load carrying capacity and rutting resistance of asphalt mixtures. They are able to provide some fundamental parameters that are linked to mixture performance." **Yao Zhang , Xue Luo, Ibrahim Onifade, Xiaoming Huang, Robert L. Lytton , Bjorn Birgisson**

"Aggregate properties can affect mix properties in different ways. For example, if the aggregates used are weak they may disintegrate easily under the action of Marshall hammer during the mix design process. Consequently, fines and filler content in the mix are increased leading j possibly, to a Marshall stability being higher than usual[l]. Gandhi and Lytton investigated large number of aggregate tests and whether these tests can be used as indicators of performance of asphalt concrete mixes. These tests include, but not limited to, Los Angeles abrasion, soundness, sand equivalent, water absorption, and percentage crushed particles. They concluded that some of these tests can be used to judge the quality of aggregates based on a suggested acceptance criterion. Specifically, they mention that aggregate disintegration may very well be linked to the results of Los Angeles abrasion, soundness, and friable particles' tests. All these properties can be related to asphalt concrete performance.” **ABDULRAHMAN S. AL-SUHAIBANI**

“Flaky and elongated particles have larger specific surface area which results in higher demand of cement paste in cement concrete mix. These particles impede compaction or break during rolling and decrease the strength of pavement layer. The effect of different percentages 0 to 50% of Combined Flaky and Elongation Aggregates (CFEA) for Pavement Quality Concrete (PQC) on the compressive and flexural strength of cement concrete and on the properties of aggregate, such as, bulk density, impact value, crushing value, water absorption.” **Kundan Meshram**

“Permanent deformation (i.e. rutting) of asphalt pavements is one of major types of distress modes experienced in the service life of pavements. Aggregates are one of the key building materials used in the construction industry and the largest portion of an asphalt pavement. Therefore, aggregate characteristics impressively affect the performance of asphalt pavements. Gradation is one of the important characteristics of aggregates affecting permanent deformation of hot mix asphalt.” **Amir Golalipoura,*, Ehsan Jamshidib , Yunus Niazic , Zahra Afsharikiad , Mahmood Khademe**

CHAPTER THREE:

METHODOLOGY

First Step of the Research is stating the Statement of the Problem along with objectives of the study. Then, literature review is made from different studies, research articles, reports, internet, etc. After this , clear mind set is made about how to take further steps for the study. Work plan is made, project site is visited. Probable quarry sites are investigated and material is collected from the crusher plants of respective quarry sites. Collected material is brought to the lab and all necessary tests are conducted following the standard steps. The data from the tests are noted down, analyzed, and then the results are presented. After getting the result, conclusion and recommendations are made.

Schematic representation of the methodology is shown in figure 3.1:

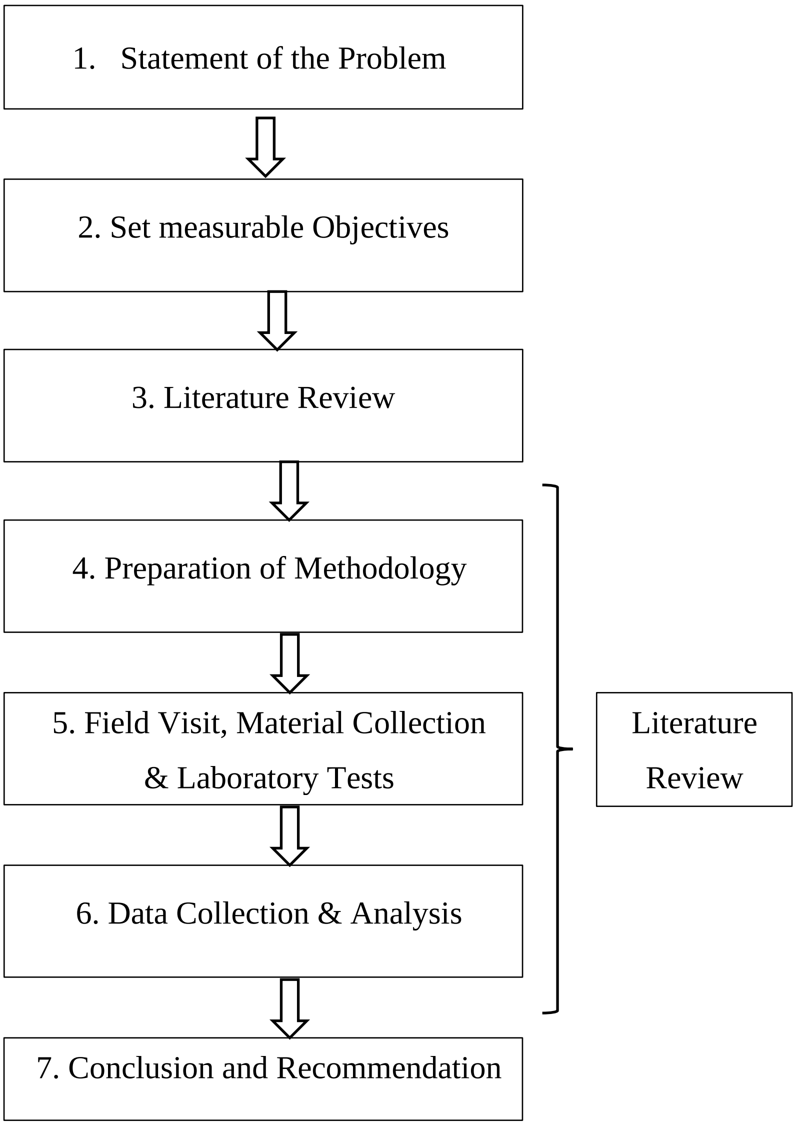

Figure 3.1: Schematic diagram of Methodology

3.1 Identification of Quarries and Material Collection

To identify the quarries, Project site was visited. The area was visited. With the help of investigation and literature review, the quarry sites were identified. The quarry sites were visited and raw construction material were collected. The quarries identified were Bakaiya River, Bagmati River and Rapti River. The materials were collected from these quarries and tested on lab to determine their physical properties and gradation.

3.2 Laboratory Tests

These raw materials collected were tested for various qualities as per specification. The methods adopted for the test are mentioned below:

3.2.1 Gradation Test

The particle size distribution or Gradation test determines individual weight retained, cumulative weight retained and total weight passing on each sieve. Aggregate gradation influences almost every important HMA property including stiffness, stability, durability, permeability, workability, fatigue resistance, skid resistance and resistance to moisture damage.

Materials available in natural quarries generally contain random or single size aggregates. Thus, crusher plant produce the raw material as per desired specification to fit for construction by determining the proportion of each group size of aggregate. The aggregate is classified into three groups based on the particle size. The blending of aggregates are carried out by trial and error of the different percentage of the aggregate types until meet the required specification as specified in Standard Specification for Road and Bridge works, 2073 or TIA Manual. Figure 3.2 shows the gradation conducting of the raw material in laboratory.

Figure 3.2:Gradation of Base Material

3.2.2 Los Angeles Abrasion Value

Abrasion test is carried out to test the hardness property of aggregates. The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge. Test is done as:

Objective:

i. To determine LAA Value

Apparatus:

i. LAA cylindrical machine having inside diameter 700 mm and length 500 mm
ii. Cast iron spheres approximately 48 mm diameter with weight in the range of 390 gm to 445 gm.

Procedure:

i. Prepared sample (5 kg to 10 kg depending upon gradation) is placed in the abrasion-testing machine.
ii. A specified number of steel spheres are then placed in the machine and the drum is rotated for 500 revolutions at a speed of 30 - 33 revolutions per minute (RPM).
iii. The material is then separated into material passing the 1.70 mm sieve and material retained on the 1.70 mm sieve.
iv. Dry the sample in an oven.
v. Calculate percentage loss due to Abrasion by calculating the difference between the retained material (larger particles) compared to the original sample weight.

Calculation:

LAA is calculated as;

$$LAA = \frac{W1 - W2}{W1} \times 100$$

Where,

W1 = Original weight of the Sample

W2 = Weight of the aggregate retained in 1.7 mm sieve.

Figure 3.3: Los Angeles Abrasion Test

3.2.3 Aggregate Impact Value (AIV)

Aggregate Impact value represents the hardness of the aggregate material tested. AIV test is Carried out as:

Objective:

i. Determine AIV of the aggregate

Apparatus:

i. Testing machine weighing 45 Kg to 60 Kg having lower base plate not less than 30 cm in diameter.
ii. Cylindrical steel cup of internal diameter 102 mm , 50 mm deep and minimum thickness 6.3 mm
iii. Metal hammer weighing 13.5 kg to 14 kg. The free fall of the metal hammer should be within 380 ± 5 mm.
iv. Tamping rod of 10 mm in diameter and 230 mm long , rounded at end.

Procedure:

i. Aggregate must be oven dried.
ii. Cylindrical steel cup is filled by oven dried aggregate passed from 12.5 mm sieve and retained at 10 mm seive as 3 layers, each layer tamped by 25 blows.
iii. 15 blows are given by the hammer making it fall from 38 mm height freely.
iv. Aggregate is then sieved in 2.36 mm sieve.

Calculation:

AIV is calculated as;

$$AIV = \frac{W2}{W1} \times 100$$

Where,

W1 = Original weight of the Sample

W2 = Weight of the aggregate passing in 2.36 mm sieve.

Figure 3.4: AIV TEST

3.2.4 Soundness Test

Soundness test is done to determine weather resisting ability of the aggregate. Soundness test is performed as:

Procedure:

i. Weight and clean the sample
ii. Immerse the sample in the saturated solution of sodium sulphate for 16 to 18 hours.
iii. Sample is oven dried at 105 to 110 ºC
iv. This process is repeated for 5 times and each time the sample is visually inspected to see splitting, crumbling or disintegration of grains.

Loss in weight after 5 complete cycle is calculated.

3.2.5 Flakiness Index

The Flakiness index of aggregates is the percentage by weight of particles whose least dimension (thickness) is less than three- fifths (0.6times) of their mean dimension. This test is not applicable to sizes smaller than 6.3mm.

Calculation:

FI is calculated as;

$$FI = \frac{W1}{W2} \times 100$$

Where,

W1 = Flaky material passing the appropriate slot from each size range of test aggregate are added up

W2 = Total weight of test sample

Figure 3.5: Flakiness Index Test

3.2.6 Specific Gravity

Specific gravity of aggregate represents the quality or strength of aggregate. Gradation specifications are valid only if the fine and coarse aggregate have approximately same specific gravity.

Aggregate sample is immersed in water for 24 hours. The sample is weighed in water. The sample is taken out , dried and then weighed. Sample then is dried in 100-110 ºC in oven for 24 hours and then weighed.

Calculation:

G is calculated as;

$$G = \frac{W}{W2-W1}$$

Where,

W = weight of oven dry sample in air

W2 = weight of saturated sample in air

W1 = weight of saturated sample in water

Figure 3.6: Specific Gravity Test

3.2.7 Stripping Test

Stripping Test is conducted to determine the adhesion of bitumen with aggregate when subjected to moisture. Test is performed as:

Procedure:

i. 100 gram of aggregate sample is taken.
ii. Aggregate is heated to 120-150 ºC and bitumen is heated to 150-175 ºC which is mixed with 5% of the bitumen.
iii. Sample is completely coated and left to cool in beaker.
iv. Distilled water is added to immerse the coated aggregate in beaker for 24 hours maintained at 40 ºC.
v. Visual Examination is done to evaluate the stripping value

3.2.8 CBR Test

CBR test is used to determine the stability of flexible pavement materials. It is defined as the ratio of force per unit area required to penetrate a soil mass with circular plunger 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration of standard material. Figure 3.7 and 3.8 shows CBR test arrangements:

Procedure:

i. Three specimens each of about 7 kg was compacted so that their compacted densities range from 95% to 100% generally with 10, 30 and 65 blows.
ii. Weight of empty mould was taken.
iii. Water was added to the first specimen (compacted it in five layer by giving 10 blows per layer)
iv. After compaction, collar was removed and surface was levelled.
v. Sample was taken for determination of moisture content.
vi. Weight of mould + compacted specimen was taken.
vii. Mould was placed in the soaking tank for four days
viii. In the similar fashion, other samples were prepared giving 30 and 65 blows respectively repeating he whole process.
ix. Mould was removed from the tank and water was allowed to drain.
x. Specimen was placed under penetration piston, load was applied and penetration load values were noted.
xi. Graph was drawn between penetration and penetration load values and CBR was noted for 2.5 mm penetration.

Figure 3.7: CBR Specimen soaking

Figure 3.8: Load application on CBR specimen

3.2.9 Alkali Reactivity Test

This test is conducted to check the potential reactivity of an aggregates with alkalis in Portland cement and concrete. Aggregate which passes from 300-micron sieve and retains in 150-micron sieve is reacted with 1 N sodium hydroxide solution during 24 hours at 80 ºC. This test is carried out in Aastha Scientific Research Service Pvt. Ltd. , Dillibazar, Kathmandu as per ASTM Designation: C 289-87 test method.

3.3 Test Pits

The depth of the material deposition and its composition is done with the test pits of the river site and figure 3.9, 3.10 and 3.11 represents test pits of Bakaiya, Bagmati and rapti river respectively:

Figure 3.9: Representation of Material Deposition at Bakaiya River

Figure 3.10: Representation of Material Deposition at Bagmati River

Figure 3.11: Representation of Material Deposition at Rapti River

CHAPTER FOUR:
RESULTS, ANALYSIS AND DISCUSSION

4.1 Raw material consumption and Quarry Capacity

After the investigation, literature review and analyzing data. Combined capacity of all three-quarry sites after deduction of wastage and railway project is shown in table 4.1:

Table 4.1: Total Raw material yield from 3 quarries

SI	Key Construction Material	Unit	Tentative Quantity
1	Sand/Silt/Clay	m^3	7,805,150.00
2	Gravel	m^3	9,405,082.00
3	Gabion/Boulder	m^3	2,181,250.00
	Total	**m^3**	**24,834,670.00**

Second International airport needs total amount of raw construction material is shown in table 4.2:

Table 4.2: Total Construction material required for Single Bay SIA

SI	Key Construction Material	Unit	Tentative Quantity
1	Aggregates		
	Subbase	m^3	625,000.00
	CS Base	m^3	415,000.00
	Concrete Pavement	m^3	120,000.00
	Structural Concrete	m^3	250,000.00
2	Sand	m^3	375,000.00
3	Boulders	m^3	150,000.00

By observing the demand of raw material , supply from these river will be enough to complete the project.

4.2 Results of the Lab test

4.2.1 Gradation

Gradation curve obtained from the quarries of the base course is shown in figure 4.1, 4.2 and 4.3 for Bakaiya River, Bagmati River and Rapti River respectively:

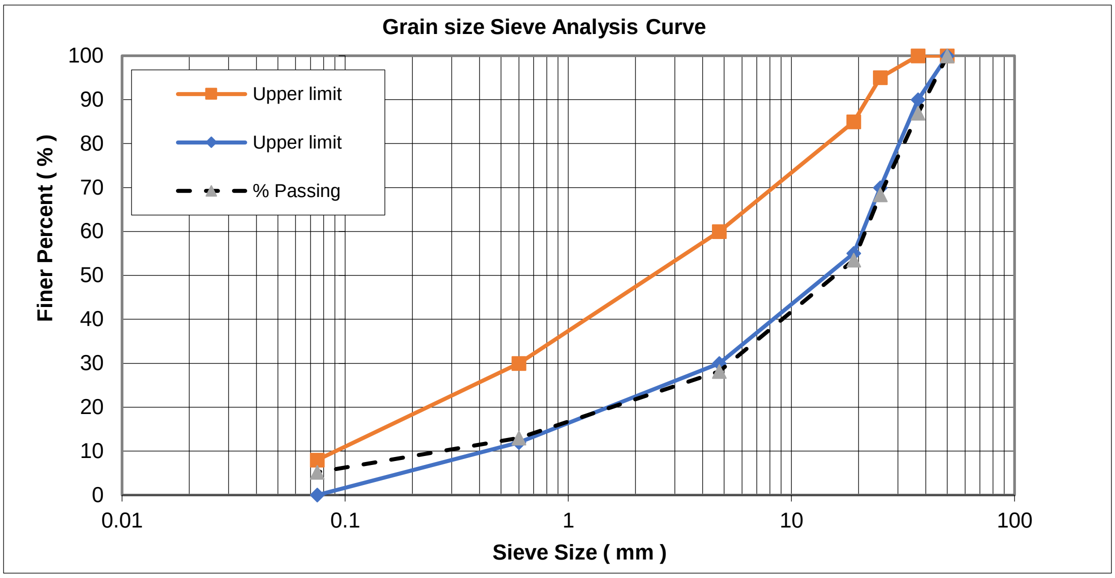

Figure 4.1: Gradation Curve of Base course of Bakaiya River

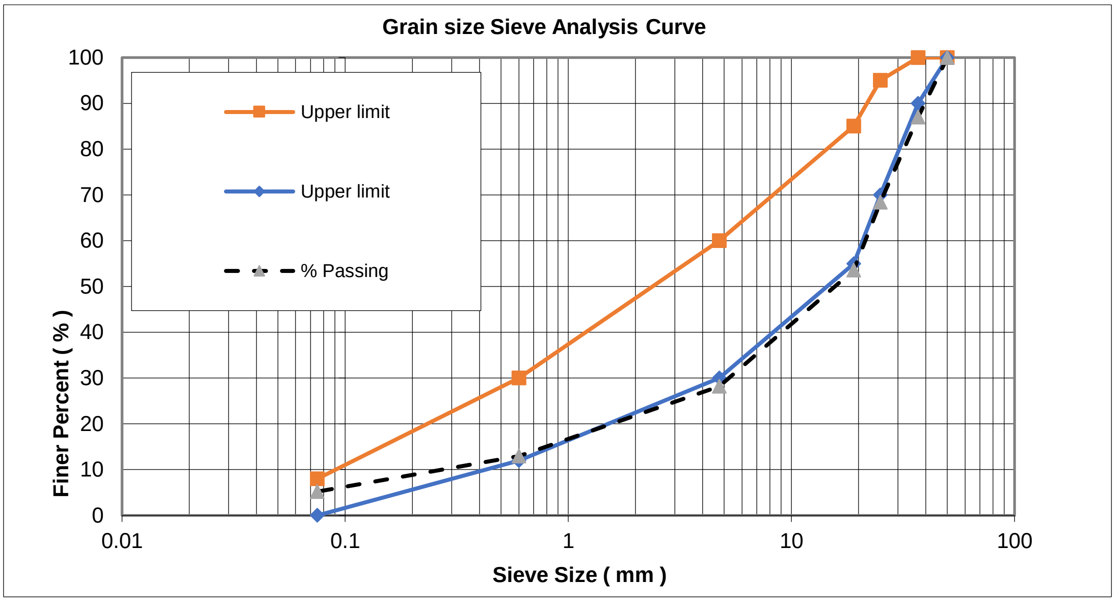

Figure 4.2: Gradation Curve of Base course of Bagmati River

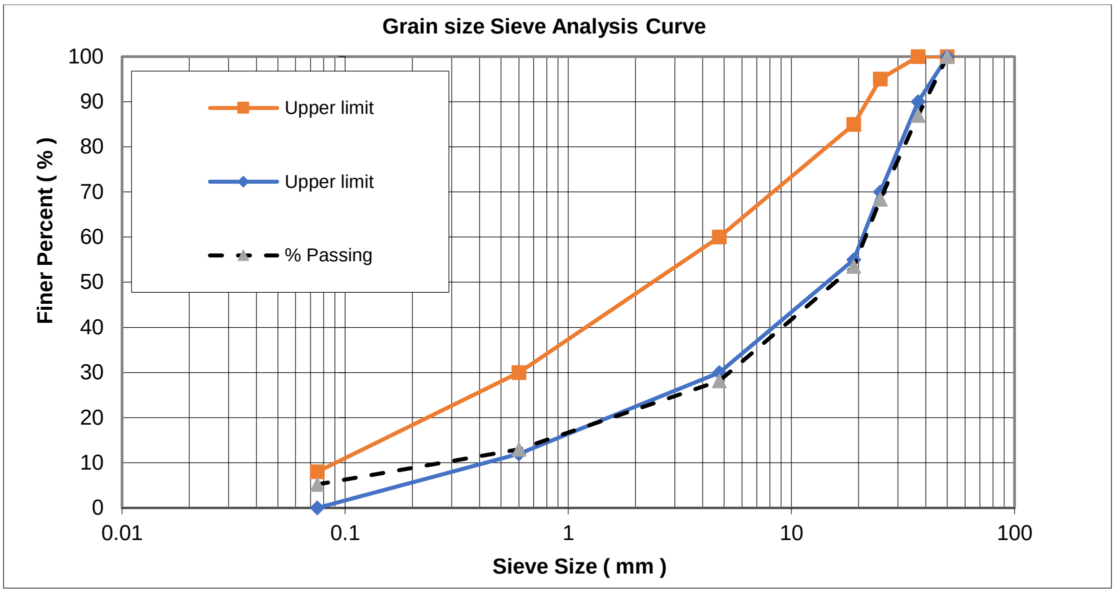

Figure 4.3: Gradation Curve of Base course of Rapti River

4.2.2 Los Angeles Abrasion Test

Los Angeles Abrasion value after lab test are summarized in table 4.3:

Table 4.3 : Test results of LAA from Quarries

SN	Quarry Site	Los Angeles Abrasion (LAA)
1	Bakaiya River	29.1
2	Bagmati River	24.24
3	Rapti River	33.79

4.2.3 Aggregate Impact Value

Aggregate Impact value of raw material of three quarries are summarized in table 4.4:

Table 4.4: AIV value from Quarries

SN	Quarry Site	Aggregate Impact Value (AIV)
1	Bakaiya River	20.12
2	Bagmati River	17.97
3	Rapti River	21.55

4.2.4 Soundness Test

Sodium Sulphate soundness of the raw material from the quarries are summarized in table 4.5:

Table 4.5: SSS value of Quarries

SN	Quarry Site	Sodium Sulphate Soundness (SSS)
1	Bakaiya River	3.6
2	Bagmati River	3.4
3	Rapti River	4.2

4.2.5 Flakiness Index

Flakiness Index of the raw material from the quarries are summarized in table 4.6:

Table 4.6 : FI of Quarries

SN	Quarry Site	Flakiness Index (FI)
1	Bakaiya River	20.3
2	Bagmati River	12.53
3	Rapti River	19.51

4.2.6 Specific Gravity

Specific gravity of the raw materials from the quarries are summarized in table 4.7:

Table 4.7: Specific gravity of Quarries

SN	Quarry Site	Specific Gravity
1	Bakaiya River	2.648
2	Bagmati River	2.652
3	Rapti River	2.646

4.2.7 Crushing Ratio

Crushing Ration of the raw materials from the crusher of the respective quarries are summarized in table 4.8:

Table 4.8: Crushing Ratio of Crusher for respective Quarries

SN	Quarry Site	Specific Gravity
1	Bakaiya River	90.66
2	Bagmati River	86.54
3	Rapti River	89.77

4.2.8 Stripping Value

Stripping Value of the raw materials of quarries are summarized in table 4.9:

Table 4.9: Stripping Value of Quarries

SN	Quarry Site	Specific Gravity
1	Bakaiya River	>95
2	Bagmati River	>95
3	Rapti River	>95

4.2.9 CBR Value

CBR value of the base material from the quarries are summarized in table 4.10:

Table 4.10: CBR Value of Quarries

SN	Quarry Site	Specific Gravity
1	Bakaiya River	81%
2	Bagmati River	85%
3	Rapti River	84%

4.2.10 Alkali Reactivity Test

Alkali reactivity of the aggregate from the quarries is shown in table 4.11 and 4.12 for Reduction in alkalinity and reactive silica respectively:

Table 4.11: Reduction in Alkalinity of Quarries

SN	Quarry Site	Reduction in Alkalinity, Rc (mmole/lt)
1	Bakaiya River	29.03
2	Bagmati River	61.03
3	Rapti River	43.95

Table 4.12: Reactive Silica in Quarries

SN	Quarry Site	Reactive Silica, Sc (mmole/lt)
1	Bakaiya River	3.18
2	Bagmati River	2.68
3	Rapti River	6.08

CHAPTER FIVE:
CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

Thus, from above results and discussion it is clear that the selected quarries can yield sufficient raw materials for the successful completion of project. Furthermore, the Physical Properties of the raw material meet the standard specification of DoR and TIA manual. Thus, using raw materials from these quarries will result in strong and durable infrastructure if proper supervision and other standards are met.

5.2 Recommendation

Recommendation are as below:

i. Crusher plants producing base course material should be adjusted to meet the gradation curve of gradation curve specified in TIA manual for the construction of Two Bay on southside of Bay No. 1 of International Apron.
ii. Cone crusher can be used to decrease the Flakiness Index of the raw materials.
iii. Capacity of quarries (Bakaiya, Bagmati, Rapti) are found to be sufficient for the construction of SIA project
iv. Bakaiya River is nearest to the site, will be most economical.
v. Bagmati river has better quality of aggregates, which shall be more preferable to be used for wearing course
vi. Rapti river is most distant from the site and raw materials can be used for base course

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APPENDIX-I: AGGREGATE TEST

A. SPECIFIC GRAVITY TESTS

- Specific Gravity of Aggregate

Specimen no.	Rapti	Bakaiya	Bagmati
Water Temperature (22^0C to 32^0C)	25.0	25.0	25.0
Room Temperature (27^0C)	27.0	27.0	27.0
Wt. of Basket in Water (gm) Y	720.0	720.0	720.0
Wt. of Basket + Saturated Aggregate in Water (gm) X	2136.0	2143.0	2144.0
Wt. of Saturated Aggregate in Water (gm) C = (X-Y)	1416.0	1423.0	1424.0
Wt. of saturated surface dry Aggregate In air (gm) B	2267.0	2276.0	2280.0
Wt. of oven dried Aggregate in air (gm) A	2252.0	2259.0	2270.0
Specific Gravity (Oven Dry) A/(B-C)	2.646	2.648	2.652
Bulk Specific Gravity (SSD) B/(B-C)	2.664	2.668	2.664
Apprent specific Gravity A/(A-C)	2.694	2.702	2.683
Water Absorption (%) 100 (B-A)/A	0.67	0.75	0.44

B. LOS ANGELES ABRASION TESTS

Test result is shown below:

Los Angeles abrasion Test Results			
Type of grading - B	**Rapti**	**Bakaiya**	**Bagmati**
Wt. of sample (g) W1	5002	5000	5000
Wt.of Sample retained on 1.70mm sieve (g) W2	3312	3545	3788
Los in weight due to wear W1-W2 (g)	1690	1455	1212
Los Angeles abrasion value % (W1-W2/W1*100)	33.79	29.10	24.24
Avg. Los Angeles abrasion value %	33.79	29.10	24.24

C. AGGREGATE CRUSHING VALUE

Test result is shown below:

Determination of Aggregate Impact Value Test As per IS : 2386 - (Part-IV) 1963				
Serial No.	**Description**	**Bagmati**	**Bakaiya**	**Rapti**
1	Total weight of aggregates sample (gm)	356.0	333.0	348.0
2	Weight of the aggregates passing 2.36 mm sieve after the test (gm)	64.0	67.0	75.0
3	Weight of the aggregates retained on 2.36 mm sieve after the test (gm)	292.0	266.0	284.0
4	Aggregate Impact Value (%)	17.98	20.12	21.55

APPENDIX-II: PHOTOGRAPHS

Material Deposition Layer wise of Bakaiya

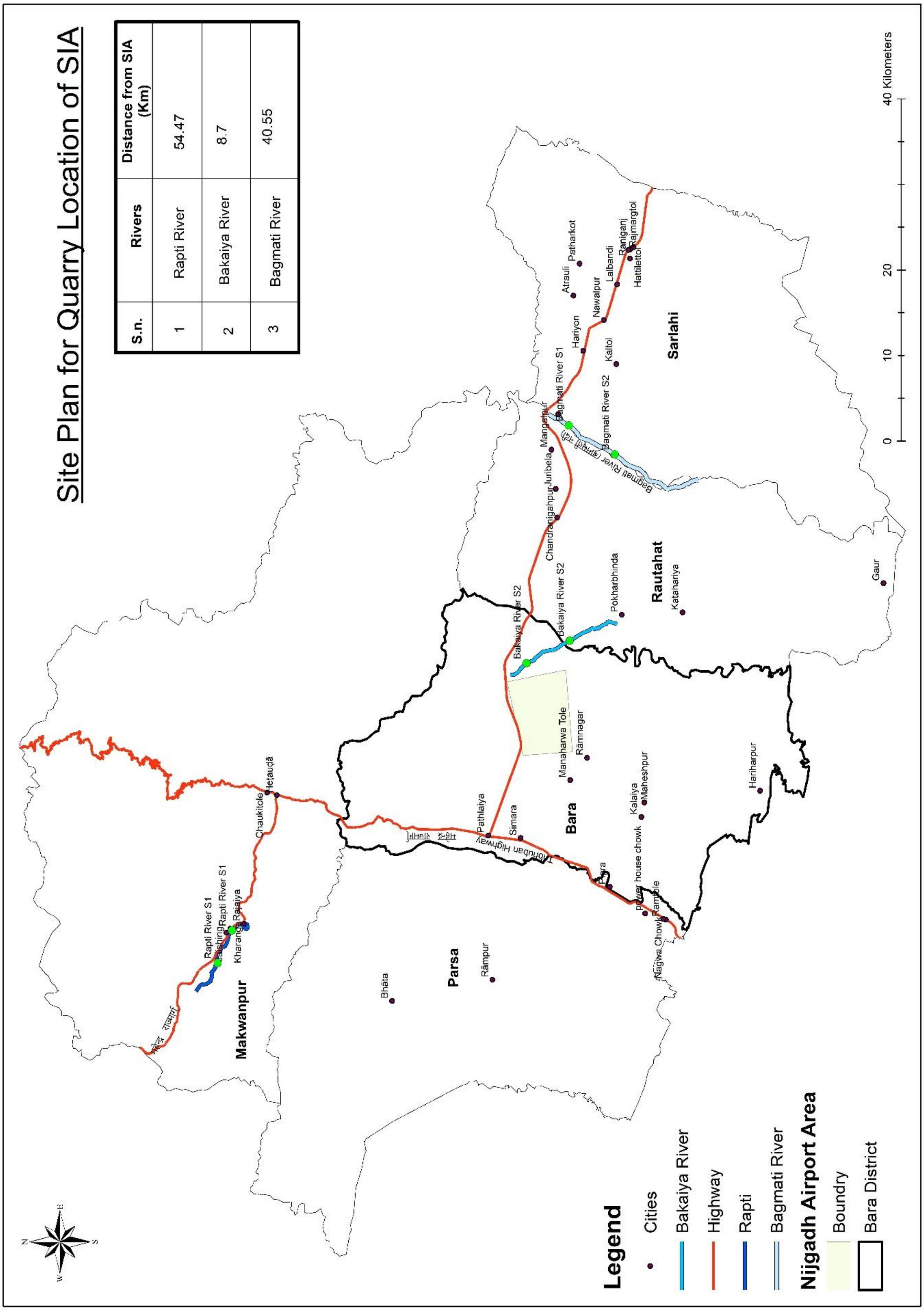
Extraction of Material from Bakaiya River

Rapti River Material Deposition

Rapti River Material Deposition

Material Deposition Layerwise for Bagmati River

Material Extraction of Bagmati River


Site Plan for Quarry Location of SIA
S.n. | Rivers | Distance from SIA (Km)
1 | Rapti River | 54.47
2 | Bakaiya River | 8.7
3 | Bagmati River | 40.55
Makwanpur
Parsa
Bara
Rautahat
Sarlahi
Hetauda
Chaukitole
Pathlaiya
Simara
Ramnagar
Manaharwa Tole
Kalaiya
Maheshpur
Hariharpur
Bhata
Rampur
Pokharbhinda
Katahariya
Chandranigahpur
Juribela
Mangalpur
Hariyon
Nawalpur
Lalbandi
Atrauli
Patharkot
Kalloi
Gaur
Rapti River S1
Bakaiya River S2
Bagmati River S1
Bagmati River S2
Tribhuban Highway
0 10 20 40 Kilometers
Legend
Cities
Bakaiya River
Highway
Rapti
Bagmati River
Nijgadh Airport Area
Boundry
Bara District

APPENDIX-III: CERTIFICATION

KALIKA - TUNDI JOINT VENTURE

Shantibasti, Sanepa, Ring Road, Lalitpur-3, Nepal, Phone: 5184173, 5184273, 5184010, 5184091
Fax: +977-1-5184274, E-mail: tundicons@gmail.com, Website: tundigroup.com.np

Date: 26 Nov. 2019

TO WHOM IT MAY CONCERN

This is to certify that the **Ashesh Kumar Yadav (2072/MST/251)** have performed all their listed necessary laboratory test related to their Masters in Transportation (M. Sc.) Thesis as per the requirements of Institute of Engineering, Tribhuvan University on Kalika – Tundi Contractor Site Lab, TIA. The lab tests were performed under the supervision of our senior lab in charge .

Tests performed:

- Aggregate tests:
  Gradation test, Flakiness Index (FI), Elongation Index, Soundness, Specific Gravity, Los Angeles Abrasion (LAA), AIV, CBR , Antistripping, Crushing Ratio etc.

Binod Shiwakoti
Sr. Lab Technician

A Joint Venture
of
Kalika Construction Pvt. Ltd.-Nepal   Tundi Construction Pvt. Ltd.- Nepal

AASTHA SCIENTIFIC RESEARCH SERVICE PVT. LTD.
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(Center for complete scientific solution)

Test Report/Certificate

Report No. : 843/2076
Entry No. : AASTHA – 569 – 2076
Sample : Aggregates
Client : Ashesh Yadav

Date received : 15 – 08 – 2076
Date completed : 18 – 08 – 2076
Sampled By : Client

S. N.	Parameters	Test Method	Observed Values		
			Bagmati	Bakaiya	Rapti
1.	Reduction in Alkalinity, Rc (mmole/lt)	ASTM Designation: C 289-87	61.03	29.30	43.95
2.	Reactive Silica, Sc (mmole/lt)	ASTM Designation: C 289-87	2.68	3.18	6.80

Analyzed By

Checked By

Authorized By