1. MATERIALS INVESTIGATIONS

1.1 General

Mugling-Pokhara Road, the road alignment passes through the Marsangdi Hydro Powerhouse station, community forest covered area with cultivated land, human settlement area and Built up areas -markets. Road having gentle climbing and rolling gradient all-weather for traffic movements. The study for availability of construction materials (boulders, cobble, gravel and sand) in river basin and pit quarries, existing local crusher plant were made. There are local crusher plants at 10+000 and 71+000 kotre area of the alignment. Source of gravel are Marsangdi River, Maadi River, Seti river basin and Borrow Pit at Kotre area adjacent of the road alignment. Their capacity and the haulage distances to the construction site were noted in order to estimate the cost and the sufficiency of quantity and quality required for the construction. Samples were collected and brought to Kathmandu laboratory for test. A list of quarries and test result of material sources are listed below in Table 4.1 and details are presented in Annexes.

The Engineering characteristics and location/availability of construction materials are essential aspects of the road design and construction. The acceptance of an appropriate design methodology carries with it a recognition that established criteria for road materials need to be looked at closely in terms of actual engineering purpose within individual road environment. Detailed specifications to safeguard these requirements are generally defined in terms of properties such as grading, strength, petrographic and plasticity. Natural construction materials are used to satisfy a range of general requirement within a road environment, namely

- as fill materials,
- pavement materials,
- as a surfacing medium,
- as concrete aggregate,
- as filter mediums,
- as masonry or gabion fill, and
- as material for maintenance purpose.

It is becoming increasingly recognised that a key objective in sustainable road construction is to best match the locally available material to its road task and suit its local environment. Construction costs of the pavement structures are typically about 35~40 per cent of the total road construction cost and it is clear that, the identification and characterisation of available road construction materials is an important stage for a road design and the following are seen as crucial points with respect to the ability of a material to carry out its assigned task within a road pavement design and it has to compliance with STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS Section 600.

- information of the engineering properties of the material,
- the method required for the processing of the material,
- the governing road environment, and
- Probable future alterations to the road environment.

Material samples from selected sources were taken to the laboratory in Kathmandu and subjected to various testing with a view to evaluate the suitability and characteristics strength of the materials. The laboratory test results are summarized in Table 4.1.

Sieve Analysis

The grain size analysis (gradation test) was carried out according to (IS: 2386 (part 1)-1963. Standard procedures were followed by receiving the sample through a stack of sieve from 63 mm to 0.075 mm in diameter. The mass of material retained in each individual sieve was determined and the cumulative percentage was calculated. Sieve analysis of the sub grade, riverbed materials, sub base materials were carried out. The gradation ratios of the gravel, sand, silts, and are shown in the Table 4.1.

Atterberg Limits (PI)

The Atterbergs Limits namely, the liquid limit and plastic limit were determined according to the standard procedure outlined in IS 2720 (part 5) - 1963.

Los Angeles Abrasion Test (LAAV)

The Los Angeles Abrasion test was carried out according to the standard procedures outlined by (IS 2386- PART 4 1963). The percentage of abrasion was calculated on the basis of the tests. Samples collected from different river basin across the alignment and away from the alignment as elsewhere sources etc.

Tested results of different probable quarry are as a Natural Gravel from Marsangdi River 27.26%, Maadi River 36.8% and Seti river basin Borrow pit 34.64% Observed.

These above said possible quarry tested vales are closer as indicated in **STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS.** Hence, these locally available materials are suitable as Construction materials. This is the scenario of Sewalik range materials Index. These sources of material can be used as the Base Course (CSB), Pavement sealing aggregates and the aggregate for Concrete works. It can be used as an aggregate as a material for wearing courses well as road Pavement Structure materials, the reference Index properties of materials are indicated in Table 4.1.

Aggregate Crushing Value Test (ACV)

The Aggregate Crushing Value test was carried out according to IS: 2386 (part IV)-1963 standard. The aggregate crushing value of different location of above said river bed material as Natural river gravel of Marsangdi River basin, Maadi River basin and Sati river basin are 15.87%, 26.5% and 26.4% respectively. To ensure the good pavement Structure materials and sealing aggregates must be resistance to crushing under gradually applied compressive load, abrasion effect etc. Usually aggregates with crushing values less than 10% are regarded as strong and above 35% are normally weak for use in road surface. The above figure indicates the border range as said in STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS, the tested results are summarized in Table 4.1.

Aggregate Impact Value Test (AIV)

The Aggregate Impact Value test was carried out according to IS: 2386 (part IV)-1963 standard. The AIV value of material from different location of river banks material listed in fig.4.3 as a Natural aggregate tested values are 17.7%,23.1% and 22.91% are complying with STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS, section 1202, Table 12.3 and Section 1303,Table 13.5 Physical requirements of Chippings. The test results of available materials are indicated in Table 4.1.

Flakiness Index (FI)

Flakiness Index test is carried out according to IS: 2386 (part IV)-1963 Standard. The flakiness Index of above said river bed Natural materials are indicated in Table 4.1.

Specific Gravity Test (Sp.Gr.)

The specific test is carried out under the standard (IS 2720-3(1980).

Maximum Dry Density "Procter" Test (MDD)

Compaction test is carried out to determine Maximum Dry Density (MDD) and Optimum Moisture Capacity (OMC).This test follows BS 1377-4:1990. Modified 4.5 Kg of rammer is used for BS heavy compaction test. Height of drop is 450 mm and compaction is carried out till 56 no of blows .Graph of dry density v/s moisture content is plotted and MDD is determined. The Maximum dry density occurs at optimum moisture content.

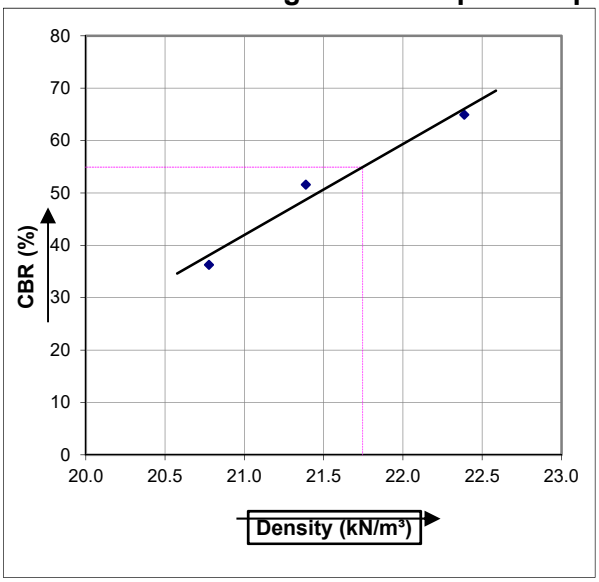
The materials obtained from different location of above said river banks, river gravel along the alignment possibly sources of construction materials as a suitability quarry are tested and tabulated in Table: 4.1.

California Bearing Ratio Test (CBR)

The Three Point CBR test was conducted for both road sub grade and proposed quarry materials. For sub grade ASTM D1883-5 method was adopted, whereas for Suitability of quarry materials AASHTO T 193-81 code was followed. The CBR at 95% modified MDD (heavy compaction) after 4 days soak was noted for Subgrade and Sub-base material.

Whereas for Suitability of quarry Construction materials for the project from different location of river bed material as Natural gravel for sub base and Local Crusher Plant Stocked pile material (CSB) the CBR values are presented in Table 4.1.

Figure 4.1: Graphical representation of CBR Calibration.



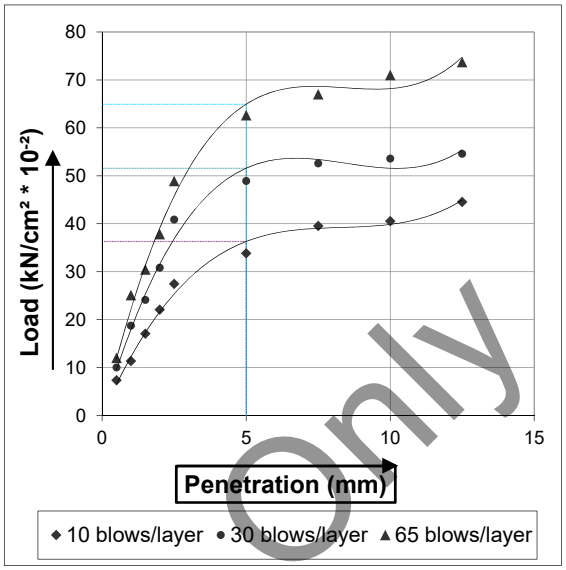


Table 4.1: Summary of Possible Construction Material Sources and the Laboratory Test Results.

S.N	Location/ Chainage	Natural Deposit Details	Crushed stone Aggregate(Base Course)						Natural Aggregate Material(Sub – Base)							Sand Approx. Qty & Composition		Remarks
			Qty*, m^3	FI%	AIV%	ACV%	LAA %	CBR %,@ 98% MDD	Qty*, m^3	LAAV, %	AIV, %	ACV, %	MDD (gm/c m^3)	OMC %	CBR,% @95% MDD	Qty*, m^3	Composition %	
1	Marsangdi River Basin Ch.9+000	Alluvial deposit comprised of boulder, cobble, gravel and sand of predominantly gneiss, quartzite and Schist. Visual Approx. Qty.= 35,450.0m3	11344.0	19.57	-	-	-	80.1	12,408.0	27.26	17.7	15.87	2.29	6.3	-	8,863.0	G= 74.84 S=24.89 C& Si=0.18	River Boulders are for Stone masonry works. If the gravel screened and selected boulders are properly crushed for Base material, course aggregate for concrete and S.D. aggregates suitable.
2	Maadi River Basin Ch.42+000	Alluvial deposit comprised of boulder, cobble, gravel and sand of predominantly gneiss, quartzite and Schist. Visual Approx. Qty.=373,750 m3	93,438.0	18.0	-	-	-	-	186,875.0	36.8	23.1	26.5	2.21	8.0	34	48,587.0	G= 87.69 S=12.25 C& Si=0.06	River Boulders for Stone masonry works. If the gravel screened and selected boulders are properly crushed for Base material, course aggregate for concrete and S.D. aggregates applicable.
3	Sati River Basin Ch.71+000,Kotre area Borrow pit	Alluvial /Colluvium deposit comprised of boulder, cobble, gravel and sand of predominantly gneiss, quartzite and Schist. Visual Approx. Qty.=460,000 m3	230,000.0	16.5	19.18	23.1	34.8	84.75	92,000.0	34.64	22.91	26.4	2.2	7.7	37.1	115,000.0	G=69.5 S=27.94 C& Si=2.56	River basin deposited gravel and Private land (borrow pit) gravel and boulders for masonry works. If the gravel screened and selected boulders are properly crushed for Base material, course aggregate for concrete and S.D. aggregates suitable.

Note: N=Natural (uncrushed), G=Gravel, S=Sand, Si= Silt, C= clay, *= Estimates Quantity, N.A. = Not applicable/ Not available at present.

1. Sources of water for construction works available from Stream/Khola across the road alignment.
2. All above quantities are approximately assessed by vicinal inspection assuming 1.0 m depth excavation.
3. Contractor can explore other material sources as well.

1.1.1 Material Sources and Quarry Survey

For the study of construction material and the possibility of quarry for construction materials (boulders, cobble, gravel and sand) , All quarries, existing Local crusher plant's ,crushed material were inspected and identified for the project as a sources of construction materials. The quarries availability of quantity, quality of material, accessibility and the haulage distances from the construction site were distinguished in order to assessment the cost of the project and the competence of quality required for the construction. Samples were collected from the probable quarries and tested at Kathmandu Laboratory. A list of suitable quarries and test results of material sources are listed in Table 4.1 and details location of quarry are presented in Annexes too.

The major sources for the Construction of Off-road Structures and Pavement Structures as a Pavement aggregates materials are Marsangdi river basin, Maadi river basin, Sati river basin and Private Land at Kotre area(borrow pits) which are shown in Table 4.1 and Annex 4.1A linear diagram and Annex 4.1B.

The stones/boulder for masonry and flexible retaining structures works is river deposited, Colluvium and residual sediments deposited along the above said locations, which are the possible quarries, the Contractor has to quarry himself with consulting the responsible authority holder agencies at the time of construction. The quantity of the construction materials are available as required from the above said location as a probable sources, the available material tested results were complies with the STANDARD SPECIFICATION FOR ROAD AND BRIDGE WORKS. The materials from possible Sources were considered as construction materials for the Project are indicated in Table 4.1.

At the time of acquiring Construction materials, Contractor should also confirm that the extraction of material from these sources will be environmentally acceptable and conserved the local human settlements and flora and fauna habitats.

The quality of materials from located sources and quantity availability of material such as boulder, gravel and sand, were found satisfactory, can be acquired using proper extraction methodology. Investigation and Study for possibility of construction materials had been done by collecting the samples from surveyed sources, which are shown in Table: 4.1and Fig.4.2.

The Water required for Construction works are available along the road Kholas/Streams across the alignment, the Contractor may have to prepare temporary access road at various locations for quarry development and water sources and the quarry has to reinstated contractor himself after quarried the construction materials.

The information given in Table 4.1 is approximately assessed by vicinal inspection and indicative only, the Contractor must satisfy himself for availability, suitability and quantities of materials prior to bidding. The Contractor has to confirm that the extraction of materials at these sources will be environmentally acceptable.

Figure 4.2: Location of Probable Quarry for Construction Materials.

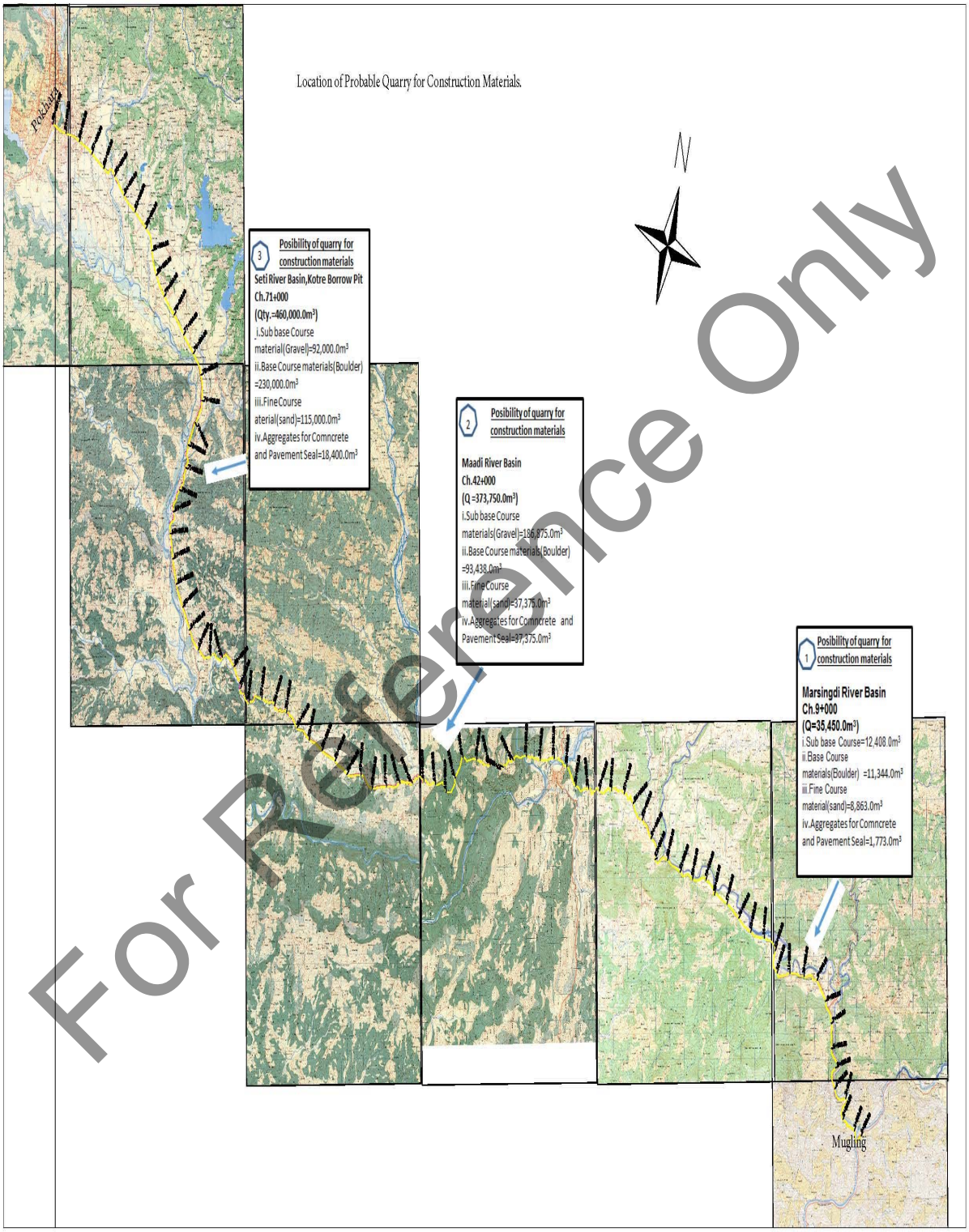
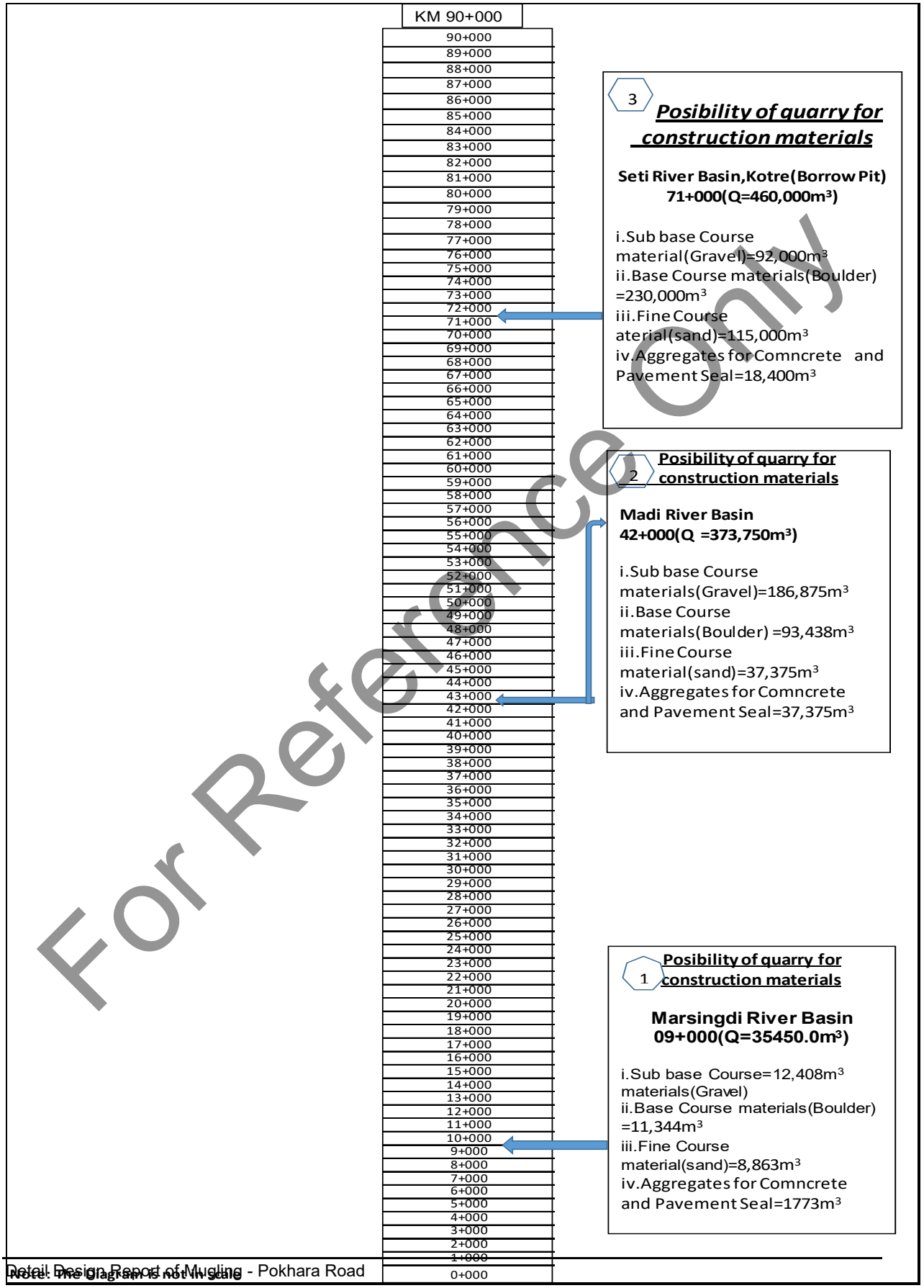


Figure 4.3: Location of Probable Quarry for Construction Materials.



Note: The diagram is not in scale

1.2 Materials for Embankment and Sub-grade

1.2.1 Embankment Fill

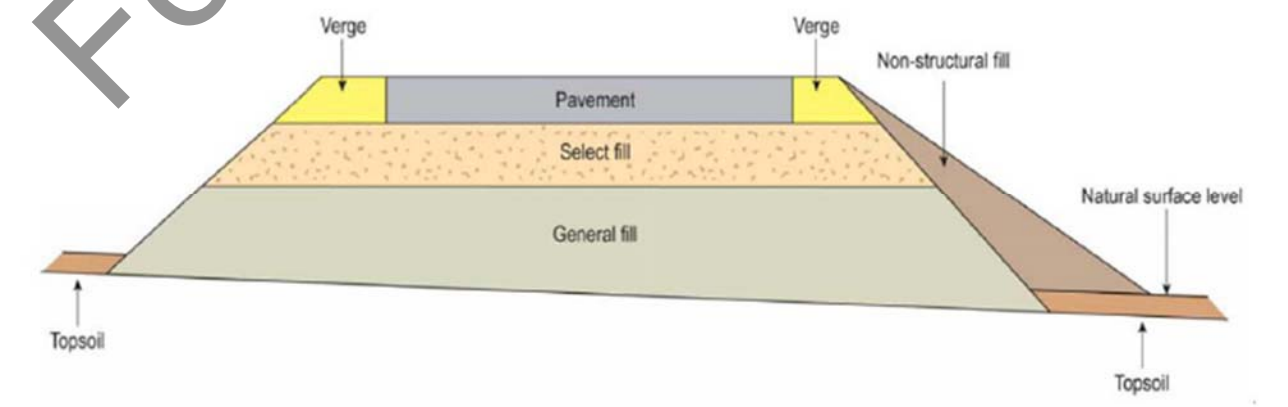
An embankment denotes to a volume of earthen material that is placed and compacted for the purpose of raising the grade of a roadway, above the level of the existing surrounding ground surface. Embankment fill refers to placed and compacted for the purpose of filling in the low level or drop section of existing ground level as formation level of road. Embankment fills are constructed of materials that usually consist of soil, but may also include aggregate, rock, or crushed paving material.

Generally, the fill materials are placed at base of the embankment (formation level) in order to provide a firm foundation, also to facilitate drainage and improve prevent withstand bearing capacity. The top portion of an embankment usually is constructed of relatively high-quality, well-compacted subgrade material that is capable of supporting the overlying pavement layers and imposed wheel loadings without deflection or undesirable movement. The embankment fill material must be capable of meeting applicable specification quality requirements and be capable of maximum achievable density and bearing strength.

Embankment fill or backfill is a very important part of every road structure. The embankment has to support the road pavement structures and shall further distribute the forces, applied onto the pavement structure, over the subsoil without exhibiting unacceptably large deformations. During constructing an embankment one should take into account a great number of variable properties of both the construction materials to be applied and the subsoil, the embankment determines the performance of the overlying road pavement structure. Normally the soil is an essential construction material.

It follows that insight into the behaviour of soil is necessary for the design and construction of roads. It has to be known how this behaviour must be analysed and how should be anticipated on this behaviour.

Figure 4.4: Composition of pavement structures layers and Embankment fill.



All fill material shall be obtained from required excavations and designated borrow areas. Embankments fill are typically constructed by compacting earthen materials in place, so the compaction properties of the material (optimum water content and maximum dry density) are very important to performance. The selection, blending, routing, and disposition of material in the various fills shall be subject to used.

1.2.2 Improved Sub-grade

The “subgrade” is the in situ material upon which the pavement structure is placed. Although there is a tendency to look at pavement performance in terms of pavement structure and mix design alone, the subgrade can often be the overriding factor in pavement performance.

The road alignment passes through formation encountering rocks, conglomerate and soft rock, mixed lattices soil with fragmented rocks and earth in sections. The sub grade and formation is mainly earthen or gravel mixed earth having either nil or low plasticity properties. Results of grain size analysis, strength characteristics and compaction, Strength of Sub grade is low, it can be improved by replacing existing material with superior quality of materials as Capping layer or by increasing the thickness of Sub –base course.

Sub-grade investigation comprises of determining the in situ CBR and other geological and geomorphologic observations along the alignment.

1.3 Pavement Construction Materials

1.3.1 Sub-base

In highway engineering, sub-base is the layer of aggregate material laid on the subgrade, on which the base course layer is located. It may be omitted when there will be only foot traffic on the pavement, but it is necessary for surfaces used by vehicles.

The sub-base shall be constructed after checking that the underlying layer conforms to the specified requirements or not, the underlying layer of Base Course to improve the Load baring capacity of Sub-grade deficiencies. The location of Sources and test results for construction materials are presented in Table 4.1and fig.4.3.

- Crusher run stone aggregate (CBR > 60 %) for crusher run modified sub-base, and
- Gravel (CBR > 30 %) for sub-base

Quality of Sub-base materials should comply with the standard Specifications Road and Bridge Works, Section 1201.

1.3.2 Base Course

A layer of Crushed Stone material of specified thickness constructed on the subgrade or sub-base of a pavement to serve one or more functions, such as distributing loads, providing drainage, or minimizing frost action.

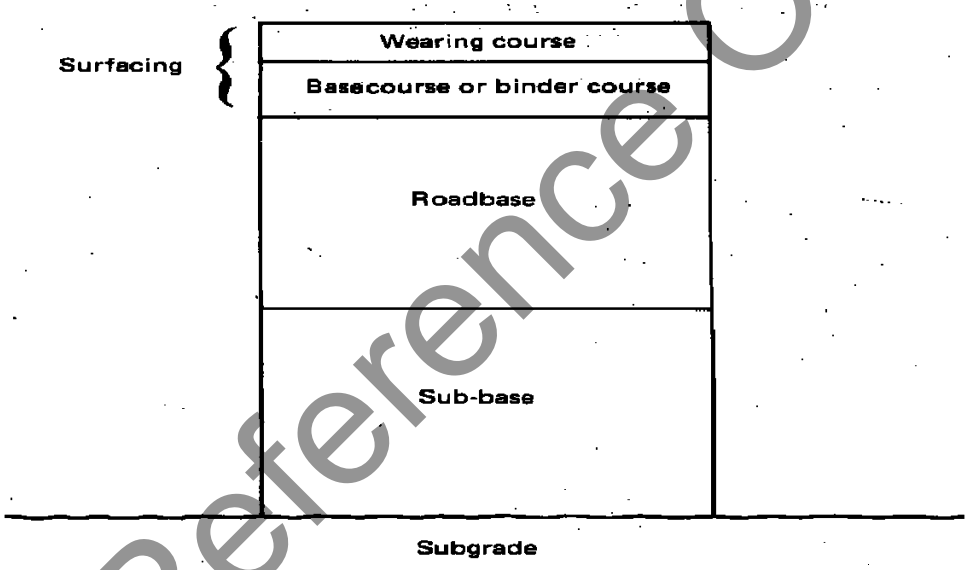
The Crushed Stone aggregates shall consist of both fine and coarse fragments of crushed stone or crushed gravel mixed or blended with sand, screenings, or other similar approved materials.

The crushed stone shall consist of hard, durable particles or fragments of stone and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter.

The method used in production of crushed gravel shall be such that the fractured particles occurring in the finished product shall be as nearly constant and uniform as practicable and Comply with Standard Specifications for Road and Bridge works Clause 1202.

If necessary to meet this requirement or to eliminate an excess of fine, uncrushed particles, the gravel shall be screened before crushing. All stones, rocks, and boulders of inferior quality in the pit shall be removed. The Physical requirements of Graded Crushed Stone Base course requirement of Table 12.3**,** standard Specifications Road and Bridge Works.

Figure 4.5: Composition of pavement structures layers



1.3.3 Stone Aggregates

Pavement Cover aggregate Index properties must be fulfil the standard and shall be natural screened gravel or crushed hard rock/stone, clean and free from adhering dust, achieved by washing and drying, or any other detrimental substance that could impair the adhesion of bitumen and shall conform to the requirements of Table 13.5 Standard Specifications Road and Bridge Works Section 1303.

1.3.4 Bitumen

Bitumen is a non-crystalline viscous material, black or dark brown, which is substantially soluble in carbon disulphide (CS2), possessing adhesive and water-proofing qualities. It consists essentially of hydrocarbons and would typically comprise at least 80% carbon and 15% hydrogen, the remainder being oxygen, sulphur, nitrogen and traces of various metals. The bitumen binder shall consist of Penetration grade bitumen, cutback bitumen or bitumen

emulsion. Penetration Grade Bitumen is commonly used in road surfacing, and some industrial applications.

Penetration Test determines the hardness of Bitumen by measuring the depth (in tenths of a mm) to which a standard, and loaded needle will vertically penetrate in 5 seconds, a sample of Bitumen maintained at a temperature of 25°C. Hence the softer the bitumen, the greater will be its number of penetration units (80/100, 60/70, 40/50) in Table 4.3.

Cutback bitumen binder shall comprise penetration grade 80/100 bitumen and cutter which shall be diesel or kerosene or a mixture of both prepared on Site". The type and proportion of cutter as required shall be add on Site, in the range 1 % to 10% after design of the surface dressing in accordance with the procedures set out in Chapter 5 of TRRL-ORN 3. The preparation of cutback bitumen shall be carried out in accordance with the TRRL Research Report RR104 "Preparation of cutback Bitumen (Hitch and Stewart). An extract from this Report is included in the Appendices and describes the preparation of cutbacks under site conditions.

Bitumen which will be using in this project should comply as said in STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS Section 618.

Table 4.2: Selection Criteria for Viscosity-Graded (VG) Paving Bitumen Based on Climatic Conditions

Lowest Daily Mean Air Temperature,°C	Highest Daily Mean Air Temperature, °C			Remarks
	Less than 20°C	20 to 30°C	More than 30°C	
More than -10°C	VG-10	VG-20	VG-30	
-10°C or lower	VG-10	VG-10	VG-20	

Table: 4.3 Specification of Penetration Grade Bitumen.

PROPERTY	GRADES			STANDARD
	BITUMEN 80/100	BITUMEN 60/70	BITUMEN 40/50	ASTM / AASHTO
Specification Gravity @25/25 °C	1.01/1.06	1.00-1.05	1.00-1.05	D-70
Penetration @ 25 ° C	80/100	60/70	40/50	D-5
Softening Point ° C	45/52	49/56	52/60	D-36
Ductility @ 25 ° C CMS	100 MIN	100 MIN	100 MIN	D-113
Loss on Heating (wt.)%	0.5 MAX	0.2 MAX	0.2 MAX	D-6
Drop in Penetration After Heating %	20 MAX	20 MAX	20 MAX	D-6 & D-5
Flash Point °C	225 MIN	250 MIN	250 MIN	D-92
Solubility in CS@ (wt.)%	99.5 MAX	99.5 MAX	99.5 MAX	D-4
Spot Test	NEGATIVE	NEGATIVE	NEGATIVE	-
Density @25° C	1.01/1.06	1.00/1.05	1.00/1.05	D70

1.3.5 Adhesion Agents (Anti-stripping additives)

Liquid adhesive agent /Anti Stripping Agent shall be added to the bitumen/cutback to increase the bond (active and passive adhesive) between the aggregates and binder. The agent used shall be good affinity with aggregates. Its application shall be in accordance to the manufacturer specifications unless otherwise instructed by the Engineer.

The agent used shall conform to the relevant IS requirements and conduct some additional periodic tests such as "under water coating tests", "stripping value for passive adhesive", 'thermal stability" or "solubility in high speed diesel" to confirm that the Adhesive agent to be used.

1.4 Availability of Materials for Concrete Works

1.4.1 General

Availability of construction material within economical distances and their suitability for different use investigated. During the field survey sources of boulder, cobble, gravel and sand quarry

sites were identified in the vicinity of the alignment. Efforts have been made to identify as many sources along the alignment as possible to reduce the haulage distances. Major three locations for possibility sources are along the alignment are acknowledge and are listed in Table 4.1 The Contractor can explore other material sources as well at the time of construction.

1.4.2 Aggregates

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete.

For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75 mm sieve. Coarse aggregates are any particles greater than 4.75 mm, but generally range between 4.75 mm and 15 mm in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

Natural gravel and sand are usually dug or dredged from a pit and river basin. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Sometime recycled concrete is a viable source of aggregate and has been satisfactorily used in granular sub-bases, soil-cement, and in new concrete.

Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that are considered include:

- grading
- durability
- particle shape and surface texture
- abrasion and skid resistance
- unit weights and voids
- absorption and surface moisture

Grading refers to the determination of the particle-size distribution for aggregate. Grading limits and maximum aggregate size are specified because these properties affect the amount of aggregate used as well as cement and water requirements, workability, pump ability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. When gap-graded aggregate are specified, certain particle sizes of aggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation and the quality of materials should complies with Standard Specifications Road and Bridge Works of Section 2003(4).Locally available materials possible sources are listed in fig.4.3.

1.4.3 Natural Coarse Sand

The quality and quantity availability of material such as gravel, sand and stones were surveyed and found to be available from the different location of the river basin with satisfactory quality and can be obtained using proper extraction methodology and the location of availability and quality are listed in Table 4.1 and located in fig.4.2.

Stone for masonry works can be obtained from the river bed as indicated in Table 4.1 sources, provided that the extraction of stone is done in an environmentally safe way with the approval of the Engineer, and the quality of materials should complies with Standard Specifications Road and Bridge Works of Section 2003(3).

1.4.4 Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. The most important uses of cement are as a component in the production of mortar in masonry, and of concrete, a combination of cement and an aggregate to form a strong building material.

Portland cement is by far the most common type of cement in general use around the world, Portland cement blends are often available as inter-ground mixtures from cement producers. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients. Cements which will be using in this project should comply as said in STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS Section 614.

Table 4.4: Comparison of Chemical and Physical Characteristics

Components of Cement Comparison of Chemical and Physical Characteristics					
Property	**Portland Cement**	**Siliceous (ASTM C618 Class F) Fly Ash**	**Calcareous (ASTM C618 Class C) Fly Ash**	**Slag Cement**	**Silica Fume**
SiO_2 content (%)	21.9	52	35	35	85–97
Al_2O_3 content (%)	6.9	23	18	12	—
Fe2O3 content (%)	3	11	6	1	—
CaO content (%)	63	5	21	40	< 1
MgO content (%)	2.5	—	—	—	—
SO3 content (%)	1.7	—	—	—	—
Specific surface (m2/kg)	370	420	420	400	15,000–30,000
Specific gravity	3.15	2.38	2.65	2.94	2.22
General use in concrete	Primary binder	Cement replacement	Cement replacement	Cement replacement	Property enhancer
a Values shown are approximate: those of a specific material may vary.					
[b] Specific surface measurements for silica fume by nitrogen adsorption (BET) method,					

Components of Cement Comparison of Chemical and Physical Characteristics					
Property	**Portland Cement**	**Siliceous (ASTM C618 Class F) Fly Ash**	**Calcareous (ASTM C618 Class C) Fly Ash**	**Slag Cement**	**Silica Fume**
others by air permeability method (Blaine).					

1.4.5 Admixtures

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

Admixtures play a vital role in production of quality concrete and mortars in all segments of the industry–Ready-mix, Precast and Site-batch. It is the ingredients in concrete other than cement, water and aggregate that is added to the mix immediately before or during mixing. Used primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

Admixtures are those components in concrete other than cement, water, and aggregates that are added to the mixture immediately before or during mixing. Admixtures can be classified by function as follows:

1. Air-entraining admixtures
2. Water-reducing admixtures
3. Plasticizers
4. Accelerating admixtures
5. Retarding admixtures
6. Hydration-control admixtures
7. Corrosion inhibitors
8. Shrinkage reducers
9. Alkali-silica reactivity inhibitors
10. Coloring admixtures
11. Miscellaneous admixtures such as workability, bonding, damp proofing, permeability reducing, grouting, and gas-forming, ant washout, foaming, and pumping admixtures.

1.4.6 Water

Water for Construction works could be Potable and available from the stream or khola across the road alignment, Contractor may have to quarry the sources of water and build a temporary access road at various locations.

1.4.7 Steel

Steel is a consequence that will strengthen an organism's future behaviour whenever that behaviour is preceded by a specific antecedent stimulus. Reinforcement bars shall be of high yield strength deformed (HYSD) Fe 500, Thermo mechanically Tested, having specified minimum 0.2 percent proof stress of 500 Mpa, Conforming to IS: 1139 or IS: 1786 or equivalent or specified on the Drawings. This strengthening effect may be measured as a higher frequency of behaviour (e.g., pulling a lever more frequently), longer duration (e.g., pulling a lever for longer periods of time), greater magnitude (e.g., pulling a lever with greater force), or shorter latency (e.g., pulling a lever more quickly following the antecedent stimulus).it increases or strengthens the behaviour. Steel which are using in this projects should comply as said in STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS Section 620.

1.5 Disposal Sites

The soil and rocks may derive from the road cut during the road construction period. Most of the cut materials along the road can be used as the construction materials for Back fill, if the available material comply the Technical Specification's requirement, if not the materials can be disposed into the designated area of the road alignment or elsewhere. The unused materials are disposal area is mentioned in Table 4.5.

Table 4.5: Possible Locations for Disposal of Excavated Material

SN	Location/Chainage	Geomorphology	Stability condition	Tentative area for disposal soil
1	1+360-1+480	Hill side Slope	Stable slope	> 1080 m2
2	2+200 – 2+670	Hill side Slope	Stable slope	> 5170 m2
3	6+480 – 6+900	Hill side Slope	Stable slope	>6720 m2
4	8+320 – 8+800	Hill side Slope	Stable slope	>5280 m2
5	10+700 – 12+520	Hill side Slope	Stable slope	>27300 m2
11	57+420 – 57+520	Hill side Slope	Stable slope	> 2200m2

1.6 Conclusions

1.6.1 Summary and Recommendation

One of the most common reasons for construction costs to escalate, once construction has started and material sources fully explored, are that the materials are found to be sufficient or deficient in quality or quantity. This leads to expensive delays whilst new sources are investigated or the road is redesigned to take account of the actual materials available. (TRL, 2005) Material investigation therefore often requires an extensive programme of site and laboratory testing, especially if the materials are of marginal quality, quantity and accessibility in the project area.

Traditionally materials are selected on their ability to perform defined engineering tasks in a road. The ability of the material to perform these tasks is normally assessed by their compliance, or non-compliance, with construction material specifications. Standard specifications and guidelines for using granular materials, such as those in set out in Overseas

Road Note 31 (TRL, 1993), need to be of a general nature. Theoretically these guidelines and other specifications refer to the material as it is finally compacted/laid on the road. The relative quality and in-service performance characteristics of road pavement materials are largely determined as required for the following main tasks

- Common embankment fill
- Capping layer (imported subgrade)
- Sub-base and road-base aggregate
- Road surfacing aggregate
- Aggregates for structural concrete
- Filter/drainage material

If the project is in an area where good quality construction materials are scarce or unavailable, alternate solutions that make use of the local materials should be considered to avoid long and expensive haulage For example consideration should be given to,

- modifying the design requirements
- modifying the material (e.g. lime or cement stabilization)
- material processing (e.g. crushing and screening)
- Innovative use of non-standard materials (particularly for low traffic volume projects).
- using a central quarry of good quality aggregate and budget for increased haulage costs
- blending materials to achieve a material that is within specification

At the time of materials investigations should take into account any future needs of the road. This is particularly important in the case of upgrading roads, gravel roads for all-weather. Sources of good material could be depleted with the result that haul distances and costs will increase. Furthermore, good quality material may be required at a later stage in the road's life when the standard needs to be improved to meet increased traffic demands.

Due respected collection of samples from different possibilities sources along the alignment and tested. Test results are varying with marginal and the availability of quantity in sources is not enough for the project, hence it is required to go for other sources of materials. So, the physical requirements of Graded Crushed Stone Base Course requirement of Table 12.3 and physical requirements of Chippings Table 13.5 and AC requirement of Course aggregates Table 13.17 of **Standard Specifications for Road and Bridge Works** has to revised the value of **LAAV maximum and AIV/ACV maximum 40% and 30%** respectively. The test result of locally available sources materials are given in Table 4.1.