

# **Technical Specifications for Low Cost Rural Roads**

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## **Low Cost Design Standards for Rural Roads Projects**

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**SPECIFICATIONS FOR LOW COST RURAL ROADS IN ROMANIA**

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## **1. INTRODUCTION**

### **1.1 GENERAL**

This Specification for the construction and maintenance of Low Cost Rural Roads in Romania is one in the series of manuals and standards commissioned by the Romanian Government as part of a wider rural development project funded through the World Bank. The complete series includes:

- Design Manual for Low Cost Rural Roads
- Technical Specifications for Low Cost Rural Roads (this volume)
- Standard Details for Low Cost Rural Roads
- Maintenance Manual for Low Cost Rural Roads

The manuals were prepared for the Project Management Unit (PMU) of the Rural Development Project (RDP), in the Ministry of Administration and Interior. The author of the manuals is the Louis Berger Group Inc. of Washington DC., USA.

### **1.2 PURPOSE**

The aim of these Specifications is to provide a basic set of quality requirements for the use of both local technical staff and contractors, to carry out and supervise construction and maintenance works on low cost rural roads projects. The requirements included here are based on similar documents prepared for national roads and take into account international practice for similar roads.

For more complex situations requiring higher levels of investment, including the construction of bituminous surfaced roads, the existing Romanian standards for roads will be applicable. County level engineers should be consulted on their use.

### **1.3 SCOPE**

The focus of the manuals is low cost solutions for rural road design, construction and maintenance. Such roads typically have traffic levels below 200 vehicles per day, although the solutions proposed may be applicable to roads carrying up to 500 vehicles per day.

The aim is to recommend solutions that can realistically be implemented for rural roads projects in Romania. Issues related to the engineering of lightly trafficked earth and gravel surfaced roads are given more prominence than bituminous surfaced roads.

## **2. DRAINAGE**

### **2.1 LONGITUDINAL DRAINAGE STABILIZATION**

#### **2.1.1 DESCRIPTION**

Ditches catch seepages and other water flows in order to keep the roadbed well drained. This section discusses protection of ditches. Excavation is covered under section 3.2.

On grades steeper than 2%, a grass cover prevents ditch erosion. On steeper grades, other protection such as rock lining or the construction of check dams may be required. If trees and shrubby vegetation in the ditch obstruct visibility or become a safety hazard, ditch maintenance strategies should favor brush cutting over ditch excavation.

#### **2.1.2 CONSTRUCTION REQUIREMENTS**

Stabilize ditches in accordance with the drawings and the following requirements:

##### **Rock-lining**

Ditches that require lining stone shall be lined to a height above the bottom of the ditch not less than one-half ( $\frac{1}{2}$ ) the diameter of the nearest culvert (upstream). However, in no case shall the lining extend less than 30 cm above the bottom of the ditch.

Lined ditches shall be constructed of sand bed and native stone. The lining shall be firmly bedded and securely attached to adjacent drainage structures. Sufficient mortar shall be used to attain a monolithic, and reasonably water tight lining.

The finished lined ditch shall conform to designated lines and grades.

##### **Sodding**

Ditches that require a grass cover shall be sodded to a height above the bottom of the ditch not less than one-half ( $\frac{1}{2}$ ) the diameter of the nearest culvert (upstream); however, in no case shall the sod extend less than 30 cm above the bottom of the ditch.

The sod shall consist of a live, dense, well rooted growth of permanent grasses, free from objectionable grasses, and suitable for the soil in which it is to be placed. The sod shall be at least 20 cm wide, not less than 30 cm long, and shall have at least 8 cm in thickness of dirt in its roots. The sod shall be placed only when the soil is moist and favorable to growth. No planting shall be done between November 1, and April 1, unless otherwise directed by the Supervisor.

The area to be sodded shall be constructed to the designated lines and grade, and the surface loosened to a depth of not less than 8 cm with a rake or other device. If necessary, it shall be sprinkled until saturated at least one 5 cm in depth and kept moist until the sod is placed thereon.

Immediately before placing the sod, commercial fertilizer shall be uniformly applied at the rate of 1kg per square meter.

The sod shall be placed on the prepared surface with edges in close contact and shall be pounded into place with wooden tamps, 25 cm by 25 cm or other satisfactory equipment. On steep slopes, pinning or pegging will be required to hold the sod in place.

The sod shall be maintained moist for a period of two (2) weeks, after which it may be treated with approved fertilizer, and watered again.

### **Seeding**

The area to be seeded shall be constructed to the proper line and grade and the surface shall be prepared to a depth of not less than 8 cm, with a rake or other device. After the top 8 cm of soil has been rendered loose, friable, and reasonably free from large clods, rocks, large roots, or other undesirable matter, lime and fertilizer shall be carefully worked into the soil.

Seeds shall be uniformly sown on the prepared area.

No Seeding shall be done from May 1 to August 1.

The mulched area shall be watered and maintained reasonably moist until germination and continued growth is insured.

### **2.1.3 TESTING**

All inspections shall be made visually by the Supervisor. All materials incorporated into the permanent works shall be certified by the suppliers, in accordance with legal provisions for materials certification.

## **2.2 CROSS DRAINAGE – GENERAL REQUIREMENTS**

### **2.2.1 DESCRIPTION**

Cross drainage structures are used where the road intersects a watercourse.

In all cases, it is good practice to try and ensure that any stream crossing is located:

- On a straight length of stream, away from bends
- Away from places where two channels join
- In an area with a well defined channel
- At a site where the road can cross at right angles

Cross drainage structures should be aligned with the existing stream channel as far as possible. Where this cannot be achieved, the culvert must be aligned with the center of the channel

immediately downstream of the outlet. If channel excavation is required to help align the culvert, it is better to excavate the upstream channel to fit the culvert entrance and then align the outlet with the existing natural channel. Minimal disturbance of the channel at the culvert outlet should be the priority consideration.

Avoid sharp vertical or horizontal grade breaks, and allow water a direct and unobstructed entry into culverts. Use catch basins as required.

### **Culvert Depth**

Ensure that culverts are not placed too low to allow sufficient slope for water to drain away. This happens frequently in flat terrain when ditches are excavated too deep. It is better to elevate the road on a low embankment to lift it above the water table. Improper drainage may also result from culverts settling in soft ground. If this is a problem, place foundations under the drainage structure.

### **Culvert Slope**

Culverts should follow the grade of the existing channel, but must also have a minimum slope of 2% to allow water to drain, and to prevent the deposition of materials inside the culvert. The outlet will need to be protected against erosion. The outlet should be at the same level as the bottom of the existing channel. Do not exceed slopes of over 20% for culvert installations – the use of a drop inlet or outfall is a better solution .

### **Cross Drain Frequency**

Cross drains used to transfer water from an upslope side drain should be spaced every 150 meters or so. On steep slopes, greater than 5%, the spacing may need to be reduced so they are frequent enough to allow small pipes to easily handle peak flows. They should discharge to a turnout drain. The discharge point of the culvert and the discharge from the turn out drain must both be protected against erosion.

Always consider consequences of plugged drains and plan for a backup.

## **2.3 CULVERTS**

### **2.3.1 DESCRIPTION**

This work shall consist of circular pipe culverts of a specified type, diameter or shape , laid upon a bed and backfilled.

The types of pipes to be used are listed as follows:

Type 1 – Non-reinforced Concrete Pipe

Type 2 - Reinforced Concrete Pipe

Type 3 - Corrugated Metallic-Coated Steel Pipe

Type 4 - Corrugated Aluminum Alloy Pipe

Type 5 - Corrugated Polyethylene Pipe

The type of pipe shall be the same throughout the length of any individual pipe culvert.

The type of pipe permitted in extending an existing pipe shall be made from the same materials as the existing pipe.

## **2.3.2 CONSTRUCTION REQUIREMENTS**

### **Laying**

Rigid pipe shall be carefully laid true to lines and grades, with hub, bell or groove ends upstream and with the spigot or tongue end entered the full length into the adjacent section of pipe. If the pipe is to be laid below the ground line, a trench shall be excavated to the required section and depth to permit required compaction of the backfill under the haunches and around the pipe.

Any pipe which is not in true alignment or which shows any undue settlement after laying, but before the fill is placed, shall be taken up and re-laid. If necessary, sufficient camber shall be built into the pipe structure to allow for settlement. All joints and lift holes shall be sealed with an approved plastic compound, cement mortar or tubular joint seal in accordance with the manufacturer's instructions.

### **Bedding**

Bedding for concrete pipe shall consist of granular material, consisting of graded mixture of stone fragments, gravel and coarse sand as well as clean, fine sand. Other types of culvert should be bedded on sand

### **Installation**

The bedding shall be placed to the required thickness and grade. The material in the haunch and lower side zones shall then be placed and compacted by hand in 15 cm layers up to the springline of the pipe.

### **Installation of Pipe prior to Placing Embankment**

When all material has been placed and compacted up to the springline of the pipe, the remaining fill material shall be placed according to the requirements of the adjacent fill. If a sub-trench is required to install the pipe to the specified grade, the width of the trench shall be 1.5 times the outside diameter of the pipe, but not less than 600 mm wider than the outside diameter of the pipe. In this manner, sufficient clearance is provided in order to attain the required compaction in the haunch and outer bedding zones.

### **Installation of Pipe after Placing Embankment**

The roadway embankment shall be placed and compacted to the required density to a minimum elevation of 300 mm below the bottom of the pavement base material. A trench shall be excavated through the embankment to a depth sufficient to place the required bedding and maintain the specified grade of the pipe. The pipe shall be installed and backfilled according to the requirements of the paragraph above.

### **Bedding in Unsuitable Material**

If rock is encountered, the bedding depth shall be increased to 1/12 the outside diameter of the pipe, but not less than 150 mm. The width of the cushion excavation shall be 1.5 times the outside diameter of the pipe, but not less than 600 mm wider than the outside diameter of the pipe. If soft, spongy, or unstable material is encountered, it shall be removed and replaced with soil compacted to the level specified for the lower side zone.

### **Backfilling**

Backfilling shall be done as soon as practicable. Suitable backfill and embankment material, free from large lumps, clods or rocks, shall be placed alongside the pipe in loose layers not exceeding 150 mm thick to provide a berm of compacted or undisturbed earth on each side of the pipe. Each 150 mm layer shall be compacted to the required density. Backfill material shall be moistened, if necessary, to facilitate compaction. Special care shall be taken to properly compact the embankment under the haunches of the pipe. Before heavy construction equipment is operated over the pipe, the contractor shall provide an adequate depth and width of compacted backfill to protect it from damage or displacement.

### **2.3.3 TESTING**

All pipe materials included into the permanent works should be certified by the suppliers for the quality specified in the drawings. The Supervisor shall visually inspect all culvert elements supplied on site before installation.

After the roadway has been completed, and before final acceptance of the project, all pipe culverts will be visually inspected. Any separation at joints sealed with either cement mortar or plastic joint compound shall be resealed with like material.

Those elements requiring minor repairs shall be identified by the Supervisor and the area of repairs marked accurately on the elements.

### **Compaction requirements**

The Contractor shall compact culvert embankment material to not less than 95% of the maximum density, normal Proctor.

The minimum frequency of the sampling for tests is shown in **Table 2.4.A**.

<b>Table 2.4.A</b>		
<b>Test</b>	<b>Minimum frequency</b>	<b>Notes</b>
Compaction characteristics, Normal Proctor method	1 test at 1000 m <sup>3</sup> for selected material from borrow pit, and 1 test every time the nature of the backfill soil changes, for excavated material	For each type of approved soil
Moisture content to establish corrections and obtain $W_{optimal}$	Daily	
Density test to determine compaction degree	1 test for every 50 cm thick of compacted backfill, measured every 10 m long or less, of similar section of backfill	The location of sampling for the top compacted layer shall be indicated by the Supervisor

The site laboratory must record all the results of the trials concerning the compaction characteristics, Normal Proctor method, the moisture content and the degree of compaction, on all layers and sections.

## **2.4 CONCRETE DROP INLETS AND HEADWALLS**

### **2.4.1 DESCRIPTION**

This work consists of furnishing materials and the construction of concrete drop inlets and headwalls. Headwalls may also be constructed from other materials such as stone pitching, which is discussed in the following section 2.5.

### **2.4.2 CONSTRUCTION REQUIREMENTS**

**Concrete:** Concrete shall conform to Class C12/15.

**a.** The concrete aggregate mixture shall contain a minimum of 50 percent coarse aggregate by weight. The aggregates for concrete shall be crushed or natural and shall originate from rocks having apparent densities between 2201 and 2500 kg/m<sup>3</sup>.

The usual types of cement can be classified as follows:

- Portland cement (type I), according SR 388-1995.
- Composed Portland cement (type II), according SR 1500-1996.

The usual types of cement, their parameters, the field and conditions of applicability are described in Annex I.1 and Annex I.2 of the Practice Code NE 012-99. The aggregates must meet the technical requirements of STAS 1667-76 or, by case, STAS 662-89 and SR 667-2001.

For the concrete preparation, the grading of the aggregates mix is established depending cement dosage and concrete workability - according to Annex I.4 of the Practice Code NE 012-99.

- b. The mixture shall contain at least 360 kg of cement per cubic meter.
- c. The minimum 28 day compressive strength shall be 28 MPa.
- d. The slump at time of placement shall be maintained between 25 mm 115 mm.
- e. The entrained air content for cast in place concrete shall be 6.5 percent plus, 1.0 percent, minus 1.5 percent.

**B. Steel Reinforcement:** Unless otherwise specified, reinforcement shall be plain or deformed steel bars meeting the requirements of one of the following: STAS 438/1-89, STAS 438/2-91 or STAS 438/3-98. Reinforcing steel shall be accurately cut and bent to the dimensions and shapes shown on the working drawings, preferably at the mill or shop

**C. Mortar:** Mortar shall consist of one part Portland cement and two parts mortar sand.

**E. Curing:** Exposed, unformed concrete surfaces which do not require a rubbed finish shall be wet-cured or membrane-cured.

Surfaces from which forms have not been removed will not require covering and curing until the forms are removed.

No additional covering or curing is required after the forms are removed if they were in place for at least 72 hours.

Concrete for drop inlets and headwalls shall be proportioned, mixed, hauled, and placed in accordance with the provisions of NE 012 – 99, *Practice Code for the execution of concrete and reinforced concrete works*.

Inlet and outlet pipe connections shall be of the same size and kind and shall meet the same requirements as the pipe they connect. Pipe sections shall be flush on the inside of the structure wall and project outside sufficiently for proper connection with the next pipe section. Masonry shall fit neatly and tightly around the pipe.

The finished surface of the concrete shall present a neat and smooth appearance.

Concrete shall be protected and cured in accordance with NE 012 – 99, *Practice Code for the execution of concrete and reinforced concrete works*.

Upon completion and curing of the unit, the sheeting, bracing, forms, and falsework shall be removed and the excavation backfilled. The unit shall not be backfilled until the completion of the 72 hour curing period, or until the concrete reaches a minimum compressive strength of 21 MPa.

Backfill shall be placed in layers not exceeding 150 mm thick and compacted to the same degree as specified for the adjacent embankment. Installations shall be finished and left in a neat appearing condition.

### **2.4.3 TESTING**

The frequency of the sampling and the tests to be performed shall be at least those indicated by the Practice Code NE 012 – 99, Annex VI.I.

Besides the control system mentioned above special attention must be paid to visual controls that can warn in advance about abnormal behaviour of the concrete during its preparation, transport and placing.

The quality control of the steel is made according to the provisions of chapter 17 in the Practice Code NE 012-99.

## **2.5 RIPRAP OR STONE PITCHING**

### **2.5.1 DESCRIPTION**

This work consists of furnishing and placing approved material for the protection of ditches, culvert inlets and outlets, embankments, and other designated locations.

### **2.5.2 CONSTRUCTION REQUIREMENTS**

**Riprap:** Stone for riprap and stone pitching shall be hard and durable and shall have a minimum weight of 1550 to 2500 kilograms per cubic meter. Riprap may be quarried ledge rock or field stone. Stone shall be free from overburden, spoil, shale, and organic material. The riprap stone shall meet the following gradation requirements:

Table 2.5.A			
Riprap Class	Rock Size <sup>1</sup> (mm)	Rock Size (Kg)	Percent of Riprap Smaller Than
<b>A</b>	400	90	100
	290	35	50
	120	2	15
<b>B</b>	550	225	100
	400	90	50
	120	2	15
<b>C</b>	690	455	100
	550	225	50
	290	35	15
<b>D</b>	870	910	100
	690	455	50
	550	225	15
<b>E</b>	1100	1815	100
	870	910	50
	690	455	15
<b>F</b>	1370	3630	100
	1100	1815	50
	870	910	15

1. Based on a specific gravity of 2.65 and spherical shape.

The riprap class is the median particle weight with 50% of the material smaller and 50% of the material larger.

Each load of riprap shall be well graded from the smallest to the maximum size specified.

Slopes to be protected by riprap shall be free of brush, trees, stumps, and other objectionable material and shall be dressed to a smooth surface. Soft or spongy material shall be removed to the specified depth and replaced with approved material. Filled areas shall be thoroughly compacted. A trench shall be provided along the toe of the slope to receive the first course of riprap. When drainage fabric is specified on the plans, the surface to be covered shall be smooth, free of obstructions, and shall conform to plan shown dimensions prior to placement of the drainage fabric.

The drainage fabric shall be placed under and along all sides of the riprap that are in contact with earth, unless otherwise shown on the plans. Lapped joints in the drainage fabric shall be placed transverse to the direction of flow with the overlap in the direction of flow. All lapped joints shall be lapped a minimum of 300 mm. Vehicles and equipment shall not be operated directly on the drainage fabric.

Riprap shall be placed in a manner, which will produce a reasonably well graded mass of stone with the minimum practicable percentage of voids. Riprap shall be placed to its full course thickness in one operation without displacing the underlying material. Bridge berms, channel slopes/bottoms and other surfaces that will be covered with riprap shall be finished to an elevation that will permit the placement of the required depth of riprap and match plan elevations or existing channels. Placing of riprap in layers, or by dumping into chutes, or similar methods likely to cause segregation will not be permitted. The larger stones shall be well distributed and the entire mass of stone shall conform to the gradation specified.

In order to produce a compact riprap protection in which all sizes of material are placed in their proper proportions, hand placing or rearranging of individual stones by mechanical equipment may be required.

The riprap protection shall be placed in conjunction with the construction of the embankment. To prevent mixture of embankment and riprap, sufficient lag in construction of the riprap may be necessary. The Contractor shall maintain the riprap protection until accepted. Material displaced by any cause shall be replaced.

### **2.5.3 TESTING**

The works will be visually inspected by the Supervisor. Material should have been quality certified by the supplier.

### **3. EARTHWORKS**

#### **3.1 CLEARING AND GRUBBING**

##### **3.1.1 DESCRIPTION**

###### **Clearing**

Clearing shall consist of the removal of all trees, brush, other vegetation, rubbish, fences and all other objectionable material including the disposal of all material resulting from the clearing and grubbing. Clearing shall include the removal of all rocks and boulders of up to 0.15 cu.m in size which are exposed or lying on the surface.

###### **Grubbing**

Where directed by the Supervisor, all stumps and roots larger than 75mm in diameter shall be removed to a depth of not less than 600 mm below the finished road level and a minimum of 75 mm below original ground level. Where the existing ground has to be compacted, all stumps and roots including matted roots shall be removed to a depth of at least 200 mm below the cleared surface, except where otherwise specified or directed by the Supervisor.

Except at borrow areas the cavities resulting from the grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

###### **Conservation of topsoil**

Where suitable topsoil exists within the limits of the area to be cleared and/or grubbed, the Contractor shall remove the topsoil together with any grass and other suitable vegetation. If not used immediately, the topsoil shall be transported and deposited in stockpiles for later use.

##### **3.1.2 CONSTRUCTION REQUIREMENTS**

###### **Areas to be cleared and/or grubbed**

The portions of the road reserve that fall within the limits of the road prism as well as certain borrow areas may require to be cleared and/or grubbed. The Supervisor shall designate the areas to be cleared and such areas shall not necessarily be limited to those mentioned above.

Individual trees designated in writing by the supervisor shall be left standing and uninjured.

###### **Cutting of trees**

The Contractor shall take the necessary precautions to prevent damage to structures and other private or public property. If necessary trees shall be cut in sections from the top downwards. The

branches of trees to be left standing shall be trimmed so as not to intrude into the space for up to 7 m in height above the roadway.

### **Disposal of material**

Material obtained from clearing and/or grubbing shall be disposed of in borrow pits or other suitable places and covered up with soil or gravel. Care must be taken to observe any regulations concerning pollution of air or ground.

### **3.1.3 TESTING**

All works shall be inspected visually by the Supervisor. No specific tests are required.

## **3.2 EXCAVATIONS AND EMBANKMENTS**

### **3.2.1 DESCRIPTION**

This work consists of excavating, hauling, placing, and compacting or disposing of all material, not being removed under some other item, which is encountered within the limits of the work necessary for the construction of the project.

#### **Excavation**

Excavation will be classified as hereafter described.

- **Common excavation** consists of all excavation within the limits of the roadway.
- **Muck excavation shall** consist of the removal and disposal of saturated or unsaturated mixtures of soils and organic matter or other materials not suitable for foundation material.
- **Rock excavation** shall consist of excavation of rock which cannot be excavated without blasting or the use of rippers.
- **Borrow excavation** shall consist of approved material required for the construction of embankment and shall be obtained from borrow areas.

#### **Embankment**

Embankment shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed within the right of way and placing and compacting of approved material within roadway areas where unsuitable material has been removed. Only approved materials shall be used in the construction of the embankments.

### 3.2.2 CONSTRUCTION REQUIREMENTS

#### *Common Excavation*

Perform all necessary clearing, grubbing and top soil removal prior to beginning excavation, grading, and embankment operations in any area.

Excavate material only within the limits on the drawings or as directed. Prevent disturbing of material and vegetation outside of the slope limits.

The excavation shall start on full width, providing at the same time the cross section slope values required.

The earth lumps or stones improperly adherent, as well as the rocks of insecure stability, must be removed from the slope.

The soil at the level of the finished subgrade in cutting shall be compacted up to 100% compaction degree Normal Proctor method, on a depth of 30 cm or as indicated by the drawings. Recommendations for normal Proctor compaction degrees for excavations other than finished subgrade value are given by **Table 3.2.A**.

<b>Table 3.2.A</b>		
<b>Zones of the earthworks</b>	<b>Type of Soil</b>	
	<i>non-cohesive</i>	<i>cohesive</i>
a/ The first 30 cm below the surface of the foundation layer, under embankments with height $h$ :		
$h \leq 2.00m$	95	93
$h > 2.00m$	92	90
b/ In the embankments having height:		
$h \leq 0.50 m$	97	97
$0.5 < h \leq 2.00 m$	97	94
$h > 2.00 m$	92	90
c/ In Cuttings, with the 30 cm below the surface of the subgrade (formation layer)	100	100

#### *Rock excavation*

Rock excavation shall be accepted only in difficult areas where common excavation is not possible. Excavating and under-grading in rock shall be performed in a manner to produce material of such size as to permit being placed in embankments in accordance with the requirements. Rock shall be removed to the limits of under-grading insofar as practicable and in such manner as to leave no un-drained pockets in the surface. Care shall be taken to avoid

overshooting when blasting. Any loose or shattered rock, overhanging ledges and boulders above the roadbed which might dislodge shall be removed.

Blasting operations shall comply will all legal requirements in-force.

### ***Muck Excavation***

If the soil encountered at the levels indicated by the plans has not the necessary qualities and bearing capacity expected by the designer and mentioned by the plans or the specifications, the Supervisor may instruct the replacement of this material with approved material from cut or borrow.

### ***Borrow Excavation***

When the volume of suitable excavation is not sufficient for constructing the fill to the grades indicated, the Contractor will provide the necessary borrow from approved sources.

All borrow pits shall be excavated with uniform slopes. Borrow pits shall be left in a neat and workmanlike conditions and in full compliance with all applicable Romanian laws and national or local authorities decisions. The Contractor shall shape the pit for cross-sectioning immediately upon completion of borrow excavation.

### **Embankments**

Embankments shall be constructed to the design template progressively for the full height. Construction of embankments shall not be started on frozen foundation soil or partially completed embankments, nor shall embankment be built with frozen material.

Where embankment is to be placed on hillsides or where new embankment is to be constructed against existing embankments, the existing slopes that are steeper than six horizontal to one vertical measured at right angle to the roadway shall be continuously benched in not less than 300 mm rises over those areas where it is required as the work is brought up in layers. Benching shall be of sufficient width to permit placing and compacting operations. Each horizontal cut shall begin at the intersection of the ground line and the vertical side of the previous bench. Existing slopes shall also be benched to prevent any wedging action of the embankment against structures.

Where an embankment less than 2.0 m high all sod and vegetative material shall be removed from the surface upon which the embankment is to be placed, and the cleared surface completely broken up by ploughing, scarifying or benching to a minimum depth of 100 mm. This area shall be compacted in the same manner as that required for the embankment placed on the area. Sod not required to be removed shall be thoroughly disked before construction of embankment.

If embankment is deposited on one side only of abutments, wing walls, piers or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of or excessive pressure against the structure.

Equipment of such weight (mass) as may cause damage to culverts or other structures will not be permitted to work over or immediately adjacent to such structures. If embankment is to be placed on both sides of a concrete wall or box type structure, operations shall be so conducted that the embankment is kept at approximately the same elevation on each side.

Roadway embankment shall be placed in layers not exceeding 200 mm (loose measurement) and shall be compacted as specified before the next layer is placed. The layers shall be placed approximately parallel to both the proposed profile grade and to the finished roadbed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. Continuous leveling and manipulating will be required during compacting operations. Construction equipment shall be routed uniformly over the entire surface of each layer. Occasional rock and boulders greater than 600 mm shall be dispersed to allow for uniform compaction between them.

Incidental stones or rock fragments exceeding the thickness of the 200 mm layer shall be removed and disposed of.

Control of compaction of embankment and treatment of cut areas shall be made with moisture and density control. The determination of optimum moisture content and maximum density obtained will be carried out for each type soil classified as approved material and intended to be used in the earthworks. If necessary, laboratory tests will be confirmed on trial sections carried out on site within the roadway limits.

The upper 300 mm of the earth subgrade extending the full width between roadbed slopes shall be compacted to at least 100 percent of normal Proctor maximum density.

Roadway embankment within 30 m of each end of a structure, on which the top slab or deck is to be used as the riding surface, and the spill fill under such a structure shall be compacted to no less than 100 percent of normal Proctor maximum density.

Each layer shall be wetted or dried, as necessary, and shall be compacted to the required density. Regardless of the type of equipment used, the roadway shall be compacted uniformly and the surface kept reasonably smooth at all times. If large pieces of heavy clay are encountered, the material shall be broken down by suitable manipulation to permit satisfactory embankment construction. If shale is encountered, it shall be broken down as much as is practicable and compacted at or above optimum moisture.

Compaction to at least 95 percent of maximum density will be required for that portion of any embankment below an elevation 15 m below the level of the finished subgrade. If, because of embankment foundation conditions, the 95 percent of maximum density cannot be obtained after reasonable compactive effort has been expended, the Supervisor may waive the 95 percent requirement for a height not to exceed 1 m above the embankment foundation.

When designated by the plans, the upper portion of the road bed, of indicated thickness, shall be constructed with selective subgrade topping materials. The type of materials to be selected and the quality requirements for this work are presented in the Formation Layers specification.

### 3.2.3 TESTING

The tests to be carried out to determine the characteristics of the soils and their suitability to be used in road earthworks are given in **Table 3.2.B**.

<b>Table 3.2.B</b>				
<b>No.</b>	<b>Testing characteristics</b>	<b>Minimum frequency</b>	<b>Testing methods according to STAS</b>	
1	Grading	When not instructed differently by the Supervisor, minimum test of three samples every 5000 m <sup>3</sup> of embankment. In case of backfills to widen the existing embankments (rehabilitation works), minimum a test of three samples every 1000 m <sup>3</sup> of processed soil. In natural soils under the embankment, at least a test of three samples every 2000 m <sup>2</sup> of roadbed. In cuttings, at least a test of three samples every 250 m of road.	1913/5	
2	Plasticity limits, Plasticity index		1913/4	
3	Non-uniform coefficient		730	
4	Free swelling		1913/12	
5	Compaction characteristics, Normal Proctor method		1913/13	
6	Freezing thawing sensitive		1709/3	
7	Apparent weight or dry density of the soil from borrow pit, the natural ground under embankment and cutting		1913/15 1913/3 12288	
8	Moisture content		Daily, but at least every 500 m <sup>3</sup> of processed soil in embankments or every 250 m of road in cut	1913/1
9	Internal friction angle $\Phi$ and cohesion c		In case of embankments which requires the stability tests or when instructed by the Supervisor.	8942/2 8942/5

## Geometrical Tolerances

The tolerances for the finished surface evenness of the roadbed and slopes are:

Subgrade profile with "formation layer"	± 3 cm
Subgrade profile without "formation layer"	± 5 cm
Unprotected Slope	± 10 cm

The surface irregularities are measured under a straight edge 3m long.

The evenness tolerance for other earthworks not referring to the roadbed or slopes is +50 cm.

The upper layer of the roadway shall be well-compacted, leveled and completed by respecting the levels, gradients and width shown in the design cross-sections and longitudinal sections, in concordance with STAS 2914-84.

## Compaction requirements

The compaction degree has to be checked for every compacted layer.

The compaction degree shall be checked comparing the site dry density of the tested soil with the maximum dry density at the optimum moisture content determined in the Contractor laboratory following the Proctor Test – normal method, according to STAS 1913/13 - 83.

For the upper layer of embankment or in cutting (formation layer), the degree of compaction shall be checked, as provided by **Table 3.2.C**.

Table 3.2.C		
Zones of the earthworks <i>to be compacted</i>	Type of Soil	
	<i>non-cohesive</i>	<i>cohesive</i>
a/ The first 30 cm below the surface of the foundation layer, under embankments having height h:  $h \leq 2.00m$ $h > 2.00m$	95 92	93 90
b/ In the embankments having height: $h \leq 0.50 m$ $0.5 < h \leq 2.00m$ $h > 2.00m$	97 97 92	97 94 90
c/ In Cuttings, with the 30 cm below the surface of the subgrade (formation layer)	100	100

The minimum frequency of the sampling for tests is shown in **Table 3.2.D**.

Table 3.2.D		
Test	Minimum frequency	Notes
Compaction characteristics, Normal Proctor method	1 test at 5000/1000 m <sup>3</sup>	For each type of approved soil
Moisture content to establish correction and to obtain $W_{optimal}$	Daily or every 500 m <sup>3</sup> of processed soil or at every 250 of road length (which is less)	
Density tests to determine compaction degree	3 test at every 2000 m <sup>2</sup> of compacted layer surface or every 250 m of full width road length (which is less).	On foundation layer under embankment, On each layer of compacted soil, On finished subgrade layer (formation layer)

The site laboratory must record all the results of the trials concerning the compaction characteristics, Normal Proctor method, the moisture content and the degree of compaction, on all layers and sections.

### 3.3 SUBGRADE SCARIFYING

#### 3.3.1 DESCRIPTION

This work shall consist of loosening the surface of the roadbed and removing all rocks larger 100 mm.

### **3.3.2 CONSTRUCTION REQUIREMENTS**

Where subgrade scarifying is specified the contractor shall perform all work necessary to loosen the surface of the roadbed over its full width to a depth of 150 mm below the finished grading section, and remove all rocks larger than 100 mm. After all of the oversize material has been removed, the roadbed shall be brought back to a satisfactory grade and cross section by the addition of extra material, if needed, without rocks that exceed 100 mm.

### **3.3.3 TESTING**

All works shall be inspected visually by the Supervisor. No specific tests are required

## **3.4 LINEAR GRADING**

### **3.4.1 DESCRIPTION**

This work shall consist of grading work necessary to bring the roadway to the required grade and cross section within reasonable tolerances. It shall also include the following:

- (a) Construction of all inlet and outlet ditches and ditch blocks within the linear grading limits unless otherwise provided for in the contract.
- (b) Construction of entrances and approaches.
- (c) Breaking up and satisfactory removal or incorporation into the roadway of all gravel, macadam or bituminous surfaces.
- (d) Compaction of the roadway subgrade within linear grading limits.

### **3.4.2 CONSTRUCTION REQUIREMENTS**

The roadway shall be brought to the required grade and cross section within reasonable tolerances by backsloping, ditching, removing stone and boulders from the roadbed surface, or any other work necessary, including drifting and hauling of any excavated material.

A reasonable tolerance in alignment means a maximum gradual deviation of 600 mm, free of sharp breaks, to take advantage of the topography. Gradual deviation in alignment will also be permitted, if necessary to centre an existing drainage structure that is to be used in place. A reasonable tolerance in grade means a final grade that is uniform in appearance, free of sharp breaks or humps, and within 150 mm of plan grade.

Finishing operations shall continue until the roadbed is free from sharp breaks in alignment and grade, and until it has been shaped to the required cross section. Material considered unsuitable for the subgrade shall be disposed of on nearby slopes.

Any subgrade upon which a paved surface is to be placed shall be compacted in accordance with Sec 3.3.

### **3.4.3 TESTING**

Linear grading requires visual inspection to assure that proper procedures are followed.

## **3.5 SUBGRADE COMPACTION**

### **3.5.1 DESCRIPTION**

This work shall consist of compacting the earth subgrade on the roadbed of a previously graded roadway.

### **3.5.2 CONSTRUCTION REQUIREMENTS**

The subgrade for the full width of the roadbed shall be scarified to a depth of at least 150 mm, and the scarified material brought to uniform moisture content either by drying or by adding water, and manipulating with suitable equipment. The upper 150 mm of soil may be removed and replaced with satisfactory material, or removed and manipulated with suitable equipment before replacing. The material shall be compacted to produce a subgrade having a density not less than the density required and within the moisture contents specified under Sec 3.3, by the use of approved equipment producing satisfactory results.

If it is determined that the required subgrade density cannot be obtained by moisture control and compaction of the upper 150 mm, the unsuitable material shall be excavated to a depth not to exceed 450 mm, and replaced with satisfactory material compacted in layers not to exceed 150 mm. Each 150 mm layer shall be processed, wetted or dried as necessary, and compacted to the required density.

## **3.6 SUBGRADE PREPARATION**

### **3.6.1 DESCRIPTION**

This work shall consist of preparing the subgrade upon which a gravel layer is to be constructed. It is also the work required for final preparation of the surface of an earth road.

### **3.6.2 CONSTRUCTION REQUIREMENTS**

The subgrade shall be substantially uniform in density throughout its entire width. It shall conform to the lines, grades and typical cross sections shown on the drawings. The subgrade shall be constructed to drain surface water to the side ditches and all ditches shall be kept open by the contractor. Where hauling results in ruts or other objectionable irregularities, the contractor shall reshape and re-roll the subgrade. If an old roadway comprises any part of the roadbed, the contractor shall loosen the compacted portions to a depth of at least 150 mm and shall reshape the

roadbed.

All subgrades shall be rolled. The subgrades shall be checked after rolling and, if not at the proper elevation at all points, sufficient material shall be removed or added and compacted to bring all portions of the subgrade to the required elevation and density. The moisture content of the top 150 mm of the finished subgrade shall be not less than the minimum specified for compacting in Sec 3.3. If the moisture content has not been maintained, the subgrade shall be scarified, wet to the required moisture content and compacted. A roughly compensating maximum deviation of 15 mm, plus or minus, from the required elevation will be permitted on the surface of the finished subgrade.

Prior to laying gravel, the subgrade shall conform to the moisture and density requirements for compaction. Soft spots and unsuitable material shall be removed to a depth not to exceed 600 mm and backfilled with approved stable material.

The finished subgrade at the time of paving shall be moist, but sufficiently firm to resist rutting or deforming under construction traffic.

### **3.7 SUBGRADING AND SHOULDERING**

#### **3.7.1 DESCRIPTION**

Subgrading and Shouldering, shall consist of preparing the earth subgrade (or surface for earth roads) by fine-grading and shaping the roadway, fill slopes, inslopes and ditches as required to complete a finished roadway conforming to the typical section.

#### **3.7.2 CONSTRUCTION REQUIREMENTS**

Subgrading and shouldering will normally be restricted to the roadway from ditch to ditch or to the roadbed and upper portions of fill slopes. No work will be required on backslopes except that necessary to blend the lower portion of the existing backslope with the ditch.

Finishing of ditches, side slopes, cuts and fills shall be to a reasonably smooth and uniform surface that will merge with the adjacent slopes. Finishing by hand methods will not normally be required, except that all brush, weeds, excess mud and silt, or other debris shall be removed from all channels and culverts.

#### **3.7.3 TESTING**

Subgrading and shouldering requires inspection to assure that proper procedures are followed.

### **3.8 SHAPING SLOPES**

#### **3.8.1 DESCRIPTION**

This work shall consist of grading and shaping existing slopes.

### **3.8.2 CONSTRUCTION REQUIREMENTS**

Slope areas to be shaped by the addition of material shall be scarified to allow bonding with the added material. The density shall be that obtained from a reasonable compactive effort consisting of not less than three passes with a roller.

### **3.8.3 TESTING**

#### **Geometrical Tolerances**

The tolerance for the finished shaped shoulders surface evenness is  $\pm 3$  cm;

### 3.9 VEGETATION

#### 3.9.1 DESCRIPTION

This work shall consist of providing topsoil and vegetation on side slopes of embankments and cuttings to protect them against erosion.

**Topsoiling** will provide vegetative soil on side slopes to the lines and grades provided by the drawings. The material used for topsoiling will be recovered from the vegetative soils salvaged as described under Sec 3.1.

**Seeding** shall consist of preparing the seed bed and placing the seed in the seeding operations on slopes and other areas shown by the drawings.

**Planting** shall consist of furnishing, transporting, and planting live stakes, live posts and live fascines. Live stakes, live posts and fascines are standard bio-engineering techniques which involves planting of dormant plant cuttings which are of a species know to produce rooting from cuttings. Work under this specification includes the harvesting, transporting and installation of live stakes, posts and fascines on streambanks and other areas as applicable to each site plan.

For the purpose of this specification, Live Stakes and Live Posts are defined as follows;

**Live Stakes** - smaller, 1 -5cm stock of 60 – 90 cm in length

**Live Posts** - larger, 5 – 10 cm stock of 120 – 240 cm in length

**Live fascines** are a standard bio-engineering technique which involves the bundling and planting of dormant plant cuttings. Work under this specification includes the harvesting, transporting and installation of Live Fascines on streambanks and other areas as applicable to each site plan.

#### 3.9.2 CONSTRUCTION REQUIREMENTS

**Topsoil** shall not be placed until the area to be topsoiled has been approved. All stones, 50 millimeters or larger in any dimension, and other debris such as wires, cables, tree roots, pieces of concrete, clods, and lumps shall be removed and the surface scarified to provide an improved bond between slope and topsoil. Slopes steeper than 1:2 shall not be bladed smooth.

The topsoil shall be spread on a previously prepared surface in a uniform layer and in accordance with the detail drawings to produce the prescribed compacted thickness. On cut and fill slopes, topsoiling shall be carried out always by starting the works from the toe of the slope to the top.

Topsoiled areas outside the limits of work shall be protected against damage caused by the delivery, handling, or storage of materials, by washouts due to drainage diversion, by workers, or by equipment. Any such damage shall be repaired by grading, fertilizing, seeding, and mulching.

**Seeding** will not be started until all stones, boulders, debris and similar material larger than 75 mm in diameter have been removed from the seedbed area. The area to be seeded shall be worked

to a minimum depth of 75 mm with a disk tiller or other equipment approved by the Engineer, reducing all soil particles to a size not larger than 50 mm in the largest dimension. The prepared surface shall be relatively free from all weeds, clods, stones, roots, sticks, and rivulets, gullies, crusting and caking.

No seed shall be sown during high winds or when the ground is not in a proper condition for seeding, nor shall any seed be sown until the purity test has been completed for the seeds to be used, and shows that the seed meets the noxious weed seed requirements.

The seeding dates shall be from March 15 to June 15 and from October 1 to December 1.

No work shall be performed when the ground is frozen, wet or otherwise un-tillable, or when even distribution of materials cannot be obtained.

The Contractor shall protect seeded areas against traffic using approved warning signs or barricades. He shall repair surfaces that are gullied or otherwise damaged following seeding by re-grading and re-seeding, as directed. The Contractor shall maintain seeded areas in a satisfactory condition until final inspection and acceptance of the work.

The Contractor shall water the seeded areas, as required by the seed supplier recommendations for proper germination and growth.

The Contractor shall reseed any seeded areas not showing evidence of satisfactory growth.

**Live Stakes/Posts and Fascines** works' success is dependent upon completing the harvesting and planting operations during the plant material's dormant period. Contractors shall conduct harvesting of the plant material and preparation/planting of the Live Stakes/Posts during appropriate time periods.

Prior to execution of a contract, the Contractor shall submit a harvesting and planting plan for approval. The plan shall include identification of the plant material source, the method of harvesting, storage and transportation plans, and installation methods.

The Contractor shall locate and secure dormant plant materials of the species proposed. Live materials shall be obtained from a source that is located within fifty (50) kilometers of the project site, and all cuttings will be installed on the same day during which they have been harvested.

Plant material shall be harvested such that maximum survival is obtained. All cuts shall be smooth and the cut surface shall be kept small. Harvesting may be done using hand tools (pruning shears) or power tools. Plant material with excessive damage or oblique cuts, or with excessive damage to the bark, will not be acceptable. All live materials shall be properly stored to insure viability. Plant material must be moved from the harvest site and planted within eight (8) hours of cutting. Contractors shall protect plant materials from drying and overheating at the time of harvest, during transport and during the construction process.

Live plant material shall receive continuous shade and well as protection from the wind. Shade fabric, heeling, mulches, plastic and watering are all techniques that may be used. Misting and watering shall not be done with water that exceeds 15° C. Live materials shall be planted the same day as harvested, or stored for a period of no longer than two (2) days.

Shrubs and young trees used in preparation of live pegs shall be cut directly above the ground. Buds on the Live Posts shall be orientated in an upward position. The basal (bottom) ends shall be tapered to a point to facilitate insertion into the soil.

The top shall be cut smooth and square. Live Stakes/Posts shall be installed according to the Harvesting and Planting Plan.

The Live Stakes/Posts shall be placed so that 2/4-4/5 of their length is buried. The Stake/Post shall be tamped or otherwise backfilled, to insure continuous soil to -cutting contact, with no excessive voids in the surrounding soil materials.

Typical spacing for Live Stakes will be 60 – 90 cm apart using a triangular spacing. Total Live Stake density will be 3-5 stakes per square meter. Spacing on Live Posts is typically 1.5 – 2.0 meters apart.

Neither Live Stakes nor Live Posts shall be split during installation. Live Stakes/Posts which are split shall be removed and replaced, or if the split is less than 1/6 of the cutting length, the top may be re-trimmed after installation to remove the damaged portion.

All Live Stakes/Posts shall be planted such that the stake/post is tamped, and has full contact between the soil and cutting. In the event that an auger is used to pre-drill holes for Live Posts, or a bar is used to initiate a pilot hole for Live Stakes, the holes will be filled with loose soil after the Stake/Post is installed. The Contractor shall use water, poured n each hole, to insure that the cutting is in firm contact with the backfill.

**Live Fascines** shall be installed according to the Harvesting and Planting Plan and in accordance with the following specifications.

The Live Fascine shall be placed so that one-quarter to one third (1/4 - 1/3) of the fascine's face is exposed at the final grade. The fascines shall not extend above the grade.

Fascines shall be placed in trenches on the slope. Trenches shall be approximately 30 cm wide and 15 – 20 cm deep based on diameter of the fascines.

Live Stakes are placed on the downslope side of the Live Fascine. Live Stakes shall be driven below and against the Live Fascine between the previously installed Dead Stakes. Live Stakes shall protrude 5 – 10 cm above the top of the fascine

Fascine bundles shall be overlapped a minimum of 30 cm where two fascines meet in a row.

Dead pegs shall be driven into and through the Live Fascine. Dead Pegs shall be placed no more than every 50 cm and no less than every 100 cm along the length of the Live Fascine. Extra stakes shall be used at the ends of each Live Fascine.

Fascines will be spaced in parallel rows as shown in the project drawings.

All Live Fascine trenches shall be backfilled to insure good soil/cutting contacts. Backfilling shall be done so as to minimize voids in the fascines.

All Live Fascines shall be covered with clean, moist soil. Backfill will be gently tamped and watered during placement to fill voids. The top of the fascine (1/4-1/3 of bundle diameter) shall be exposed, but flush with the surface, when completed.

### **3.9.3 TESTING**

Topsoil shall be inspected for acceptance, together with seeding and planting, on completion of works. Areas where vegetation did not grow to the required density will be reworked by the Contractor, including seeding and planting.

## 4. UNBOUND MATERIALS

### 4.1 GRAVEL SUBBASE

#### 4.1.1 DESCRIPTION

This specification refers to sub-base courses made of approved granular material, conforming to the required lines, grades, and dimensions This work includes:

- Placement of the sub-base course.
- Compaction of the sub-base course.
- Profiling the sub-base course.
- Disposal of excess material after profiling is completed.

River or pit granular materials, as well as quarry waste having a maximum size of 71 mm shall be used for the construction of the gravel sub-bases.

The rock the gravel originates from must be stable and of siliceous origin. Calcareous origin material may be used only with Supervisor approval, provided that meets the grading requirements presented in **Table 4.1.A**.

Granular material shall be free of soft or friable particles, inalterable by weather adverse conditions and free of unsuitable material that can be noticed by visual inspection (clay lumps, coal, wood, organic matters or other).

Gravel for sub-base shall meet the requirements for quality presented in **Table 4.1.A**.

<b>Table 4.1.A</b>		
<b>Characteristics</b>	<b>Quality Requirements</b>	<b>Testing methods</b>
Type of material (gradation limits)	0-71	STAS 1913/5
Fraction content %		
below 0.02 mm	max. 3	STAS 4606
below 8 mm	15...70	
below 71 mm	100	
Gradation	Continuous	STAS 4606
Uniformity Ratio (Un), min.	15	STAS 730
Sand Equivalent (EN), min.	30	STAS 730
Los Angeles Wearing (LA), %, max.	35	STAS 730

## **4.1.2 CONSTRUCTION REQUIREMENTS**

### **Laying**

The Contractor shall place and profile the sub-base course.

The sub-base course material shall be mixed and moistened, at moisture content between optimum and 3 percentage points below optimum.

Before sub-base course placement, the subgrade shall be sprinkled lightly with water.

The sub-base course material shall be hauled to the road, spread in a uniform layer, and compacted to at least 100 percent of the maximum modified Proctor density, as determined by initial tests of Contractor's laboratory.

Material placement shall be in sufficient quantity to allow compaction and profiling of the entire surface of a section.

Uncontaminated material recovered in profiling one section may be uniformly spread on an adjacent unprocessed section.

Gravel containing snow or ice lumps will not be used in the sub-base courses.

Sub-base works will not be carried out on frozen sub-grade or if the sub-grade is covered by ice or snow.

The compaction will be performed by appropriate equipment, according to the method approved by the Supervisor following the trial section conclusions.

### **Trial Section**

The Contractor must carry out a trial section at the beginning of the works. Prior to carrying out the trial section the Contractor will submit to the Supervisor for approval, at least one week in advance, the method statement concerning the execution of granular sub-base layers.

The trial shall be carried out on a section of at least 30 m long and at least 3.40 m wide (the double width of compaction equipment). The trial section shall be carried out in the presence of the Supervisor; the compaction control shall be made by laboratory tests. The results of the tests will be presented to the Supervisor the next day after the execution of the trial section.

If the required compaction degree, measured for the whole trial section according to the agreed measurement method does not comply, the Contractor shall carry out a new test after the methods have been modified or the equipment has been adjusted and a new method statement has been presented to the Supervisor for approval.

The parameters to be surveyed during the trial section shall be:

- the optimum thickness of the gravel course laid, before compaction;
- the number of passes by each type of compactor, vibrating and without vibration, in order to determine the compaction intensity;

**Compaction Intensity =  $Q / S$**

$Q$  = gravel volume laid in time unit (hour, day, shift), expressed in m<sup>3</sup>;

$S$  = area, expressed in m<sup>2</sup>, covered by each compacting equipment, within a given period.

If the trial section is successful, the recorded parameters mentioned above will become references for the sub-base works carried out with material supplied from a singular source. For each different source of material, a new trial section will be carried out according to the schedule presented above.

#### **4.1.3 TESTING**

The thickness of the sub-base course shall be as per the provisions of the working drawings.

The thickness deviation limits are  $\pm 15$  mm at every measured point. The thickness control will be made by direct measurements in test pits. The thickness measurements will be at least one every 150 m of two-lane road construction, or two every 100 m for more than two-lane construction.

The level tolerance in cross sections shall be  $\pm 10\%$  of the designed level for the sub-base.

The regularity tolerances in longitudinal profile, measured under a three metre straight edge, shall be  $\pm 2$  cm at any measurement point.

The width tolerances shall be  $\pm 5$  cm, measured at the designed cross section stations.

The cross-fall tolerances shall be  $\pm 0.4\%$  measured at the designed cross section stations or at cross sections positioned every 25 m, which is the less.

#### **Compaction requirements**

The aggregate surface course shall be compacted to 100 % Modified Proctor compaction degree in min 95 % of measurement points and a min. of 98 % Modified Proctor compaction degree in the remaining 5% measurement points.

The density of compacted aggregate surface course shall be measured on site, by the sand replacement method, according to *STAS 1913/15 – 75* and *STAS 12288 -85*.

The moisture content shall be measured according to *STAS 1913/1 – 82*.

The density measurement will be carried out at least two tests every 150 m of two-lane road construction, or two tests every 300 m for single-lane roads, at locations indicated by the Supervisor. The results of the measurements will be provided to the Supervisor no later than one day after the execution of the tested sub-base course section.

## 4.2 AGGREGATE SURFACE

### 4.2.1 DESCRIPTION

This work shall consist of furnishing and placing gravel or crushed stone surfacing in the quantity and to the lines and grades required.

The aggregate for surfacing shall consist of sound durable particles of gravel and sand, may include limited amounts of fine soil particles, but shall be free of sod, roots, vegetation, wood, paper, metal, glass, and other foreign objectionable material.

Granular material of which 30% of the particles retained on the 5mm sieve shall contain one or more fractured faces.

Surfacing gravel shall meet the requirements for quality presented in **Table 4.2.A**.

<b>Table 4.2.A</b>			
<b>Particle Size Distribution for Gravel Surfacing</b>			
Sieve size	Percentage passing (*)		
	Nominal maximum size		
	40 mm	20 mm	10 mm
40	100		
20	80-100	100	
10	55-80	80-100	100
5	40-60	60-85	80-100
2.5	30-50	45-70	50-80
0.5	15-30	25-45	25-45
0.075	5-15	10-25	10-25

(\*) Not less than 10% should be retained between each pair of such successive sieves specified for use, excepting the largest pair.

For fines passing the .5 mm sieve, the plastic characteristics are given in **Table 4.2.B:**

<b>Table 4.2.B</b>			
<b>Preferred Plasticity Characteristic for Gravel Surfacing</b>			
Climate	Liquid limit not to Exceed (%) (*)	Plasticity Index Range (%) (*)	Linear Shrinkage
Cold Areas	35	4-9	2-5
Warm Areas	45	6-20	3-10

Higher limits are acceptable for concretionary gravels that have a structure that is not easily broken down by traffic. Lower limits are appropriate for some other gravel, like limestone ones, that are easily broken down by traffic. Any variation from these limits shall be approved by the Supervisor

Gravel aggregate for surfacing shall have a Los Angeles Abrasion loss percentage of not more than 40.

Gravel aggregate for surfacing shall have a soundness loss of not more than 12 percent by mass at the end of 5 cycles using sodium sulphate solution

The surfacing gravel shall be obtained from sieved gravel, by re-mixing the resulting sizes into given proportions to comply with the specification’s requirements; pit gravel may be used directly as optimal gravel if it complies with the requirements in **Tables 4.2.A** and **4.2.B** above. The compliance with the plasticity limits requirements may be achieved by adding clay into the mix.

River gravel is generally unsuitable – the particles are rounded, and do not interlock to form a stable surface.

The conditions for quality and the frequency of the sampling and testing for the material supplied on site are those required by *STAS 662 – 89*, Chapters 3 and 4.

#### **4.2.2 CONSTRUCTION REQUIREMENTS**

The contractor shall furnish, haul and spread surfacing material on the subgrade or on a sub-base

course.

The Contractor shall be responsible for the uniform unloading and distribution of the required quantity of material throughout each station. The subgrade shall be prepared as specified in Sec 3.4 to 3.9 and any work done in reshaping the subgrade before placing surfacing material shall be carried out by the Contractor.

The material shall be deposited on one shoulder on tangents and on the high shoulder of curves. Material shall be spread to a uniform thickness over the subgrade or sub-base course within 24 hours after being deposited on the roadbed, unless the condition of the subgrade is such that additional time should elapse. Surplus material shall be left on one shoulder on tangents and on the high shoulder of curves in a neat and symmetrical windrow, leaving openings for all approaches and for the drainage of low points.

After being initially compacted, the material shall be shaped and ruts filled by blading the roadbed as frequently as is necessary to prevent cutting through the surfacing material into the subgrade. Irregularities which develop and which are not filled by blading shall be filled by adding more material from the windrow. The material shall be shaped until it conforms to the cross section indicated in the contract, and until it is free from ruts and waves. Maintenance of the surface shall continue until acceptance is made.

### **Existing Surfacing**

Designated areas shall be scarified to the full depth of the existing surfacing and such material pulverized to a maximum size of approximately 50 mm. Salvaged surfacing material shall be maintained as free as practicable of dirt, vegetation or other objectionable material.

### **4.2.3 TESTING**

#### **Optimal Compaction Characteristics**

Contractor's approved laboratory, or any other specialized laboratory, will carry out tests to determine the optimum moisture content and maximum dry density of the material used as gravel or optimal gravel. These tests will be carried out at least one week prior to start the works or one week prior to works with a material from a different source.

The compaction characteristics of the granular material for the sub-base layer will be determined using the modified Proctor test (PM) method, in accordance with *STAS 1913/13* as follows:

$$\begin{aligned} \rho_{d \text{ max. PM}} &= \text{maximum mass of dry sample, expressed in g/cm}^3; \\ W_{\text{opt PM}} &= \text{optimum moisture content for compaction, expressed in \%}. \end{aligned}$$

#### **Compaction requirements**

The aggregate surface course shall be compacted to a compaction degree of 100 % Modified Proctor test at a min. of 95 % of measurement points and a min. of 98 % at all measurement points.

The density of compacted sub-base layer shall be measured on site, by the sand replacement method, according to *STAS 1913/15 – 75* and *STAS 12288 -85*.

The moisture content shall be measured according to *STAS 1913/1 – 82*.

The density measurement will be carried out at least two test every 150 m of two-lane road construction, or two tests every 300 m for single-lane construction, at locations indicated by the Supervisor. The results of the measurements will be provided to the Supervisor no later than one day after the execution of the tested surface course section.

### **4.3 DUST CONTROL**

#### **4.3.1 DESCRIPTION**

This work shall consist of the application of a magnesium chloride solution or a calcium chloride solution to a prepared surface for dust control.

#### **4.3.2 CONSTRUCTION REQUIREMENTS**

**Dust Control Chlorides:** Dust control chlorides shall conform to the following specification requirements:

A bill of lading shall accompany each delivery of calcium chloride or magnesium chloride. The bill of lading shall contain the following information:

1. Liters or cubic meters of solution.
2. The weight of the solution.
3. The percent concentration by weight of anhydrous calcium chloride or anhydrous magnesium chloride.
4. The specific gravity and temperature of the solution at the time of loading.
5. A concentration chart shall be provided listing the specific gravity of solution levels at a temperature of 20°C.

Each delivery of material to be used will be sampled by the Supervisor, and submitted for a chemical analysis to an independent Testing Laboratory.

**A. Chlorides:** Dust control chlorides shall be uniformly applied under pressure in liquid form by mechanical equipment. The equipment must be such that the application rate can be set, determined and changed as required.

The rate of application shall be 0.65 kilograms per square meter of surfacing. This weight shall be the anhydrous weight of calcium chloride or magnesium chloride in the solution as determined from the certificate of compliance. The material may be applied in one or two applications.

The dust control material shall be blended into the top 25 to 50 mm of the gravel surfacing.

The addition of water may be necessary to adequately compact the material.

Rolling will be required as determined by the Supervisor.

Additional applications or spot applications may be necessary to maintain dust control.

### **4.3.3 TESTING**

The works will be visually inspected by the Supervisor.

## **4.4 GEOTEXTILE**

### **4.4.1 DESCRIPTION**

This specification covers geotextile for use in subsurface drainage, sediment control, and erosion control or as a permeable separator.

### **4.4.2 CONSTRUCTION REQUIREMENTS**

#### **Material**

Geotextiles shall meet the physical and chemical requirements of Romanian norm *MTCT – NP 075/2002 – Norms for the use of geotextiles on constriction site* and the following specifications.

#### **General**

The sieve number corresponding to the apparent opening size (AOS) shall not exceed 150  $\mu\text{m}$  for geotextile used in contact with any soil with more than 50 percent passing the 75  $\mu\text{m}$  sieve nor shall the AOS exceed 200  $\mu\text{m}$  when used between any two dissimilar granular material, less than 50 percent passing the 75  $\mu\text{m}$  sieve, or when used to control movement of fines from a granular backfill through structural joints or into a drain pipe.

The minimum permittivity shall be 1.0 sec-1.

Areas on which geotextile is to be placed shall be reasonably smooth and free from mounds, windrows, debris or projections. Geotextile shall be placed in a manner to minimize wrinkles or creases in the material. When used for erosion control or to separate soil and granular material, geotextile shall be placed loose to the contour of the ground so as to be free to adjust to minor indentations and protrusions as rock or fill is placed against or over the material but secured sufficiently to preclude sliding or displacement during fill placement and under traffic.

Geotextile shall be secured in place as necessary to perform the work with steel pins or by other suitable means.

Lengths and widths of geotextile shall be chosen to minimize the required number of overlaps or seams. Adjacent rolls or strips of geotextiles shall either be sewn in accordance with recommendations of the manufacturer, or overlapped.

Overlaps shall be sufficient to prevent openings in the geotextile coverage as a consequence of subsequent filling operations and shall meet the following minimum requirements: 450 mm overlap on slopes 3:1 (1:3) or flatter; 600 mm on slopes steeper than 3:1 (1:3); 900 mm if placed underwater or on soft, yielding ground which, in the opinion of the Supervisor, ruts excessively under construction traffic; 300 mm when used to cover structural joints or drain pipes; and equal to the trench width, when used to line drainage trenches unless otherwise shown on the working drawings.

Strips installed horizontally on slopes shall be overlapped upslope over downslope.

Strips placed transverse to channel slopes shall be overlapped in the direction of flow. If a preformed "sock" is not used to cover pipe embedded in sand, the pipe shall be wrapped one and one-half times, tied or otherwise secured at intervals as required to maintain the integrity of the overlap and laid in the trench with the exposed lap end oriented toward the bottom of the trench.

Fill placement and spreading on geotextile shall not be performed against the direction of geotextile overlap.

Traffic shall not operate directly on uncovered geotextile. Sudden stops, starts and turning motions shall be kept to a minimum unless at least two lifts of overfill are in place. Unless otherwise specified, the initial lift of overfill shall not be less than 200 mm, loose measurement, in thickness or twice the maximum particle size, whichever is greater.

Damaged or punctured geotextile shall be replaced or patched to the satisfaction of the Engineer. Patches may be sewn or overlapped. Unsown patch overlaps beyond the area of damage shall exceed roll overlap requirements of this section by at least 300 mm.

Erosion control geotextile shall be protected from damage due to the placement of large rock by limiting the height of drop of the material to no greater than three feet 900 mm.

In addition, either a cushioning layer of sand shall be placed on top of the geotextile or a zero drop height shall be utilized to place the rock. Regardless of the required placement technique, the contractor shall demonstrate that the placement technique will prevent damage to the geotextile. Placement of material shall begin at the toe and proceed up the slope.

When placed behind wall panels or facing elements, geotextile shall be installed and secured in a manner proposed by the Contractor and approved by the Supervisor such that migration of fines is controlled while allowing free drainage.

Drainage trenches to be lined with subsurface drainage) geotextile shall be prepared with smooth sides and bottoms. The geotextile shall be placed to conform loosely to the shape of the trench and laid back on either side of the trench to allow for placement of aggregate backfill and pipe and for backfill compaction, which shall be done in a manner to prevent damage to the geotextile. After compaction, the geotextile shall be lapped over the completed installation trench width or as shown on the working drawings.

During shipment and storage, geotextiles shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 60 C, mud, dust and debris.

#### **4.4.3 TESTING**

Geotextile material shall be evaluated by visual inspection and by examination of quality certificates issued by the manufacturer.

The contractor shall furnish a manufacturer's certification to the Supervisor, for each lot of material furnished stating the name of the manufacturer, the chemical composition of the filaments or yarns and certifying that the material supplied conform to all requirements specified. The certification shall include or have attached typical results of tests from specific lots for all specified requirements.

Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the Supervisor.

**5. BITUMINOUS SURFACING**

**5.1 SEAL COAT**

**5.1.1 DESCRIPTION**

This work shall consist of the application of bituminous material followed by the application of stone chippings.

**Material**

*Aggregate for Seal Coats*

The aggregate will be in accordance with the following:

<b>Table 5.1.A</b>					
<b>Requirements</b>	<b>Type 1</b>		<b>Type 2</b>		<b>Type 3</b>
	A	B	A	B	
<b>Sieve</b>	<b>Percent Passing</b>				
16.0 mm					100
12.5 mm	100			100	
9.50 mm	90-100	100	100	30-90	
6.25 mm	0-70				
4.75 mm	0-15	10-90	0-70	0-50	10-75
2.36 mm	0-5	0-30	0-28	0-20	0-62
0.425 mm		0-4	0-4	0-5	0-35
0.075 mm	0-10	0-3.0	0-3.0	0-3.0	0-18.0
Processing Required	Crushed	Crushed	Crushed	Crushed	Crushed
Flakiness Index (max)	30%				
Plasticity Index (max)	Non-Plastic	3	3	3	3
L.A. Abrasion Loss (max)	40%		40%	40%	40%
Soundness Loss (max)	12	15	15	15	15
Foot Notes	1	2	1.2	1.2	2

1. At least 50 percent of material retained on the 4.75 mm sieve shall have two or more fractured faces produced by crushing.
2. The plasticity index may be waived if not more than 4.0 % of the material passes the 425 µm sieve.

**The Binder**

The material to be used shall be rapid setting cationic emulsified asphalt, containing 60% pure bitumen, and identified as type EBCR 60, as defined by STAS 8877 – 72 and norm AND 552 – 99, table 2.

If the Contractor shall use ready-mix emulsion supplied by a traditional manufacturer, than the emulsion shall meet the following requirements, when tested using norm AND 551 – 99 and listed in **Table 5.1.B** below:

<b>Table 5.1.B</b>	
<b>Tests on emulsion</b>	<b>Requirement</b>
Viscosity Engler @ 20 °C, sec.*	5 – 15
Storage Stability, 7 days, on 0.63 mm sieve, %	0.5 max
Sieve Test, % retained on 0.63 mm sieve	0.5 max
Residue, %	58 min
Breaking point index, IB:	
- Method I (with French filler, SIKAISOL)	max. 80
- Method II (with size less than 0.09 mm from Romanian filler, SC DOBROMIN SA.)**	max. 20
Adhesion on standard aggregate***, %	min. 80

\* *If viscosity meter STV(4 mm nozzle) shall be used, the test results shall be transformed in Engler degrees by the relation:*

$$1 \text{ sec STV} = 1.6^{\circ} E$$

\*\* *Standard aggregate means fine chippings 4 – 8 mm from the andesite quarry near Chileni, in Romania*

The tests mentioned above shall be carried out for each shipment supplied to site. The supplier will provide also all necessary quality documents, for each shipment, as per Romanian legal provisions.

The transport and storage conditions shall be as per the requirements of norm AND 552 – 99.

If the Contractor shall use his own equipment to prepare the emulsion, then the component materials shall meet the quality requirements as follows:

### **The bitumen**

The bitumen shall be road bitumen type D 80/100, as per norm AND 537 – 98, emulsionable (salt free). The capability of the bitumen to form emulsions will be guaranteed by the supplier.

### **The emulsifier**

The cationic emulsifier shall be the amine or amide–amine type, having the characteristics in **Table 5.1.C**:

Table 5.1.C		
Item	Characteristics	Requirements
1	Aspect:	
	at 25° C	viscous fluid or paste
	at 70° C	fluid
2	Amine nitrate content, %	8-12
3	Aspect of a solution of 1% product in 2% solution of chloric acid	Clear to opalescent

### The chloric acid

Meeting the requirements of *STAS 339*.

### The water

Meeting the requirements of *STAS 1342*.

Periodical tests shall be carried out on stocks held on site every month or at the Supervisor's request. The periodical tests will be performed on the following characteristics:

1. Adhesion on standard aggregate
2. Storage Stability, at 7 days
3. Characteristics of the bitumen in the emulsion:
  - a. Ring & Ball
  - b. Penetration at 25° C
  - c. Ductility
    - i. at 0° C
    - ii. at 25° C

The control of the surface to be primed shall be based on the residual bitumen on the treated surface, by measuring on site the application rate with a square metal sheet 1.00 m x 1.00 m square. The plate shall be weighed clean before the operation and after the passage of the bitumen distributor due allowance given for the time necessary for the emulsion to break and the water to drain off.

### Equipment

The following equipment or its equivalent will be required:

(a) A distributor for heating and applying bituminous material.

(b) A rotary power broom.

(c) A minimum of one oscillating-type pneumatic-tire roller. The pneumatic-tire roller shall be self-propelled, having a mass of 4.5 to 7.5 tonnes.

Pneumatic-tire rollers shall be operated at a speed not to exceed 8 km/h.

(d) A self-propelled aggregate spreader of approved design. The aggregate spreader shall be equipped with a means of applying the larger cover aggregate to the surface ahead of the smaller cover aggregate and with positive controls so that the required quantity of material will be deposited uniformly over the full width of the bituminous material.

### **5.1.2 CONSTRUCTION REQUIREMENTS.**

#### **Weather Limitations**

Bituminous material shall not be applied when either the air temperature or the temperature of the surface to be sealed is below 21 C. Bituminous material shall not be applied on a wet surface or when weather conditions would prevent the proper construction of the seal coat.

#### **Preparation of Surface**

The surface to be treated shall be thoroughly cleaned and swept to remove all mud, matted earth, dust and other foreign material.

#### **Application of Bituminous Material**

Bituminous material shall be applied by means of a pressure distributor in a slow, uniform, continuous spread, without missing or overlapping, at a truck speed consistent with the placement of the cover aggregate. Unless otherwise provided, the bituminous material shall be applied to one half the width of the surface at a time, with the centre lap of the application placed at the lane line of the traveled way and kept as narrow as is practicable. The other side of the roadbed shall be left open to traffic. The application on one lane shall not exceed that on the adjacent lane by more than 5 km. The actual quantity of bituminous material to be used per square meter shall be as specified by the Supervisor. The rate of application is based on the specified minimum residual binder content as it applies directly to asphalt binder. The rate of application of emulsified asphalt shall be such that the residual binder content is equivalent to asphalt binder.

The angle of the spray nozzles and the height of the spray bar shall be set to provide a triple coverage fan pattern. The frame of the distributor shall be blocked or snubbed to the axle of the truck to maintain a constant height of the spray bar above the road surface during discharge of the load. An alternate method of maintaining constant spray bar height may be approved.

To ensure uniform application of the bituminous material at the beginning of each distributor load, a portion of the roadbed surface shall be covered with building paper. The area covered by the building paper shall be used as the starting point for each distributor load or each part of a load after a temporary delay. If the cut-off is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed of in a satisfactory manner. The distributor shall be moving forward at proper application speed when the spray bar is opened. Any skipped areas or deficiencies shall be corrected. Junctions of spreads shall be carefully made to ensure a smooth riding surface. The application of bituminous material on adjacent Portland cement or asphaltic concrete pavements, curbs, bridges or any areas not specified to be sealed shall be avoided.

### **Application of Cover Aggregate**

In general, the cover aggregate shall be placed within two minutes following the application of the bituminous material. Operations shall not proceed in such manner that bituminous material will be allowed to chill, set up, dry or otherwise impair retention of the cover aggregate. The cover aggregate shall be spread by means of a self-propelled mechanical spreader accurately measuring and uniformly spreading the aggregate. The actual quantity of cover aggregate to be used per square meter shall be as specified by the Supervisor. Spreading shall be accomplished in a continuous manner, without stopping between trucks, and in such manner that the tires of the trucks or aggregate spreader at no time contact the uncovered and newly applied bituminous material.

All portions of the surface not covered by mechanical spreaders shall be hand spotted so that the entire surface will be uniformly covered. Light hand brooming may be necessary to distribute excessive aggregate.

When emulsified asphalt is used, the moisture content of the aggregate shall not exceed 5 percent by mass. If specified by the Supervisor, the cover aggregate shall be moistened with water to enhance cohesive properties of the emulsion.

Rolling shall begin immediately behind the spreader and shall consist of two complete coverages with the pneumatic-tire roller. All rolling shall be completed the same day the cover aggregate is applied.

After the embedded aggregate has set, the surface shall be lightly broomed or otherwise maintained as directed for a period not to exceed four days. Maintenance of the surface shall include the distribution of cover aggregate over the surface to absorb any free bituminous material, and the removal of excess aggregate. Generally, the maintenance shall be confined to the cooler hours of the day and shall be conducted so as not to displace embedded material. The surface shall be free of excess aggregate at the time of acceptance of the work.

### **Traffic Control**

No traffic shall be permitted on the seal coat until all rolling has been completed. The contractor

shall control traffic by means of pilot vehicles to a maximum speed of 30 km/h for at least two hours after the completion of rolling. The contractor's supply trucks shall observe these traffic controls. Pilot vehicles shall also be used to maintain one-way traffic through areas of placing and rolling.

### **5.1.3 TESTING**

Visual inspections will be carried out by the Supervisor no later than 24 hours after the completion of a treated road section.

All material used in the process will be quality certified by the suppliers in accordance with the legal requirements.

The Contractor shall retain copies of his supplier's QC testing results, and undertake the quality control and quality assurance testing as required by the QC/QA Program. The Contractor shall supply material samples to the Supervisor for QA (Audit) testing purposes when requested.

## REFERENCES

“Design and Appraisal of Rural Transport Infrastructure: Ensuring Basic Access for Rural Communities”, World Bank Technical Paper No.496, Lebo and Schelling

“Principles of Low Cost road Engineering in Mountainous Countries”, 1997, Overseas Road Note 16, Transport Research Laboratory, UK

“Overseas Road Note 2: Maintenance Techniques for District Engineers (2<sup>nd</sup> Edition)”, Transport and Road Research Laboratory, UK, 1997

“Gravel Roads, Maintenance and Design Manual”, US Department of Transportation, Federal Highway Administration, 2000

Romanian Road Construction Standards and Norms in force.