

ROAD CONSTRUCTION GENERAL SPECIFICATIONS

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NATIONAL BOARD OF PUBLIC ROADS AND WATERWAYS

R O A D C O N S T R U C T I O N

GENERAL SPECIFICATIONS

EQUIPMENT, INSTALLATIONS AND FINISHING WORK 1700

ROAD CONSTRUCTION
General Specifications

EQUIPMENT, INSTALLATIONS AND
FINISHING WORK 1700

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1710 PERMANENT SAFETY DEVICE

Guardrails and other safety devices shall be made in conformance with the Plan at places set forth on the Plan. The construction, erection and placing of guardrails shall be in conformity with the Standard Specifications of the National Board of Public Roads and Waterways unless otherwise specified on the Plan.

The steel rails and posts of guardrails shall be given a hot-zinc coating unless otherwise specified. The thickness of the hot-zinc coating shall correspond to value ZnK 700. The parts coated with zinc shall not be welded. Holes and cut surfaces breaking the hot-zinc layer shall be coated with sprayed zinc film. The thickness of the zinc coating shall be the same as in hot-zinc treatment.

The material used in wood rails and posts of guardrails shall be pressure-impregnated. A guardrail made of impregnated wood may be left unpainted.

Steel wire fences and other devices specified on the Plan shall be erected in locations considered necessary in accordance with Special Directions for this work.

Wire fences shall generally be erected at the edges of high rock slopes in cuttings more than 4,0 m in depth. In rolling terrain the ground shall be levelled in such manner that the appearance of the fence will be good. Owing to appearance the construction of short (< 40 m) fences should be avoided.

1720 PERMANENT TRAFFIC CONTROL DEVICE

Permanent traffic signs shall be manufactured in accordance with Special Drawings and erected in locations shown on the Plan. Unless more detailed instructions concerning the location of traffic signs have been given on the Plan, the location referred to the cross section of the road shall be as specified in the Standard Specifications of the National Board of Public Roads and Waterways. In the longitudinal direction, the decision of the Ministry of Communications and Public Works, November 27, 1957/384 and amendments thereto shall be followed.

Traffic signs shall be manufactured and painted in conformity with the standards and principles of the National Board of Public Roads and Waterways. Signs made of sections shall be assembled with rust-proof material. Signs installed into posts shall be attached with two rust-proof clasps. The sign posts shall be manufactured either of light metal or of steel. The posts for illuminated signs shall be made of pipes. Signs not to be illuminated shall be installed in posts made of E-profile material. Unless otherwise indicated on the Plan, steel posts shall be coated with zinc as specified in Item 1710 above. The lower end of a light metal post in contact with concrete shall be coated with bitumen. If the sign will be illuminated later on, the top of the post shall be closed with a plastic plug. Concrete elements should be used as footings for traffic signs. More detailed data on traffic signs, posts and footings are generally given on the Drawings.

1730 CARRIAGEWAY MARKINGS

Carriageway markings shall be in locations shown on the Plan and the Standard Specifications of the National Board of Public Roads and Waterways.

Painting

The paint types used for carriageway markings shall be approved by the National Board of Public Roads and Waterways.

The layer of paint shall be uniform and even. The consumption of paint shall be about 0,25...0,35 litres/m². In order that marking is properly done and especially from the point of view of the durability of paint it is very important that the base is dry and clean. Painting shall be started only after the dew has dried from the surface. Painting shall not be carried out in foggy weather. In the evening, painting operations shall be finished in good time to allow the paint to dry before dew falls on the surfacing and to enable the removal of safety devices before dark. The finished carriageway marking shall have the correct line with no bends or waves. On new surfacings, carriageway markings shall not be painted sooner than 4...6 weeks after the sur-

facing has been laid, if a paint dissolving bitumen from the newly laid asphalt surfacing and changing its colour is used. On oil gravel roads, carriageway markings shall not be made earlier than 2 months after placing of the oil gravel provided that there is no risk of oil rising to the surface necessitating scarifying. The most advantageous time for marking operations from the point of view of durability is the period from May to September.

The visibility of markings in the dark is improved by means of glass pearls spread on wet paint. The diameter of glass pearls ranges between 0,1...0,6 mm. Pearls shall be spread by means of a device placed in connection with the marking machine simultaneously with painting.

1740 ROAD ILLUMINATION

The road illumination system shall be constructed in conformance with Plan Drawings and Special Specifications.

1750 FACINGS

Slopes, bank ends, central reserves, divisional islands, drains etc shall be constructed as shown on the Plan and of material indicated on the Plan.

F a c i n g w i t h G r a v e l a n d S t o n e C h i p s

Facing with gravel and stone chips is to be considered mainly in slopes of embankments and underneath bridges. A gravel or stone chip layer not containing stones larger than $\frac{2}{3}$ of the thickness of the layer shall be spread on slopes. Depending on available material and conditions, the thickness of the layer shall be 10...30 cm unless otherwise provided on the Plan.

G r a s s i n g

Slopes, bank ends, central reserves, divisional islands, drains etc shall be grassed by a method specified on the Plan or by some other acceptable method. It is often advisable to grass

slopes as soon as possible after excavation and completion of embankments, since damage to unprotected slopes can thus be prevented.

Prior to grassing of the central reserve, divisional islands and inner slopes the surface shall be compacted and covered with a layer of about 20 cm of material rich in fine earth material retaining moisture unless otherwise specified on the Plan or provided that the surface to be grassed is not dense. The above shall also concern all rock cutting slopes excavated to the gradient of the earth cutting slope and to be grassed. The surface of the slope of the road pavement section shall not, however, be compacted in such manner that the flow of water from the road pavement is prevented.

Grass types used shall be thick in growth, short, strong-rooted and resistant to drought. If possible, the seed mixture should be selected on the basis of local conditions and surroundings.

The general principle can be that topsoil shall only be used in areas where a particularly good finish is required. Even at locations where topsoil should be used, it can frequently be substituted by turf or by soils obtained in connection with replacement of soil. When some other organic material is used instead of topsoil, a growth test shall be made to ensure that the material is suitable for the purpose and fertilizers and other chemicals to be added to the material shall be determined. Prior to their use, the materials used instead of topsoil shall be generally treated with lime in stockpile areas to reduce excessive acidity.

Three different grassing methods (I, II and III) are used in facing of road structures. The grassing method IV shall be used in finishing of gravel pits, borrow sources etc.

Grassing may be supplemented by protective layers, turf sheets or natural turf.

Protective Layer

A protective layer may be made of twigs, springs, straw, turf-straw or bitumen or Resin emulsion. When straw and a mixture of turf and straw are used, emulsion shall always be used as

binder in order to prevent wind from blowing off the light protective layer. Protective layers shall be used in slopes susceptible to erosion and at locations susceptible to drought and the layer shall be laid as soon after sowing as possible.

Protective Layer

- a) straw about 4...5 mm
- b) cut turf about 4...5 mm
- c) bitumen emulsion (ab. 0,6 kg/m² + ab. 0,6 kg/m² water)
- d) resin emulsion
- e) sprigs
- f) twigs

The essentials of various grassing methods have been given in the Table below.

Table No. 1

	Grassing Method			
	I	II	III	IV
Topsoil, cm	10	5	-	-
Lime, kg/ha	3000	2000	-	-
Fertilizer, kg/ha	1000	1000	1000	500
Protective crops kg/ha	-	150	-	-
Seed mixture, kg/ha	200	150	100	50

Lime application: agricultural lime

Fertilizer: Forest Y-fertilizer or special Y-fertilizer

Protective crop: in spring oats

in autumn rye (as from August 15th)

Seed mixture: in grassing methods I, II and III standard mixture of the National Board of Public Roads and Waterways, in grassing method IV variable or standard mixture.

Grass seed mixture:

Festúca	45 %
Póa pratensis	30 %
Agróstis tenuis	15 %
Festúca ovina	5 %
Trifólium répens	2 %
Phleum pratense	1 %
Trifólium hybridum	1 %
Trifólium pratense	1 %
	<u>100 %</u>

Grassing Method I

The essential feature of this method is a topsoil layer 10 cm in thickness. The method shall be used at large divisional islands, central reserves, surroundings of buildings of permanent job bases and other, mainly horizontal, even grassed areas requiring a particularly good finish.

The work shall be carried out as follows:

- 1) Topsoil mixed as thoroughly as possible with lime shall be dumped on the graded soil. The surface shall be levelled.
- 2) Y-fertilizer shall be spread and worked to a depth of about 4...5 cm after which the surface shall be raked even.
- 3) The grass mixture shall be sown after which the ground shall immediately be rolled or compacted by some other method.
- 4) If topsoil is likely to become muddy after rain, the surface shall be covered with a layer of coarse gravel about 1 cm in thickness or with cut turf.
- 5) When the growth is about 20 cm high cutting shall be started.
- 6) During very sunny periods grass shall be watered.

Grassing Method II

The essential feature of this method is a topsoil layer 5 cm in thickness and the use of protective crops at the time grass is sown. The use of protective crops shall be considered separately for each case. Timbers may also be used at locations with large gradients. The method shall be used at the ramps of road interchanges, at the approach and through roads of major population

centres, on high bridge embankments and in the surroundings of parking areas.

The works shall be carried out as follows:

- 1) Seeds of the protective crops and one-half of the Y-fertilizer shall be spread on the graded foundation.
- 2) A layer of topsoil shall be spread at once and lime shall be applied in course of spreading. The surface shall be raked even.
- 3) The grass mixture shall be sown on the graded surface and the surface shall be compacted at once.
- 4) The other half of the Y-fertilizer shall be applied only when the height of protective crops is about 10...15 cm, that is, about 3 weeks after sowing.
- 5) Protective crop shall be cut down when ears begin to form.
- 6) Grassed areas shall be watered only in exceptional cases when the risk of withering is evident.

It shall furthermore be mentioned that the work shall be arranged in such a way that only such an area should be sown with protective crop and covered with Y-fertilizer each day that can be covered with a topsoil layer during the same day. Finishing of the surface and sowing of grass seed shall be effected within four days after sowing of the protective crop.

If the topsoil layer has already been placed on the surface to be grassed at an earlier stage of construction, the seeds of the protective crop and one-half of the Y-fertilizer spread simultaneously should be worked into the soil to a depth of about 3...5 cm where there is sufficient moisture for germination.

Grassing Method III

In this method, no topsoil is used grassing being effected by sowing seeds and fertilizers direct onto the trimmed soil. The grooves in the soil shall be parallel with the road at a spacing of 10...15 cm and with a depth of about 5 cm. This grassing method shall be used in large road slope areas.

The work shall be carried out as follows:

The grass mixture and the Y-fertilizer shall be spread on the surface of graded soil provided with grooves parallel with the road.

Should the growth of grass next spring prove poor, the soil shall be refertilized as soon as possible with Forest Y-fertilizer applied in a quantity of about 300 kg/ha. If possible, sowing shall be carried out mechanically.

Grassing Method IV

No topsoil is used in this method. The seed mixture may be even highly varying containing seeds of weeds and even trees depending on the local conditions of the grassed area. The method shall be used in finishing borrow sources and stockpile areas.

The work shall be carried out as follows:

- 1) Y-fertilizer, and the grass seed mixture shall be sown on a sufficiently levelled and shaped foundation after which the area shall be left untended.
- 2) If larger areas are concerned, suitable trees characteristic for the area shall be planted or sown.

In addition to the above specifications the following shall be taken into consideration:

A general instruction for the time of sowing is as follows:

- spring sowing from melting of snow to the middle of June
- autumn sowing from the beginning of August to the middle of September
- Sowing shall not be carried out during long sunny periods.
- A separate agreement shall be reached on sowing after September 15th.

The prescribed quantities are given as average quantities in the Table above. These quantities shall be applied on the site as follows:

On roads in a north-south direction, where slopes are equally exposed to sunshine, the quantities given in the Table shall be used on both slopes.

On east-west roads where the slopes on the southern side are highly exposed to sunshine, the quantity of seed on these

shall be as set out in the Table + 30 %, and on slopes in the shade 30 % less than the quantity specified in the Table. The average quantity per hectare shall thus be as specified in the Table.

On other road sections the above principle shall be applied depending on local conditions.

Fertilizing and the application of lime shall be in conformance with the Table at all locations. In areas where topsoil is highly acid, as generally in coastal areas, it may be advisable to use larger quantities of lime than specified in the Table. Forest Y-fertilizer or Special Y-fertilizer shall be used.

Bitumen emulsion, cut turf and straw are most suitable for the protective layer provided that appropriate machines are available for spreading.

In addition to the methods described above, even other acceptable methods may be used.

A latticework of plank may be constructed for binding the slopes placed obliquely on the slope and fixed to the ground by means of wooden pegs 0,5...0,6 m in length. The proper size of the latticework is 1,5...2,0 m. The latticework may be made either of planks or of laths. Facing above the latticework shall be as specified in other Items above. On more difficult and larger slope areas the latticework shall be made as specified on a Special Plan.

T u r f F a c i n g

In exceptional cases such as on very steep slopes facing with natural or cultivated turf may be considered. Pegs or battens shall if necessary be used to secure the turf to the soil. Interstices shall be filled with topsoil. The proper size of turf is about 0,1 m². Turf may be placed direct onto a graded slope.

S i m p l e S t o n e F a c i n g

Broken rock shall preferably be used in simple stone paving. The thickness of the stone layer shall be not less than 40 cm. Stones shall be placed tightly and interstices filled with smaller stones so that there will be no gaps larger than 10 cm in the finished surface. Smaller interstices shall be filled with gravel.

The final surface shall be so even that there will be no irregularities larger than 10 cm on a length of 2 m. On frost-susceptible soils the stone paving shall be founded on a filter course of sand and gravel 50 cm in thickness.

Stone paving in ditches shall be made of stones 30 cm large placed on a foundation graded with gravel. The thickness of the gravel layer shall be not less than 10 cm.

Dense Stone Facing

A dense stone paving may be used at the ends and slopes of embankments at bridges. It shall be constructed of dressed stones with a thickness of not less than 20 cm and an area of about 0,20 m². Stones shall be placed tightly side by side so that a hard and durable surface is obtained. The size of individual interstices at the joints shall not exceed 3 cm.

Polytrichium shall, for example, be used as filling material. The finished surface shall be so even that there will be no irregularities larger than 5 cm on a length of 2 m.

On frost-susceptible soils and in locations where the flow of water may cause erosion in the foundation of the facing, an inverted anti-erosion blanket shall be used as foundation. The blanket shall then be constructed in the following manner starting from the bottom:

10 cm sand	0,2...2 mm
20 cm gravel	2...20 mm
20 cm stone chips	40...60 mm

The blanket shall be constructed in layers, each layer being compacted separately. Should the original soil be coarser than some of these materials, the finer layers of the blanket shall be omitted.

In order to prevent erosion, grooved planking may also be used.

Stone facing shall be supported on a foundation not likely to subside.

Other Facing Types

Traffic islands so small or in such location that grassing will not succeed may be faced by some other method, e.g. with asphalt,

concrete, concrete slabs, stones etc as specified on the Plan. When these methods are used, the suitability of the surfacing in the surroundings shall be taken into consideration.

F i l t e r

See Item "Dense Stone Facing".

1760 PLANTATIONS

Planting shall be carried out in conformance with Plan Drawings and with Specifications for Planting Work.

1780 SPECIAL WORK, STRUCTURES AND EQUIPMENT

The work shall consist of the relocation - either complete or at least during the construction work - of equipment and structures susceptible to damage by the work or harmful to traffic or the road located in the road area or in its vicinity. The work shall generally always be carried out as set forth on the Plan or on Specifications for this work excluding minor operations. Directions on the performance of the work are generally given by the owner of the equipment to be relocated. Contact shall always be taken with the owner prior to the start of relocation work. In most cases, the owner himself will carry out at least part of the work included in this Item.

Skilled labour shall always be used in special work.

B u i l d i n g s

The reconstruction and re-erection of buildings shall be carried out in such manner that the building or structure relocated is in absolute conformance with the Plan or with its original condition. Parts damaged during the work shall be replaced with new ones. The work shall be carried out by skilled labour.

E l e c t r i c i t y a n d T e l e p h o n e C a b l e s

Special care shall be taken in uncovering of existing cables. The owner of the cable shall give information on the location and depth of the cable. The final uncovering of the cable shall

always be carried out manually. Excavating and backfilling of the new trench outside the road area shall be carried out as indicated by the owner of the cable. As for cables within the road area, instructions of the National Board of Public Roads and Waterways shall be followed.

The cable should be located on the roadside area or at the edge of the road area at a distance of not less than 0,5 m from the bottom of the ditch or from the outside edge of the slope/cutting. Should this be impossible, the cable may exceptionally be placed in the slope, however not closer than 0,5 m from the bottom of the ditch. The cable is generally installed underneath the road pavement under the carriageway at a depth of not less than 0,8. 1,0 m and elsewhere in the road area to such a depth that it will not have effect on the maintenance, improvement or underdrainage of the road. When the cable crosses under the road, it shall be protected or placed inside a casing pipe.

NATIONAL BOARD OF PUBLIC ROADS AND WATERWAYS

R O A D C O N S T R U C T I O N

GENERAL SPECIFICATIONS

CONSTRUCTION OF ROAD FORMATION: ROCK 1400

ROAD CONSTRUCTION
General Specifications

C O N S T R U C T I O N O F R O A D
F O R M A T I O N : R O C K 1 4 0 0

C O N T E N T S

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1410. EXCAVATION IN ROCK

U n c o v e r i n g

Prior to the start of excavation operations soil overlying the rock shall be removed so thoroughly that remaining soil material will not make the base of the excavation or structures to be constructed of ~~crushed~~^{broken} rock frost-susceptible. In the determination of the accuracy requirements specified for uncovering, attention shall be given to the frost-susceptibility of soil overlying the rock, to the later use or ~~crushed~~^{broken} rock materials, to the height of the heading and to the depth of excavation. As regards frost-susceptible materials, the accuracy shall range between 1...10 cm the lower limit corresponding to the area of a shallow cutting ($h < 1,0$ m) when deep blasting method is not used and the upper limit to the area of a high cutting ($h > 6,0$ m) when the deep blasting method is applied. The rock on both sides of the road shall be uncovered to a width greater than the theoretical width of excavation. The additional width shall be as specified on the Plan but not less than 1,5 m.

Uncovering shall be continued after blasting, if necessary, so that rock remaining in the sides of the cutting is generally exposed for a width of about 1,0 m in the horizontal direction in order to prevent overlying earth and stones from falling down. Earth removed in this additional exposal should preferably be placed on ledges formed in the sides of the cutting to encourage growth, or it shall be used for shaping the cutting. Earth slopes lying above the cutting shall have a slope of earth slopes and the upper edges shall be rounded off. If such large overbreaks occur during blasting operations that the rock cannot be exposed for a width of 1,0 m without making unsightly bends in the earth slope, a retaining wall of stone shall be constructed.

When the sides of a cutting are excavated to a slope of an earth slope, the width of uncovering shall be determined on the basis of the final slope boundaries.

C l e a n i n g

Should ~~crushed~~^{broken} rock be used as material for road pavement or

for the manufacture of stone chips and crushed stone, the surface of the rock shall be carefully cleaned by hand.

B l a s t i n g

Methods and explosives used shall be such that rock situated outside the cutting will remain as undisturbed as possible and that there will be no rock within the theoretical cross-section. It is recommended that prior to the start of blasting operations the quality of rock be studied and that at the initial stage of the work tests be made to determine the hole spacing and the charging density. If necessary, blasting experts shall be used.

As a rule, blasting shall be carried out as normal open blasting.

If separately indicated on the Specifications for Blasting, the pre-split technique, supplementary blastings or some other method of precision blasting ensuring similar results shall be used in order to obtain an even and resistant rock wall in cases when rock walls steeper than earth slopes are to be constructed. In the lower portion of edge holes in a rock cutting a tolerance of not more than 20 cm is permitted in individual cases.

Rock shall be blasted into sizes making it possible to use ~~crushed~~ ^{broken rock} material for the intended purpose. Blasting operations shall be carried out in such manner that there is no undue danger or damage to the surroundings, and the laws, statutes, other regulations and instructions given by the Employer concerning blasting work, materials used and their storage shall be followed.

The sides of rock cuttings shall be brought to slopes specified on the Plans, as a rule into a slope ranging between 10:1.... 5:1. In the case of short and sometimes even of long shallow cuttings, the sides may be given the same slope as in excavation in soil. As regards the appearance of cuttings at difficult locations the blasting method shall be selected as set forth on separate directions. In the performance of work allowance shall be made for excessive excavation needed for any soil layer

to be covered with grass. In rock excavations with steep sides the slope shall decrease towards the ends of the cutting so that a gentle transition will be obtained. In special cases, for example when rock is weak or when the appearance shall be considered, the slope may be specified separately.

Any small pieces of rock found in soil excavations shall, once they have been uncovered, be blasted to a depth corresponding to the thickness of the road pavement of adjacent sections. The depth of blasting in Road Pavement Categories 1, 2, 3 and 4 below the carriageway shall, however, be not less than 1,0 m measured from the surface of the completed road (deep blasting). The stone blasted shall be removed so that the base course may be constructed as a continuous course. Any transition wedges required around rock faces shall be constructed in conformance with directions given in Item 1510 for transition wedges. Small rock pieces or large isolated boulders shall be removed to a depth specified for the transition wedge and the excavation shall be filled with surrounding material and compacted to the density of the surrounding area.

Normal Open Blasting

In normal open blasting, the advance, the hole spacing and the charging indicated in Table No. 1 below may be used. The detonation shall be arranged in such manner that the explosion will advance into the rock in a form of a plough thus preventing any pressure impacts against rock walls.

Table 1

Height of heading m	Bottom dia of hole mm	Bottom charge kg/m	Hole charge kg/m	Max ad- vance m	Max.hole spacing m
0-2,5	25	0,63	0,25	1,15	1,5
	29	0,84	0,34	1,3	1,7
0-5	32	1,0	0,40	1,5	1,9
	38	1,4	0,60	1,8	2,3
	44	1,9	0,80	2,0	2,6
4-10	50	2,5	1,0	2,3	3,0
	63	4,0	1,6	3,0	3,9
6-15	75	5,6	2,3	3,5	4,5

In the cases when the largest hole spacings and advances are used, additional holes, about $1/3$ of the length of large holes should be drilled in between the large holes in order to decrease the size of boulders. The hole size is determined on the basis of permissible vibration and of the desired boulder size. As a rule all holes shall be drilled to a slope of 3:1. The holes shall extend to a depth about $1/3$ of the advance below the theoretical bottom level.

Surface Blasting

Surface blasting shall be carried out either by precision blasting or by the pre-split method used in advance so that the final rock surface is as even and compact as possible.

In the pre-split method a fracture is shot in the wall of the cutting either before or in conjunction with other blasting by arranging the detonation in such manner that charges along the line of the intended fracture will explode first. The hole spacing along the line of the fracture shall, depending on the type of rock, be 30...60 cm. Drilling shall be performed by a wagon drill with good directioning properties. The row of holes shall be drilled to a depth of not less than 50 cm below the excavation and the explosives shall be dynamite at the bottom and low-velocity explosives higher up. In long holes, dynamite may be used also in the middle of the hole. All holes in the outer row shall be exploded simultaneously. Every second hole may be left uncharged if close spacing is used. Results may be improved by using detonating fuses. Remaining blasting operations shall be performed by a normal method, but near the fracture the hole spacing shall not exceed 80 cm and the explosive here shall also be of a low-velocity type. In order to render the use of the pre-split method successful, a rock slab not less than 2 m in thickness shall be used as counterweight on both sides of the fracture.

In precision blasting an even wall is obtained by using a short hole spacing, a small charging density, low-velocity explosives and a delayed detonation. The middle portion of the cutting may be blasted by normal methods, but depending on the stability of rock a portion 1,5...2,0 m in

width next to the wall shall be blasted by special methods. In the direction parallel to the wall the hole spacing shall be 20...60 cm and at right angles to the wall 30...100 cm depending on the type of rock. Directioning of holes shall be accurate. Therefore, holes in the outer row shall be exploded first in small fields so that any errors could be made good at once. Blasting shall be carried out by using low-velocity explosives and delay detonators.

Should the direction of foliation or shale be parallel to the wall, but the fall of blasted material deviates from the slope of the wall, changing the slope of the sides into the slope of holes shall be considered in order to prevent subsequent failures.

Deep Blasting.

The rock shall be blasted to a level 1 m below the finished road surface.

Blasting shall be carried out as follows:

Underdrilling, measured in the direction of the hole shall be extended to (a) m below the level of deep blasting. The value selected for (a) shall be larger of the following two values: either $a = \frac{1}{3} \times \text{advance}$ or $a = \frac{1}{10} \times \text{vertical depth of the hole (excl. underdrilling)}$. The work shall be arranged in such manner that it is possible, either by random tests or by continuous testing to check the bottom level of drill holes which shall be done by comparing known level marks with the level of wooden measuring sticks inserted in the holes before charging.

Effect of Vibration

In urban areas and in the vicinity of buildings and installations the size of charges shall always be restricted because of vibrations caused by blasting.

If the risk of vibrations is evident, a statement of an expert shall be acquired prior to the start of blasting operations. In all cases when buildings or structures are in the sphere of vibration, a written statement shall be acquired by the Contractor about the situation before blasting, so that any dam-

ages by blasting could be undisputedly determined and paid for.

Depth of Blasting for Different Road Pavement Categories

If the road is to be provided with a road pavement of categories 1, 2, 3 or 4 in conformance with instructions and Standard Specifications of the National Board of Public Roads and Waterways, the rock shall be excavated to a depth not less than 1,0 m from the finished road surface (deep blasting). Broken rock shall be removed only to such a level that the remaining material may be graded and compacted and that the required road pavement or the base course and the wearing course may be constructed. If broken rock from a rock cutting is loaded from too large a depth and if the cutting shall therefore be backfilled, the backfill material shall conform to the quality requirements specified for stone embankments.

Should the original rock surface be lying below the underside of the base course, only such rock as has heaved above the underside of the base shall be removed. In that case, allowance shall be made also for required blinding material of the broken rock surface.

In the case of Road Pavement Categories 5, 6, 7 and 8, the rock shall be blasted generally only to such a depth that it may be removed to a level at least 5 cm below the underside of the finished road pavement (base course). In this case, holes shall generally be drilled below the said level to a depth corresponding to about half the advance. After blasting, the bottom shall be thoroughly cleaned of frost-susceptible soils and, if necessary, graded. Well-cleaned rock fragments, gravel or crushed products shall be used in grading.

Directions concerning grading a subgrade made of crushed rock have been given in Item 1440.

T r i m m i n g o f R o c k W a l l s

In conjunction with loading of broken rock, such loose material shall be removed from the rock walls as may later roll down (manual removal). Unsightly rock sections and overhanging or projecting rock shall also be removed, if considered necessary from the point of view of traffic safety or appearance. Fixing with bolts may also be considered in certain cases.

Construction in Winter

The surfaces of rock cuttings should be cleaned and uncovered when the ground is unfrozen.

In excavation during winter, rock should be blasted in small quantities and loading should be carried out as soon as possible, so that excavated rock is not unduly exposed to snow and freezing.

440 EMBANKMENTS OF ^{BROKEN}~~CRUSHED~~ ROCK

General

See Item 1540

Stone Embankments

A stone embankment shall generally be constructed as an open stone embankment and in special cases only as a dense embankment. An open high stone embankment means a stone embankment, the height of which is not less than 2 m from the principal longitudinal profile. This kind of embankment shall be hauled in not less than two layers in such manner that the interface of the layers is at a depth of about 1,5 m from the principal longitudinal profile. Both layers shall be spread by means of end tipping so that broken rock is always tipped onto a finished layer, from which it is pushed to its final position. There is no maximum limit for the size of boulders in the lower layer, but in the upper layer - from the level principal longitudinal section - 1,5 m - upwards, smallest possible rock particles shall be used. The largest dimension of individual boulders shall not exceed 60 cm.

The height of an open low embankment shall be less than 2 m from the principal longitudinal profile. This kind of embankment may be constructed in one layer. Rock material shall be small the maximum grain size being 60 cm.

The surface of an open stone embankment and, if necessary, also the slopes shall be blinded with small stones or chips and finished with crushed gravel, crushed stone or gravel conforming to the quality requirements specified for mineral aggregate curve of Class B.

A stone embankment may also be constructed in such manner that the lower portion is made of broken rock and the upper portion of crushed rock material. Crushed material shall be relatively coarse, e.g. 0...200 mm and the thickness of the crushed rock layer shall be not less than twice the largest grain size of crushed rock. The layer of crushed rock shall be constructed in such manner that crushed rock is spread onto the layer from which it is pushed to its final position.

A dense stone embankment shall be constructed in layers by filling the void of the embankment with fine ~~crushed~~^{broken} rock or with soil frost-resistant down to a depth required by the transition wedge (1,6 ; 1,8 ; 2,0 m). The maximum thickness of a layer spread at one and the same time shall be 1,20 m. The boulder size shall not exceed the layer thickness and in the upper portion of the embankment, 1,5 m in thickness starting from the road surface, boulders shall not be more than 60 cm in diameter. In order to make the fine material penetrate into the interstices of stones, strong water jetting or vibration shall be used, if necessary.

Should a low stone embankment be constructed on wet frost-susceptible subsoil or on soft embankment fill and if there is the risk of pumping action during the construction work or later, a layer not less than 30 cm in thickness shall be constructed or filter material underneath the stone fill.

If the height of a stone embankment measured from the principal longitudinal profile is not less than 1,5 m, no sub-base is needed on the embankment, the base course being constructed on a graded and compacted stone fill.

Backfilling Behind Abutments and Bank Ends

See Item 1540.

Backfilling in Replacement of Soil (Displacement by Blasting)

See Item 1540.

Treatment of Surface of Sub-grade

In addition to what has been said above of the treatment of the surface of cuttings and embankments, the following shall be observed:

Stone Embankments and Rock Cuttings

In rock cuttings and in cases when the subgrade has been constructed of stones or broken rock, the surface shall first be roughly graded and blinded with small rock material or stone chips to an extent considered necessary. In order to prevent the road pavement from flowing out, the surface shall be finally graded, compacted and finished by using crushed gravel conforming to the mineral aggregate curve of Class B, crushed stone or gravel. The surface may also be impregnated with bituminous binders. In special cases the bottom of rock cuttings may be graded with concrete.

If a base course is laid on the surface after grading and compacting, the surface shall not contain irregularities larger than 30 mm over a length of 5 m. There shall not be individual deviations in the level of the surface from the theoretical level larger than - 4 cm, + 0 cm. The surface shall have true form and the average permissible deviation from the correct level shall not exceed - 2 cm, + 0 cm.

Blinding before final grading shall be carried out thoroughly in order to ensure that grading material, when having dried, will not flow into the interstices and cause settlements. Rough grading and blinding with broken rock and stone chips shall be carried out in such manner that the thickness of grading material shall not exceed 10 cm at any spot.

The requirement for bearing capacity shall conform to that of the surface of sub - base.

Protecting Surface During Work

Fine-grained materials (e.g. stone dust or frost-susceptible soils) left at the bottom of rock cuttings or in the upper portion of stone embankments shall not make the structure frost-

susceptible. Subgrades of rock and stone embankments shall therefore be compacted and graded, in general as soon as possible, since there is the risk that unsuitable soil gets mixed with the surface during haulage.

If there is the risk that unsuitable materials fall down from hauling equipment during construction work to a detrimental extent, the subgrade shall be provided with an extra gravel layer not less than 5 cm in thickness. The gravel layer shall later be removed simultaneously with unsuitable materials. Traffic on the finished surface of the subgrade shall be avoided.

1450 CONSTRUCTION AND REMOVAL OF SURCHARGES OF BROKEN ROCK

1460 See Item 1550....1560.