PETROBRAS | N-1602 | REV. C | ENGLISH | 11 / 2013

Pavement Construction

Procedure

This Standard replaces and cancels its previous revision.

The CONTEC - Authoring Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is responsible for adopting and applying the sections, subsections and enumerates thereof.

Technical Requirement: A provision established as the most adequate and which shall be used strictly in accordance with this Standard. If a decision is taken not to follow the requirement ("non-conformity" to this Standard) it shall be based on well-founded economic and management reasons, and be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by imperative nature.

Recommended Practice: A provision that may be adopted under the conditions of this Standard, but which admits (and draws attention to) the possibility of there being a more adequate alternative (not written in this Standard) to the particular application. The alternative adopted shall be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by verbs of a nonmandatory nature. It is indicated by the expression: **[Recommended Practice]**.

Copies of the registered "non-conformities" to this Standard that may contribute to the improvement thereof shall be submitted to the CONTEC - Authoring Subcommittee.

Proposed revisions to this Standard shall be submitted to the CONTEC - Authoring Subcommittee, indicating the alphanumeric identification and revision of the Standard, the section, subsection and enumerate to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

CONTEC
Comissão de Normalização Técnica

SC - 04
Civil Construction

Introduction

PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting specialized of Technical Collaborators from Company and its Subsidiaries), are commented by Company Units and its Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of technicians from the same specialty, representing the various Company Units and its Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the Company Units and its Subsidiaries). A PETROBRAS Technical Standard is subject to revision at any time by its Authoring Subcommittee and shall be reviewed every 5 years to be revalidated, revised or cancelled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS Technical Standard N-1. For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.

Sumário

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Foreword

This Standard is the English version (issued in 08/2014) of PETROBRAS N-1602 REV. C 11/2013. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

1 Scope

1.1 This Standard prescribes the minimum requirements for pavement construction.

1.2 This Standard is applicable to work started as of its date of issuance.

1.3 This Standard contains Technical Requirement and Recommended Practice.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

Resolução ANP Nº 19 de 11/07/2005 - Especificações dos Cimentos Asfálticos de Petróleo;

Resolução ANP Nº 30 de 09/10/2007 - Asfaltos Diluídos de Petróleo;

Resolução CNP Nº 1 de 20/02/1973 - Norma CNP 17 - Dispõe sobre o estabelecimento de Norma relativa a Emulsões para a Lama Asfáltica;

Resolução CNP N° 7 de 06/09/1988 - Dispõe sobre as especificações das Emulsões Asfálticas Catiônicas;

DNIT 031/2006-ES - Pavimentos Flexíveis -Concreto Asfáltico;

DNIT 032/2005-ES - Pavimentos Flexíveis – Areia Asfalto a Quente;

DNIT 047/2004-ES - Pavimento Rígido - Execução de Pavimento Rígido com Equipamento de Pequeno Porte;

DNIT 048/2004-ES - Pavimento Rígido - Execução de Pavimento Rígido com Equipamento de Fôrma-Trilho;

DNIT 049/2009-ES - Pavimento Rígido - Execução de Pavimento Rígido com Equipamento de Fôrma-Deslizante;

DNIT 137/2010-ES - Pavimentação - Regularização do Subleito;

DNIT 138/2010-ES - Pavimentação - Reforço do Subleito;

DNIT 139/2010-ES - Pavimentação - Sub-base Estabilizada Granulometricamente;

DNIT 140/2010-ES - Pavimentação - Sub-base de Solo Melhorado com Cimento;

DNIT 141/2010-ES - Pavimentação - Base Estabilizada Granulometricamente;

DNIT 143/2010-ES - Pavimentação - Base de Solo-Cimento;

DNIT 144/2012-ES - Pavimentação Asfáltica - Imprimação com Ligante Asfáltico;

DNIT 146/2012- ES - Pavimentação Asfáltica - Tratamento Superficial Simples;

DNIT 147/2012-ES - Pavimentação asfáltica - Tratamento Superficial Duplo;

DNIT 150/2010-ES - Pavimentação Asfáltica - Lama Asfáltica;

DNIT 152/2010-ES - Pavimentação - Macadame Hidráulico;

DNIT 153/2010-ES - Pavimentação Asfáltica - Pré- Misturado a Frio com Emulsão Catiônica Convencional;

PETROBRAS N-862 - Execução de Terraplenagem;

PETROBRAS N-1601 - Construção de Drenagem e de Despejos Líquidos em Unidades Industriais;

ABNT NBR 6118 - Projeto de Estruturas de Concreto - Procedimento;

ABNT NBR 7182 - Solo - Ensaio de Compactação;

ABNT NBR 7207 - Terminologia e Classificação de Pavimentação;

ABNT NBR 7208 - Materiais Betuminosos para Emprego em Pavimentação;

ABNT NBR 9781 - Peças de Concreto para Pavimentação - Especificação e Métodos de Ensaio;

ABNT NBR 9910 - Asfaltos Modificados para Impermeabilização sem Adição de Polímeros - Características de Desempenho.

NOTE For documents referred in this Standard and for which only the Portuguese version is available, the PETROBRAS department that uses this Standard should be consulted for any information required for the specific application.

3 Terms and Definitions

For the purposes of this document terms and are adopted of the in ABNT NBR 7207 and ABNT NBR 7208 and the following.

3.1
earthwork
earth moving activities needed for achieving the alignments and sections indicated in the design

3.2
grade
surface obtained by the earthwork or road structure, and shaped according to its grade and cross-sections

3.3
subgrade
foundation soil of the pavement

3.4
levelling of subgrade
operation intended to shape the grade, when necessary, in the crosswise and longitudinal directions, comprising cuts or fills up to 20 cm thick. Whenever the thickness exceeds 20 cm, this is considered to be earthwork

3.5
reinforcement of subgrade
a layer whose thickness is constant in the crosswise direction and variable in the longitudinal direction, according to the sizing of the pavement of which it is an integral part and being, for technical and economic reasons, applied over the subgrade

3.6
subbase
the layer used for correction of the subgrade or complementation of the base, applied when, for technical and economic reasons, it is not advisable to construct a base directly over the levelled grade or over the reinforcement of the subgrade

NOTE 1 The subbase is stabilized when it is composed of soil layers, crushed stone materials or by any combination of those materials.
NOTE 2 The subbase consists of soil improved with cement or lime when it is composed of a closely bound and compacted mixture of soil, cement or lime and water, in laboratory-measured proportions.

3.7
base
the layer intended to support and distribute traffic stresses and over which the coating is applied

NOTE 1 The base is stabilized when it is comprised of layers of soils, mixtures of soils, crushed stone material, or by any combination of those materials.
NOTE 2 The base consists of soil improved with cement or lime when it is comprised of a closely bound and compacted mixture of soil, cement or lime, and water, in laboratory-measured proportions.

3.8
primer coat application
the application, before any bituminous coating is applied, of a layer of bituminous material to the surface of a completed base, with a view to:

a) increasing the cohesion of the surface of the base by penetration of the bituminous material used;
b) promoting bonding conditions between the base and the coating;
c) waterproofing the base.

3.9
coating
layer, which is rendered waterproof to the greatest extent possible, which is the running surface for vehicular traffic and is intended for:

a) improving running conditions in terms of comfort and safety;
b) withstanding horizontal and vertical stresses imposed thereon, thereby making the running surface more durable.

3.10
pavement
the structure constructed after the earthwork and intended for:

a) withstanding and distributing to the subgrade the vertical stresses from vehicles;
b) improving the conditions of the running surface in terms of comfort and safety;
c) withstanding the horizontal stresses imposed thereon, thereby making the running surface more durable.

3.11
complementary works
the works intended to provide finish to pavements. For the purposes of this Standard, complementary works are deemed to be drainage works, slope protections, curbs, gutters, sidewalks, standard and special road structures, horizontal and vertical signalling, among others

3.11.2
curbs and gutters
elements used for conveying rain water and limiting vehicular traffic on the roadway

3.11.3
sidewalks
elements at the side of a roadway used for pedestrian traffic

4 General Conditions

4.1 For the purposes of this Standard, the following elements are considered to have been completed described in 4.1.1 to 4.1.3.

4.1.1 Provisional or definitive drainage works, in accordance with PETROBRAS N-1601.

4.1.2 Earthworks in accordance with PETROBRAS N-862.

4.1.3 Complementary concrete works in accordance with ABNT NBR 6118.

4.2 For asphalt petroleum-based materials, the specifications of the technical regulations for asphalt products of the DNC, the resolutions of CNP ANP Nº19 de 11/07/2005, CNP N° 7 de 06/09/1988, CNP Nº 1 de 20/02/1973, ANP Nº 30 de 09/10/2007 and ABNT NBR 9910. For other materials, the specifications of DNIT, with the exception of the measurement criteria.

5 Specific Conditions

5.1 The subgrade shall be levelled in accordance with DNIT 137/2010-ES.

5.2 The subgrade shall be reinforced in accordance with DNIT 138/2010-ES..

5.3 The subbase shall be constructed in accordance with DNIT 139/2010-ES, for the stabilized subbase and in accordance with DNIT 140/2010-ES, for the subbase of soil improved with cement. For the base of soil-cement standard DNIT 143/2010-ES.shall be used.

5.4 The base shall be constructed in accordance with DNIT 141/2010-ES, for the stabilized base and DNIT 141/2010-ES, for the base of soil improved with cement. For the base of soil-cement DNIT 143/2010-ES.shall be used.

5.5 The prime coat shall be applied in accordance with DNIT 144/2012-ES.

5.6 The coatings shall consider the following conditions:

a) Portland cement concrete;
b) pavement stone with joints sealed with Portland cement mortar and sand;
c) articulated and interlocked pre-cast concrete blocks;

d) primary coating with use of stabilized soil;
e) primary coating with hydraulic macadam;
f) pavement stone with joints sealed with flexible materials;
g) single inverted penetration surface treatment;
h) double inverted penetration surface treatment;
i) hot sand-asphalt;
j) hot-mix bituminous concrete;
k) asphalt mud;
l) cold premixed running layer.

5.6.1 Portland Cement Concrete Coating

It is composed of non-reinforced concrete panels, which may occasionally be reinforced, simultaneously performing the functions of base and coating, and shall be applied in accordance with DNIT 049/2009-ES, DNIT 047/2004-ES e DNIT 048/2004-ES.

5.6.2 Stone Pavement

It is composed of granite blocks, or another solid stone, with a minimum compressive strength of 98 MPa (1 000 kgf/cm^2) and a minimum specific weight of 23.5 kN/m^3 (2 400 kgf/m^3), with rectangular-shaped flat faces. It shall be applied as indicated below, assuming that the installation of curbs as described further ahead in 5.7, has already been completed:

a) pavement stones shall be shaped as a straight prism with a rectangular base with approximate dimensions of 10 cm x 20 cm x 15 cm;
b) when indicated in the corresponding design, the elements comprising the pavement shall be constructed according to 5.1 to 5.3;
c) a loose 5 cm thick layer of sand or stone dust shall be applied on the prepared grade to make up for the irregularities and unevenness of the stones;
d) stones shall be laid in tiers with the largest dimension of the part perpendicular to the road centerline, with a spacing between blocks of 1.5 cm and in an alternating arrangement so that they can be joined together;
e) alignments and levels shall be made by means of pointers with a maximum spacing of 10 m, where the levels corresponding to the cross-sections of the road shall be marked;
f) once the levels have been marked, the cross-sections shall be obtained by means of strings firmly stretched transversally and longitudinally to the centerline of the road;
g) cross slopes shall be least 2 %;
h) after the network of strings is ready, the stones shall be placed on the loose layer and manually tamped so that their upper faces are located 1 cm above the reference lines.

5.6.2.1 Sealing of joints with mortar cement and sand:

a) before joints are sealed, the pavement shall be duly compacted with a roller compactor of 80 to 100 kN, so as to achieve the design grade;
b) the compaction of parts inaccessible to rollers shall be performed by mechanical compactors;
c) joints shall be sealed by filling them completely with cement mortar and sand in a proportion in volume of 1:3, or in the proportion indicated in the design, being frizzled with the mortar still fresh with an iron with the end turned toward the largest dimension of the blocks.

5.6.2.2 Sealing of joints with flexible materials:

a) joints shall be sealed with sand or stone dust by spreading a 2 cm thick layer of sand or stone dust over the pavement, forcing, by means of suitable brooms, the penetration of those materials into the joints of the stones;
b) joints shall be sealed with bituminous material by initially spreading a layer of crushed stone (zero crushed stone) 1 cm thick over the pavement and forcing, by means of suitable brooms, the penetration of the material until it fills 1/3 of the depth of the joints;
c) next, the process of filling up joints is completed with suitable sprinklers and with bituminous material until it emerges to the surface of the pavement;
d) after the sealing of joints, the pavement shall be duly compacted with a smooth roller compactor weighing at least 100 kN;
e) the parts inaccessible to roller compactors shall be compacted by suitable hand or mechanical tampers.

5.6.3 Covering of Pre-Cast Concrete Blocks

It is composed of plain articulated and interlocked concrete blocks highly vibrated and pressed and shall be prepared as follows:

a) the blocks shall have a regular shape, flat faces, with a minimum crushing strength of 24.50 MPa (250 kgf/cm^2) and a specific weight of 15.7 kN/m^3 (1 600 kg/m^3);
b) concrete shall be prepared in accordance with ABNT NBR 9781.
c) when indicated in the corresponding design, the elements comprising the pavement shall be executed in accordance with it 5.1 to 5.3;
d) a 4 cm thick loose layer of sand or stone dust shall be spread over the prepared grade;
e) concrete blocks shall be laid in tiers perpendicular to the centerline of the road;
f) the spacing between blocks, compaction and sealing of joints shall be in accordance with the conditions indicated by the manufacturer.

5.6.4 Primary Coating with Use of Stabilized Soil

It is composed of a stabilized layer applied to the grade of the road and capable of offering a roadway surface superior to that of the natural soil.

5.6.4.1 The primary coating should preferably be applied with existing site materials meeting the following requirements:

a) materials shall be free from organic and vegetable material, clay lumps and fall into one of the grain sizes C, D, E or F of Table 1:
b) coarse aggregate (retained up to the No. 10 sieve) is composed of hard and durable particles of fragments of stone, rubble or slag; its percentage of wear in the Los Angeles test shall not exceed 50;
c) coarse aggregate with a percentage of wear exceeding 50 (Los Angeles test) may also be used, if it has proven to have reached satisfactory results in other primary coating or paving services;
d) fine aggregate (passing a No 10 sieve) shall be composed of natural sand (or produced by crushing) and fine particles passing a No. 200 sieve;
e) the liquidity limit of the fraction passing a No. 40 sieve shall be equal to or smaller than 35 ($LL \leq 35$), and the plasticity index shall be equal to or greater than 4, and equal to or smaller than 9 ($4 \leq IP \leq 9$);
f) it is also recommended that, when the coating is to be maintained for several years without undergoing bituminous treatment or receiving another waterproofing layer over it, a value of at least 8 % passing a No. 200 sieve shall be specified instead of the minimum percentages indicated above for grain size curve C or E.

Table 1 - Ranges of Grain Sizes of DNIT 141/2010-ES

Sieve	Percentages in weight, passing					
	A	B	C	D	E	F
2”	100	100	-	-	-	-
1”	-	75-95	100	100	100	100
3/8”	30-65	40-75	50-85	60-100	-	-
No. 4	25-55	30-60	35-65	50-85	55-100	70-100
No. 10	15-40	20-45	25-50	40-70	40-100	55-100
No. 40	8-20	15-30	15-30	25-45	20-50	30-70
No. 200	2-8	5-15	5-15	10-25	6-20	8-25

5.6.4.2 The following basic items of equipment are indicated for the coating application:

a) heavy motor grader with scarifier;
b) water distribution tank car;
c) roller compactors;
d) soil pulverizing mixer;
e) disk screens.

5.6.4.3 The operations involving spreading, mixing and spraying, wetting and drying, compacting and finishing of imported materials on the runway shall be carried out as follows:

a) the roadway shall be perfectly regularized and consolidated according to the conditions of alignment, longitudinal section and cross section; gutters, in cuts, shall be in perfect operating conditions;
b) the coating shall cover the roadway and shoulders, if any, and be at least 20 cm thick throughout its extension and width, and the soil may either be mixed on the roadway itself or at a fixed or mobile plant;
c) a pulverizing mixer shall be used for mixing the soil on the roadway in case use is made of the materials from the roadway itself and from a single nearby bed;
d) fixed or mobile asphalt plants should be preferably used when it is necessary to mix soils from beds of different origins;
e) in case a pulverizing mixer is used, the material is deposited on the runway in piles aligned along the centerline of the road and spread out with a motor grader to ensure conformity with the cross-section;
f) with the water distribution car the spread material is then wetted until it reaches an optimum moisture content and with the use of a pulverizing mixer the materials are mixed together until a uniform mixture is achieved;
g) the next stage is compacting, and it shall be necessary to achieve at least 100 % in relation to the dry maximum apparent specific mass obtained in the test ABNT NBR 7182, with a moisture content reaching the optimum content of the test mentioned above with a $\pm$ 2 % variation;
h) after mixing, in case fixed or mobile asphalt plants are used, soil shall be deposited along the road and then spread out and compacted according to paragraphs e), f) and g).

5.6.4.4 Technological control and geometric control shall be exercised in accordance with the specific items of DNIT 141/2010-ES.

5.6.5 Primary Hydraulic Macadam Surface

It is composed of one or more layers of crushed aggregate (stone, slag or gravel) joined together by means of stone dust and water, so as to form a compact mass, and shall be prepared according to DNIT 152/2010-ES.

5.6.6 Single Inverted Protection Surface Treatment

It is comprised of bituminous material and mineral aggregate, in which the aggregate is uniformly placed over the bituminous material applied in a single layer, and shall be prepared in accordance with DNIT 146/2012- ES.

5.6.7 Double Inverted Protection Surface Treatment

It is comprised of 2 applications of bituminous material, with each one covered with mineral aggregate, and shall be executed in accordance with DNIT 147/2012-ES..

5.6.8 Hot Sand-Asphalt Coating

It is comprised the hot mix, at a suitable asphalt plant, of fine aggregate, filler and asphalt cement, spread out and compressed in the hot condition, and shall be prepared according to DNIT 032/2005-ES.

5.6.9 Hot Mix Bituminous Concrete Coating

It is comprised the hot mix, at a suitable asphalt plant, of graded mineral aggregate, filler and bituminous material, spread out and compressed in the hot condition, and shall be prepared in accordance with DNIT 031/2006-ES.

5.6.10 Asphalt Mud Coating

It is comprised the mix, in fluid consistency, of fine mineral aggregates, filler, asphalt emulsion and water, duly spread out and leveled. It shall be used exclusively for restoration of pavements undergoing segregation, in accordance with DNIT 150/2010-ES.

5.6.11 Cold Premixed Bituminous Concrete Coating

It is comprised of bituminous material and mineral aggregate in which the materials used are not pre-heated and shall be applied in accordance with DNIT 153/2010-ES.

5.7 Curbs, gutters and sidewalks shall be built according to the details indicated in the corresponding engineering design and comply with the following conditions:

a) excavations shall be performed after the roadway base has been built;
b) where fills are necessary to reach the installation elevation, it shall be duly compacted in layers not over 15 cm thick until it reaches a degree of compaction of 100 % in relation to the dry maximum apparent specific mass obtained in the ABNT NBR 7182 and the optimum moisture content of the test mentioned with a ± 2 % variation;
c) curbs may be made of pre-cast concrete or in-situ concrete, granite or another solid stone with the physical characteristics described in item 5.6.2 above;
d) gutters may be made of concrete cast in-situ, or with the same coating material used for the paving;
e) sidewalks may be in pre-cast concrete panels, concrete cast in-situ, or articulated cement blocks;

f) pre-cast parts shall be laid on a compacted ground and joints shall be sealed with mortar cement and sand in the proportion in volume of 1:4;
g) backfilling shall be performed with material from the excavation and compacted by a mechanical compactor in 15 cm thick layers.

6 Tolerances

6.1 The allowable tolerances for the work described in this Standard are described in 6.1.1 to 6.1.3.

6.1.1 For stone pavements:

a) alignment: ± 1.5 cm;
b) leveling: ± 1.0 cm.

6.1.2 For coverings of concrete pre-cast blocks:

a) alignment: ± 0.5 cm;
b) leveling: ± 0.5 cm.

6.1.3 For curbs, gutters and sidewalks.

a) dimensions: ± 5 cm;
b) leveling: 0.5 %;
c) alignment of each part: ± 1.0 %;
d) excavation: not more than 5 cm from the laying level.

6.2 For other services, the allowable tolerances of the DNER standards mentioned in specific items shall be adopted.

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2	Replacing the DNER-ES 312/97 by DNIT 032/2005-ES. Replacing the DNER-ES 313/97 by DNIT 031/2006-ES. Replacing the DNER-ES 324/97 by DNIT 049/2004-ES. Replacing the DNER-ES 326/97 by DNIT 048/2004-ES.
5.6.1	Replacing the DNER-ES 324/97, DNER-ES 325/97 e DNER-ES 326/97 by DNIT 049/2004-ES, DNIT 047/2004-ES and DNIT 048/2004-ES, respectivamente.
5.6.8	Replacing the DNER-ES 313/97 by DNIT 031/2006-ES.
5.6.9	Replacing the DNIT 031/2004-ES by DNIT 031/2006-ES.