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STRATEGIC DIRECTION SESSION ST1
Road quality service levels and innovations to meet user expectations

Introduction

An explanation is presented on the general context of the new Communications and Transportation Secretariat Standards for transportation infrastructure, reasons justifying development, extent, organization and design and updating process. Previous conditions of the Communications and Transportation Secretariat technical standards are also briefly described.

As may be noted, the new standards apart from incorporating novel concepts, are in no way compulsory as was previously the case. This is beneficial as, by not being compulsory, they enable the project to be designed with a free hand and in general lead to more creative freedom for the designer or constructor to do better work

In the second part of the report, one particular case using the new standards is presented, dealing with a recently constructed paved surface, leading to great benefits for users. Specifically it deals with the criteria of acceptance of a satisfactory surface, whether it be asphalt or hydraulic concrete.

Prior record

The standards used by the Communications and Transportation Secretariat date from 1932, when they were drawn up by the then *National Highway Directorate*, under the title *Highway Specification*s. Towards the late fifties, the then Communications and Public Works Secretariat drew up the *General Construction Specifications*, which to all intents and purposes are those which have been used until now. Although their presentation has been changed, the contents are substantially the same.

The circumstances under which the transportation infrastructure of the country developed was according to the said standards, which were both compulsory and limiting as there was insufficient national experience in this field. In one way this was a positive factor, leading to a unification of criteria and infrastructure quality but in the long term it has been counterproductive. The final result is that those standards made it difficult to introduce new technology and have stifled engineering creativity. This led to a deterioration in quality and cost-effectiveness as both the project designer and the constructor had to conform to the standards while knowing that the result would not be the one that was required.

Currently, request for infrastructure work are far more than those of the mid 1900's in addition to which, research and experience enable the use of a wider variety of materials and equipment. All this, added to the great experience acquired by Mexican engineers since the origin of the standards used hitherto, means that the said standards became unsuitable and in many cases even obsolete.

For the reasons stated, the SCT, became convinced of the need for a new set of standards and these were approved in 1998. The *SCT (Communications and Transportation Secretariat) Norms for Transportation Infrastructure*, commonly known as *SCT Norms*, introduced a number of far reaching changes.

Basic Principles

Probably the most important change of the *SCT Norms* it their non-compulsory nature since the main intention is to provide general outlines to **guide** the selection and application of criteria for the construction and conservation of the infrastructure, permitting the use of other criteria in specific cases when their viability is justified to the Secretariat. Apart from allowing both the project designer and the constructor more freedom, this also enables them to take more responsibility since the *SCT Norms* recognise that the final result are more important than the simple adherence to a set of rules or pre-established prescriptions which in may cases do not apply.

SCT Norms may become compulsory when:

- The project designer uses them for a specific project
- The Secretariat sets them as terms of reference for a study to be carried out.
- The Secretariat includes them as a basis for an invitation to bid.
- In its own judgement, the Secretariat considers the Norms as indispensable for uniform criteria, as in the case of road signs or certain aspects of a geometric highway project.

Another important change is their presentation, in collectable volumes as opposed to the previous norms, which were bound in “book” form making it difficult to update them without reprinting the whole document. Each chapter or volume of the *SCT Norms* can be updated or reprinted so that the standards described therein are always up to date.

Objectives

The main objectives of the *SCT Norms* are the following:

1. Uniformity of style and quality in public works and related services carried out by the SCT for transportation infrastructure, establishing criteria and procedures for planning, project design, bidding, awarding, personnel hiring, carrying out, supervision, operation and reduction of the environmental impact.

2. The establishment of criteria and procedures for the concession of transportation infrastructure.

3. To set standards for the Secretariat's relation with individuals and companies engaged for carrying out public works or related services, or those granted a concession for transportation infrastructure.

4. To advise on the most convenient selection and application of the criteria, methods, procedures for carrying out the studies and projects for the execution, supervision, assurance of quality, operation and reduction of environmental impact during the construction, conservation, reconstruction and/or modernisation of the infrastructure.

Types of publication

The *SCT Norm is organized as follows*::

1. Norms ("what")
   They propose specific values for the design, characteristics and quality of the material and equipment used as web as the tolerance of finishes, general methods of execution, measuring, and a basis for payment for different items of work and in general, all those aspects which might become specifications when included in the project or its terms of reference.

2. Manuals ("how")
   They contain a compendium of procedure for carrying out activities related to transportation infrastructure, design assistance and methods of sampling and testing for quality control.

3. Recommended practices ("why")
   They propose and explain the establishment of criteria and the applicability of theories in specific cases, in such a way that the user has indications for the selection of methods and procedures from among those in the manuals.

Organization and subject matter

The *SCT Norm* is organized as twelve Books which are:

INT.	Introduction	CSV.	Conservation
LEG.	Legislation	OPR.	Operation
PLN.	Planning	CAL.	Quality Control and Assurance
DRV.	Right of Way and Adjoining Areas	CMT.	Characteristics of Materials used
PRY.	Project	EIP.	Characteristics of Equipment and Permanent Installation Systems
CTR.	Construction	MMP.	Methods of Sampling and Testing Materials

The Books on PLN. Planning; DRV. Right of Way and Adjoining Areas; PRY. Project; CTR. Construction; CSV. Conservationand OPR. Operation, are divided into the following five Subject Headings:

CAR.	Highways	PUE.	Ports
AER.	Airports	EDV.	Miscellaneous Constructions
FER.	Railroads		

These subjects or Books, which are not divided according to subject matter, are usually in Parts under different headings and these in turn, when necessary, are separated into Chapters. A Chapter is the smallest independent subdivision and these are presented, published and issued individually as collectable sections to be kept in a special binder. This enables them to be up to date, facilitating their ongoing revision and updating or, if necessary, their replacement. Similarly updated or replaced are Sections which are not divided into Chapters or Parts which are not divided in Section Headings.

Responsibilities

The drafting of specifications for a project determine the responsibility of the engineer and authorities who approve them. Norms used for specifications and validated by their signatures, must then be considered as compulsory.

If work is carried out under a contract, the contractor must complete the project according to its specifications, At the same time, he is solely responsible for all that is needed for completion of the work and, as applicable, for the establishment of the most efficient and safest building procedures to reach the objective as well as its quality control.

Drafting Process

The stages for the drafting process for the *SCT Norms* can be summed up as follows:

N°	Stage	Official Responsibility
1	Preliminary Pre-Project	Outside specialist
2	Final Pre-Project	IMT (Mexican Transportation Institute)
3	Preliminary Project	IMT / General Directorate of Technical Services (SCT)
4	Final Project	IMT / General Directorates of Technical Services (SCT)
5	Norm Approved	Comisión for Norms, Specifications and Unit Prices)
6	Norm Published	IMT

As a first step in coordinating the *Communications and Transportation Secretariat Norms,* IMT (the Mexican Transportation Institute), which is the organization detailed by the SCT for its integration, identifies the need for a specific norm and engages an outside specialist to draw up the Preliminary Pre-Project. Sometimes the norm is drafted directly by the IMT, through SCT Norm Coordination.

By means of reviewing and adapting the *Preliminary Pre-projects*, so that they conform to current legislation and are included in the *SCT* Norms under the correct reference, the IMT drafts the *Final Pre-projects*. If a *Preliminary Pre-project* is unnecessary, the IMT draws up the final one directly, in collaboration with SCT. The final pre-project is sent when completed to the DGST, (General Directorate of Technical Services) for a review of its technical content.

Based on the DGST observations and suggestions, the IMT then drafts the *Preliminary Project,* which is sent to all SCT General Directorates and dependencies concerned with transportation infrastructure, in order to receive their observations and suggestions as well as to have different points of view. Taking these into account, the IMT then drafts the *Final Project,* which is submitted for consideration to the Specifications, Norms and Unit Prices (CNEPU), the dependency assigned by the SCT for the acceptance or rejection of norms.

Once approved by the CNEPU, the IMT produces the final edition of the appropriate Recommended Norms, Manuals y Practices and sends it to be printed. The printed copies are delivered to the DGST for distribution.

Final Comment

In order to have a permanent up to date set of Norms, all those involved, from SCT to the end users, can contribute their experience to the *Norms.* They may make their comments, suggestions or proposals known in writing to the CNEPU of the SCT, through the DGST or the *Communications and Transportation Secretariat Norms Department* of the IMT to email: normas@imt.mx, where they will be studied, evaluated and if suitable, considered for inclusion in the latest ammendment.

A SPECIAL CASE FOR APPLICATION OF NEW NORMS

SUMMARY

Conditions for the acceptance of criteria concerning driving surface layers and the bonus or penalty incurred by the constructor for the characteristics of the surface of these layers.

Previous Record

Recently the Communications and Transportation Secretariat of Mexico (SCT), as part of is Norm updating program, through the Mexican Transportation Institute (IMT), issued new norms for both asphalt and hydraulic concrete paving, for the purpose of improving the quality of paving throughout the country.

These norms include, as one of the criteria for acceptance or rejection, the requirements for regulating paved surfaces. The maximum limits were established by California Profiles to avoid the results of poor quality surfaces which include increased maintenance costs for vehicles, reduced speed of operation, discomfort to drivers, increased accident rates and a reduction in the useful life of the paved surface. Furthermore, these norms take into account that the constructor might be rewarded or penalised according to the quality of the surface. Ranges of reward or penalty have been established according to the profile index obtained.

Introduction

The final layers of the surface are applied so as to provide users with a safe and comfortable surface for transit as well as for their structural function. The driver's comfort and safety are closely linked to the road surface. When this is even, there will be less vibration which might damage the vehicle and place strain on the surface, leading to increased vehicle and highway operation costs as well as a deterioration in user comfort and increased accident rate. It is therefore necessary that a quality standard be established for road surfaces, permitting tolerable irregularities, and which minimises the negative effects mentioned. Thus, in Mexico the concept of Profile Index has been adopted, determined by profiles obtained using the California Profile Graph.

The profile index is the sum of the magnitude of irregularities above and below the theoretical profile line, in excess of 2,5 mm, in 1 km length and is expressed as cm/km.

It has been observed that paving with an index of over 24 cm/km causes inconvenient vibrations. This means that recently constructed surfaces on new highways whose profile index is above that limit must be rejected unless the builder carries out the necessary corrections, at his own expense.

It has also been noted that surface layers with an index of between 10 and 14 cm/km, enable both vehicles and the road surface to operate properly. These figures are not difficult to obtain if the correct construction equipment if used by trained personnel and the correct procedures are followed.
In order to encourage the construction of suitable surface layers, criteria need to be established for suitable surfaces to earn reward for the builder and penalties for those outside the acceptable range, leading to rejection of the concept. All these aspects are taken into account for the surface norms set out in the new SCT *Transportation Infrastructure Norms*(SCT Norms):

a) N·CTR·CAR·1·04·006/01, *Hot Mix Asphalt*
b) N·CTR·CAR·1·04·007/01, *Cold Mix Asphalt*
c) N·CTR·CAR·1·04·009/01, *Hydraulic Concrete*

Communications and Transportation Secretariat Norms

To achieve a suitable surface, *SCT Norms* take the following into account:

a) Prior to beginning work on the driving surface, the constructor will prepare a trial length of 400 m, in order to evaluate the procedure and equipment used, taking into consideration that:

- The trial section will be built according to the established norm.

- Once the trial length of driving surface has been completed, it will be tested to ensure that it metes the standards set in the corresponding norm, leading to its acceptance or rejection. In the latter case, the constructor must repeat the tests on trial lengths until the necessary standards are met.

- If the trial length meets with conditions set, it will be taken as satisfactory work; otherwise the Communications and Transportation Secretariat will not pay for it and will decide if the constructor should remove it at his own expense.

- For surface irregularities on the trial length to be acceptable, they must not exceed a maximum of 14 cm/km unless the project indicates a different figure.

b) For the driving surface to be considered as finished and acceptable to the Transportation Secretariat it must be proven that surface irregularities do not exceed a maximum of 14 cm/km unless the project indicates a different figure. The constructor will carry out this test within 48 hours of the completion of the driving surface, according to norm ASTM E 1274, with some modifications indicated in the Norms. The Communications and Transportation Secretariat will evaluate the results obtained, daily.

c) Each section of highway will be tested for driving surface profile, be it asphalt or concrete and will be divided into 200 meter sections, or sub-sections whereby the constructor can be rewarded or penalised according to the results obtained.

d) If the driving surface profile of a 200 meter sub-section is less than 10,1 cm/km, the constructor will earn a bonus for quality improvement, based on the unit price of the driving surface.

e) Each working day the average surface index profile will be calculated according to the figures obtained that day. If the daily average is over 24 cm/km, work will immediately be stopped until the defects can be corrected and before continuing the constructor must run tests on other trial lengths, as if work were just beginning.

f) After obtaining the surface profile index for each 200 meter sub-section, all those in which the figure shows a prominence of 1 cm or more in 7.5 meters or less, will have the driving surface corrected.

g) Once all the individual prominences have been corrected, any 200 meter sub-section that shows a surface profile of more than 24 cm/km on any of its construction lines will be corrected. In each case, when the correction has been completed, new profile indices will be measured to determine that everything is as it should be. Corrections will be carried out by means of one of the procedures outlined below or others approved by the SCT.:

- Continuous drilling of the driving surface on stretches of no less than 50 meters, over the width of two.lane highways or on all the lanes in one direction on a multi-lane highway, in order to reduce the profile index to 24 cm/km or less. If the driving surface is asphalt, over the drilled surface there will be a special layer applied, as approved by the SCT; this layer will be a minimum of 2 cm thick unless the project stipulates an open or semi-open granulometric layer.

- Over the driving surface an extra layer will be applied with 3 cm minimum thickness on lengths of not less than 50 m over the width of two-lane highways or on all the lanes in one direction on a multi-lane highway. This layer will consist of the same material used for the original driving surface, in accordance with the conditions set out in the corresponding norm and with a profile index of not more than 24 cm/km, maximum.

- Removal of the concrete driving surface and its replacement by a new one which metes the specifications indicated in the corresponding norm and has a profile index of not more than 24 cm/km, maximum.

h) When the profile index of any 200 m sub-section is between 14,1 and 24 cm/km, the constructor can choose whether to correct the finished surface as indicated in the preceding paragraphs or to accept the penalty for poor quality work, calculated on the unit price of the surface layer.

i) Todos los trabajos de corrección referidos serán por cuenta y costo del constructor y, previamente a su ejecución, los procedimientos de corrección serán sometidos a la aprobación de la SCT. No se permitirá efectuar trabajos de corrección con equipo de impacto que pueda dañar la estructura del pavimento, ni con resanes superficiales adheridos.

j) All driving surface correction work must be carried out before line, gradient and thickness studies are made, unless the correction is carried out according to an SCT officially approved procedure, in which case the thickness study will be made before the correction.

Measuring the driving surface layer for payment purposes

The layer will be measured taking each completed square meter as a unit. The amount to be paid will be per Km or fraction thereof, using the following formula:

$$V = L \times \bar{e} \times \bar{a}$$

Where:

V = Volume of the driving layer on each 1 km stretch or section, (m^3)
L = Length of the section, (m)
$\bar{e}$ = Average thickness of the section, (m)
$\bar{a}$ = Average width of the driving layer on the section, (m)

Calulation of bonus or penalty

When a bonus is applicable for improved quality or a penalty for failure to meet standards, according to profile indices of driving surfaces, these will be made according to the following calculation using one of the following formulae:

a) For asphalt driving surfaces

$$E = V \times PU \times \overline{F}$$

Where:

E = Bonus when result is positive or deduction when negative for each stretch of 1 km or section, ($)

V = Volume of asphalt driving surface on each 1 km stretch or section, (m^3)

PU = Unit price of the surface layer, ($/m^3$)

$\overline{F}$ = Average bonus or penalty according to profile index corresponding to arithmetical average of factors outlined in Table 1, for each 200 m sub-section on each adimensional construction line.

Tabla 1.- Factors for bonus or penalty according to profile index

Profile index * cm / km	**Bonus or penalty factors (*F* ó *FIP*)**	
4,0 or less	Bonus	+ 0,05
4,1 to 5,5		+ 0,04
5,6 to 7,0		+ 0,03
7,1 to 8,5		+ 0,02
8,6 to10,0		+ 0,01
10,1 to 14,0	0	
14,1 to 16,0	Penalty	- 0,02
16,1 to 18,0		- 0,04
18,1 to 20,0		- 0,06
20,1 to 22,0		- 0,08
22,1 to 24,0		- 0,10
Greater than 24,0	To be corrected	

* For each 200 m stretch or section of each construction line

b) For concrete driving layers

$$E = V \times PU \times \left(\overline{FIP} - FRT\right)$$

Where:

E = Bonus when result is positive or deduction when negative for each stretch of 1 km or section, ($)

V = Volume of concrete driving surface on each 1 km stretch or section, (m^3)

PU = Unit price of the surface layer, ($/m^3$)

$\overline{FIP}$ = Average bonus or penalty according to profile index corresponding to arithmetical average of factors outlined in Table 1, for each 200 m sub-section on each adimensional construction line.

FRT = Penalty factor due to insufficient concrete resístance on the stretch of road, determined as indicated in Norm N·CTR·CAR·1·04·009/01, *Hydraulic Concrete Layers*, (adimensional)

Conclusions

Although in Mexico the criteria describe herein are of recent application, experience in other countries has shown that norms or specifications designed for road works improve product quality for the user, especially when they subjected to a bonus or penalty scheme for the builder.

There can be no doubt that comfort and safety are the aspects which are of greatest concern for the road user, so they must be attended with great care, without neglecting other aspects such as durability and cost which in certain ways are also connected with comfort and safety.

The profile index measurements on recently constructed SCT road and highway paving where the machinery, operators and procedures are as they should be, together with a good quality control system, show that it is possible to obtain quality driving surfaces without increased cost.

The new Norms for Transportation Infrastructure in Mexico are included among the objectives of Strategic Subjects 1 as one of the principal aims is to contribute to roads with better characteristics of direct benefit for users.