A Quantitative Assessment of the Use of a Reduced-Thickness Chemcrete Asphalt Pavement Design in the Construction of the Acceso Oeste a la Capital Federal Tramo Avda. General Paz - Arroyo Moron

Summary

The purpose of this proposal is to present a quantitative assessment of the use of the Chemcrete Modifier in the Acceso Oeste a la Capital Federal Tramo Avda. General Paz - Arroyo Moron. To do this, we have examined the geometric pavement design proposed for this new construction via three internationally-accepted pavement design rationales to assess the impact which the use of Chemcrete will make on the proposed construction.

A critical strain pavement design analysis conducted with the assistance of the BISAR-PC computer program indicates that the use of Chemcrete will reduce the maximum strains which develop in the proposed pavement due to the application of a standard wheel-load. This confirms that, from the perspective of engineering first principals, the use of Chemcrete will result in both reduced pavement rutting and reduced pavement cracking relative to conventional constructions.

Similarly, by applying the structural properties of conventional and Chemcrete materials to the procedure described in the Shell Pavement Design Manual we have determined that with Chemcrete it is possible to reduce the thickness of the asphalt base layers by approximately 15-25% without in any way reducing the pavement design life which would be obtained through the use of conventional asphalt materials. In fact, in the more-critical case of the carriles exteriores, the reduced thickness Chemcrete design will attain a design life which is twice that of the conventional asphalt design currently under consideration.

Finally, application of the rationale described in the 1986 AASHTO Pavement Design Guide permits the precise quantification of the Design Structural Number and Expected Pavement Lifetime of both the proposed conventional and Chemcrete pavement designs. This analysis confirms that the additional pavement strength generated by the use of the Chemcrete Modifier translates to an increase in expected pavement design life (as measured by equivalent standard axle loads carried prior to failure) of approximately 3-5 times.

Introduction

In order to provide an engineering and economic justification for the use of the Chemcrete Modifier in the construction of the Acceso Oeste a la Capital Federal Tramo Avda. General Paz - Arroyo Moron, we will examine the project specific design parameters within the context of internationally accepted, independent analytical tools. First, we will conduct a critical strain pavement design analysis using the BISAR - PC computer software program as licensed from the Shell International Petroleum Company. This will allow us to assess how the use of Chemcrete will affect the critical pavement strains which are experienced by the proposed pavement due to the application of a standard wheel-load. Next, we will examine the geometric pavement design proposed both with & without Chemcrete by means of the rationale described in the Shell Pavement Design Manual. With this technique we will establish the design life of both asphalt pavement designs presently proposed. Finally, we will verify the suitability of each pavement design (conventional and Chemcrete) using the procedure described in the 1986 AASHTO Manual on the Design of Pavement Structures. This will allow us to calculate the Design Structural Number & Expected Pavement Lifetimes of each of our candidate designs.

BISAR Critical Strain Pavement Design

The BISAR computer analysis technique was developed by the Shell International Petroleum Company, Ltd. to calculate the stresses and strains which are induced by the application of a standard wheel-load at every point throughout the pavement structure and to locate the point at which they reach their maxima. The thickness design charts of the famous Shell Pavement Design Manual were developed by repeating these calculations thousands of times on a mainframe computer for different construction materials and prevailing pavement conditions. The Shell BISAR-PC software assumes the same multi-layer linear elastic pavement system as the Shell Pavement Design Method (see below).

An essential step in the design of any pavement structure is the determination and evaluation of the critical stresses and strains induced in the road by traffic loading. From the point of view of structural design, the two criteria which determine the pavement thickness required to carry the anticipated traffic volume are the following:

1. **The compressive strain at the surface of the subgrade**. If this is excessive, permanent deformation will occur at the top of the subgrade, and this will cause deformation at the pavement surface.

2. **The horizontal tensile strain at the bottom of the asphalt layer**. If this is excessive, cracking will occur in the asphalt layer.

Three engineering inputs drive the BISAR software. These are the Resilient Modulus, Poisson's ratio and thickness of each of the layers. In our analysis we have assumed the Resilient Modulus values as determined by the Instituto de Mecanica Aplicada y Estructuras (Report dated June 1995, Figure 18, Resilient Modulus Mastercurve, 28° C). We have also assumed a Poisson's ratio for all asphaltic concrete layers of 0.35. This value of 0.35 is internationally recognised as a good first-order approximation for all bituminous layers. Furthermore, since other studies have shown that Chemcrete materials have the same Poisson's ratio as conventional materials, our assumptions concerning the Poisson's ratio are quite valid. Finally, since the thickness of each conventional pavement layer is known from the recommendations set forth by the project design consultant, we can apply this information directly in the analysis. We have assumed that the Chemcrete Modifier has been added to the inferior and superior asphaltic concrete base layers of the proposed pavement and that the thicknesses of those layers have been reduced by approximately 25% and 15%, respectively. The actual structure of each of our candidate designs is completely described in Table 1, below:

TABLE 1: CANDIDATE PAVEMENT DESIGN LAYER THICKNESS, CM

	CONVENTIONAL		CHEMCRETE	
LAYER	INT	EXT	INT	EXT
Carpeta de Concreto Asfaltico (CA)	8	8	8	8
Base Superior de C A	7	9	6	7.5
Base Inferior de CA	7	9	6	7.5
Subbase de Suelo Seleccionado	22	20	22	20
Recubrimiento con Suelo Selec.	42	40	44	43
TOTAL	86	86	86	86

The critical pavement strains calculated by the BISAR software for the subject pavements under consideration are presented in Table 2 below:

TABLE 2: CRITICAL PAVEMENT DESIGN STRAINS (MICROMETERS PER METER)

	COMPRESSIVE STRAIN AT THE SURFACE OF THE SUBGRADE		HORIZ. TENSILE STRAIN AT THE BOTTOM OF THE ASPHALT LAYER	
	INT	EXT	INT	EXT
CONVENTIONAL	254	235	252	205
CHEMCRETE	223	196	120	97

From Table 2 we note that both the compressive strain at the surface of the subgrade and the horizontal tensile strain at the bottom of the asphalt layer are lower for the reduced thickness Chemcrete design than the corresponding values for the conventional asphalt design. This proves that the reduced thickness Chemcrete design has both a lower potential for rutting and a lower cracking potential than the full-depth conventional asphalt design. We can not state unequivocally on the basis of these results that the Chemcrete design will neither rut nor crack. However, we can state unequivocally that the Chemcrete design will show less rutting and less cracking than the unmodified section which, a priori, must have been judged to be acceptable in terms of both rutting and cracking before it was specified for use in the Acceso Oeste a la Capital Federal Tramo Avda. General Paz - Arroyo Moron project. The full details of the Shell BISAR Critical Strain Pavement Design Analysis can be found in Appendix 1.

Shell Pavement Design Analysis

The pavement structure assumed by the Shell Pavement Design Manual is a multi-layer linear elastic system in which the materials are characterised by the resilient modulus and Poisson's ratio. The materials are assumed to be homogeneous and isotropic and the layers are assumed to be of uniform thickness and to extend for an infinite distance in the horizontal direction. The whole structure is assumed to rest on a semi-infinite subgrade. Traffic is expressed in terms of standard loads, acting vertically and/or horizontally on the pavement surface, which are assumed to be uniformly distributed over one or more circular areas. In the basic design procedure the engineer inputs information concerning the anticipated traffic volume, service temperature and materials properties of the bound and unbound layers in order to ultimately determine, by way of a number of charts and nomographs, the pavement thickness required for the road in question.

However, for our present purposes the design problem is a little bit different. In the case of the Acceso Oeste a la Capital Federal Tramo Avda. General Paz - Arroyo Moron project, the required pavement thicknesses have already been determined by the project design consultants. Therefore, our task in the present analysis is to run the Shell Method in reverse so as to quantify the design lives of the established design and the reduced thickness Chemcrete design. (N.B. - In the present context, the term "design life" is defined as the cumulative number of standard axle loads which a pavement can carry throughout the whole of its service life.) The curves depicted in the Shell thickness design charts have been drawn so as to satisfy both of the critical strain criteria discussed in the previous section. Therefore, the engineer can be assured that the pavement thickness determined by this method will be sufficient to prevent any significant rutting or cracking in the constructed pavement.

To run the Shell Pavement Design Method in reverse, as we must for our purpose, one inputs information concerning the service temperature of the pavement, the modulus of the subgrade and the stiffness and fatigue characteristics of the asphaltic concrete layers in order to determine the design life of the pavement structure. First, to account for the effects on design of daily and monthly variations in the pavement temperature, the in-service pavement temperature is expressed as a "weighted mean annual air temperature" (MAAT). The MAAT is derived by applying a weighting factor to the monthly mean air temperature obtained from meteorological publications. The MAAT for this project has been determined to be 27° C. Next a minimum subgrade CBR value of 5% has been specified for this project. This translates into a minimum subgrade modulus of 50 MPa. Finally, we have used the information provided in the IMAE report (cited above) to express the properties of the asphaltic concrete materials.

On the basis of the above information and the procedures outlined in the Shell Manual, the pavement design life that will be achieved by each material can now be derived from the Shell Pavement Design Charts by referencing stiffness code S1 at the appropriate value of the adjusted MAAT (28° C for the conventional pavement and 12° C for the Chemcrete) and the appropriate asphalt thickness. The results obtained are presented in Table 3 below:

TABLE 3: COMPARATIVE DESIGN LIVES, ESA x 10^6

	DESIGN LIFE	
	INT	EXT
CONVENTIONAL	30	45
CHEMCRETE	30	100

Table 3 indicates that with the reduced thicknesses proposed in the Chemcrete design, the design life of the carriles interiores will be equivalent to that of the conventional design, while the design life of the carriles exteriores will be increased by a factor of two. This result proves that, due to the additional load-bearing capacity generated through the use of the Chemcrete, the pavement thickness specified for the Acceso Oeste a la Capital Federal Tramo Avda. General Paz - Arroyo Moron project can be safely reduced by approximately 15-25% without in any way reducing the design life achievable through the use of conventional asphalt materials at the originally-specified pavement thickness. In fact, the proposed Chemcrete design would achieve a significantly longer pavement design life in the carriles exteriores. In this way, the use of Chemcrete can be seen as insuring against the premature failure of that part of the road structure which will bear the most severe loadings. The full details of the Shell Pavement Design Analysis can be found in Appendix 2.

AASHTO Pavement Design Analysis

The structural design of asphalt pavements employed by the project design consultant is based upon the data collected in the AASHO (American Association of State Highway Officials) Road Test as embodied in the 1972 AASHTO Interim Guide for Design of Pavement Structures. As such it combines information on the subgrade soil CBR value and the equivalent standard axle load over a 10 year period to determine an equivalent thickness required to carry the anticipated traffic loadings. This total equivalent thickness is then partitioned into thicknesses for each constituent layer through the use of structural layer coefficients. While this is a perfectly acceptable method for designing conventional asphalt pavements, it can not be applied when the use of asphalt modifiers is being considered because it does not provide a mechanism for determining the structural layer coefficient of modified asphalt materials.

Fortunately, this problem can be overcome through the use of the updated AASHTO Guide published in 1986. The 1986 Guide follows precisely the same design approach as the 1972 Guide except that layer coefficients are assigned on the basis of the Resilient Modulus of each construction material. The 1986 Guide also embraces the effect of subsurface drainage on pavement performance and determines a reliability factor which quantifies the probability that the candidate design will actually survive for the full design period. The 1986 Guide combines the estimated equivalent standard axle loads with the soil resilient modulus and a design serviceability loss (which is very similar to the old terminal serviceability index) to determine the Design Structural Number. Structural layer and drainage coefficients are then applied to translate the Design Structural Number into individual pavement layer thicknesses.

Since we already know both the layer thicknesses of each of our candidate pavement designs, as well as the structural properties of the materials used to construct each layer, we can determine the structural layer coefficient of each candidate pavement layer from Figures 2.5, 2.6 and 2.7 of the 1986 Guide. By combining these with the applicable drainage coefficients selected from Table 2.4 of the 1986 Guide, we can determine the Design Structural Number (SN) of each pavement section. These values are presented in Table 4 below:

TABLE 4: DESIGN STRUCTURAL NUMBER (SN)

	SN	
	INT	EXT
CONVENTIONAL	4.6	4.91
CHEMCRETE	5.5	5.99

Table 4 shows that, for both the carriles interiores and the carriles exteriores, the pavement design which includes Chemcrete has a higher Design Structural Number than the conventional asphaltic concrete design. Further, we note from Table 4 that the Design Structural Numbers calculated via the 1986 AASHTO method employed in this analysis show good agreement with those determined by the project design consultant for the conventional pavement design. However, the additional structural strength imparted by the Chemcrete leads to an increase in the Design Structural Number of the Chemcrete design of approximately one unit. This analysis verifies that the improved structural integrity gained through the addition of Chemcrete does translate into increased structural capacity for the pavement.

Once the pavement Design Structural Numbers have been determined, we may use the Design Chart for Flexible Pavements (Figure 3.1 of the 1986 Guide) to translate these Design Structural Numbers into estimated standard (i.e. - 18 kip equivalent) single axle loads which can be borne by each pavement section. By so doing, we can actually quantify the performance capabilities of the pavement sections constructed with both the conventional and Chemcrete asphalt materials. The estimated pavement design lives thus determined are presented in Table 5 below:

TABLE 5: ESTIMATED PAVEMENT DESIGN LIVES

	DESIGN LIFE (ESA x 10^6)	
	INT	EXT
CONVENTIONAL	7.5	10
CHEMCRETE	25	50

Table 5 indicates that the additional pavement strength generated by the use of the Chemcrete Modifier translates to an increase in expected pavement design life (as measured by equivalent standard axle loads carried prior to failure) of approximately 3-5 times.

Accordingly, this AASHTO Pavement Design Analysis verifies the results obtained via the Shell Pavement Design Method and the BISAR Critical Strain Pavement Design Analysis in that it confirms that the pavement performance which will be achieved through the use of proposed Chemcrete design will be at least equivalent, and probably superior, to that which can be expected from the conventional pavement design. The full details of the AASHTO Analysis can be found in Appendix 3.

Conclusions and Recommendations

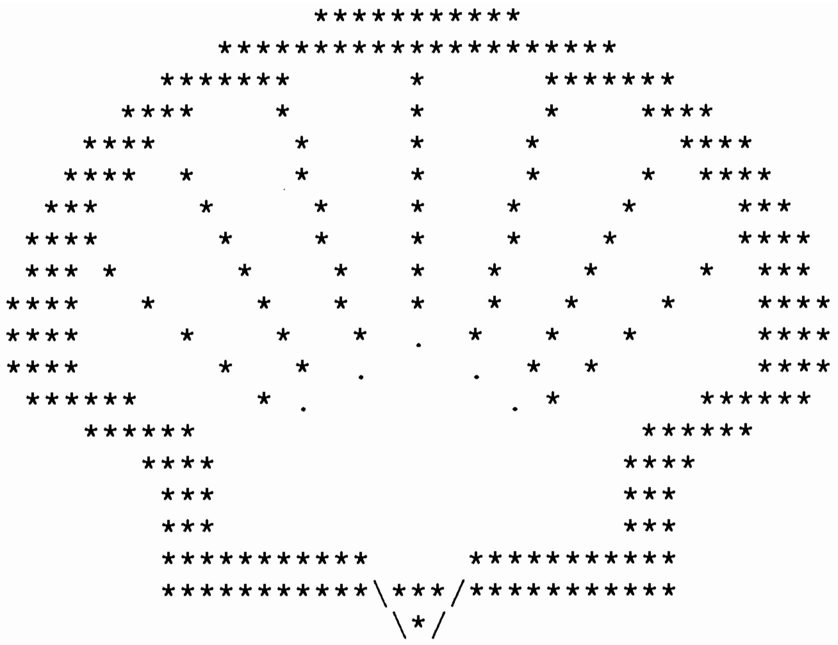
With the aid of internationally-accepted pavement design techniques, we can translate the material properties measured by IMAE for both conventional and Chemcrete asphaltic concrete into the quantifiable engineering benefits which can be derived from pavement sections constructed with each candidate material. By so doing we can verify that, despite the reduction in thickness of the asphaltic concrete base layers, the additional pavement strength generated through the use of the Chemcrete Modifier will reduce the maximum strains which will develop in the subject pavement due to the application of a standard wheel-load. This indicates that the Chemcrete design will demonstrate superior performance, relative to the conventional asphalt pavement design, in terms of both pavement deformation and pavement cracking. Additionally, we can determine that this improved pavement strength and reduced flexure will, in turn, increase the number of standard single axle loads which can be carried by the Chemcrete modified pavement over its useful lifetime. This increase in pavement design life is particularly important in the carriles exteriores which will carry significantly more and heavier loads than the carriles interiores.

Taken together, these results allow us to conclude that the in-service performance of the reduced-thickness Chemcrete asphalt pavement design proposed herein will be at least equivalent, and probably superior, to that which can be expected from the conventional pavement design.

APPENDIX 1:

BISAR-PC CRITICAL STRAIN

PAVEMENT DESIGN ANALYSIS



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                           PPPPPPPPP        CCCCCCC
                           P       PP      C       C
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                           P       PP     C
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                           P              C
                           P               C       C
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 *  *     *     *   *   *   *   *  *           *       *   *
****    *****    ***    *   *   *   *          *        ***
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Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN
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Stop  time: 16:12:14.88

A.  DESCRIPTION OF THE SYSTEMS               (Systems: 1 to  4   OF  4 Systems)
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----#-------------------------------------------------------------------------
    #
  2 # CARRILES EXTERIORES:  CHEMCRETE DESIGN
    #
----#-------------------------------------------------------------------------
    #
  3 # CARRILES INTERIORES:  CONVENTIONAL DESIGN
    #
----#-------------------------------------------------------------------------
    #
  4 # CARRILES INTERIORES:  CHEMCRETE DESIGN
    #
----#-------------------------------------------------------------------------
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B.  CHARACTERISATION OF THE CONSTRUCTIONS   (Systems: 1 to  4   OF  4 Systems)
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Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN

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----#-----------------#-----------------#-----------------#-----------------
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----#-----------------#-----------------#-----------------#-----------------
  3 #E-mod: 1225.0 MPa#E-mod: 1225.0 MPa#E-mod:  115.0 MPa#E-mod:   50.0 MPa
    #Thick:   .080 m  #Thick:   .140 m  #Thick:   .640 m  #Thick: infinite
    #PR   :    .35 -  #PR   :    .35 -  #PR   :    .35 -  #PR   :    .35 -
----#-----------------#-----------------#-----------------#-----------------
  4 #E-mod: 1225.0 MPa#E-mod: 6850.0 MPa#E-mod:  115.0 MPa#E-mod:   50.0 MPa
    #Thick:   .080 m  #Thick:   .120 m  #Thick:   .660 m  #Thick: infinite
    #PR   :    .35 -  #PR   :    .35 -  #PR   :    .35 -  #PR   :    .35 -
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C.  CHARACTERISATION OF THE LOADS           (Systems: 1 to  4   OF  4 Systems)
==============================================================================
Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN

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    #X-coor:    .000 m#X-coor:    .000 m#                 #
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D.  POSITIONS AND RESULTS    (Pos.: 1- 5)     (Systems: 1 to  3   OF  4 Systems)
==============================================================================
Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN

   SIGN convention STRESSES and STRAINS: + = TENSILE     stress or strain;
                                         - = COMPRESSIVE stress or strain.

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    # Vert.:  +18.4# Vert.: -253.4# Vert.: -567.1# Vert.: -596.3# Vert.: -253.
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D.  POSITIONS AND RESULTS   (Pos.: 6-10)    (Systems: 1 to  3   OF  4 Systems)
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Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN

   SIGN convention STRESSES and STRAINS: + = TENSILE     stress or strain;
                                         - = COMPRESSIVE stress or strain.

SYS.#< POSITION 6 >#< POSITION 7 >#< POSITION 8 >#< POSITION 9 >#< POSITION 10
----#--------------#--------------#--------------#--------------#-------------
  1 #COORDINATES(m)#              #              #              #
    # X-crd:  .0000#              #              #              #
    # Y-crd: +.1575#              #              #              #
    # Depth:  .8600#              #              #              #
    # Layer:layer 4#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRESSES (MPa)#              #              #              #
    # Hor.X:+.00085#              #              #              #
    # Vert.: -.0108#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRAINS (um/m)#              #              #              #
    # Hor.X:  +88.8#              #              #              #
    # Vert.: -225.2#              #              #              #
----#--------------#--------------#--------------#--------------#-------------
  2 #COORDINATES(m)#              #              #              #
    # X-crd:  .0000#              #              #              #
    # Y-crd: +.1575#              #              #              #
    # Depth:  .8600#              #              #              #
    # Layer:layer 4#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRESSES (MPa)#              #              #              #
    # Hor.X:+.00045#              #              #              #
    # Vert.: -.0092#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRAINS (um/m)#              #              #              #
    # Hor.X:  +72.1#              #              #              #
    # Vert.: -189.7#              #              #              #
----#--------------#--------------#--------------#--------------#-------------
  3 #COORDINATES(m)#              #              #              #
    # X-crd:  .0000#              #              #              #
    # Y-crd: +.1575#              #              #              #
    # Depth:  .8600#              #              #              #
    # Layer:layer 4#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRESSES (MPa)#              #              #              #
    # Hor.X:+.00097#              #              #              #
    # Vert.: -.0116#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRAINS (um/m)#              #              #              #
    # Hor.X:  +96.4#              #              #              #
    # Vert.: -242.6#              #              #              #
----#--------------#--------------#--------------#--------------#-------------
```

```
D.  POSITIONS AND RESULTS    (Pos.: 1- 5)     (Systems: 4 to  4   OF  4 Systems)
================================================================================
Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN

   SIGN convention STRESSES and STRAINS: + = TENSILE     stress or strain;
                                         - = COMPRESSIVE stress or strain.

SYS.#< POSITION 1 >#< POSITION 2 >#< POSITION 3 >#< POSITION 4 >#< POSITION  5
----#--------------#--------------#--------------#--------------#-------------
  4 #COORDINATES(m)#COORDINATES(m)#COORDINATES(m)#COORDINATES(m)#COORDINATES(m
    # X-crd:  .0000# X-crd:  .0000# X-crd:  .0000# X-crd:  .0000# X-crd:  .000
    # Y-crd:  .0000# Y-crd: +.1575# Y-crd:  .0000# Y-crd: +.1575# Y-crd:  .000
    # Depth:  .0800# Depth:  .0800# Depth:  .2000# Depth:  .2000# Depth:  .860
    # Layer:layer 1# Layer:layer 1# Layer:layer 3# Layer:layer 3# Layer:layer
    #              #              #              #              #
    #maximum       #maximum       #maximum       #maximum       #maximum
    #STRESSES (MPa)#STRESSES (MPa)#STRESSES (MPa)#STRESSES (MPa)#STRESSES (MPa
    # Hor.Y: -.1618# Hor.Y: -.3598# Hor.Y: -.0133# Hor.Y: -.0106# Hor.X:+.0006
    # Vert.: -.0662# Vert.: -.4834# Vert.: -.0492# Vert.: -.0486# Vert.: -.010
    #              #              #              #              #
    #maximum       #maximum       #maximum       #maximum       #maximum
    #STRAINS (um/m)#STRAINS (um/m)#STRAINS (um/m)#STRAINS (um/m)#STRAINS (um/m
    # Hor.Y:  -67.8# Hor.Y:  -58.2# Hor.X: +120.1# Hor.X: +115.5# Hor.X:  +84.
    # Vert.:  +37.6# Vert.: -194.5# Vert.: -363.0# Vert.: -367.8# Vert.: -223.
----#--------------#--------------#--------------#--------------#-------------
```

```
D.  POSITIONS AND RESULTS    (Pos.: 6-10)     (Systems: 4 to  4   OF  4 Systems)
===============================================================================
Title: ACCESO OESTE A LA CAPITAL FEDERAL:  CRITICAL STRAIN PAVEMENT DESIGN

   SIGN convention STRESSES and STRAINS: + = TENSILE     stress or strain;
                                         - = COMPRESSIVE stress or strain.

SYS.#< POSITION 6 >#< POSITION 7 >#< POSITION 8 >#< POSITION 9 >#< POSITION 10
----#--------------#--------------#--------------#--------------#-------------
  4 #COORDINATES(m)#              #              #              #
    # X-crd:  .0000#              #              #              #
    # Y-crd: +.1575#              #              #              #
    # Depth:  .8600#              #              #              #
    # Layer:layer 4#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRESSES (MPa)#              #              #              #
    # Hor.X:+.00064#              #              #              #
    # Vert.: -.0104#              #              #              #
    #              #              #              #              #
    #maximum       #              #              #              #
    #STRAINS (um/m)#              #              #              #
    # Hor.X:  +83.0#              #              #              #
    # Vert.: -214.6#              #              #              #
----#--------------#--------------#--------------#--------------#-------------
```

APPENDIX 2:

SHELL PAVEMENT DESIGN ANALYSIS

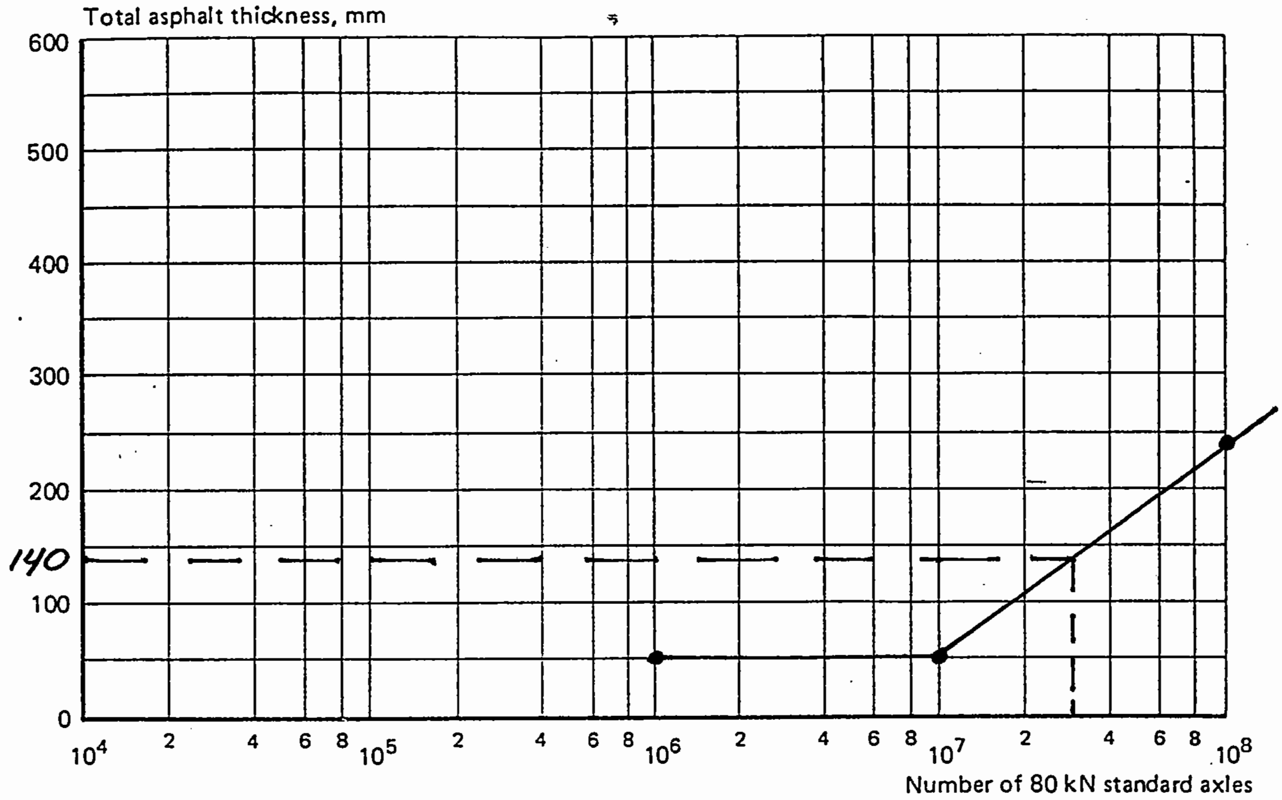

CHART N–

CARRILES
INTERIORES

See charts HN for minimum modulus of unbound base layers

Mix code	S1-F1-100	Subgrade modulus, N/m^2	5×10^7
w-MAAT, °C	12 (CC)	Unbound layers h_2, mm	660

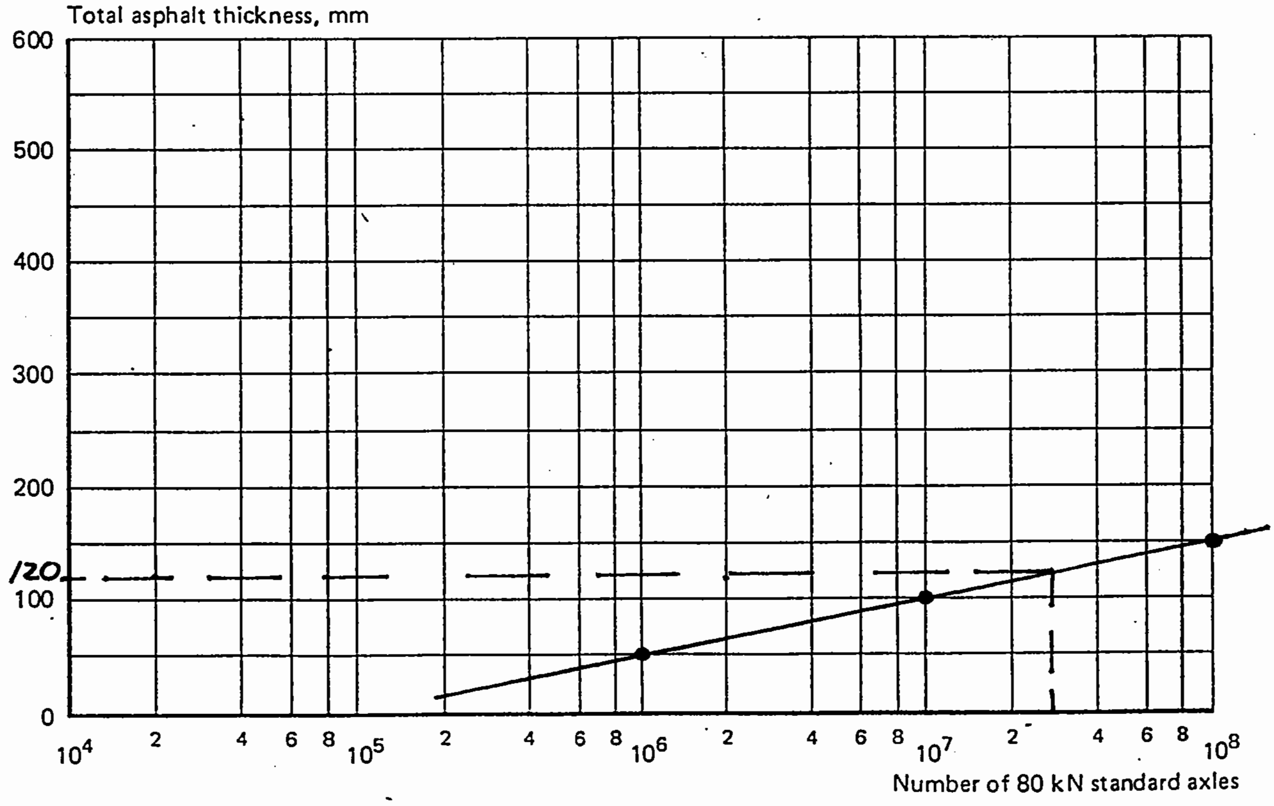

CHART N–

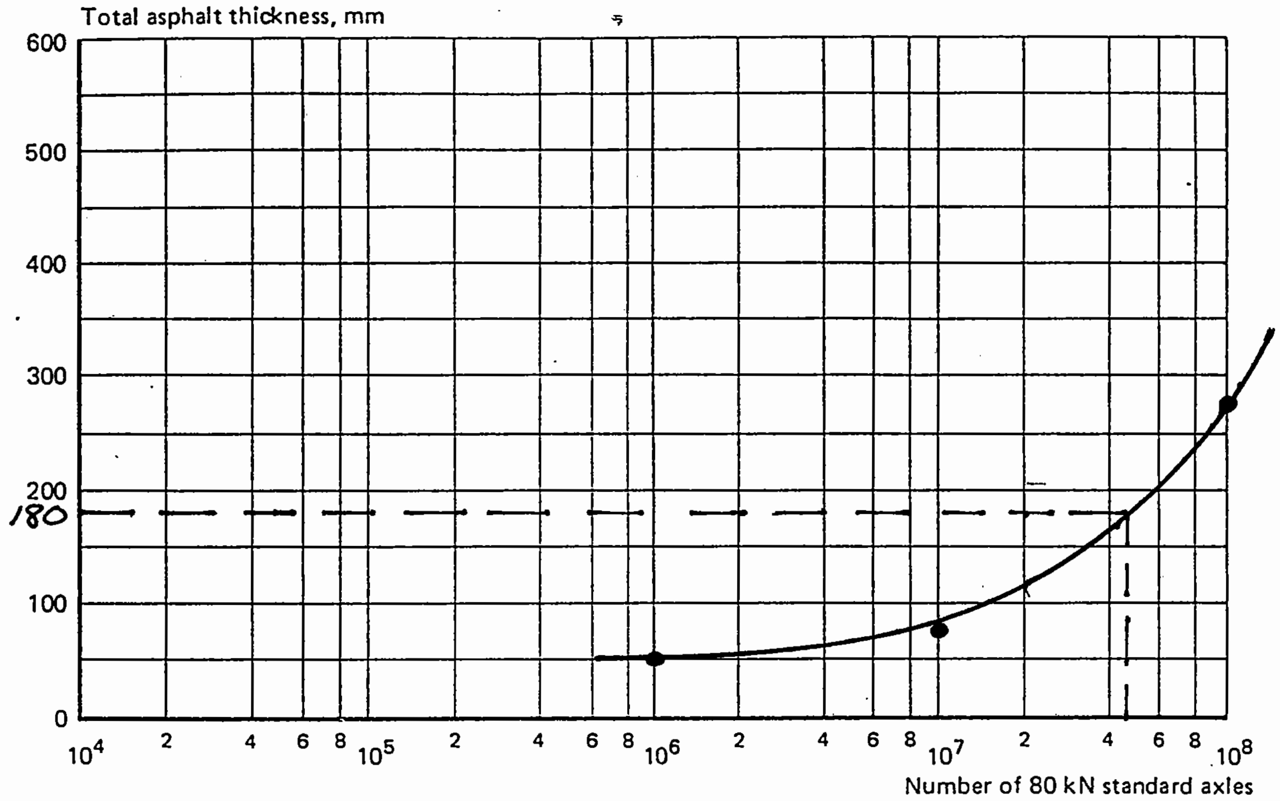

CHART N–

CARRILES
EXTERIORES

See charts HN for minimum modulus of unbound base layers

Mix code S1-F1-100	Subgrade modulus, N/m^2 5 x 10^7
w-MAAT, °C 12 (CC)	Unbound layers h_2, mm 630

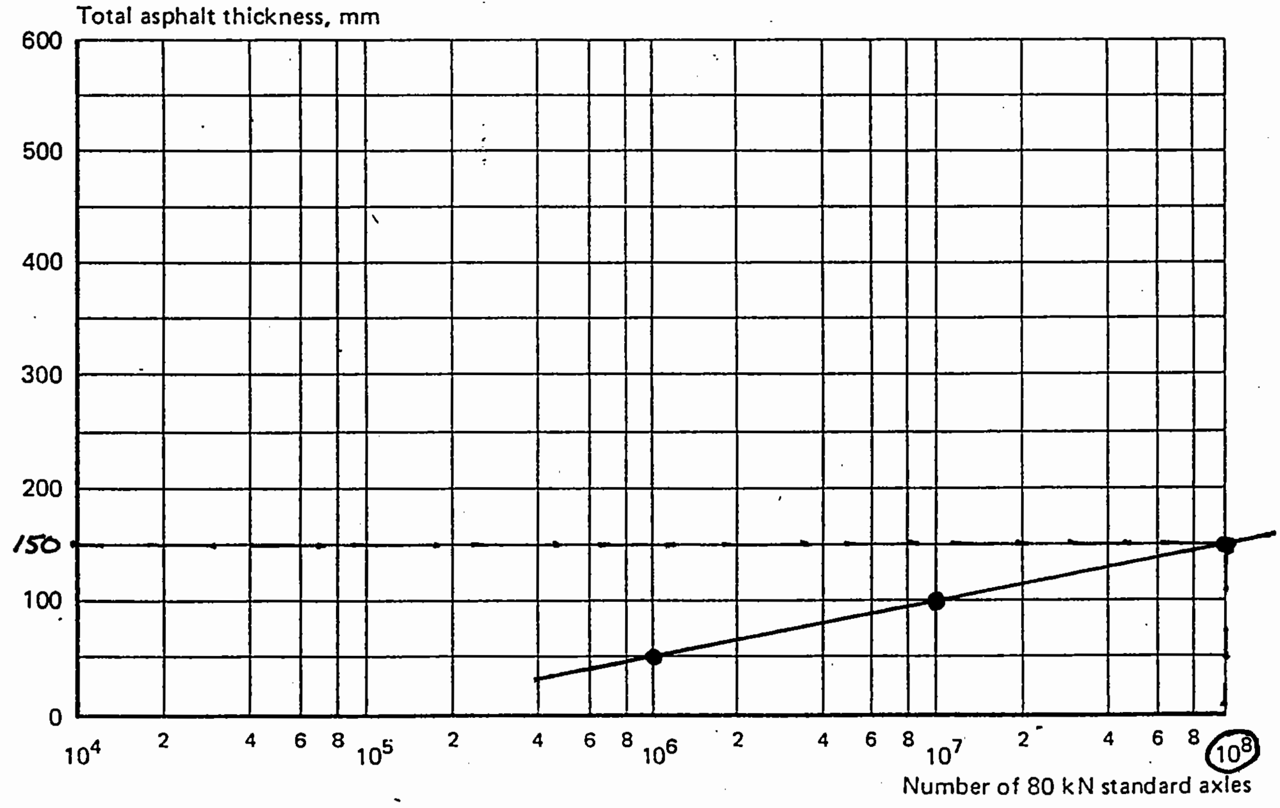

CHART N–

APPENDIX 3:

AASHTO PAVEMENT DESIGN ANALYSIS

ACCESO OESTE A LA CAPITAL FEDERAL
TRAMO Avda. GENERAL PAZ - ARROYO MORON
AASHTO PAVEMENT DESIGN
DESIGN PARAMETERS

1. STRUCTURAL LAYER COEFFICIENTS (a_i)

PAVEMENT LAYER	MAT'L PROPERTY	(a_i)	SOURCE
CARPETA	M_R = 178,000 psi [1]	0.46 0.28	Fig. 2.5
BASE SUP&INF	M_R = 178,000 psi [1]	0.50	Fig. 2.5
BASE SUP&INF + CC	M_R = 990,000 psi [1]	0.46 0.28	Fig. 2.5
SUBBASE	M_R = 11,500 psi [2]	0.09	Fig. 2.7
RECUBRIMIENTO	M_R = 10,000 psi [2]	0.08	Fig. 2.7

Notes:

[1] Resilient Modulus values obtained from Instituto de Mecanica Aplicada y Estructuras Test Report dated June 1995, Fig. 18 (Master Curve).

[2] Resilient Modulus values inferred from AASHTO Interim Guide for the Design of Pavement Structures (1986) for the layer coefficients given in the Pavement Design Calculations.

2. DRAINAGE COEFFICIENT (m_i)

Given the variation in annual rainfall and drainage conditions which are experienced at the project site, it is most appropriate to take the conservative assumption that the pavement structure is exposed to moisture levels approaching saturation between 5 - 25 % of the time. If, for the sake of engineering conservatism, we further assume that the quality of drainage is only fair, than AASHTO Table 2.4 dictates that the recommended drainage coefficient for this project is 1.00.

ACCESO OESTE A LA CAPITAL FEDERAL
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AASHTO PAVEMENT DESIGN
DESIGN STRUCTURAL NUMBERS

The following general equation relates the relative impact of the structural coefficient (a_i) and the thickness (D_i) of each pavement layer in order to determine the design structural number of each candidate pavement design:

$$SN = \sum a_i D_i m_i$$

where

a_i = layer coefficients representative of surface, base and subbase courses,

D_i = actual thicknesses (in inches) of surface, base and subbase courses, and

m_i = drainage coefficients for base and subbase layers.

[N. B. - The possible effect of drainage on the asphalt concrete surface course is not considered.]

CASE 1: CARRILES EXTERIORES

1. CONVENTIONAL PAVEMENT DESIGN

$$SN = 0.28*3.2 + 0.28*7.2 + 0.09*8.0*1.0 + 0.08*16.0*1.0$$

SN = 4.91

2. CHEMCRETE PAVEMENT DESIGN

$$SN = 0.28*3.2 + 0.50*6.0 + 0.09*8.0*1.0 + 0.08*17.2*1.0$$

SN = 5.99

ACCESO OESTE A LA CAPITAL FEDERAL
TRAMO Avda. GENERAL PAZ - ARROYO MORON
AASHTO PAVEMENT DESIGN
DESIGN STRUCTURAL NUMBERS
(CONTINUED)

CASE 2: CARRILES INTERIORES

1. CONVENTIONAL PAVEMENT DESIGN

SN = 0.28*3.2 + 0.28*5.6 + 0.09*8.8*1.0 + 0.08*16.8*1.0

SN = 4.60

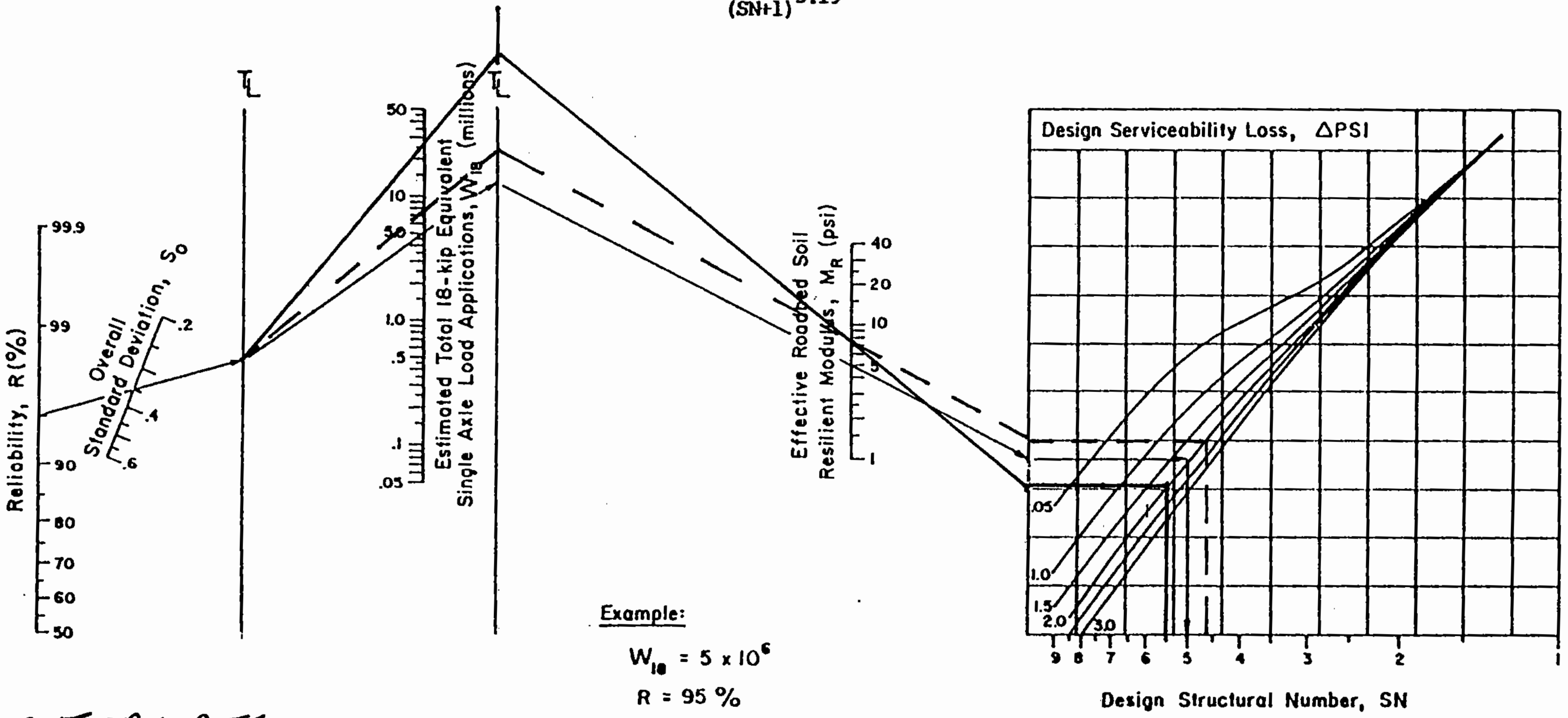
2. CHEMCRETE PAVEMENT DESIGN

SN = 0.28*3.2 + 0.50*4.8 + 0.09*8.8*1.0 + 0.08*17.6*1.0

SN = 5.50

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 9.36*\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32*\log_{10} M_R - 8.07$$



Example:

$W_{18} = 5 \times 10^6$

R = 95 %

$S_o = 0.35$

M_R = 5000 psi

ΔPSI = 1.9

Solution: SN = 5.0

CARRILES INTERIORES

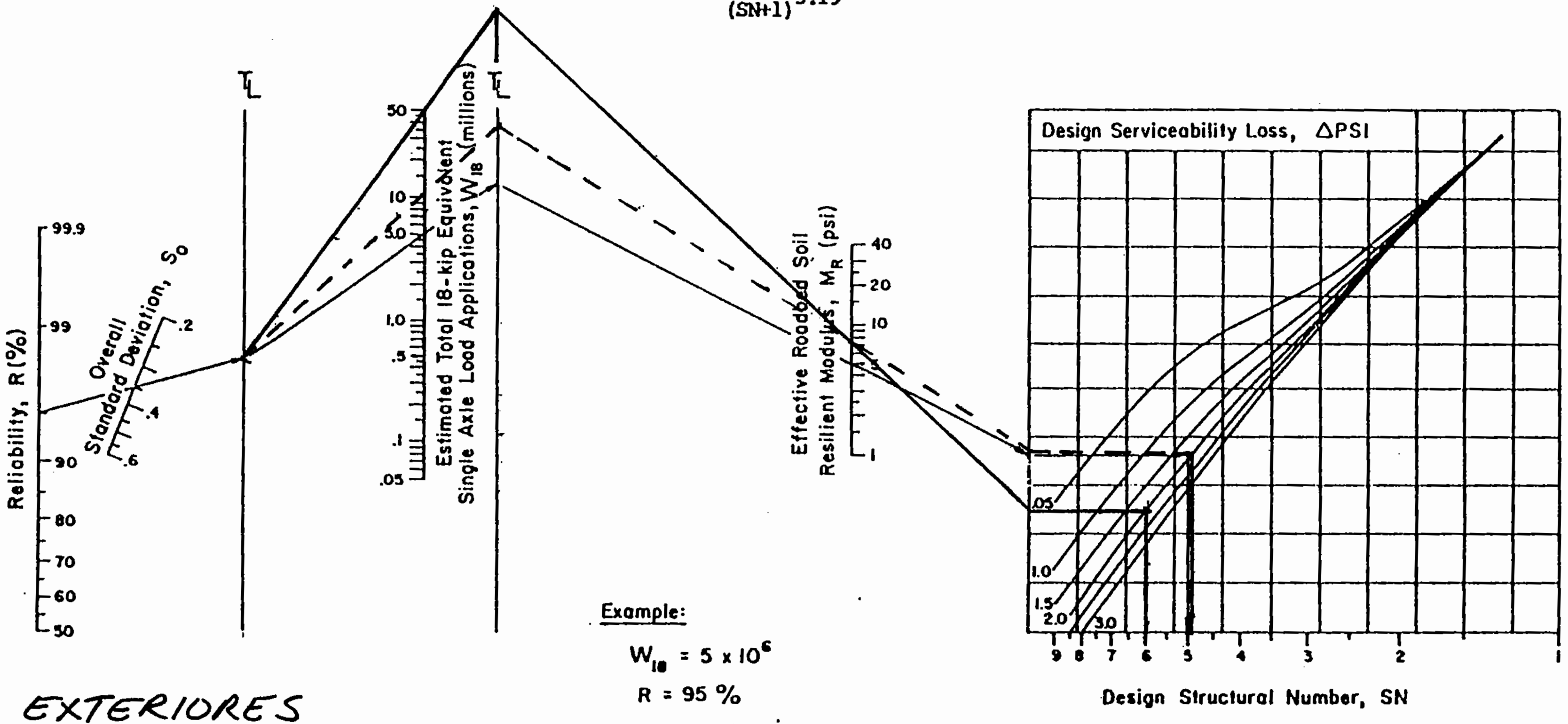
CONVENTIONAL : $W_{18} = 7.5 \times 10^6$ ESA

CHEMCRETE : $W_{18} = 25.0 \times 10^6$ ESA

Figure 3.1. Design chart for flexible pavements based on using mean values for each input.

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$



Example:

$W_{18} = 5 \times 10^6$

R = 95 %

$S_o = 0.35$

$M_R = 5000$ psi

ΔPSI = 1.9

Solution: SN = 5.0

CARRILES EXTERIORES

CONVENTIONAL: $W_{18} = 10.0 \times 10^6$ ESA

CHEMCRETE : $W_{18} = 50.0 \times 10^6$ ESA

Figure 3.1. Design chart for flexible pavements based on using mean values for each input.