TAC User Guide

to

CAN/CGSB-16-3-M90
"Asphalt Cements for Road Purposes"

Transportation Association of Canada
Association des transports du Canada

The overall mission of the Transportation Association of Canada (TAC) is to promote the provision of safe, efficient, effective and environmentally sustainable transportation services in support of the nation's social and economic goals. To this end, TAC acts as a neutral forum for the discussion of transportation issues, serves as a technical focus in the field of roadway transportation, promotes R&D activities, and disseminates transportation related information published by TAC and others. The role of TAC's Research and Development Council is to foster innovative, efficient and effect research and technology transfer in support of Canadian transportation. This project was conducted as part of the Council's cooperative reserach program with funding provided by the federal, provincial and territorial ministries of transportation.

La mission de l'Association des transports du Canada (ATC) est de promouvoir la sécurité, l'efficience, l'efficacité et le respect de l'environnement dans la prestation de services de transport, en vue d'appuyer les objectifs sociaux et économiques du pays. À cette fin, l'ATC offre une tribune neutre pour la discussion des enjeux et des problèmes liés aux transports, sert de centre d'études techniques dans le domaine des transports routiers, encourage les activités de R-D et diffuse l'information sur le secteur les transports qu'elle-même et d'autres organismes réunissent. Le rôle du Conseil de la recherche et du développement de l'ATC est de contribuer à l'essor du secteur canadien des transports en favorisant la mise en oeuvre de projets de recherche innovateurs, efficients et efficaces ainsi que le transfert de la technologie issue de ces derniers. Le présent projet a été exécuté à la faveur de programme de recherche collaborative du Conseil, programme financé par les ministères fédéral, provinciaux et territoriaux des Transports.

2323 St. Laurent Blvd., Ottawa, Canada K1G 4K6
Tel. (613) 736-1350 Fax (613) 736-1395

ISBN 1-55187-096-7

TAC REPORT DOCUMENTATION FORM

Project No.	Report No.	Report Date	IRRD No.
1316		January 1996	

Project Manager

Christopher Hedges

Title and Subtitle

TAC User Guide to CAN/CGSB-16-3-M90
"Asphalt Cement for Road Purposes"

Author(s)	Corporate Affiliation(s)
Cece Dawley Bert Pulles	EBA Engineering

Sponsoring/Funding Agency and Address	Performing Agencies Names and Addresses
TAC R&D Council 2323 St. Laurent Blvd. Ottawa, ON K1G 4K6	EBA Engineering 14535 - 118 Avenue Edmonton, AB T5L 2M7

Abstract

The purpose of this study was to document a set of procedures for the selection of paving asphalts based on the Canadian General Standards Board (CGSB) 1990 specification ***Asphalt cements for road purposes*** **(CAN/CGSB-16.3-M90)**. This specification was published in 1990 and was intended to serve as a national standard for asphalt cements. While the Strategic Highway Research Program has more recently produced new performance-based binder specifications, several Canadian jurisdictions have indicated their intention to continue using the CGSB penetration grades for some time into the future. A User Guide to accompany the CGSB specification was never published, although a number of draft versions were developed. It was recognized by TAC that the selection of asphalt paving cements on a project specific basis using the CGSB standard alone is not a straightforward procedure. Therefore, TAC has sponsored the development of this User Guide to the CGSB specification based on the best information currently available on: 1) Canadian climatic conditions, 2) sources and characteristics of asphalts used in Canada; 3) Canadian pavement performance data; 4) current provincial asphalt specifications and test procedures; 5) the likely impacts of the results of the Strategic Highway Research Program asphalt research results; and 6) use of premium and polymer modified asphalts. The User Guide is intended to be used as a supplement to the CGSB standard and contains step by step procedures with worked examples for the selection of asphalts for any paving project in Canada based on climatic conditions and anticipated traffic levels.

A detailed final report is also available which contains full documentation of the research that led to the development of the User Guide. To assist with the pavement selection process, a printout of minimum and maximum temperature data from Canadian weather stations has been extracted from the SHRPBIND weather database and is also available separately from TAC.

Keywords (IRRD)

Bituminous mixture
Design (overall design)
Selection
Specifications
Guidance
Traffic count
Weather
Durability
Properties
Canada

No. of Pages	No. of Figures	Language	Price
		English	

Supplementary Information

FICHE DE RAPPORT DE L'ATC

Projet n°	Rapport n°	Date du rapport	DIRR n°
1316		JAN 96	

Gestionnaire du projet

Christopher Hedges

Titre et sous-titre

TAC User Guide to CAN/CGSB-16-3-M90
"Asphalt Cements for Road Purposes"

Auteur(s)

Cece Dawley
Bert Pulles

Affilliation(s)

EBA Engineering Consultants

Nom et adresse de l'organisme parrain

Conseil de la recherche et du développement
Association des transports du Canada
2323, boulevard Saint-Laurent
Ottawa (Ontario) K1G 4K6

Nom et adresse de l'organisme exécutant

EBA Engineering Consultants
14535 - 118 Avenue
Edmonton, Alberta T5L 2M7

Résumé

La présente étude décrit les modalités de sélection d'un liant bitumineux en fonction de la norme de 1990 de l'Office des normes générales du Canada (CGSB, intitulée ***«Liants bitumineux pour les routes» (CAN/CGSB-16.3-M90).*** Cette norme, publiée en 1990, devait servir de norme nationale pour les liants bitumineux. Bien que le programme stratégique de recherche routière ait donné lieu plus récemment à une nouvelle norme sur les liants axée sur le rendement, plusieurs administrations canadiennes ont exprimé leur intention de continuer à utiliser les catégories de pénétration CGSB. Plusieurs versions provisoires d'un guide d'utilisation de la norme CGSB ont été préparées, mais aucune n'a été publiée. L'ATC a reconnu que la sélection d'un liant bitumineux en vue d'un projet particulier d'après la seule norme CGSB n'est pas une tâche simple. Par conséquent, l'ATC a fait préparer le présent guide d'utilisation comme complément de la norme CGSB en fonction des meilleures connaissances actuelles relatives 1) au climat canadien, 2) aux sources et aux caractéristiques des bitumes utilisés au Canada, 3) aux données canadiennes sur le rendement des revêtements, 4) aux normes et méthodes d'essai provinciales actuelles se rapportant aux bitumes, 5) à l'effet probable des résultats du programme stratégique de recherche routière se rapportant aux bitumes et 6) à l'utilisation des bitumes de qualité supérieure et des bitumes modifiés par des polymères. Le guide d'utilisation doit servir de complément de la norme CGSB et il décrit méthodiquement les étapes, avec exemples à l'appui, de la sélection des bitumes pour tout projet de revêtement exécuté au Canada, compte tenu des conditions climatiques et de la densité de la circulation.

Il existe également un rapport final détaillé qui contient une documentation complète sur les recherches ayant mené à la préparation du guide d'utilisation. Afin de faciliter la sélection des revêtements, on a extrait de la base SHRPBIND des données sur les températures minimales et maximales signalées par les stations météorologiques canadiennes, données qui sont également diffusées séparément par l'ATC.

Mots-clés

Enrobe
Dimensionnement
Choix
Recommandation
Guidage
Comptage (trafic)
Climat
Durabilité
Caracteristiques
Canada

Nombre de pages	Nombre de figures	Langue	Prix
		Anglais	

Renseignements supplémentaires

Acknowledgements

This project was conducted with funding provided by TAC's Research and Development Council.

TAC would like to express its appreciation to the members of the project steering committee who volunteered their time to provide advice, guidance and direction. TAC would also like to thank all those individuals and agencies who contributed to the success of the study by responding to survey questionnaires.

Project Steering Committee

David Haughton (Chairman)
B.C. Transportation & Highways

Imants Deme
Shell Canada Products Limited

Keith Foster
Nfld. Dept. of Works, Services & Transportation

Chuck Juergens
Husky Oil Marketing Company

Anne-Marie Leclerc
Ministère des Transports du Québec

Daryl Macleod
Saskatchewan Department of Highways and Transportation

Lyle Moran
Imperial Oil Ltd. Research Department

Dave Palsat
AGRA Earth & Environmental

Kai Tam
Ministry of Transportation, Ontario

Christopher Hedges (Project Manager)
Transportation Association of Canada

Principal Consultants

Cece Dawley
Bert Pulles

EBA Engineering Consultants Ltd.

In Memoriam

John Corkill
1930-1993

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 THE PURPOSE OF THIS GUIDE

A National Standard of Canada for Asphalt Cements for Road Purposes has been developed as CAN/CGSB-16.3-M90 by the Canadian General Standards Board (CGSB). The current standard is the product of several years of development by a group of leading Canadian experts in asphalt paving technology. The Transportation Association of Canada (TAC) recognized that utilization of the current Standard may be enhanced through development of a User Guide intended to describe how the asphalt cement selection procedure should be conducted.

Selection of the grade and group of asphalt cement for an asphalt concrete pavement, on a project-specific basis, from the alternative products that are available in the Standard, is appropriately dependent upon several project related factors. The purpose of this Guide is to provide the user with a logical step-by-step procedure to enable the most appropriate grade and group of asphalt cement to be chosen in consideration of these factors. Methodology for identifying and addressing these factors in the asphalt cement selection process is provided in following Sections. The methodology specifically addresses selection of conventional asphalt cements for new pavements. Asphalt cement selection for overlay projects should be undertaken in recognition of pre-existing pavement conditions and distress features.

1.2 THE CONCEPT FOR SELECTION OF THE ASPHALT CEMENT

Factors which are most significant in the selection of the type and grade of asphalt cement for a project include:

- traffic volume and loading
- service temperature range
- thickness and design of the pavement structure
- characteristics of the available aggregates

The asphalt cement that is ultimately selected for a project will usually be a compromise between those candidate materials which provide the best performance with respect to primary pavement distress modes, and are most commonly considered to be fatigue cracking, instability rutting and cracking due to thermal stresses. Some types of pavement distress, such as cracking due to thermal stresses, are predominantly associated with the properties of the asphalt cement.

On the other hand, other types of pavement distress, such as instability rutting, are predominantly associated with aggregate properties, and the properties of the asphalt cement are considered to be contributory.

The concept associated with use of this Guide is to enable the most appropriate asphalt cement as provided for within CAN/CGSB-16.3-M90 to be selected, in consideration of the relative significance of the factors that influence asphalt concrete pavement performance under prevailing climatic, traffic and other service conditions.

1.3 CONTENTS OF THE USER GUIDE

In following Sections of this Guide, a brief description is provided of the mechanisms that cause distress to occur in asphalt concrete pavements, and of the role played by the asphalt binder in mitigating their occurrence. An explanation is provided of the CGSB specification, and of the manner in which the rheological properties of asphalt cements have been used to create a matrix of products for use over the range of climatic conditions which prevail throughout Canada. A step-by-step procedure is presented for selecting the most appropriate asphalt cement grade and group for those anticipated project specific climatic and traffic conditions that the user must identify. Examples are provided of how the methodology serves to define an asphalt cement for specific service conditions.

This Guide is not intended to provide either direction or specifications relative to other components of an all-encompassing project of constructing an asphalt concrete pavement, including:

- pavement structure design
- paving mixture design
- aggregate selection and processing
- construction quality control and quality assurance
- construction specifications

Under certain climatic and service conditions, it is possible that asphalt cements specified in the CGSB Standard will not comply with certain requirements that are associated with prevailing traffic and/or climatic conditions. In such instances, consideration may have to be given to selection of alternative products such as polymer modified asphalt. The CGSB Standard does not contain specifications for any types of enhanced binders, and it is beyond the scope of this Guide to provide guidelines for their selection.

Full documentation of the research that led to the development of this guide is contained in the report "Characteristics, Performance and Selection of Paving Asphalts", referred to throughout the User Guide as the TAC Report. That report also contains discussion of developments under the Strategic Highway Research Program (SHRP) and the Canadian counterpart (C-SHRP). The Guide user should reference the TAC Report for details which are beyond the scope of the Guide.

1.0 INTRODUCTION

1.1 BUT DU PRÉSENT GUIDE

Une norme nationale du Canada intitulée «Liants bitumineux pour les routes» (CAN/CGSB-16.3-M90) a été préparée par l'Office des normes générales du Canada (CGSB). La norme actuelle est le résultat de plusieurs années de travaux menés par un groupe de spécialistes canadiens de la technologie des revêtements bitumineux. L'Association des transports du Canada (ATC) a compris que l'utilisation de la norme actuelle serait plus facile s'il existait un guide de sélection des liants bitumineux.

La sélection d'un type de liant bitumineux en fonction d'un revêtement particulier, parmi les différents produits mentionnés dans la norme, relève bien entendu de plusieurs paramètres liés au projet. L'utilisateur du présent guide y trouvera une série d'étapes permettant de choisir, en fonction de ces paramètres, le liant bitumineux le plus approprié. Les sections qui suivent décrivent l'identification et l'analyse de ces paramètres en vue de la sélection d'un liant bitumineux. Le cas particulier des liants bitumineux conventionnels destinés à de nouveaux revêtements est également abordé. Le choix d'un liant bitumineux en vue d'un projet de revêtement devrait tenir compte des conditions existantes et de la dégradation de la chaussée.

1.2 PARAMÈTRES DE SÉLECTION D'UN LIANT BITUMINEUX

Les paramètres les plus importants de la sélection d'un liant bitumineux pour un projet donné sont les suivants :

- le débit de la circulation et les contraintes de charges,
- la gamme de températures de service,
- l'épaisseur et la conception du revêtement,
- les caractéristiques des granulats.

Le liant bitumineux retenu en vue d'un projet représente habituellement un compromis entre les matériaux qui offrent le meilleur rendement compte tenu des modes de dégradation du revêtement, qui sont le plus souvent la fissuration par fatigue, l'orniérage dû à l'instabilité et la fissuration causée par des contraintes thermiques. Certains types de dégradation, par exemple la fissuration causée par des contraintes thermiques, sont associés principalement aux propriétés du liant bitumineux. D'autres types de dégradation, par exemple l'orniérage dû à l'instabilité, sont surtout liés aux propriétés du granulat, les propriétés du liant bitumineux étant considérées comme un facteur contributif.

Le présent guide cherche à faciliter la sélection du liant bitumineux le plus approprié dans le cadre de la norme CAN/CGSB-16.3-M90, compte tenu de l'importance relative des paramètres qui influencent le rendement d'une chaussée de béton bitumineux (conditions climatiques, routières et autres).

1.3 CONTENU DU GUIDE

Les sections du guide décrivent brièvement les mécanismes de la dégradation des chaussées de béton bitumineux, ainsi que le rôle du liant bitumineux dans la réduction de cette dégradation. On y trouve une description de la norme CGSB et des propriétés rhéologiques des liants bitumineux qui ont permis d'offrir un choix de produits adaptés aux conditions climatiques existantes dans l'ensemble du Canada. Le guide expose méthodiquement les étapes de la sélection du liant bitumineux le plus approprié en fonction des conditions climatiques et routières particulières identifiées par l'utilisateur. Des exemples de liants bitumineux sont présentés pour des conditions de service particulières.

Le présent guide ne cherche ni à orienter ni à normaliser les autres aspects d'un projet global de construction d'une chaussée de béton bitumineux, par exemple :

- la conception de la structure de la chaussée,
- la conception du mélange routier,
- la sélection et le traitement des granulats,
- l'assurance de la qualité et le contrôle de la qualité,
- les normes de construction.

Compte tenu des conditions climatiques et de service, il est possible que des liants bitumineux décrits dans la norme CGSB ne répondent pas à certaines exigences liées à des conditions climatiques ou routières existantes. Le cas échéant, il faudra peut-être choisir d'autres produits comme un bitume modifié par des polymères. La norme CGSB ne comporte aucune spécification relative à des liants améliorés et la sélection de tels produits dépasse le cadre du présent guide.

L'ATC a publié un rapport intitulé «Characteristics, Performance and Selection of Paving Asphalts». Ce rapport, qui contient beaucoup de détails qui ont appuyé la préparation du présent guide, cite une bonne partie de la recherche qui a été menée au Canada et ailleurs, et il aborde des démarches entreprises dans le cadre du programme stratégique de recherche routière (SHRP) et de son homologue canadien (C-SHRP). Pour en savoir davantage, l'utilisateur du guide pourra consulter ce rapport de l'ATC.

2.0 CAN/CGSB-16.3-M90

The Guide user should be thoroughly familiar with the contents of the CGSB Standard for Asphalt Cements for Road Purposes. Six penetration grades are provided for within the Standard:

60 - 70	150 - 200
80 - 100	200 - 300
120 - 150	300 - 400

In addition, three Groups of asphalt cements are defined in accordance with their temperature susceptibility properties. Temperature susceptibility is defined as the change in consistency (viscosity or penetration) that an asphalt cement undergoes for a given change in temperature. Thus the temperature susceptibility properties, by Group, are:

Group A - asphalt cements that have a high viscosity at 60°C (or 135°C), for a given penetration at 25°C (low temperature susceptibility).

Group B - asphalt cements that have a medium viscosity at 60°C (or 135°C) for a given penetration at 25°C (medium temperature susceptibility).

Group C - asphalt cements that have a low viscosity at 60°C (or 135°C) for a given penetration at 25° (high temperature susceptibility).

A matrix of eighteen candidate asphalt cements exists, as a function of penetration grade and temperature susceptibility Group.

Requirements and specifications for these asphalt cements are outlined in Table 1 of the Standard. Table 1 of the Standard contains reference to Figure 1 (viscosity at 60°C) or Figure 2 (viscosity at 135°C), as the means by which viscosity properties for Group A, B and C asphalt cements are specified. The Committee that developed this Standard agreed that the asphalt cement specification should be based on:

i) viscosity at 60°C, which would serve as a performance criterion to focus on rutting, and

ii) penetration at 25°C, which when used in conjunction with viscosity at 60°C would serve as a means for defining temperature susceptibility to avert or minimize low temperature pavement cracking.

The asphalt cement selection procedure contained in this Guide has been developed on the basis of temperature susceptibility criteria that were utilized to develop Figure 1 of the Standard. No further reference to Figure 2 is made herein.

The term Penetration Index (PI) was used by researchers to describe the temperature susceptibility parameter as a function of the relationship of penetration and temperature. Thus, with knowledge of penetration (100 g, 5 sec.) at two temperatures (eg. 25°C and 10°C), the PI of an asphalt could be determined, and hence its temperature susceptibility property could be defined. It was subsequently demonstrated that, by nomographical methods, use of $\text{pen}_{25°C}$ and $\text{viscosity}_{60°C}$ values could be used to approximate, very closely, the PI determined by the two-penetration method, for <u>most</u> conventional asphalts. Thus the main specified criteria in the Standard were developed on the basis of the $\text{pen}_{25°C}$ - $\text{viscosity}_{60°C}$ temperature susceptibility parameter.

3.0 PAVEMENT DISTRESS TYPES AND THEIR MITIGATION

3.1 BACKGROUND

The primary types of distress and related factors that may develop and influence long term performance of asphalt concrete pavements are:

- low temperature cracking
- permanent deformation (rutting)
- fatigue cracking
- moisture sensitivity and stripping
- aging of the asphalt/aggregate system
- durability

The role played by the asphalt cement in the paving mixture, as it influences pavement performance, is discussed below. For certain types of distress, such as low temperature cracking, the asphalt cement properties are dominant in respect to its occurrence. For other types of distress, such as permanent deformation, the quality of the aggregate in the paving mixture is dominant in preventing its occurrence, while the asphalt cement is a secondary or contributing factor. Nevertheless, the asphalt cement should be selected on the basis of the dominant and/or contributing factors that influence pavement performance.

3.2 LOW TEMPERATURE CRACKING

Low temperature cracking in newly constructed asphalt concrete pavements is predominantly controlled (up to 90 percent) by the properties of the asphalt cement. Other contributory factors include pavement thickness, pavement age, subgrade characteristics, the asphalt mix design and mixture production procedures. Low temperature cracking in newly constructed pavement overlays may be influenced by pre-existing transverse cracking in the original pavement.

Several researchers have developed predictive methods for estimation of the cracking temperature of pavements that contain conventional asphalt cements whose rheological (viscosity, penetration) properties are known. Methodology selected for incorporation into this Guide was developed by E.E. Readshaw (1972) and it, along with that of others, is discussed in the TAC Report.

Readshaw's procedure is based on a critical asphalt stiffness of 2 x 10^8 N/m^2 at two hours loading time. That is, the pavement cracking temperature is that temperature which exists for two hours, at which time the asphalt attains a stiffness value of 2 x 10^8 N/m^2. Cracking temperatures of pavements containing CGSB Groups A, B and C asphalt cements of the six previously defined penetration grades have been computed using Readshaw's methodology.

To mitigate low temperature cracking, an asphalt cement should be selected that has a stiffness value that is less than 2 x 10^8 N/m^2 at two hours loading time at the low design pavement temperature. The design pavement temperature selection procedure is explained in Section 4.0.

Figure 1 may be used to predict the cracking temperature of a pavement containing asphalt cement whose original penetration (100 g, 5 sec, 25°C) and viscosity (Pa.s, 60°C) are specified or known. Figure 2 may be used for this purpose when the original penetration (100 g, 5 sec) at 25°C is known or specified, and at least one additional penetration value (100 g, 5 sec) at a different temperature (eg. 10°C) is also specified or known, with which to determine the Penetration Index (PI) of the asphalt cement. It should be recognized that the CGSB Standard does not specify penetrations (100 g, 5 sec) at more than one temperature.

A procedure for determining the minimum pavement temperature for design purposes, as a function of coldest air temperature, is described in Section 4.0.

3.3 PERMANENT DEFORMATION

Permanent deformation, commonly referred to as rutting, can be of several types, and the cause of each type differs. Instability rutting, which occurs within the asphalt concrete layer develops when the properties of the compacted asphalt concrete pavement are inadequate to resist the stresses imposed upon it. The degree of instability rutting is enhanced when high ambient temperatures prevail and when frequent repetitions of heavy axle loads are applied. The time of loading, i.e. low vehicle operating speed, further accelerates the rate of which instability rutting develops.

Properties of the aggregate that is incorporated into the paving mixture have the predominant role in controlling instability rutting. Physical properties (particle shape, soundness and toughness) and gradation characteristics of the aggregate must be carefully specified to provide adequate shear resistance and to achieve the aggregate "skeleton" that is required within the compacted pavement to provide for load transfer from tires to the pavement support layers.

Methodology has been described in the TAC Final Report (92-4 Vol. 1) to control traffic-induced permanent deformation of asphalt pavements under high seasonal temperature conditions. The methodology is based on concepts which include:

I) The critical stiffness modulus (i.e. relationship between stress and strain as a function of time of loading and temperature) of a compacted paving mixture at 40°C is 2.38×10^8 N/m^2.

ii) A relationship exists between paving mixture stiffness at 40°C and the minimum stiffness which the asphalt cement should exhibit at that temperature, if the asphalt cement is to serve its contributory role in mitigating permanent deformation.

iii) The critical stiffness of initially aged (after plant mixing) conventional asphalt cement is 5.0×10^5 N/m^2 at 40°C, if the mineral aggregate in the paving mixture possesses excellent angularity properties, and is 1.0×10^6 N/m^2 at 40°C, if the mineral aggregate is of poor angularity. The critical stiffness value of 5.0×10^5 N/m^2 for initially aged asphalt translates to a limiting stiffness of approximately 1.5×10^5 N/m^2 for asphalt in its original (as delivered) condition.

Figures 3, 4 and 5 illustrate stiffness properties of CGSB Group A, B and C asphalts respectively, at various loading times, in their original (as delivered) condition. In principle, to mitigate permanent deformation at the prevailing operating speed, it is necessary to select an asphalt cement (if available) that possesses the critical stiffness properties defined above, and to specify aggregates that exhibit excellent angularity properties.

To this point, methodology which has been described to determine asphalt stiffness at elevated temperatures, under a range of loading times, is based on long established, conventional technology. Some members of the TAC Steering Committee have suggested that, on the basis of Canadian experience, nomographic solutions from Figures 3, 4 and 5 are too conservative (i.e. softer asphalts are regularly used than would be specified using those Figures). The TAC Report describes a concept which has evolved recently, and which was made possible using SHRP asphalt binder specifications and testing protocols. This initiative has enabled a series of design pavement temperature isotherms to be superimposed onto Figure 3, 4 and 5 to create Figure 6, 7 and 8 respectively (for each of Group A, B and C asphalts). The method of proposed use of Figures 6, 7 and 8, for selecting the appropriate asphalt cement for the high pavement design temperature condition is described in Section 7.0 (Step 5.2).

3.4 FATIGUE

Two types of fatigue distress, thermal and structural, can develop within an asphalt concrete pavement structure. Thermal fatigue results from repetitive thermal cycles, but the process is not well understood and is not further referenced. Structural fatigue cracking usually occurs when a pavement is stressed to the limit of its fatigue capacity by repetitive loads, or when loads are applied that exceed the capacity of the pavement structure.

Predominant paving mixture properties that influence fatigue related performance include:

I) excessively stiff asphalt cement
ii) deficient asphalt cement content.

To mitigate structural fatigue cracking, following guidelines have been proposed:

- when the total asphalt concrete layer thickness is less than 125 mm, paving mixtures of low stiffness (i.e. low viscosity asphalt cements) are preferred.
- when the total asphalt concrete layer thickness is greater than 125 mm, paving mixtures of high stiffness (i.e. high viscosity asphalt cements) are preferred.

In the actual asphalt cement selection procedure described in Section 7.0, methodology is provided for considering pavement fatigue issues when more than one alternative asphalt cement is available that satisfies both low and high service temperature requirements (i.e. transverse cracking and instability rutting).

3.5 MOISTURE SENSITIVITY AND STRIPPING

Stripping of the asphalt film from the aggregate occurs when there is loss of adhesion between the aggregate surface and the asphalt cement, and is primarily due to the action of water. This problem is essentially one of aggregate-asphalt cement compatibility, and is normally resolved by incorporation of an anti-stripping agent into the asphalt mix. Performance tests are normally performed in the laboratory to determine stripping potential and the effectiveness of such admixtures in limiting its occurrence.

Stripping potential does not appear to be directly related to the penetration grade or group of asphalt cement selected, but it is related in a complex physical and/or chemical manner to the interaction between the asphalt and aggregate forming the paving mixture.

3.6 AGING OF THE ASPHALT/AGGREGATE SYSTEM

Aging, or age hardening of the asphalt cement, in an asphalt paving mixture, is the change in the rheological properties (viscosity, penetration) that occurs during the plant mixing and placement operation, and that continues during the service life of the pavement. The aging process can be controlled by ensuring that suitable volumetric properties of the paving mixture are provided during the mix design process and that proper plant mixing and compaction practices are followed during construction. However, it is important to be aware that selection of the best quality of asphalt cement that is available in the CGSB Standard will have positive effects on the pavement quality, if all other design and construction practices are properly undertaken.

3.7 DURABILITY

Durability of an asphalt pavement refers to its competence to maintain structural integrity under operating conditions, i.e. under the influence of traffic, moisture and freeze/thaw. Durability of a compacted pavement is influenced by mixture and compaction qualities achieved during construction, by the air voids in the compacted pavement and by the thickness of asphalt film provided on the aggregate particles within the mixture. Durability properties are less significantly influenced by the grade of asphalt selected than by matters associated with asphalt-aggregate compatibility and by the paving mixture design process.

4.0 SELECTION OF DESIGN PAVEMENT TEMPERATURES

4.1 INTRODUCTION

SHRP has created a weather database that contains temperature statistics for approximately 1850 weather stations in Canada. The database is contained within the Superpave Binder Selection Program: SHRPBIND, Version 2.0, May, 1995. Location information includes station names, province or territory, longitude, latitude and elevation of each station, and the following relevant temperature information:

I) DMAT - which is the design maximum air temperature, and is the average of at least ten years of yearly maximum air temperature (YMAT), and YMAT is defined as the yearly maximum 7 day floating average of the daily maximum temperatures.

ii) σ_{DMAT} - which is the standard deviation of at least ten years of YMAT.

iii) T_{air} - which is the average of at least ten years of the annual coldest air temperature.

iv) σ_{air} - which is the standard deviation of T_{air}.

Within the TAC Report, descriptions are provided of methodology that has been used in this Guide, to enable design pavement temperatures to be predicted, for both the hot and cold service temperature conditions, using the four temperature statistics defined above.

An understanding of statistics principles, that are associated with normal distribution theory, is necessary to appreciate how SHRP has accommodated the issue of risk, i.e. probability. A normal distribution curve is shown in Figure 9. The area under a normal distribution curve represents the total number of records in a dataset. The area under a portion of the curve represents the number of pieces of data (and hence the percent) of the dataset. In the illustration in Figure 9, the 7-day average maximum pavement temperature situation is represented. For each case of $\bar{x} \pm 1\sigma$, 2σ, or 3σ, the percentage of occurrences, and also the probability of temperatures occurring outside of those limits may be determined. In the high design temperature case, one is only concerned with probability that a temperature occurrence may exceed (i.e. fall to the right) of a definable probability level. Thus, when the mean temperature ($\bar{x}$) is considered, there exists a 50 percent probability that an annual temperature occurrence will exceed $\bar{x}$. Similarly for $\bar{x} + 1\sigma$ and for $\bar{x} + 2\sigma$, there exists 84 percent and 98 percent probabilities respectively, that annual temperature occurrences will not exceed those limits.

The same principles apply for probability consideration for the low temperature design case.

4.2 SOURCE OF CANADIAN TEMPERATURE DATA

The SHRPBIND (Version 2.0) program includes a database of 1800+ Canadian weather stations. A copy of the Canadian data is available from TAC at the following address:

Transportation Association of Canada
2323 St. Laurent Boulevard
Ottawa, Ontario, Canada K1G 4K6
Telephone: (613) 736-1350
Fax: (613) 736-1395

For more information about the SHRPBIND program, contact:

Mr. Monty Symons
Pavement Performance Divisin NHR-30
U.S. Federal Highway Administration
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296
FAX (703) 285-2767

Climate information is available at Environment Canada offices throughout Canada. Table 1 shows the addresses and current (1995) telephone numbers of some regional and local Environment Canada offices.

Figure 10 is presented to illustrate the cold air temperature regime in Canada. Values of T_{air} - $2\sigma_{air}$ (as defined in Section 4.1) for the Canadian weather stations included in the SHRP database have been used to develop cold air isotherms at intervals at 5°C. This Figure should be used only for information purposes and should not be used as a substitute for determining more precise site-specific information.

Figure 11 is presented to illustrate the hot air temperature regime in Canada. Values of DMAT + 2σDMAT (defined in Section 4.1) for the Canadian weather stations included in the SHRP database, have been used to develop high air temperature isotherms at intervals at 5°C. This Figure should be used for information purposes only. It should not be used as a substitute for determining more precise site-specific information.

4.3 SELECTION OF THE DESIGN LOW PAVEMENT TEMPERATURE

TAC provided following guidelines that are to apply to the methodology for selection of the design low pavement temperature:

I) pavement temperature at surface, as estimated from air temperature, is to be used.
ii) the SHRP Superpave air temperatures are to be used.
iii) the method for estimating pavement surface temperature is to be based on previous work of other researchers, and is to recognize temperature correlations that are available from existing Canadian test roads, including the three C-SHRP sites. Pavement temperatures in the winter are known to be warmer than prevailing air temperatures.

Pursuant to completion of an analysis to correlate air and pavement surface temperature data at Canadian test road sites, the following equation has been adopted to determine design low pavement temperature at the 98 percent probability level (i.e. 98 percent probability that the design low pavement temperature will not be exceeded):

Design Low $T_{pavement}$ (°C) = $0.859\,(T_{air} - 2\sigma_{air}) + 1.7$°C ---- Equation 1

T_{air} and σ_{air} are defined in Section 4.1, and values of these statistics may be sourced as referenced on Section 4.2. The user, at his discretion may accept increased risk by deleting the $2\sigma_{air}$ value from Equation 1 (i.e. 50 percent risk factor) or by substituting 1σ (84 percent risk factor).

The TAC Report may be referenced for detailed information relative to the development of Equation 1 above.

The Guide user is reminded of the need for validating the value of T_{air}, available in the reference source, for any project specific application.

Note: **The Guide user is cautioned to read and to understand fully the contents of Chapter 6.1 (Safety Factors) and the requirement contained therein for refining design low pavement temperature values derived from Equation 1, in accordance with guidelines contained in Chapter 6.1.**

4.4 SELECTION OF THE DESIGN HIGH PAVEMENT TEMPERATURE

Protocols that were developed by SHRP have been adopted for determining the design high pavement temperature from air temperature data that is provided in the SHRPBIND program.

In the methodology that is defined below for determining the design high pavement temperature, SHRP has defined the critical location in the pavement structure as being that point located 20 mm below the surface of the pavement. The user may assign the risk of the design high pavement temperature being exceeded, in terms of probability, by defining T_{air} in Equation 2 below, as follows:

Probability (%)	**Value of T_{air}**
98	$DMAT + 2\sigma_{DMAT}$
84	$DMAT + 1\sigma_{DMAT}$
50	DMAT

DMAT and σ_{DMAT} are defined in Section 4.1 and values of these statistics may be sourced as referenced in Section 4.2

The SHRP procedure to determine the design high pavement temperature at 20 mm depth (Design High T_{20mm}) in °C is determined in the following manner:

I) Determine pavement surface temperature using the following equation:

$$T_{surf}\,(°C) = T_{air} - 0.00618\ lat.^2 + 0.2289\ lat. + 24.4 \qquad \text{---- Equation 2}$$

where: lat. = latitude of the project site

ii) Convert T_{surf} to °F using:

$°F = 9/5°C + 32$

iii) Determine Design High $T_{0.75\ in.}$ using:

Design High $T_{0.75\ in.}$ (°F) = $0.9564\ T_{surf}$ ---- Equation 3

iv) Convert Design High $T_{0.75\ in.}$ to Design High T_{20mm} using:

°C = 5/9 (°F - 32)

5.0 TRAFFIC

5.1 CONSIDERATION OF TRAFFIC AND MAXIMUM DESIGN TEMPERATURE

A prerequisite to undertaking selection of the asphalt binder required at the design high pavement temperature is to characterize the traffic that will use the pavement. Two characteristics should be identified, i.e.:

i) operating speed
ii) design traffic loading, expressed in terms of 80 kN ESALs

Three operating speeds (i.e. loading times) have been considered in developing the asphalt binder selection methodology presented in this Guide. These speeds are 100 km/h, 50 km/h and 20 km/h, for which corresponding pavement loading times are 0.01 seconds, 0.02 seconds and 0.05 seconds. These vehicle operating conditions are similar to those that are used by SHRP in the Superpave mix design process. Figures 6, 7 and 8 have been developed on the foregoing basis.

Asphalt binder requirements for other prevailing operating speeds may be interpolated in Figures 6, 7 and 8.

Design traffic loading, expressed in cumulative ESALs over the design life of the pavement structure, influences the binder selection process in the manner presented in Section 7.0. Three traffic levels are provided in Superpave, and have been selected for utilization in this Guide, i.e.:

Design Level	**Design 80 kN ESALs**
1 (Low)	$\leq 10^6$
2 (Intermediate)	$> 10^6 \leq 10^7$
3 (High)	$> 10^7$

The influence of design traffic is predominantly provided for by specifying requirements of the mineral aggregate (gradation, particle shape, texture, fracture, etc.). In high and intermediate design level cases, the coarse aggregate fraction should be of the maximum practical nominal size and should consist of 85 percent or more of particles with two or more fractured faces. The fine aggregate fraction should be of high angularity. Selection of the most appropriate asphalt binder, from those alternatives that may satisfy the maximum design pavement temperature requirements, is a function of the design traffic level, and is described in Section 7.0. In principle, for low traffic volumes (Design Level 1), the softest penetration grade that satisfies the high design pavement temperature requirement (at the prevailing operating speed) should be identified. Conversely, for high traffic levels (Design Level 3) the hardest penetration grade, of those potential candidates, would be identified.

5.2 CONSIDERATION OF TRAFFIC AND MINIMUM DESIGN TEMPERATURE

Selection criteria relative to minimum design temperature are subjective in nature and should be in accordance with the following guidelines:

I) For low traffic volumes (Design Level 1), identify one of the softer penetration grades that are available candidates.

ii) For high traffic volumes (Design Level 3) identify the hardest penetration grade from available candidates.

iii) For intermediate traffic volumes (Design Level 2) identify the most appropriate penetration grade from available candidates, using discretion and in consideration of the range of available materials.

6.0 OTHER CONSIDERATIONS

6.1 SAFETY FACTORS

.1 For Design Service Temperature

It has been discussed, in previous Sections, how the probability of extreme temperature occurrences, that exceed average annual mean temperature values, can be recognized by adding (or subtracting) 1σ or 2σ to or from mean temperature values. In this manner the temperature variable may be addressed.

.2 For Initial Age Hardening of Asphalt Cement

Asphalt cements are specified in their original (tank) condition in the CGSB specification. During asphalt plant mixing initial hardening of the asphalt cement occurs and the age hardening process continues during the service life of the pavement. As a result, rheological properties that influence low temperature pavement performance (i.e. low temperature properties) are not the same as for the original asphalt cement. This must be recognized in the asphalt cement selection process to ensure that satisfactory pavement performance results. This may be accomplished by incorporation of a "safety factor" to further reduce the design low pavement temperature (Equation 1, Chapter 4.3). Robertson (1987) used a value of 10°C to, at least in part, account for the age hardening factor. A 10°C safety factor should be used in the asphalt selection procedure outlined in Chapter 7.0, unless a Canadian agency has sufficient experience to warrant use of an alternate safety factor value.

The user should review the Final TAC Report (Section 6.3.4) for further explanation in respect to aging of CGSB asphalt cements.

6.2 AGGREGATE SELECTION FOR PAVING MIXTURES

It is beyond the scope of this Guide to identify the detailed properties required of aggregates that should be used for each traffic level and operating speed condition. The designer of paving mixtures may refer to the SHRP Superpave Mix Design Manual for guidance in this regard. As well, previous experience with locally available aggregates may provide an indication of their suitability for similar uses in the future.

6.3 PERFORMANCE TESTING OF PAVING MIXTURES

The purpose of this Guide is to provide the user with guidelines to select the most appropriate asphalt binder for an asphalt paving mixture on a project specific basis. Beyond this point, the procedure for developing the job mix formula, on the basis of laboratory trial mixtures, require methodologies that are beyond the scope of this Guide. In this regard key properties of paving mixtures, that should be considered, are related to aggregate and mixture volumetric properties.

Laboratory testing programs exist that can assess the probable performance of candidate paving mixtures in respect to permanent deformation, fatigue, durability and moisture sensitivity and stripping. The Guide user should refer to the TAC report for further information in this regard.

6.4 LIMITATIONS

CAN/CGSB-16.3-M90 contains specified requirements for asphalt cements for road purposes that are applicable to Canadian conditions. Using the asphalt binder selection procedure that is provided in Section 7.0 of this Guide, the user may occasionally identify requirements for asphalt binder that cannot be provided by conventional asphalt cements that are available in this Standard. Hence the continuing use of the term "asphalt binder" in this Guide. The user may have to look to other sources such as polymer modified asphalts or specially "engineered" asphalts to fulfil some project specific requirements.

7.0 THE ASPHALT CEMENT SELECTION PROCEDURE

7.1 BACKGROUND

A detailed step-by-step procedure is provided in this Section, to enable the Guide user to identify, from those candidate materials which are found in CAN/CGSB-16.3-M90, that asphalt cement that is optimum for use on a project specific basis.

7.2 STEP-BY-STEP PROCEDURE

The step-by-step asphalt cement selection procedure is illustrated in Figure 12, which may also be used as a Worksheet for performing the analysis. Each step is discussed below.

Step 1: Name the Project; provide highway or street identification and the terminal (start and stop) points. Determine latitude, longitude and elevation of project.

Step 2: Define the Traffic Parameters

2.1 Design Traffic (Refer to Chapter 5). Information on heavy traffic - i.e. ESALs - is normally available from traffic engineering personnel within the highway or street agency. In the absence of available data from such sources, ESALs may be estimated using the following equation:

$$ESAL = AADT * HVP * HVDF * NALV * TDY$$

where:

ESAL	=	Equivalent Single Axle Loads per Lane per Year
AADT	=	Average Annual Daily Traffic (all lanes, both directions)
HVP	=	Heavy Vehicle Percentage (divided by 100)
HVDF	=	Heavy Vehicle Distribution Factor (percent of heavy vehicles in the design lane)
NALV	=	Number of equivalent axle loads per vehicle (Truck Factor)
TDY	=	Traffic Days per Year

The above equation provides an estimate of the number of ESALs in the design lane in one year. It is simply necessary to know the project design life and traffic growth factor to determine the anticipated cumulative ESALs in the project design life.

2.2 Operating Speed; geometric designers and/or regulatory agencies usually dictate what the operating speed will be, especially with respect to truck traffic. These sources should be requested to provide relevant information.

Step 3: Determine Low and High Air Temperatures; Refer to Chapter 4 and ascertain the four air temperature statistics that are required to determine the relevant design pavement temperatures. Sources of air temperature statistics are provided in Chapter 4.

A risk analysis should be performed, at this stage, to establish the level of probability that is acceptable in respect to those selected design temperatures being exceeded during the design period. Reference should be made to Chapter 4 in this regard. Assign either the mean temperature ($\bar{x}$) or mean temperature plus or minus 1σ or 2σ as being the high and low design air temperatures respectively.

Step 4: Calculate Low and High Design Pavement Temperatures

4.1 Design Low Pavement Temperature

Using the low air temperature statistics determined in Step 3, calculate the design low pavement temperature (Design Low $T_{pavement}$) as follows:

$$\text{Design Low } T_{pavement}\ (^\circ C) = 0.859\ (T_{air} - 2\sigma_{air}) + 1.7^\circ \qquad \text{---- Equation 1}$$

If the risk analysis undertaken in Step 3 determines that the 98 percent probability level (i.e. $2\sigma_{air}$) is excessive, adjust ($1\sigma_{air}$) or delete the σ_{air} factor to suit the selected risk factor (i.e. 84 percent or 50 percent).

A Safety Factor of 10°C should be applied to the design low pavement temperature determined from Equation 1. **To clarify, the value of Design Low $T_{pavement}$ (°C) should be reduced an additional 10°C, as explained in Section 6.1.**

4.2 Design High Pavement Temperature

I) Select the value of T_{air} on the basis of acceptable risk level (probability) from the following tabulation:

Probability (%)	Value of T_{air}
98	DMAT + $2\sigma_{DMAT}$
84	DMAT + $1\sigma_{DMAT}$
50	DMAT

Refer to the source referenced in Chapter 4 for values of DMAT and σ_{DMAT}.

ii) Determine pavement surface temperature from Equation 2:

T_{surf} (°C) = T_{air} - 0.00618 lat.^{2} + 0.2289 lat. + 24.4 ---- Equation 2
where: lat. = latitude of project in degrees

iii) Convert T_{surf} from °C to °F using:
°F = 9/5°C + 32

iv) Determine Design High $T_{0.75\ in.}$ from Equation 3:
Design High $T_{0.75\ in.}$ (°F) = 0.9564 T_{surf} ---- Equation 3

v) Convert Design High $T_{0.75\ in.}$ (°F) to Design High T_{20mm} (°C) using:
°C = 5/9 (°F - 32)

It is important to note that Equations 2 and 3, as currently issued by SHRP, require the user to convert temperatures (°C) to and from °F.

Step 5: Identify Candidate Asphalt Cements

5.1 For Design Low Pavement Temperature

Using the design low pavement temperature (adjusted colder by the 10°C Safety Factor in Step 4.1) as the pavement cracking temperature, refer to Figure 1 and record those candidate Group A, B or C asphalts by penetration grade, where the cracking temperature isotherm intersects the lines that represent the specification boundaries for each penetration grade specified in the CGSB standard.

5.2 For Design High Pavement Temperature

Using the design high pavement temperature, as determined in Step 4.2, and the design or legislated operating speed determined in Step 2.2, enter Figures 6, 7 or 8. Identify the horizontal line that represents the operating speed for the project, and proceed to the right to its intersection with the dashed line that most closely represents the design high temperature value. Interpolation between design temperature lines is a valid procedure. Identify and record those penetration grades of asphalt cement (i.e. the labelled, solid lines) that lie to the right hand side of the intersection of the operating speed/design pavement temperature intercept. If an intercept point occurs on that part of a design pavement temperature line that is shown in dot legend (i.e. not the dashed portion) then this means that there is no CGSB Group A, B or C asphalt cement that meets the required properties at the design high temperature end of the spectrum.

Step 6: Select the Optimum Asphalt Cement

Three possibilities exist at this point. These are defined below and an appropriate final step is described in each case.

I) One or more CGSB asphalt cements exist in both the lists prepared in Step 5.1 and Step 5.2 (i.e. there is more than one product that satisfies both design temperature conditions). In this situation, the Guide user should consider the significance of the selected product upon permanent deformation and fatigue as discussed in Chapter 3. This is done by reviewing preferred paving mixture and asphalt cement stiffness requirements as a function of traffic level and pavement thickness, using the following matrix:

Traffic Level	Pavement Thickness ($T_{pavement}$)	
	≤ 125 mm	> 125 mm
1 (Low)	low viscosity	high viscosity
2 (Intermediate)	user discretion	high viscosity
3 (High)	not normally applicable	high viscosity

ii) One or more CGSB asphalt cements will satisfy each of the two design temperature conditions, but none will satisfy both.

In this situation, the Guide user should re-consider the risk analysis that was undertaken as part of Step 3. In the Canadian climate environment, it is not normally desirable to knowingly increase the risk of incurring low temperature pavement cracking by selecting a design cold air temperature than is warmer than $T_{air} - 2\sigma_{air}$ (Chapter 4). However, it may be acceptable to compute the design high pavement temperature (T_{20mm}) on the basis of DMAT rather than DMAT + 1σDMAT or 2σDMAT, especially if Traffic Levels 1 or 2 have been estimated. That is to say, the Guide user assesses whether some increased risk of permanent deformation (rutting) can be tolerated in order to accommodate selection of a CGSB asphalt cement.

iii) One (or more) CGSB asphalt cements will satisfy the low design pavement temperature requirement, but none will satisfy the high design pavement temperature requirement at the prevailing operating speed.

In this situation, the Guide user has two fundamental options, i.e. -

- Ignore the risks that are associated with either the design low or high pavement temperature condition, and select that CGSB product that is the best compromise (not recommended), or
- Specify an alternative asphalt binder that will meet the service temperature requirements. Alternative products may include polymer modified asphalt or other types of enhanced binders.

7.3 WORKED EXAMPLES

The following examples demonstrate some of the basic possibilities that the Guide user may encounter, as identified in Step 6 of the above selection procedure. Flow Charts that have been used to complete the selection process, are provided following the examples.

Example 1: -

The project is located on a provincial highway in western Canada. The highway traverses gently rolling terrain and has a design operating speed of 100 km/h. Traffic Level No. 1 conditions prevail (ESALs $< 10^6$). The total design pavement thickness is 100 mm.

The SHRP database contains the following statistics for a nearby weather station, which is in close proximity to the project.

Latitude - 49.3°
Longitude - 101.0°
Elevation - 442 m

Average Low Temperature	(T_{air}) =	- 39°C
	σair =	2.9°C
Average High Temperature	(DMAT) =	32°C
	σ_{DMAT} =	2.4°C

Following policies exist in respect to risk in pavement design and performance for Traffic Level 1 roads: -

- Low temperature cracking to be mitigated at the 98% probability level
- Low pavement temperature safety factor = 10°C applies
- Permanent deformation (rutting) tolerable at the 50% probability level

At the completion of Steps 1 to 5 on the accompanying flow chart, it is apparent that to satisfy low service temperature conditions a 300-400 Group A or a grade with a higher penetration should be used.

To satisfy high service temperature requirements, a 200-300 Group A is required or a 150-200 Group B or harder.

A compromise solution is necessary since the candidate products for low temperature are not the same as for high temperature. In this instance, since permanent deformation is not critical (50% probability level required for rutting design), a 300-400 Group A would be most suitable for cold temperature cracking.

Example 2: -

The project involves construction of a passing lane on a rural highway that will be subjected to loaded logging and chip trucks operating at a speed of 80 km/h or less. The design traffic level is Intermediate ($> 10^6$ ESALs $\leq 10^7$). The total design pavement thickness is 150 mm.

The SHRP database contains the following relevant statistics at a nearby weather station:

Latitude - 51°
Elevation - 500 m

Average Annual Coldest Air Temperature	(T_{air}) =	- 30°C
	σair =	3°C
Average Yearly Maximum Air Temperature	(DMAT) =	34°C
	σDMAT =	2°C

Following jurisdiction policies exist is respect to risk for pavement design for Travel Level 2 designs: -

- Low temperature cracking is to be mitigated at the 98% probability level.
- A low pavement temperature safety factor of 10°C applies.
- Permanent deformation is to be mitigated at the 98% probability level.

The candidate asphalt cements identified in Step 5.1 on the accompanying Flow Charts are the lowest pen./Group products that may be used. The candidate asphalt cements identified in Step 5.2 are the highest penetration/Group products that may be used. The CGSB penetration grade/Group products are then: -

For Low Temperature	For High Temperature
150-200 Group A	150-200 Group A or harder
200-300 Group A or softer	

Thus, a 150-200 Group A asphalt should be selected as suitable for this project.

A compromise solution is necessary since the two candidate products that most closely satisfy both temperature design requirements are 200 - 300 (Group A) and 150 - 200 (Group A).

Since a 10°C safety factor was designated for design at the low temperature condition, it is concluded that 150-200 pen. Group A asphalt cement should be specified for the project. This selection most adequately satisfies the criteria required to mitigate fatigue distress in a pavement whose thickness is greater than 125 mm.

Example 3: -

The project is located on an urban freeway just outside of Toronto, Ontario. The design operating speed is 100 km/h. However, heavy traffic conditions will mean that traffic will be frequently stopped or slow moving. Traffic level 3 conditions prevail (ESALs > 10^7). The tentative pavement design calls for in excess of 200 mm of asphalt concrete over a granular base layer.

The SHRP database contains the following statistics for Toronto Pearson International Airport (Station Code #6158733).

Latitude - 43.67°
Longitude - 79.63 m
Elevation - 173 m

Average Low Temperature	(Tair) =	-25°C
	σair =	3.2°C

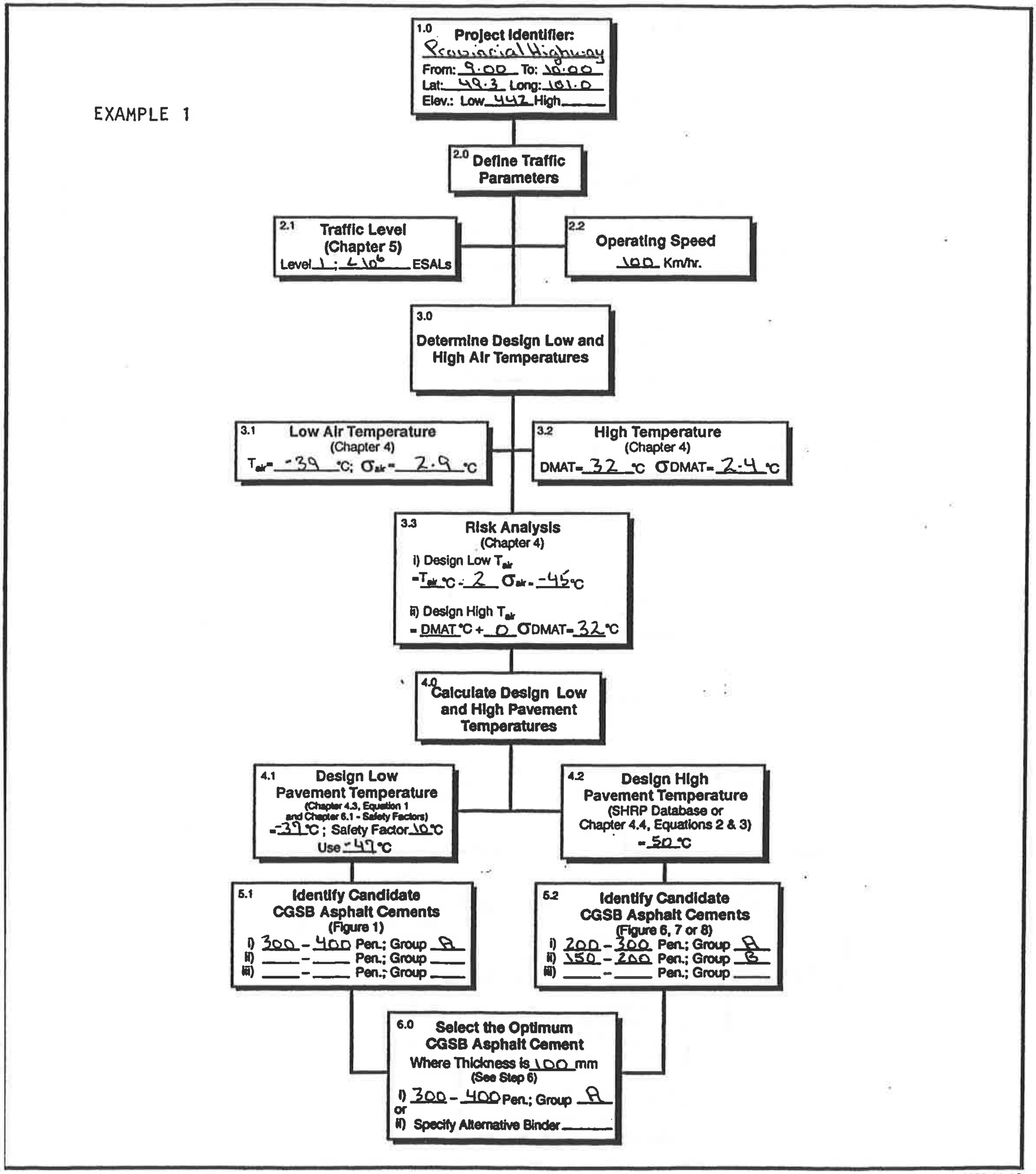
Average High Temperature	(DMAT)	=	31°C
	σDMAT	=	1.8°C

The following policies exist in respect to risk for Traffic Level 1 roads: -

- Low temperature cracking to be mitigated at the 98% probability level.
- Low pavement temperature safety factor = 10°C.
- Permanent deformation (rutting) is to be mitigated at the 98% probability level.

To satisfy low temperature requirements, a 120 - 150 A or B Grade or softer and some C Grades are suitable.

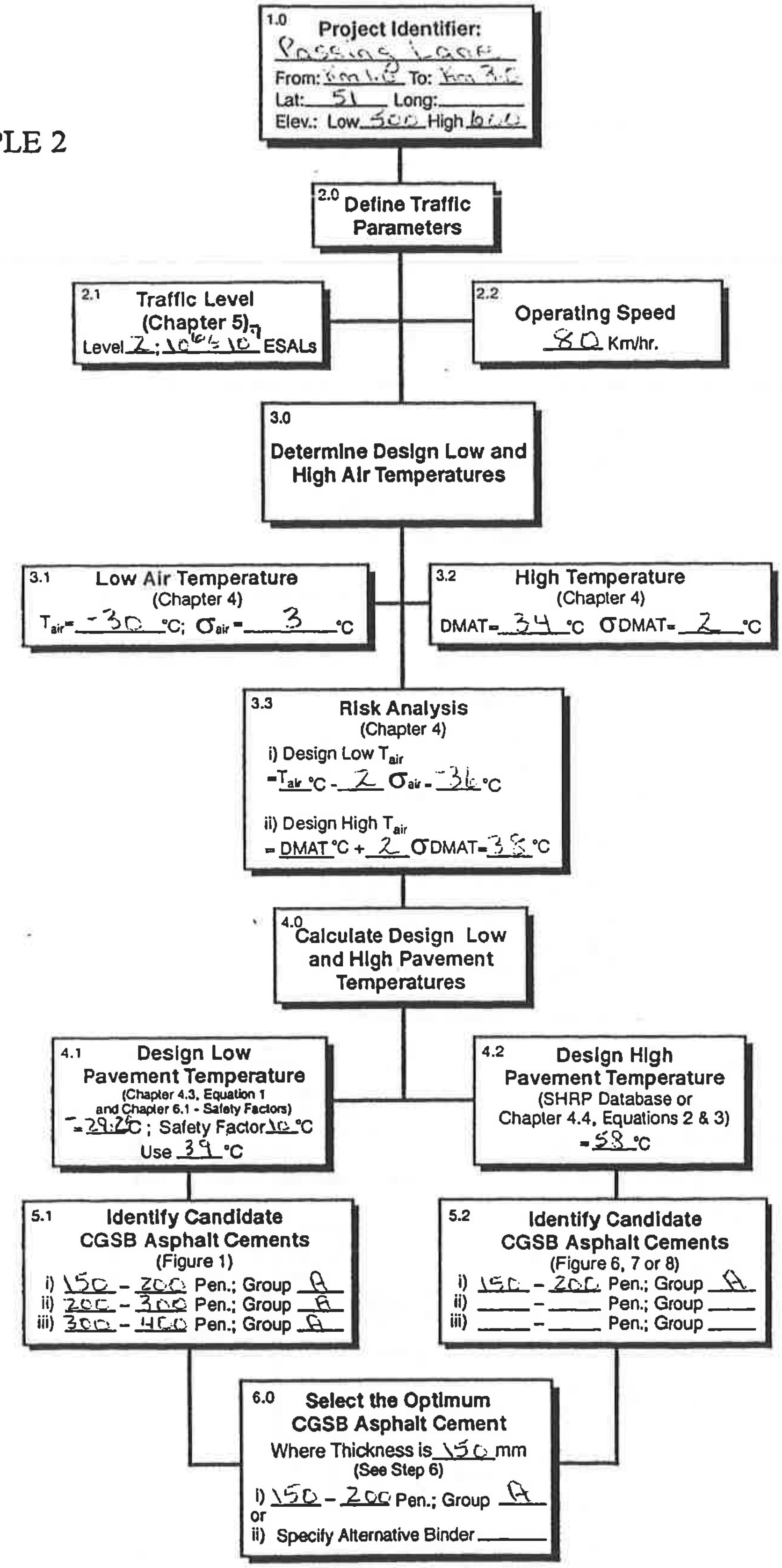
However, for high temperature considerations, the A Grade that may be acceptable (requires extrapolation of curves on Figure 6) is harder than 80 pen. In this instance it would be preferable to select some premium asphalt.



R9754M12G

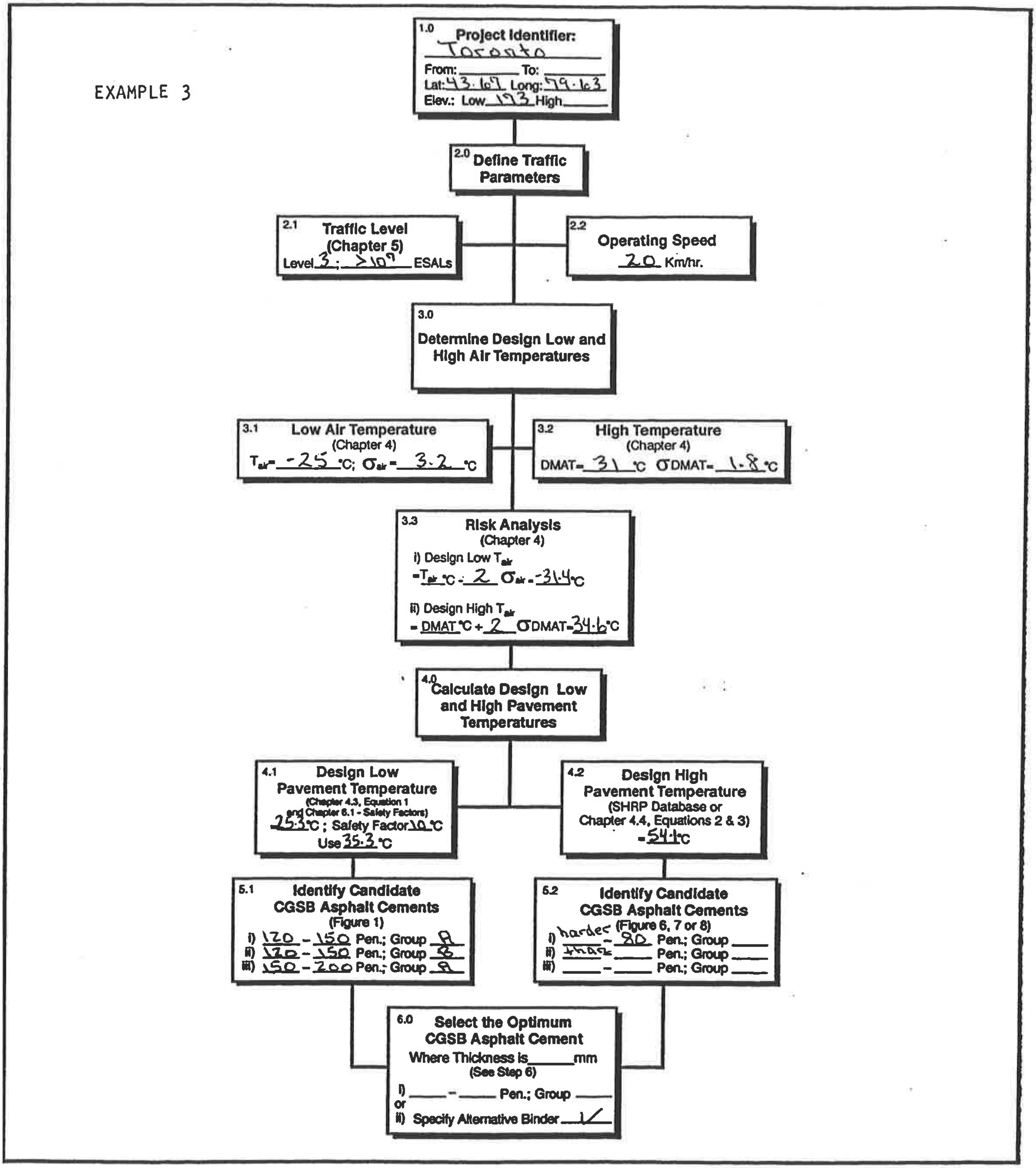
FIGURE 12 FLOW CHART FOR SELECTION OF ASPHALT BINDER

EXAMPLE 2



R9754M12G

FIGURE 12 FLOW CHART FOR SELECTION OF ASPHALT BINDER



R9754M12G

FIGURE 12 FLOW CHART FOR SELECTION OF ASPHALT BINDER

TABLES

TABLE 1
SELECTED ENVIRONMENT CANADA OFFICES

<u>National Office</u> Climate Information Branch Canadian Meteorological Centre 4905 Dufferin St. Downsview, Ontario M3H 5T4 Tel: (416) 739-4328 Fax: (416) 739-4446	Climate Services Room 1000/266 Graham Ave. Winnipeg, Manitoba R3C 3V4 Tel: (204) 983-0586 Fax: (204) 983-4884	<u>Ontario Climate Centre</u> Ontario Climate Centre 4905 Dufferin Street Downsview, Ontario M3H 5T4 Tel: (416) 739-4516 Fax: (416) 739-4521
<u>Regional and Local Offices</u> Pacific & Yukon Region Climate and Applications Suite 700/1200 W 73rd Avenue Vancouver, BC V6P 6H9 Tel: (604) 664-9156 Fax: (604) 664-9133	Climate Services 300 Park Plaza 2365 Albert St. Regina, Saskatchewan S4P 4K1 Tel: (306) 780-6341 Fax: (306) 780-5311	<u>Quebec Region</u> Climate Services 100 Alexis Nihon Blvd. 3rd Floor, Ville Saint Laurent, Quebec H4M 2N8 Tel: (514) 283-1296 or (514) 283-1107 Fax: (514) 283-7149
<u>Prairies & Northern Region</u> Climate Services Twin Atria Building Room 200/4999 - 98 Avenue Edmonton, Alberta T6B 2X3 Tel: (403) 951-8881 Fax: (403) 495-3529	Climate Services Room 301/111 Research Dr. Saskatoon, Saskatchewan S7N 3R2 Tel: (306) 975-6909 Fax: (306) 975-5954	<u>Atlantic Region</u> Atmospheric Environment Branch 1496 Bedford Highway Bedford, NS B4A 1E5 Tel: (902) 426-9226 Fax: (902) 426-9158

FIGURES

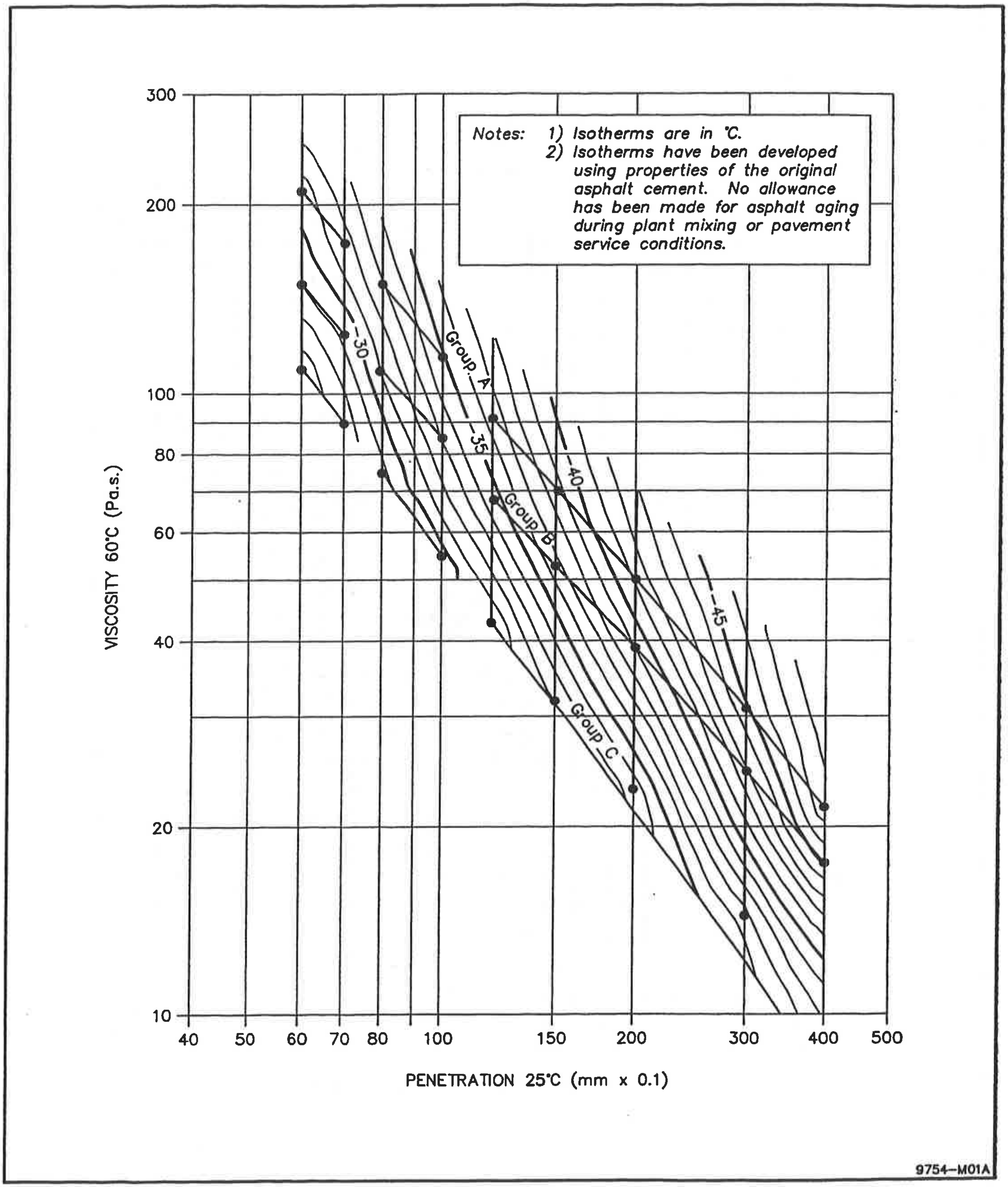


FIGURE 1 CRACKING TEMPERATURES VERSUS CGSB ASPHALT GRADE

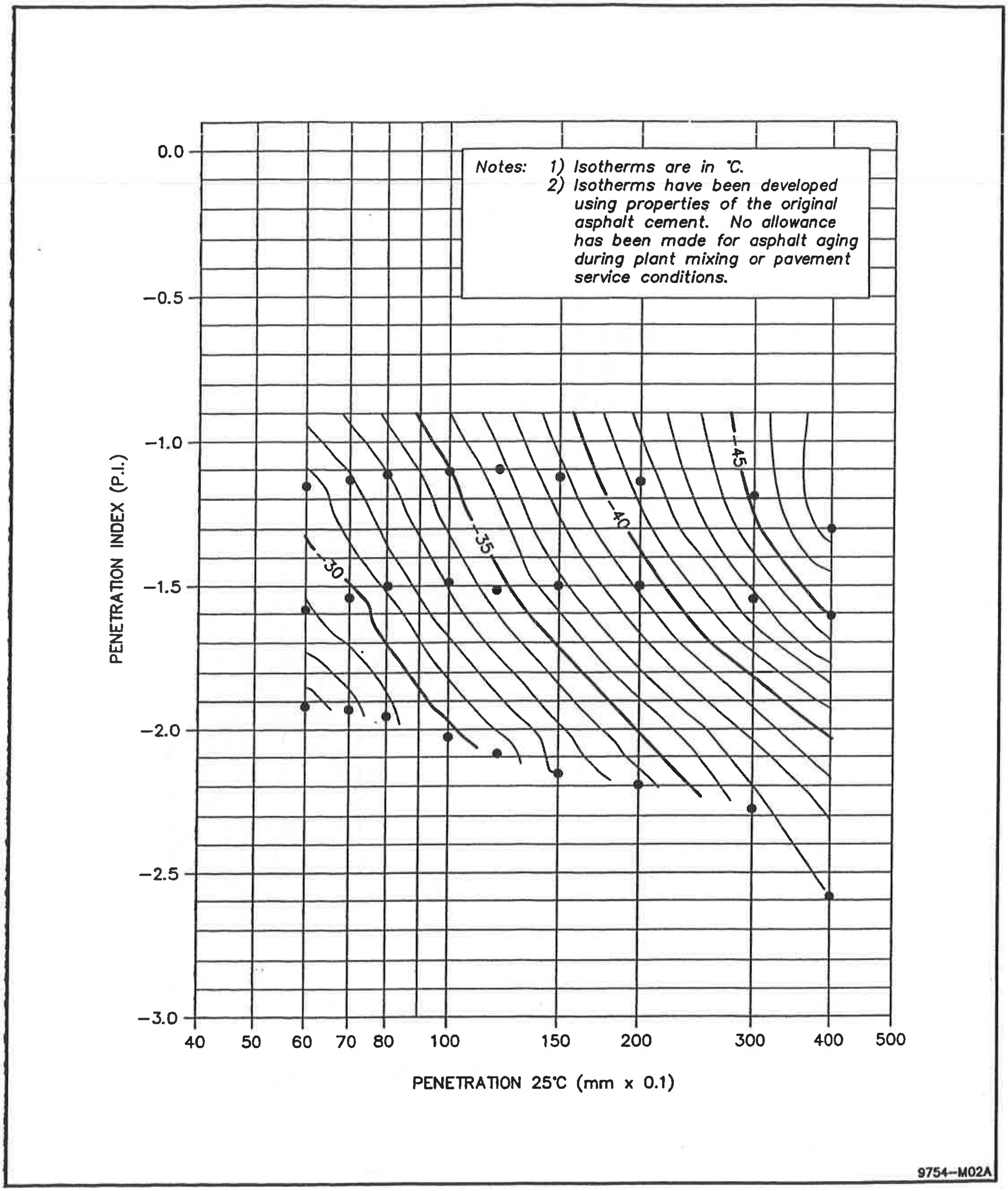


FIGURE 2 CRACKING TEMPERATURES VS PENETRATION AND PENETRATION INDEX (P.I.)

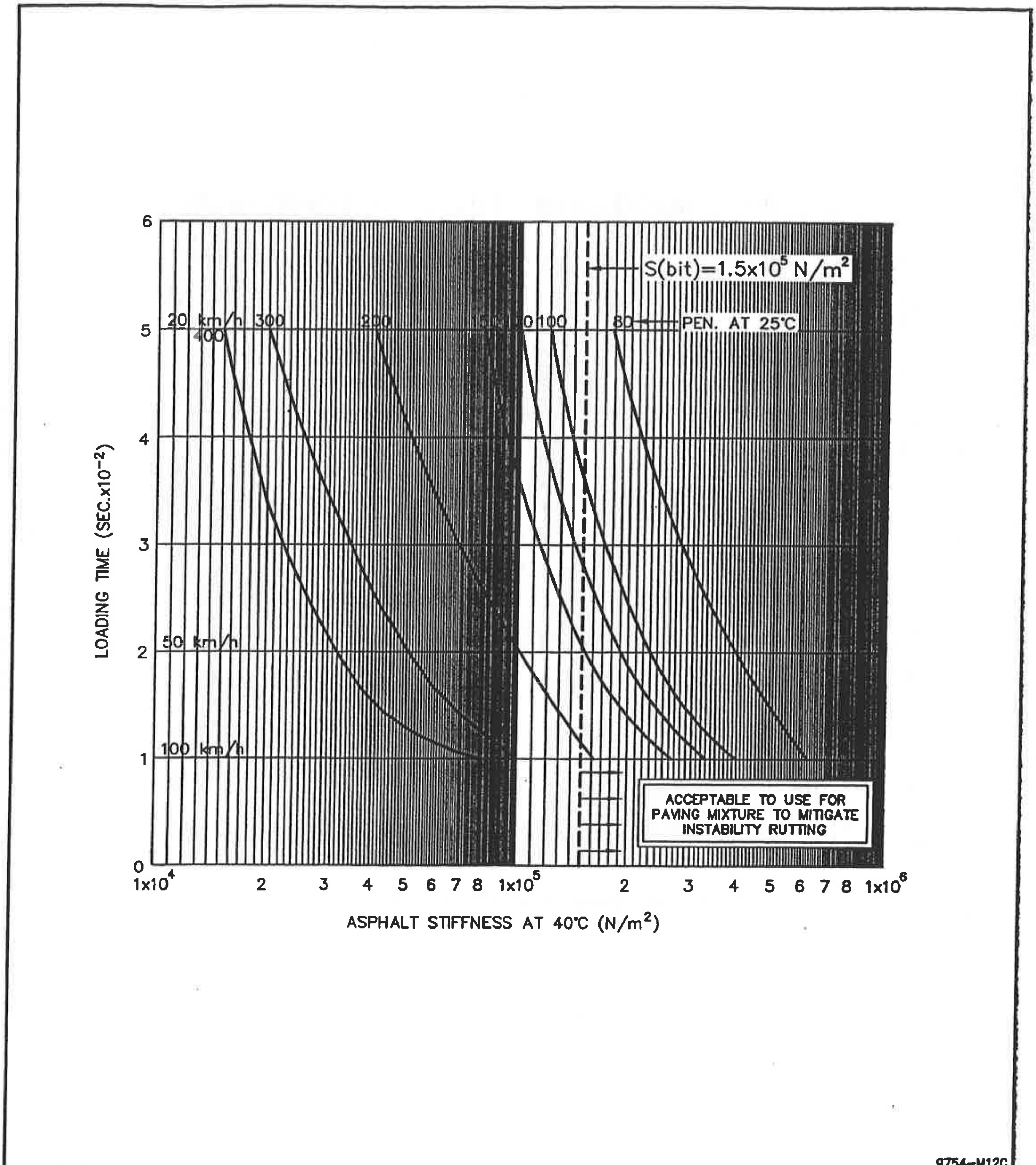


FIGURE 3 STIFFNESS OF CGSB TANK ASPHALTS (GROUP A) AT 40°C AND VARIABLE LOADING TIME

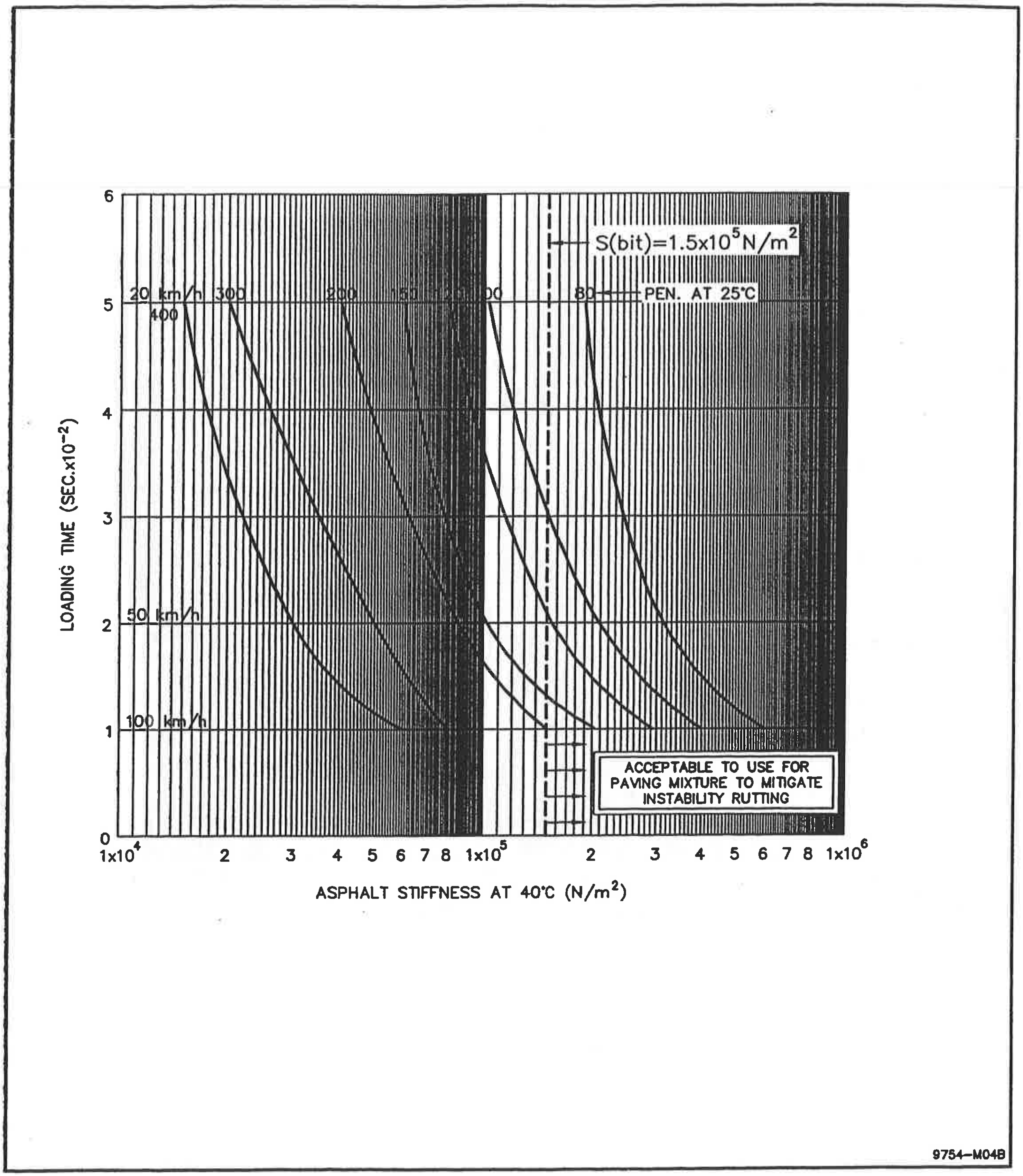


FIGURE 4 STIFFNESS OF CGSB TANK ASPHALTS (GROUP B) AT 40°C AND VARIABLE LOADING TIME

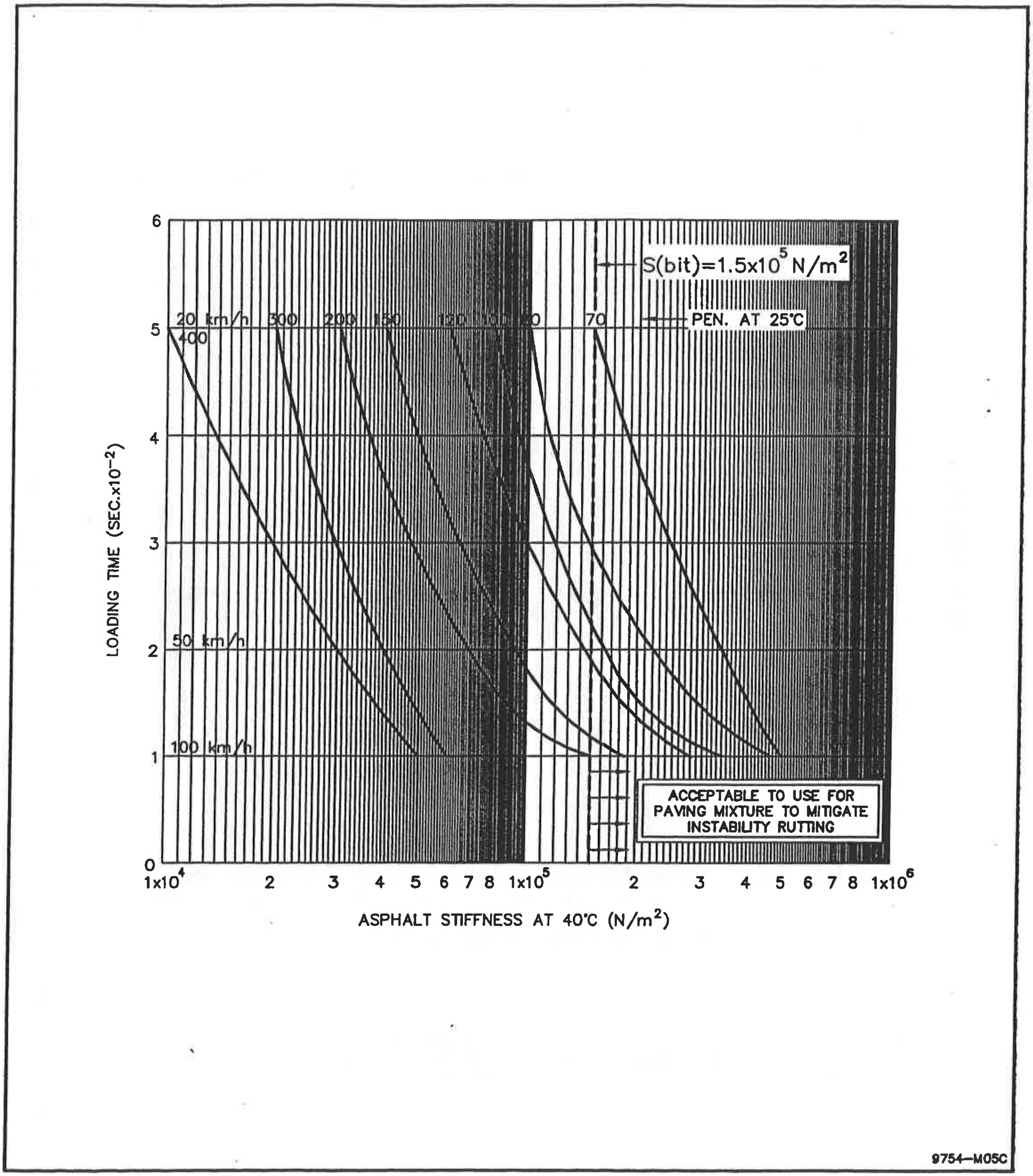
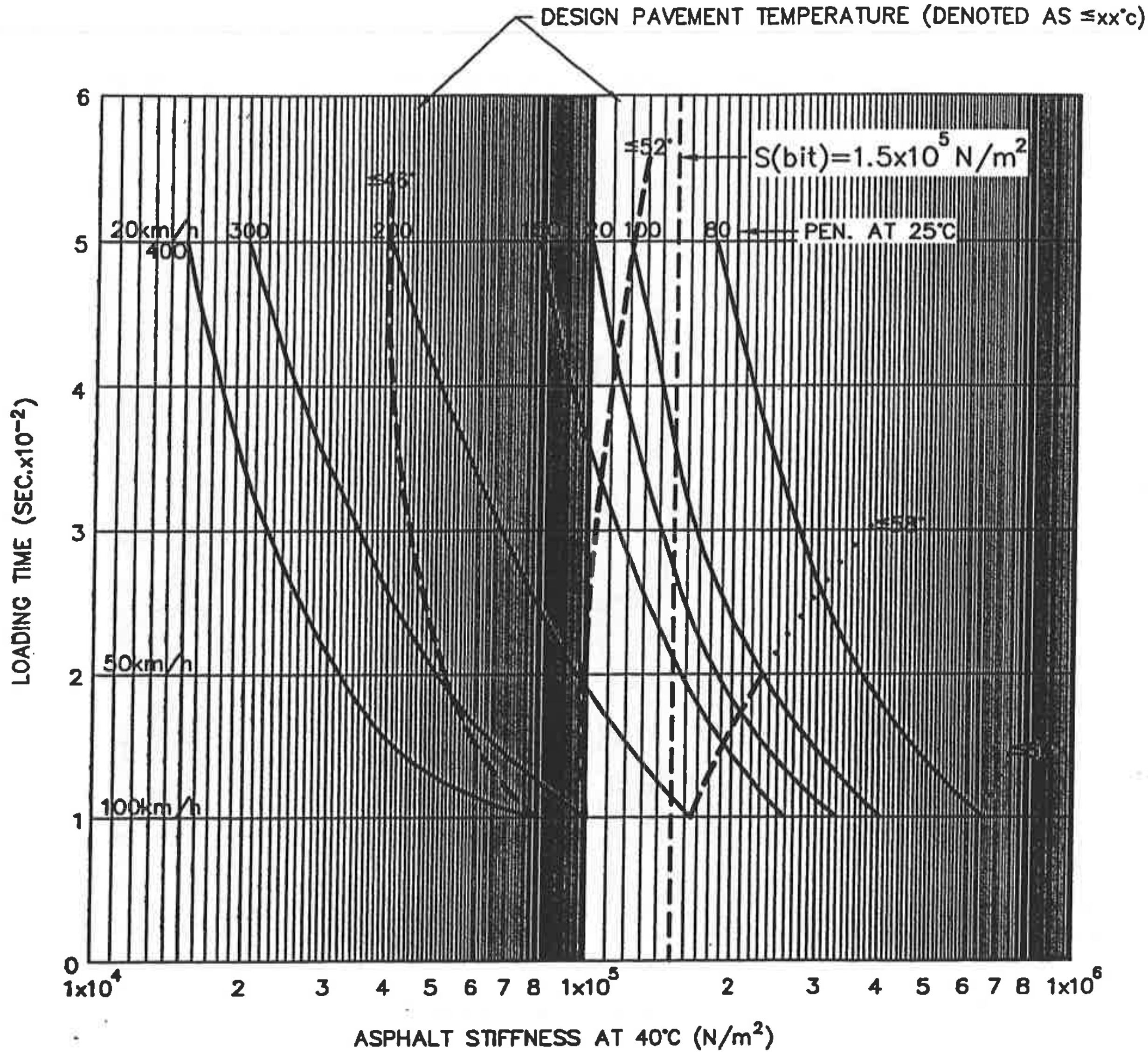


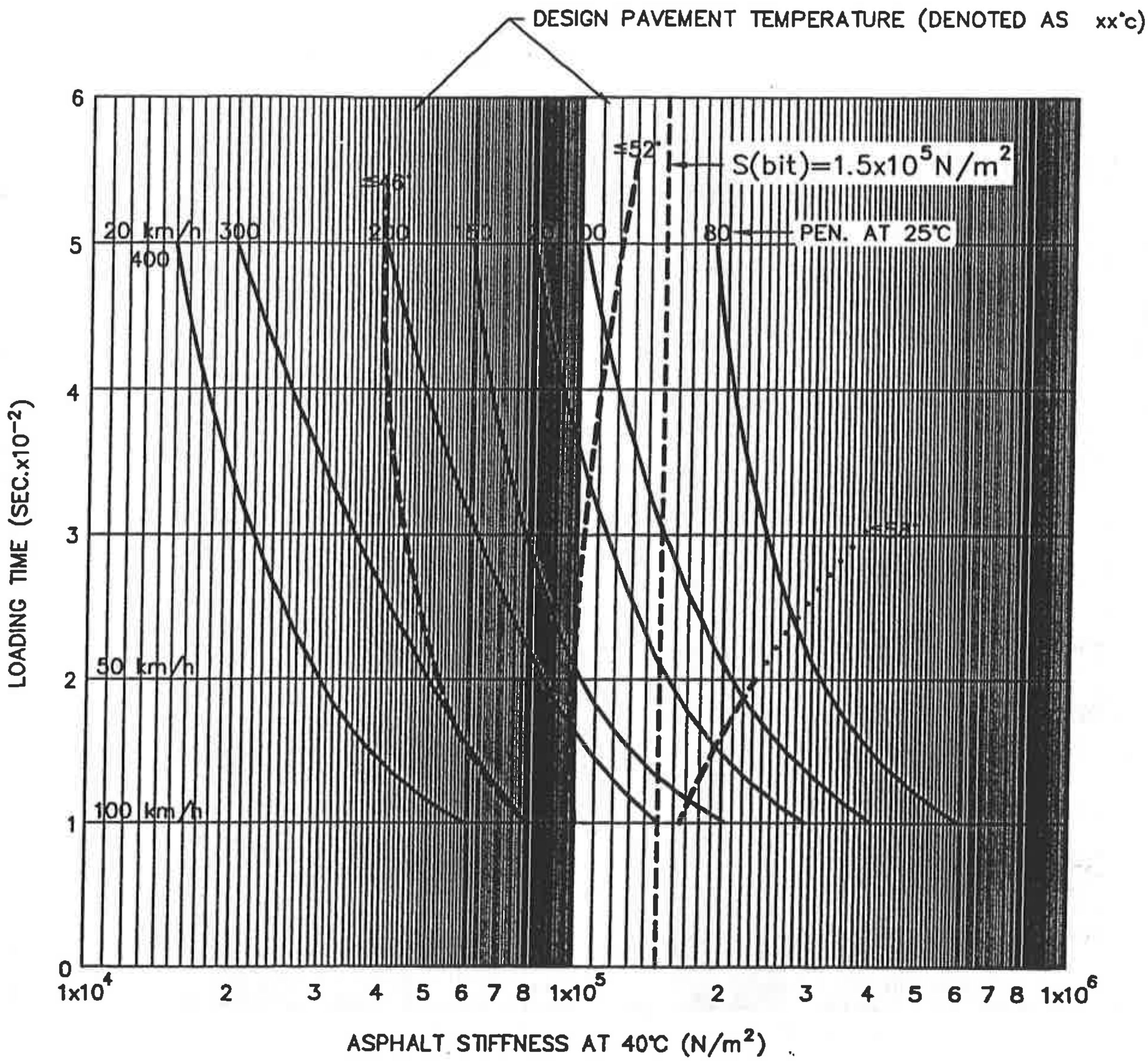
FIGURE 5 STIFFNESS OF CGSB TANK ASPHALTS (GROUP C) AT 40°C AND VARIABLE LOADING TIME



Notes: 1) *Service conditions that prevail where the heavy lines are plotted (• • • • •) would have to be satisfied using a modified asphalt binder.*
2) *Section 7.0 should be read in conjunction with this Figure.*

9754–M06D

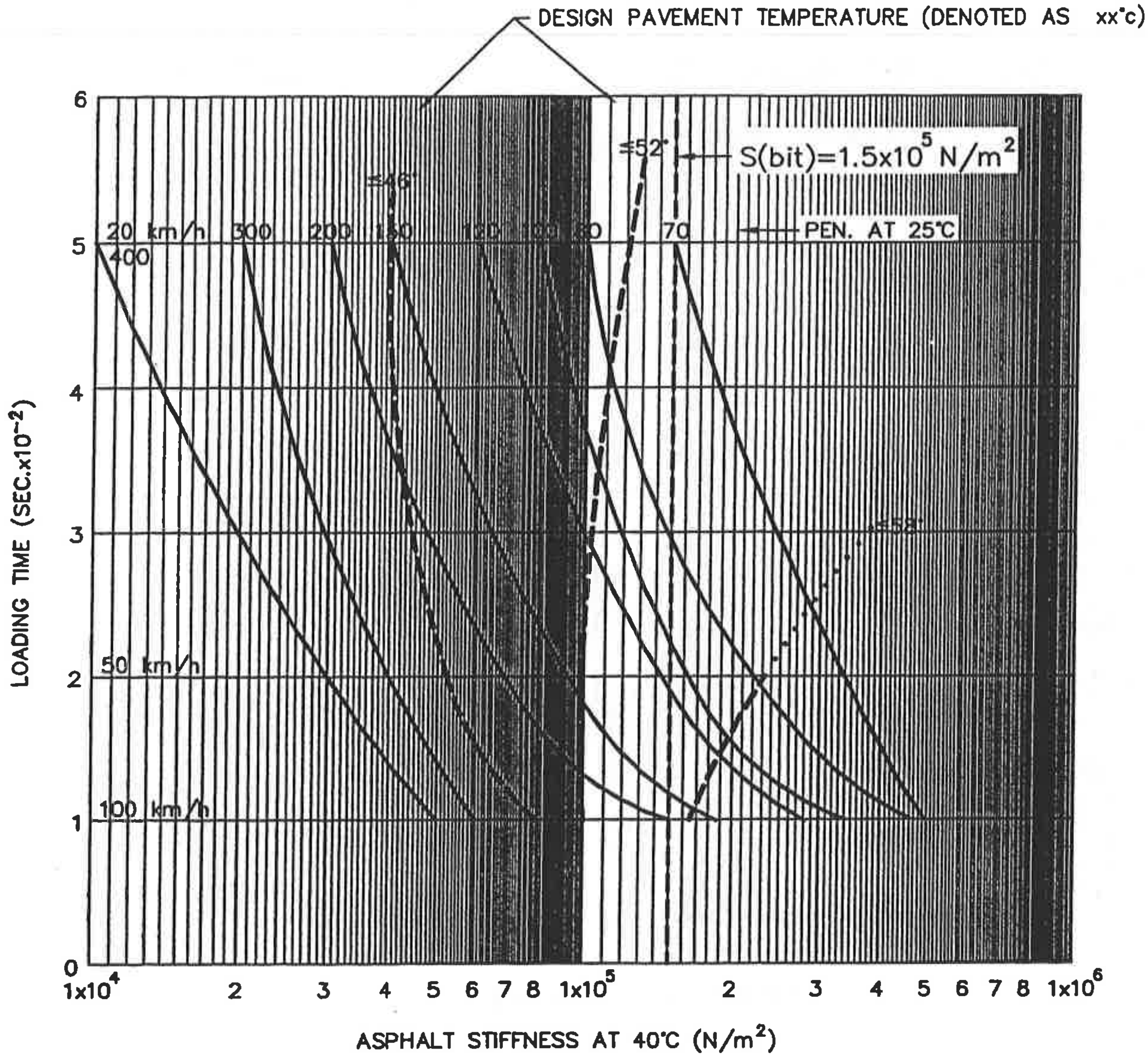
FIGURE 6 CGSB GROUP A ASPHALTS WITH MAXIMUM DESIGN PAVEMENT TEMPERATURE ISOTHERMS SUPERIMPOSED



Notes: *1) Service conditions that prevail where the heavy lines are plotted (• • • • • •) would have to be satisfied using a modified asphalt binder.*
2) Section 7.0 should be read in conjunction with this Figure.

9754–M07C

FIGURE 7 CGSB GROUP B ASPHALTS WITH MAXIMUM DESIGN TEMPERATURE ISOTHERMS SUPERIMPOSED



Notes: *1) Service conditions that prevail where the heavy lines are plotted (• • • • • •) would have to be satisfied using a modified asphalt binder.*
2) Section 7.0 should be read in conjunction with this Figure.

9754–M08C

FIGURE 8 CGSB GROUP C ASPHALTS WITH MAXIMUM DESIGN TEMPERATURE ISOTHERMS SUPERIMPOSED

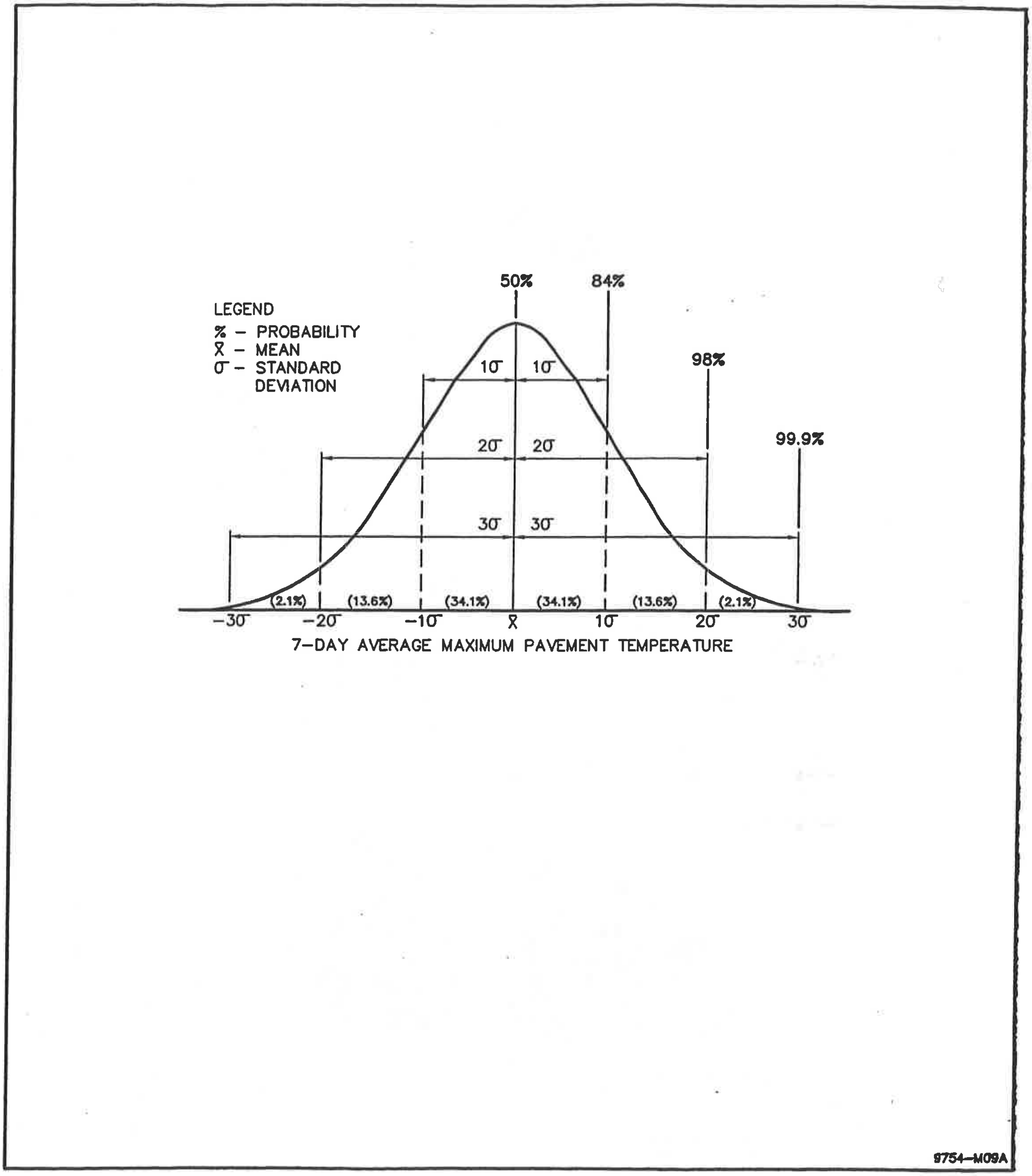


FIGURE 9 NORMAL DISTRIBUTION CURVE

Note: *This figure is for illustration pupose only and should not be used to estimate Project Specific Design Temperatures*

R9754M10A

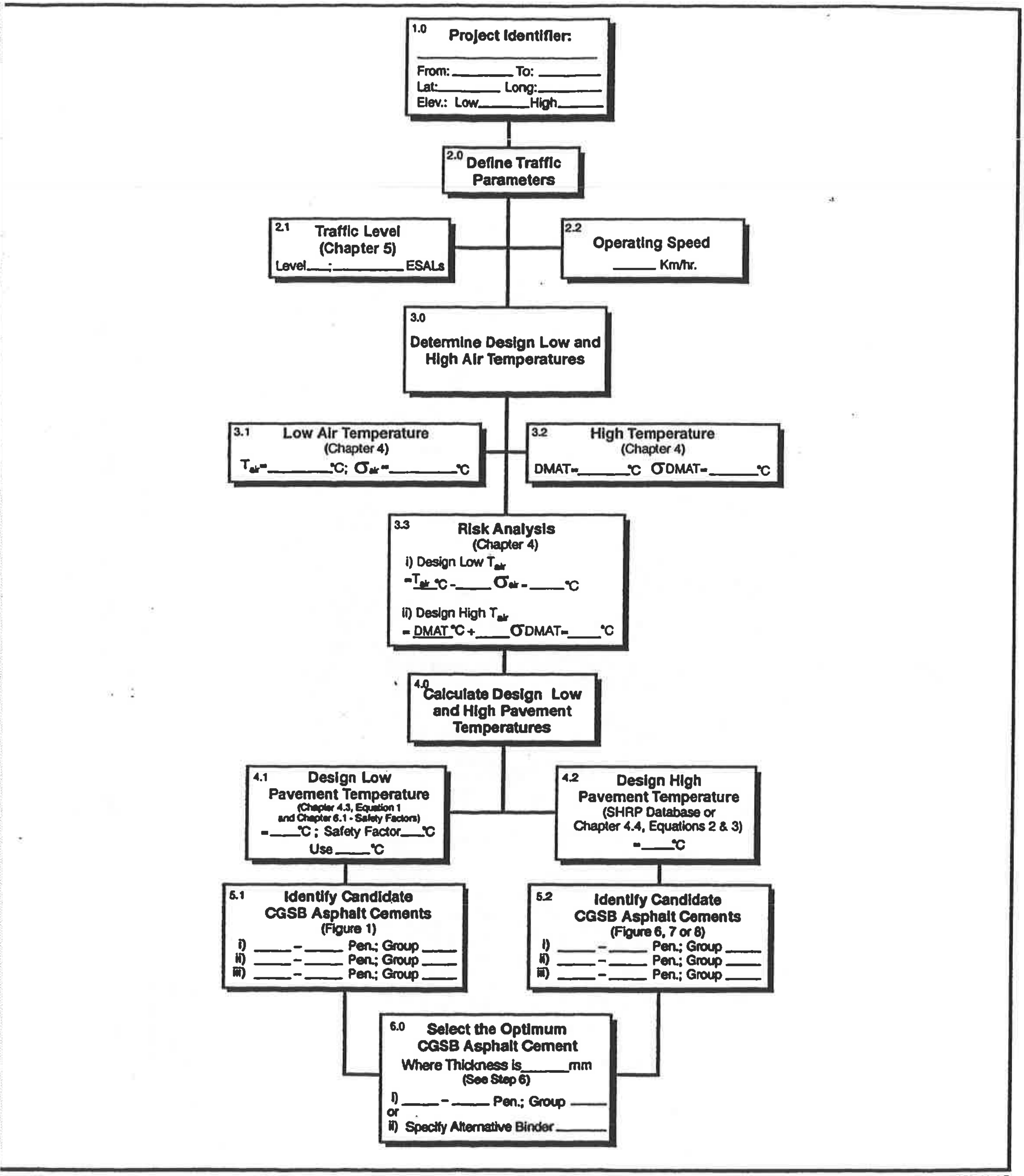
FIGURE 10 MINIMUM DESIGN AIR TEMPERATURE/ISOTHERMS (T_{air} - 2 σ_{air})

Note: See Section 4.1 for Definitions of T_{air}, σ_{air}

Note: This figure is for illustration pupose only
and should not be used to estimate
Project Specific Design Temperatures

FIGURE 11 MAXIMUM DESIGN AIR TEMPERATURE ISOTHERMS (DMAT+ 2σDMAT)

Note: See Section 4.1 for Definitions of DMAT and σDMAT



R9754M12G

FIGURE 12 FLOW CHART FOR SELECTION OF ASPHALT BINDER