INTERIM GUIDE TO PREDICTION OF PAVEMENT MOISTURE FOR STRENGTH ASSESSMENT OF GRANULAR BASECOURSE AND SUBBASE MATERIALS

1. INTRODUCTION

The strength of a soil is dependent on its moisture content, density and confinement. The control of pavement moisture is an essential prerequisite to reliable moisture prediction and satisfactory pavement performance. In this road note, guidelines are presented for the selection of moisture and density conditions for strength assessment of both base and sub base course materials for sealed roads by either Californian Bearing Ratio (CBR) or Western Australian Confined Compression Test (WACCT). These guidelines deal with a range of field drainage conditions including methods for identifying and avoiding inverted permeabilities between pavement layers and the subgrade likely to cause perched water conditions. They indicate that by avoiding permeability inversions between pavement layers and the subgrade in a moisture deficit climate the seasonal wetting effect about the outer wheelpath can be considerably reduced, thus enabling the use of thinner pavements and non standard materials.

The interim nature of the guidelines, in particular the selection of design moisture content, is stressed. This report represents the state of knowledge at this stage in time. The prediction of moisture is based on classifying pavements into one of four basic design units related to the major modes of moisture entry. One of these design units is based on Wallace and Leonardi’s infiltration theory, which has yet to be verified for pavement conditions in Western Australia. Another (design unit 3) is expected to be refined to facilitate more accurate prediction. Despite these deficiencies the road note provides for considerably more accurate moisture prediction than was possible in the past.

2. DESIGN MOISTURE CONTENT

Of the several factors, which affect the strength of a granular material, moisture content is usually the most important. It is essential therefore, when assessing the potential of a soil to perform as a base or subbase that its design moisture content is equal to the highest moisture content that the material will be required to sustain during the life of the pavement.

Because of climatic and geological conditions in Western Australia, low design moisture contents, which permit the use of natural materials and thin pavements, are often possible. Commonly equilibrium moisture conditions under a sealed area are significantly lower than modified optimum moisture content (OMC) hence pavement material strengths are high and unsaturated CBR thickness design is applicable. This road note describes the selection of design moistures for this condition and provides guidelines for the control and prediction of moisture for those circumstances where this condition would not otherwise apply. It also deals with situations affected by ground and flood waters.

The presentation is given under four pavement design units based on major modes of moisture entry. Figure 1. The first unit relates to well drained (internal and external) low water table, non-inverted permeability pavement structures that are presented as the normal design goal for much of the state. The second design unit relates to well drained structures, but with perched water table potential due to a permeability inversion between pavement layers or the subgrade. The third unit relates to high water table or moisture surplus situations and the fourth to pavements over very high water table levels or subjected to inundation causing saturated pavement conditions.
In some circumstances the simplified approach of classifying pavement structures into four categories may require adjustment based on local experience and common sense.

Throughout, the assumption is made that adequate dry back has been achieved prior to priming or sealing and that no significant quantities of soluble salts are present in the pavement materials. Where relatively high salt contents occur, depending on overall circumstances, a more conservative design may need to be adopted, here again local experience should be used as a guide.

Generally when selecting the design moisture condition, consideration of moisture control strategies will be involved. For each control strategy and its associated design moisture condition there will be costs and risks. The ultimate design will need to involve an iterative procedure assessing and comparing the costs and risks of applying different moisture control strategies.

3. MOISTURE DESIGN UNIT I - WELL DRAINED PAVEMENT STRUCTURE

Design unit 1 is defined as a pavement structure not significantly affected by groundwater, stormwater, and atmospheric water or perched water.

3.1 Attributes
- Deep water table
- Good external drainage
- Dry moisture deficit climate
- No permeability inversion

3.1.1 Deep Water Table

The depth of the water table below the pavement for the former to have negligible effect on design moisture contents will depend on the material type. Generally, this depth needs to be greater than 6 m in clays, 3 m in sandy clays or silts and 1 m in free draining sands. The highest seasonal position must be taken for design purposes. Temporary water tables which may be caused by seepage from surrounding landforms adjacent to the road, (e.g. sidling formations) or for any other condition resulting in an elevated water table must be considered. Where a significant temporary high water table is expected, design unit three must be referred to for assessment of design moisture content (DMC).

3.1.2 Good External Drainage

All factors affecting external drainage must be assessed. These include level of the road above surrounding country and the effectiveness of the seal, table drains, catch drains, culverts, etc. A high formation in itself is not sufficient to guarantee having good external drainage. All the other components contributing to efficient external drainage must be present with a low risk of being negated. The pavement must be sufficiently impermeable to prevent significant water entry during rain and when water is draining away.

3.1.3 Dry Moisture Deficit Climate

A moisture deficit climate is defined in this road note as one in which for four consecutive months the monthly precipitation does not exceed the monthly potential evaporation. In all but a small part of the state (see map figure 2) this condition prevails. For those areas of the State with a non moisture deficit climate, that is a moisture surplus, the procedures described in Section 5 (design unit 3) should be used.
3.1.4 No Permeability Inversion

A no permeability inversion condition is essential for good internal drainage and is obtained by having the permeability of the pavement and subgrade layers at least equal or increasing with depth. For example, the permeability of the subbase must be equal or greater than the base and the subgrade must be equal or greater than the permeability of the subbase in a three layered system. To determine this, it is necessary to assess or measure the permeabilities of the pavement and subgrade layers.

3.2 Calculation of Design Moisture Content

3.2.1 The statewide moisture investigation carried out between 1969 and 1979 was used as a basis to develop the pavement moisture prediction model represented by equation 1. This data was reanalysed by processing information only from pavements that appeared to conform to Design Unit 1 category. The resulting prediction equation 1 gave a coefficient of variation of 0.15. This degree of reliability can only be expected when equation 1 is applied to pavement structures conforming to pavement design unit 1 category.

\[
MC = 0.70(OMC) + 0.29(AR - PE) + 0.58\left(\frac{P_{0.425}}{P_{0.075}}\right) - 0.02P_{2.36} \quad \ldots(1)
\]

Where

- \(MC\) = Predicted pavement moisture content in outer wheelpath %
- \(OMC\) = Optimum Moisture Content %
- \(P_{2.36}\) = % finer than 2.36 mm
- \(P_{0.425}\) = % finer than 0.425 mm
- \(P_{0.075}\) = % finer than 0.075 mm
- \(AR\) = Annual rainfall (m) - refer to fig 3
- \(PE\) = Potential evaporation (m) - refer to fig 4

It is necessary to incorporate a statistical factor of safety so that there is only a small probability that the moisture content will be exceeded. It is suggested that this probability should be limited to 15% and the design moisture content should be calculated using the following formula:

\[
DMC = MC \times \left[1 + 1.04(CV)\right] \quad \ldots(2)
\]

Where

- \(CV\) = the coefficient of variation (0.15)
- \(DMC\) = Design Moisture Content

3.3 Limitations

Implicit in the estimation of DMC using equations 1 and 2 is the assumption that the distance from the edge of seal to the outer wheel path exceeds the lateral movement of infiltrating water due to matric suction. For materials with high matric suction, i.e. high PI and/or high fines content (see equation 3) then part width shoulder sealing may be necessary to ensure that this assumption is applicable.
4. MOISTURE DESIGN UNIT 2 - PAVEMENT STRUCTURE HAVING A PERMEABILITY INVERSION

Moisture design unit 2 is defined as a pavement structure significantly not affected by groundwater, stormwater or atmospheric water but significantly affected by perched water due to a permeability inversion. This category is equivalent to unit 1 in all respects except that it has a permeability inversion.

4.1 Attributes
- Deep water table
- Good external drainage
- Dry moisture deficit climate
- Permeability inversion

The first three attributes are the same as for design unit one. The fourth attribute is described in paragraph 4.2.

4.2 Permeability Inversion

A permeability inversion exists when the permeability of the pavement and subgrade layers decreases with depth. Under infiltration of rainwater, there is a potential for moisture accumulation at the interface of the layers. The creation of a perched water table which could lead to shoulder saturation and rapid lateral wetting under the seal may occur. This may lead to base or subbase saturation in the outer wheel path (OWP) and result in catastrophic failure of the base layer when trafficked.

The likelihood of shoulder saturation and the extent of lateral wetting may be estimated by using a model developed by Wallace and Leonardi (1975). This model involves the calculation of what is termed the characteristic time \( T_C \), which is the duration of rainfall of sufficient intensity, \( R_s \), before rapid lateral wetting under the seal will commence, given a relatively impervious lower layer. It represents the shortest time of rainfall which will bring the shoulder layer to saturation. By comparing \( T_C \) with rainfall intensity and duration data the probability of moisture problems and estimates of the extent and degree of lateral wetting may be made.

4.3 Calculation of Design Moisture Content

The following procedure should be used when a permeability inversion has been confirmed by measurement of layer permeabilities (i.e. laboratory testing of compacted specimens of proposed subgrade and base or field testing in the case of an existing road).

4.3.1 Data Required

To analyse a pavement moisture problem having a permeability inversion the following data needs to be obtained by measurement or by estimation when necessary.

\[
\begin{align*}
D & \quad \text{Thickness of shoulder layer in mm} \\
D_p & \quad \text{Depth of water ponding on the shoulder in mm} \\
\theta_i & \quad \text{Initial volumetric moisture content} \\
\theta_r & \quad \text{Volumetric moisture content of (re)saturated soil (i.e. the saturation moisture content adjusted for air trapped in the voids)}
\end{align*}
\]
Fillable pore space ($\theta_r - \theta_i$)

$PB_w$  Matric suction at (re)saturated moisture content, $\theta_r$

$K_r$  Permeability m/s (Resaturated Hydraulic Conductivity)

$D_{10}$  Particle size (mm) which 10% of the soil mass is finer than.

$D_{60}$  Particle size (mm) which 60% of the soil mass is finer than.

$P_{0.075}$  % finer than 0.075 mm

$MDD$  Modified maximum dry density t/m$^3$

$d$  Particle density t/m$^3$

$n$  Porosity $= \frac{1-MDD}{d}$

(a) Depth of Water Ponding ($D_p$) mm

For a well maintained shoulder $D_p$ will be zero. For a degraded shoulder, where water ponding continues after rain, the depth of ponding must be measured or estimated. In the absence of more specific data a value of 10 mm may be used.

(b) Matric Suction ($PB_w$) mm

The matric suction at (re)saturation moisture content relates to the capillary moisture suction characteristics of the pavement material during infiltration conditions.

This parameter may be determined either by measurement or derived from Particle Size Distribution data using the following relationship given by Wallace and Leonardi (1976):

$$PB_{w\text{approx}} = \frac{15}{D_{10}} \text{ to } \frac{25}{D_{10}}$$  \hspace{1cm} (3)

Typical values of $PB_w$ for base course materials will vary from about 50 mm for sandy gravels to 600 mm for clayey gravels.

(c) Permeability ($K_r$) m/s

This parameter is critical and should be measured on compacted specimens of proposed materials or field tested in the case of an existing road.

A formula exists for the calculation of $K_r$ however it is not accurate and should only serve as a rough guide.

Calculation of $K_r$:

$$K_r = \frac{2.192(D_{10})^{1.478}(n)^{6.654}}{(P_{0.075})^{0.597}}$$  \hspace{1cm} (4)
Measured field values of permeability for some Western Australian base course materials have been reported by Skender and Leach (1988).

Typical values of $K_r$ for granular base course materials will range from $5 \times 10^{-6}$ (relatively permeable) to $5 \times 10^{-8}$ m/s (relatively impermeable).

(d) Fillable Pore Space ($f$)

The fillable pore space is the difference between the volumetric moisture content of the (re)saturated soil ($\theta_g$) and the initial volumetric moisture content ($\theta_i$).

$$f = \theta_g - \theta_i$$

Where measured values are not available, $\theta_g$ may be assumed to be equal to the 5% air voids value.

i.e. $\theta_g = n - 0.05$

Typically $f$ will range from 0.2 to 0.3.

The initial volumetric moisture content $\theta_i$ may be measured or estimated but for many calculations the hydroscopic moisture content will suffice. Typically this will range from 0.05 to 0.15.

Note: volumetric moisture content = $\%$ moisture by mass $\times$ MDD

4.3.2 Calculation of $T_C$

(a) Determine or estimate necessary start data (4.3.1).

(b) Determine $\beta$, using the relationship:

$$\beta = \frac{D}{D_p + PB_w} \quad \ldots (5)$$

(c) Determine $\alpha$:

Input the value of $\beta$ into the Green and Ampt graph (figure 5) and obtain the non-dimensional time parameter $\alpha$

(d) Determine $T_C$ using the relationship:

$$T_C = \frac{\alpha \times f \times D}{K_r \times 1000} \quad \ldots (6)$$

4.3.3 Calculation of $R_S$

Calculate the sufficient intensity rainfall rate ($R_S$) in mm/hr, which will impinge sufficient water on the shoulder to satisfy the maximum shoulder infiltration rate as follows. The appropriate rainfall concentration factor must be selected to take into account the catchment effect of the sealed area. In the absence of more specific data, a concentration factor of 10 may be used.
(a) Calculate the water depth $W$ in mm that needs to impinge on the shoulder to bring the shoulder from its initial moisture condition ($\theta_i$) to (re)saturation ($\theta_r$).

\[ i.e. \ W = f \times D \ (mm) \]

(b) Calculate the rainfall depth ($R_d$) considering the total catchment area, sealed and unsealed, which will provide the depth $W$ of water at the shoulder.

\[ i.e. \ R_d = W / \text{catchment rainfall concentration factor} \]

(c) Calculate the actual rainfall intensity rate ($R_s$) in mm/hr, which will provide the above required amount of water in time $T_C$.

\[ i.e. \ R_s = R_d / T_C \ mm/hr \]

4.3.4 Comparison with Rainfall Duration Data

(a) Enter $R_s$ into rainfall intensity diagram for the site concerned. The recurrence interval should be selected on circumstances taking into consideration class of road, consequences of failure, acceptance of risk etc. Rainfall intensity diagrams are available from the Bureau of Meteorology or may be generated using the program DRAROUT V.2.

(b) Determine the rain duration $T_D$ (hours) for which $R_s$ will fall, over the design life of the pavement.

(c) Compare $T_D$ with $T_C$.

(d) If $T_C$ exceeds or is equal to $T_D$ the shoulder is relatively impermeable for the given climate and the presence of an inversion will not cause a pavement moisture problem.

(e) If $T_C$ is less than $T_D$ determine the moisture infiltration profiles for the parameters concerned. Use "THEWET" or standard moisture infiltration profiles, which may be obtained from Wallace and Leonardi (1976). Appendix A contains some examples of moisture infiltration profiles. The likely event of wetting up should be assessed in accordance with para 4.3.5.

4.3.5 Assessment

The moisture infiltration profiles will show the extent of wetting up for various multiples of $T_C$ and enable the pavement moisture condition at any distance from the seal edge to be estimated for any multiple of interest. Two profiles will usually be of particular interest. The first relates to that multiple of $T_C$ given by $T_D / T_C$, which can be used to determine the maximum likely extent of lateral saturation over the pavement design life. The second relates to the multiple of $T_C$ required to saturate to a given distance, for example 0.3 m in from the seal edge. This can be used to estimate the frequency of the occurrence over the design life by reference to the rainfall intensity diagram.

It should be remembered that $T_C$ is the shortest period of rainfall in which shoulder saturation can occur. Saturation can also occur over longer periods of lesser intensity rainfall or from closely spaced multiple rainfall events. This data cannot be extracted from the rainfall intensity diagrams and local knowledge and judgment will have to be exercised when predicting pavement moisture conditions from the infiltration profiles in these circumstances.

If the pavement moisture condition predicted using the moisture infiltration profiles and rainfall data is not acceptable (i.e. base or subbase strength are inadequate at this moisture) then consideration should be given to the following method of modifying the moisture environment and the most cost effective option selected.
4.3.6 Modification of Moisture Environment

(a) Eliminate Permeability Inversion
- Change base and/or subgrade infiltration properties
- Change materials (select from different pits, areas, etc)
- Modify permeability by use of appropriate construction technique, chemicals, etc

(b) Modify T_C (Minimise extent of wetting front)
- Reduce permeability of shoulder
- Change geometry of pavement, subgrade
- Increase shoulder/base thickness

(c) Shift Wetting Zone
- Seal shoulders

(d) Minimise Effect of Water
- Stabilise base

(e) Intercept Wetting Front
- Install subsurface drains
- Install permeable shoulder/subbase layer
- Install vertical membrane

Considering the most cost effective option for the circumstances, repeat the above steps inputting the changed soil and/or pavement parameters. If the result indicates a no inversion condition, refer to design unit 1 for determination of DMC.

If an inversion cannot be avoided, still select the most cost effective option and proceed to determine the DMC appropriate to the OWP.

5 MOISTURE DESIGN UNIT 3 - HIGH EFFECTIVE WATER TABLE

Moisture design unit 3 is defined to include pavement structures in a moisture surplus climate or those significantly affected by high water table but not inundation. Where a moisture surplus climate does not result in a high base moisture content, for example a pavement over well drained sands then that pavement should be considered in design unit 1 rather than design unit 3. In all cases local experience should be used in addition to these general guidelines.

5.1 Attributes
- Moisture surplus climate
- High water table.
- Good external drainage
- No permeability inversion
5.1.1 Moisture Surplus Climate

A moisture surplus climate that is, a non moisture deficit climate is defined in this road note as one in which for four consecutive months the monthly rainfall exceeds the monthly potential evaporation. In these areas (ref map fig 1) seasonal moisture influences can affect the pavement about the outer wheelpath.

5.1.2 High Water Table

It is generally accepted that water table will significantly affect pavement moisture if the highest water table level is less than 6 m below subgrade in clays, 3 m in sandy clays or silts and 1 m in free draining sand. For water tables less than 0.5 m below the subgrade level the pavement has a high risk of being saturated and the design should follow design unit 4 recommendations.

The highest seasonal ground water level and any other significant temporary water table levels shall be assessed. Temporary high water levels may be caused by seepage from surrounding land forms or dams adjacent to the road or from any other source resulting in free water ponding alongside, under or near the road for a significant period of time. This time will depend on the suction and permeability characteristics of the subgrade and base materials.

5.1.3 Good External Drainage

Basically the same conditions apply as given in paragraph 3.1.2 for design unit 1. However, if the good external drainage is negated by rising water table level, due to whatever cause, to the extent that it exceeds the condition described in 5.1.1, then the DMC should be determined as per design unit 4.

5.1.4 No Permeability Inversion

A no permeability inversion condition in a pavement structure is one having the permeability of the pavement and subgrade layers at least equal or increasing with depth. If a permeability inversion is suspected the action outlined for design unit 2 should be considered.

5.2 Design Moisture Content

Although in theory moisture conditions could be calculated for specific depths to water table and from moisture conditions of in situ local materials, most pavements in this design unit will be subject to seasonal variation of moisture in the outer wheel path. The highest moisture content which occurs should be used for design. For practical purposes this will usually equate to the OMC. This figure should be used as the DMC (i.e. DMC = 100% of OMC) unless local experience indicates otherwise.

6 MOISTURE DESIGN UNIT 4 - CONDITIONS LEADING TO PAVEMENT SATURATION INCLUDING FLOOD CROSSINGS

This pavement design unit includes pavement structures subject to water table levels less than 0.5 m below the subgrade or inundation leading to base and subgrade saturation about the outer wheelpath (OWP). The period of very high water table level or inundation to cause base saturation in the OWP will depend on material properties and each case will need to be individually assessed.

Where base saturation occurs base material selection criteria must take into account material performance under development of pore pressures. Pavement material modification such as stiffening by stabilisation or providing a coarse open structure may be necessary to accommodate saturated repetitive loading conditions.
Base saturation often leads to subgrade saturation and the necessity for pavement thickness design to cater for saturated subgrade conditions.

7 DRY DENSITY RATIO

The density at which material strength is evaluated should be compatible with the compaction specification for the pavement layer in which it is to be used.

MRWA has adopted a statistically based specification of the form:

\[ R_C = (0 - ks) \geq L \]  

Where \( R_C \) = (referred to as) the characteristic dry density ratio  
\( k \) = is a multiplier  
\( 0 \) = the average dry density ratio within a lot  
\( s \) = the standard deviation of dry density ratio tests in a lot  
\( L \) = the specification limit

A more detailed discussion of the principles upon which this type of specification is based is presented in Engineering Road Note 8.

The suitability of a pavement material in terms of strength should be evaluated at a density corresponding to the specification limit (L).

In the absence of more site-specific data the values listed in Table 1 are recommended:

<table>
<thead>
<tr>
<th>WORKS COMPONENT</th>
<th>MATERIAL TYPE</th>
<th>SPECIFICATION LIMIT (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-bases</td>
<td>Aeolian Calcarenite</td>
<td>94.0</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>94.0</td>
</tr>
<tr>
<td>Base Course</td>
<td>Natural Gravel</td>
<td>95.0</td>
</tr>
<tr>
<td></td>
<td>Crushed Rock Base</td>
<td>98.0</td>
</tr>
</tbody>
</table>

* The limit L refers to dry density ratios determined in accordance with Test Method WA 133.1 (Modified Compaction)

8 EFFECT OF CONSTRUCTION TECHNIQUE

The use of design moisture content and dry density ratio is to some extent an oversimplification. Soil granular structure is affected by moulding moisture content as well as density and soil strength is related to soil suction and moisture content. The relationship between soil suction and moisture content is not unique but is a function of the wetting and drying history of the material.

A soil sample prepared at a high moisture content \( M_1 \) and dried back and tested at a moisture content \( M_2 \) is likely to give a higher strength result than a sample of the same soil prepared and tested at moisture content \( M_2 \).
Advantage may be taken (of this potential strength gain) in the field, in regions where the design moisture content is less than the moisture content to be used during field compaction. However, if this potential strength gain is to be mobilised, it is essential that the works procedure adopted include a "drying back" phase in the operations prior to placement of the primerseal. Control over the compaction moisture content is also necessary.

Both the moulding moisture content and the type of compaction used can affect soil structure and therefore permeability of the compacted material. Generally the higher the moulding moisture and greater the remoulding effect of the compaction process on the soil the greater the potential change in soil structure and permeability. The latter may change by one order of magnitude for a 2% change in moulding moisture. Similar changes in permeability may also result from the use of soil dispersants, however, this area has yet to be developed.

9. STRENGTH ASSESSMENT PROCEDURE

The WACCT (Test Method WA 142.1) is preferred for the strength assessment of base materials. As moisture sensitivity is an important selection criteria, tests should be carried out over a range of moisture and density conditions. The class number and other criteria should be assessed by interpolation to the design moisture content (DMC) and density. Consideration also needs to be given to the likely effect on strength if wetting up in excess of the DMC should occur when the material is in service. This consideration should be related to the class of road and the confidence held in the value of the predicted DMC.

Where the potential strength gain through drying back is to be assessed the following procedure should be used:

- Prepare sets of WACCT specimens at optimum moisture content to a range of density values.
- Extrude the specimens from the mould and allow to dry to a range of moisture contents.
- Cure the specimens to a uniform moisture content for three weeks under an airtight plastic membrane then test.
- Interpolate to obtain the strength at the design moisture content and density conditions.

Dry back should only be considered in assessment where there is confidence that the material in the field will be dried back from the construction moisture content to the DMC prior to sealing and will not rewet beyond the DMC.

Where the CBR (Test Method WA 141.1) is used to evaluate base course material, it is generally prudent to carry out the test under soaked conditions. However where highly favourable conditions exist, i.e. design unit 1 with sealed shoulders in an arid environment, then consideration may be given to evaluating CBR at OMC. Subbases may be evaluated at a DMC determined in accordance with this note.

It should be noted that satisfying criteria for soaked CBR is not enough to guarantee pavement performance if the base course becomes saturated. The CBR is a static test, which does not take into account the repetitive loading and pore pressure that develops under real traffic loading conditions. No unbound base material can perform when saturated except under very light traffic even if its soaked CBR value exceeds 80. Reported uses of unmodified base course materials performing satisfactorily in floodways can be attributed to the fact that the material did not wet up to saturation in the limited time it was subject to inundation.
10. CONCLUDING REMARKS

Moisture is the most important single parameter determining pavement performance. Moisture control is the key factor in reliable moisture prediction and design of economic thin pavements using natural materials. The prime factor for proper moisture control is good drainage. This includes all aspects of drainage both external and internal as detailed in section 3. Permeability is an important component in moisture control both to prevent internal drainage problems and wetting up from external temporary water sources. Western Australia's climate and geology permits design and construction of low moisture content pavements provided attention is paid to proper drainage and this allows substantial economies. Failure to achieve adequate drainage can lead to saturated base course conditions, which will require the expensive step of stabilisation to guarantee performance.

REFERENCES:

MRWA (1987): "Statistically Based Quality Control for Density Road Construction "Engineering Road Note 8" MRWA, PERTH.


FIGURE 1: MODES OF MOISTURE ENTRY IN PAVEMENTS
Figure 2

MOISTURE SURPLUS CLIMATE
FIG. 3 AVERAGE ANNUAL RAINFALL (mm)
Source: Bureau of Meteorology (1979)
FIG. 4 ANNUAL AVERAGE EVAPORATION (mm)
(WITH 7% BIRD SCREEN CORRECTION)
Source: Bureau of Meteorology (1975)
FIGURE 5 - NON-DIMENSIONAL GREEN AND AMPT MODEL SOLUTION
APPENDIX A
MOISTURE PROFILES

The appendix gives a number of wetting front profiles for drainage conditions described in Table A1.

The profiles can be used for all base thicknesses by scaling off the distance in terms of D the pavement thickness concerned and converting this to an actual distance.

The profile case nearest to that representing the conditions under investigation should be used. Table A1 summarises the conditions covered by the profiles included.

| **TABLE A1** |
| MOISTURE PROFILES ANALYSED |
| ALL CASES BASED ON IMPERVIOUS SUBGRADE WITH 3° CROSSFALL |

<table>
<thead>
<tr>
<th>Fig No</th>
<th>Variable Studied</th>
<th>PB for Shoulder</th>
<th>Rainfall Intensity</th>
<th>Depth of Ponding</th>
<th>Duration of Rain Ponding</th>
<th>Duration of Subsequent Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Interpretation Diagram</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A2, A3</td>
<td>Standard Case</td>
<td>0.5D</td>
<td>&gt;&gt;K_r</td>
<td>-</td>
<td>16T_c</td>
<td>64 T_c</td>
</tr>
<tr>
<td>A4, A5</td>
<td>Capillary Moisture Suction</td>
<td>1.5D</td>
<td>&gt;&gt;K_r</td>
<td>-</td>
<td>16T_c</td>
<td>64 T_c</td>
</tr>
<tr>
<td>A6</td>
<td>Rainfall Intensity</td>
<td>0.5D</td>
<td>K_r</td>
<td>-</td>
<td>16T_c</td>
<td>Not presented</td>
</tr>
<tr>
<td>A7</td>
<td>Ponding on Shoulder</td>
<td>0.5D</td>
<td>-</td>
<td>0.5D</td>
<td>16T_c</td>
<td>Not presented</td>
</tr>
<tr>
<td>A8, A9</td>
<td>Ponding on Shoulder</td>
<td>0.5D</td>
<td>-</td>
<td>1.5D</td>
<td>16T_c</td>
<td>64 T_c</td>
</tr>
</tbody>
</table>

K_r  Resaturated permeability of the shoulder material
PB  Matric suction
T_c  Characteristic time
D  Base Layer thickness
FIGURE A1 - INTERPRETATION OF MOISTURE PROFILES
\( t = 0.11 \, T_C \)

\( t = 0.445 \, T_C \)

\( t = 1.0 \, T_C \)

\( t = 4.0 \, T_C \)

\( t = 16.0 \, T_C \)

FIGURE A2 - STANDARD CASE INFILTRATION
FIGURE A3 - STANDARD CASE SUBSEQUENT DRAINAGE
FIGURE A4 - CAPILLARY MOISTURE SUCTION VARIATION IN FILTRATION
FIGURE A5 - CAPILLARY MOISTURE SUCTION VARIATION
SUBSEQUENT DRAINAGE

$t = 1.0 \, T_c$

$t = 4.0 \, T_c$

$t = 16.0 \, T_c$

$t = 64.0 \, T_c$
Figure A6 - Rainfall Intensity Variation

Infiltration
FIGURE A7 - PONDING ON SHOULDER (DEPTH 0.5D) INFILTRATION
FIGURE A8 - PONDING ON SHOULDER (DEPTH 1.5D)
INfiltration

\( t = 0.11 T_C \)

\( t = 0.445 T_C \)

\( t = 1.0 T_C \)

\( t = 4.0 T_C \)

\( t = 16.0 T_C \)
FIGURE A9 - PONDING ON SHOULDER (DEPTH 1.5D) SUBSEQUENT DRAINAGE