DESIGN OF FLEXIBLE PAVEMENTS
for Low Volume Roads - IRC SP 72:2007

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MYTH

- Rural Roads Require no Design
- Rural Roads will not Have High Traffic Loads
- Iron-tyred Animal Drawn Vehicles do not Cause Significant Damage
- Rural Road Construction require no Soil and Material Investigation
- Thumb Rule Design will be Adequate for Rural Roads

CONSEQUENCE

- Considerable length of Rural Roads built every year using Resources of Different Rural Developmental Programmes fail Prematurely
Objectives of Pavement Design

✓ To provide a stable surface under the wheel loads.
✓ To provide good riding surface.
✓ To have durability.
✓ To have cost effectiveness
Problems

- **High Moisture**
  - Weak and Soft Sub-grade
  - Yielding under Heavy Wheel Loads

- **Unevenness**
  - Increased VOC
  - Discomfort
  - Fatigue
Requirements of Pavements

- Stable, Non Yielding Surface
- To limit elastic deformation
- Least Rolling Resistance
- Smooth Riding Surface
- Transfer Stresses over a Wider Area on Soil Sub-grade
- To arrest capillarity
Structural Requirements

Traffic loads
Load repetition
Climatic variables (rain, temperatures)
Environmental factors
Functional Requirements

Riding comfort
Economic operation
Safe operation
Choice of Type of Pavement

- Gravel Roads
- Flexible Pavement (BT Surface)
- Cement Concrete Pavement
FACTORS GOVERNING CHOICE OF PAVEMENT

- Initial Cost
- Rainfall and Temperature
- Type and Strength of Soil along the Alignment
- Availability of Good Aggregates
- Availability of Industrial Wastes (Fly ash, Slag etc.) in the Proximity
PRESSURE DISTRIBUTION THROUGH TYPICAL GRANULAR MATERIALS

A) LARGE BOULDER SOILING

B) LARGE SIZE STONES

C) STONE AGGREGATES
Pavement Component Layers

- Sub Grade
- Sub Base
- Base Course
- Wearing Course
Design Cross-Section of Road

(All dimensions in mm, Not to scale)
Functions of Sub-base and Base Courses

- To Provide Stress Transmitting Medium
- To Spread Wheel Loads
- To Prevent Shear and Consolidation Deformation
Functions of Wearing Course

- Seal and protect the base and provides strength at the road surface
- Transmit to the base the vertical and horizontal forces imposed by moving traffic
- Protect the pavement from moisture ingress
- Improve safety by providing a superior skid resistance surface, free from corrugations, dust and mud
- Prevent gravel loss
Factors Influencing Design

Design Traffic
Sub-grade Soil Strength
Climatic & Environmental Factors
Pavement Component Materials
Design Traffic

- Gross Wheel load, ‘P’
- Contact pressure, ‘p’
- Multiple wheel load and ESWL
- Repetition of wheel load and EWL factors
- Cumulative standard axles, CSA in msa
- Other factors - pavement width and coverage or lane distribution factor, speed etc.
1. DESIGN WHEEL LOAD
   AXLE LOAD
   Revised = 10.2 t
   Old = 8.17 t

2. TYRE INFLATION PRESSURE
   1.2 – 7 – 14 Kg/Sq.Cm
3. TOTAL LOAD

4. ESWL

- Up to d/2
  - independent, P

- Beyond 2s
  - overlap, Single load 2P

- In Between
  - Interpolate

Vertical Stress Kg/Cm

Bullock cart

Truck

LOG DEPTH

LOG LOAD

Depth-Cm

2P

P

1.8t

36t
Design Traffic as per IRC SP20:2002

- Traffic is evaluated in terms of number of Commercial Vehicles Per Day (CVPD).
- Design Curves A, B, C, D for different categories of traffic namely 0-15, 15-45, 45-150 and 150-450 CVPD.

Limitations:
- Categorization of Commercial vehicles include heavy commercial vehicles like trucks or full size buses, light commercial vehicles like tractors, tractor trailers, pick up vans, mini buses and tempos.
- No distinction made between laden, unladen and overloaded vehicles.
Design Traffic as per IRC SP72:2007

- Traffic intensity in terms of cumulative 80kN (8.16 tonnes) Equivalent Standard Axle Load (ESAL) applications during the design life.

- For Low Volume Roads the maximum ESAL considered is 1 million in its design life.
Estimation of Design Traffic

- **New Roads**: Carry out traffic counts on an existing road, preferably in the vicinity with similar conditions.

- **Upgradation / Rehabilitation of Existing Roads**: actual traffic counts on existing road.
  - 3 day count, both during peak harvesting season and also during the lean season for various vehicle types
  - Carry out classified Traffic Volume Count with laden and unladen categorization for motorized commercial vehicles of gross laden weight of 3 tonnes and above.
Annual Traffic = \( T \times 365 + 2nT \cdot [0.6 \, t] \)
Average Annual Daily Traffic (AADT) = \( T + \frac{1.2nTt}{365} \)
Equivalency Factor = \((W/W_s)^4\)

\(W = \) Single axle load (in KN) of the rural vehicle

\(W_s = \) Single axle load of the Standard Commercial Vehicle (Generally Taken as 80KN)
## Equivalency Factors for different Axle Loads

<table>
<thead>
<tr>
<th>Axle Load (Tonnes)</th>
<th>kN</th>
<th>Equivalency Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>29.4</td>
<td>0.02</td>
</tr>
<tr>
<td>4.0</td>
<td>39.2</td>
<td>0.06</td>
</tr>
<tr>
<td>5.0</td>
<td>49.1</td>
<td>0.14</td>
</tr>
<tr>
<td>6.0</td>
<td>58.8</td>
<td>0.29</td>
</tr>
<tr>
<td>7.0</td>
<td>68.7</td>
<td>0.54</td>
</tr>
<tr>
<td>8.0</td>
<td>78.5</td>
<td>0.92</td>
</tr>
<tr>
<td>9.0</td>
<td>88.3</td>
<td>1.48</td>
</tr>
<tr>
<td>10.0</td>
<td>98.1</td>
<td>2.25</td>
</tr>
<tr>
<td>11.0</td>
<td>107.9</td>
<td>3.30</td>
</tr>
<tr>
<td>12.0</td>
<td>117.7</td>
<td>4.70</td>
</tr>
<tr>
<td>13.0</td>
<td>127.5</td>
<td>6.40</td>
</tr>
<tr>
<td>14.0</td>
<td>137.3</td>
<td>8.66</td>
</tr>
<tr>
<td>15.0</td>
<td>147.1</td>
<td>11.42</td>
</tr>
</tbody>
</table>
Vehicle Damage Factor (VDF)

VDF is a multiplier for converting the number of commercial vehicles of different axle loads to the number of standard axle load repetitions and it is defined as “equivalent number of standard axles per commercial vehicle”.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Laden</th>
<th>Unladen / Partially Laden</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCV (Heavy trucks &amp; full-sized buses)</td>
<td>2.86</td>
<td>0.31</td>
</tr>
<tr>
<td>MCV (Tractor-trailers, Mini buses, pick-up vans)</td>
<td>0.34</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Traffic Growth Rate

- Trend Analysis
  - $T_n = T_0(1+r)^n$

- Econometric model

- Recommended growth rate – 6%

- Design Life – 10 years
Estimation of Design Traffic

Assuming a uniform traffic growth rate \( r \) (6%) and design life of \( n \) years (10 years) the cumulative ESAL applications (\( N \)) may be obtained as

\[
N = T_0 \times 365 \times \left( \frac{(1+0.01r)^n - 1}{0.01r} \right) \times L
\]

\[
= T_0 \times 365 \times \left( \frac{(1+0.06)^{10} - 1}{0.06} \right) \times L
\]

\[
= T_0 \times 4811 \times L
\]

Where \( T_0 \) = ESAL per day = number of commercial vehicles per day in the year of opening \( X \) VDF

and \( L \) = Lane distribution factor;

\( = 1 \) for single lane/ intermediate lane, and

\( = 0.75 \) for two-lane roads
Correction factor for Solid Wheeled Carts (SWC)

<table>
<thead>
<tr>
<th>AADT</th>
<th>CORRECTION FACTOR FOR SWC TRAFFIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.70</td>
</tr>
<tr>
<td>150</td>
<td>1.25</td>
</tr>
<tr>
<td>200</td>
<td>1.20</td>
</tr>
<tr>
<td>300</td>
<td>1.15</td>
</tr>
<tr>
<td>400</td>
<td>1.10</td>
</tr>
<tr>
<td>500</td>
<td>1.07</td>
</tr>
</tbody>
</table>
The final design traffic is classified into 7 categories as shown below:

<table>
<thead>
<tr>
<th>Traffic Category</th>
<th>Cumulative ESAL Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$</td>
<td>10,000–30,000</td>
</tr>
<tr>
<td>$T_2$</td>
<td>30,000–60,000</td>
</tr>
<tr>
<td>$T_3$</td>
<td>60,000–100,000</td>
</tr>
<tr>
<td>$T_4$</td>
<td>100,000–200,000</td>
</tr>
<tr>
<td>$T_5$</td>
<td>200,000–300,000</td>
</tr>
<tr>
<td>$T_6$</td>
<td>300,000–600,000</td>
</tr>
<tr>
<td>$T_7$</td>
<td>600,000–1,000,000</td>
</tr>
</tbody>
</table>
### Cumulative ESAL for 10 year Design Life

<table>
<thead>
<tr>
<th>ADT</th>
<th>CVPD</th>
<th>Break up of CV</th>
<th>Cumulative ESAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HCV</td>
<td>MCV</td>
</tr>
<tr>
<td>100</td>
<td>25</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>150</td>
<td>35</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>200</td>
<td>50</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>300</td>
<td>75</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>400</td>
<td>100</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>500</td>
<td>125</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>1000</td>
<td>300</td>
<td>60</td>
<td>240</td>
</tr>
</tbody>
</table>

- CV – HCV (0 to 20%); MCV (80%)
- 10% of CVPD are overloaded to the extent of 20% of the maximum permissible load
Sub-grade

“Subgrade can be defined as a compacted layer, generally of naturally occurring local soil, assumed to be 300mm in thickness, just beneath the pavement crust, providing a suitable foundation for the pavement.”

- **Soil type and index properties**
- **Strength properties (CBR, K - value or E-value)**
- **Drainage characteristics**
Subgrade Strength Evaluation as per IRC SP20:2002

- Subgrade strength parameter is evaluated in terms of 4-day soaked CBR, except in areas with annual rainfall less than 500 mm and where the water table is too deep.
Subgrade Strength Evaluation as per IRC SP 72 2007

- During soil survey depth and fluctuation of ground water table need to be recorded.
- Minimum 3 samples are to be taken per km length.
- Simple classification tests (wet sieve analysis, liquid and plastic limits) are to be carried out to identify soil group. And then to identify uniform stretches.
- For each of the soil groups identified, at least one CBR test should be conducted.
Subgrade CBR Evaluation for the Design of New Roads

The following 4 methods are available for the estimation of subgrade CBR:

- By IS Soil classification.
- By using nomograph based on wet sieve analysis.
- By empirical formulae.
- By conducting actual CBR (For each one km length, at least one CBR test, in case there is no variation in the soil type).

Typical presumption design CBR Values

<table>
<thead>
<tr>
<th>Description of Subgrade Soil</th>
<th>IS Soil Classification</th>
<th>Typical Soaked CBR Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Plastic Clays and Silts</td>
<td>CH, MH</td>
<td>* 2-3</td>
</tr>
<tr>
<td>Silty Clays and Sandy Clays</td>
<td>ML, MI CL, CI</td>
<td>4-5</td>
</tr>
<tr>
<td>Clayey Sands and Silty Sands</td>
<td>SC, SM</td>
<td>6-10</td>
</tr>
</tbody>
</table>
Nomo graph for Computing Soaked CBR value from Wet Sieve Analysis

STEPWISE PROCEDURE

1. Mark the % passing 75 µ ISS on axis 1-1; join with fixed point X and extend to axis AA (Say, at S)

2. Mark the % fraction (-425 µ, +75 µ) on axis 2-2; join with fixed point X and extend to axis AA (SAT, AT T)

3. Starting with O on axis BB, mark OC-ST. Further ADD the % fraction (+425 µ) on axis BB, getting to D (SAY)

4. Perpendicular line from D reads the soaked C.B.R. (%).
Quick Estimation of CBR for Empirical Formulae

**Plastic Soil**

\[
\text{CBR} = \frac{75}{1+0.728 \text{ WPI}}, \quad R^2 = 0.67
\]

where

- WPI = Weighted Plasticity Index = P0.075 x PI
- P0.075 = % Passing 0.075mm sieve in decimal
- PI = Plasticity Index of the soil, %.

**Non-Plastic Soil**

\[
\text{CBR} = 28.091 \times (D60)^{0.3581}, \quad R^2 = 0.84
\]

where

- D60 = Diameter in mm of the grain size corresponding to 60% finer.

Soil Classification can be used for preliminary report preparation.
# Determination of Subgrade Moisture Content

<table>
<thead>
<tr>
<th>Subgrade Classification</th>
<th>Estimating Subgrade Moisture Content</th>
</tr>
</thead>
</table>
| **I** Where the GWT is close enough to the ground surface to influence the subgrade moisture content. In non-plastic soils, GWT will influence the subgrade moisture content, if it rises to within 1m of the road surface; in clays of low plasticity (Pl<20), if GWT rises within 3m of the road surface and in heavy clays (Pl>40), if GWT rises within 7m of the road surface. This category also includes coastal areas and flood plains where the GWT is maintained by the sea, by a lake or by a river, besides areas where GWT is maintained by rainfall. | 1. The most direct method is to measure the moisture content in subgrades below existing pavements in similar situations at the time of the year when the GWT is at its highest level.  
2. The subgrade moisture content for different soil types can be estimated by using the ratio \[
\frac{\text{Subgrade Moisture Content}}{\text{Plastic Limit}}
\] which is about the same when GWT and climatic conditions are similar.  
3. Where such measurements are not possible, the subgrade strength may be determined in terms of 4 day soaked CBR value. |
| **II** Subgrades with deep GWT but where seasonal rainfall brings about significant changes in moisture conditions under the road. | 1. The subgrade moisture condition will depend on the balance between the water entering the subgrade through pavement edges/shoulders during rains and the moisture leaving the ground during dry periods. The design moisture content can be taken as optimum moisture content obtained from Proctor Compaction Test IS:2720 (Part 7) corresponding to maximum dry density or from the nomograph given in Fig.2, whichever is higher.  
2. The possibility of local perched GWTs and effects of seasonal flooding should, however, also be considered while deciding on GWT depth. Where such situations are encountered, the subgrade strength may be determined in terms of 4-day soaked CBR value. |
Nomogram for the Computation of Equilibrium Subgrade Moisture Content

Steps for Computation:
1. Locate the In-Situ (Subgrade) Dry Density on scale A-A, say, at 'L'.
2. Draw a perpendicular at 'L' to the axis A-A to meet the relevant curve for the depth of shallowest water table, say, at 'W'.
3. From point 'W' draw a horizontal line to meet the vertical axis B-B, say, at 'M'.
4. Join point 'M' to the fixed point 'O' and extend to meet the vertical axis C-C, say, at 'N'.
5. Along the vertical axis C-C, add the Plasticity Index of the soil from 'N', say, up to 'R' (where, NR=Plasticity Index).
6. Join point 'R' with the average annual rainfall axis D-D, say, at 'T' and extend to meet the axis E-E at the point, say, 'U' which finally reads the Equilibrium Subgrade Moisture Content (%).

Fig. 2. Nomograph for the Computation of Equilibrium Subgrade Moisture Content
Design CBR for Upgradation

- The in-situ subgrade strength of an existing road will be determined in terms of CBR value on remoulded to the in-situ density at the field equilibrium moisture content, after the recession of the rainy season.

- If the above is not possible, 4 days soaked CBR value of the remoulded subgrade soil samples, compacted to field density, is taken as design CBR.

- CBR can be determined by using Dynamic Cone Penetrometer (DCP).
Details of DCP

- Handle
- Upper Stop
- Hammer (8 kg)

- Cone angle 60°
- 20 mm

- Approx. 1935 mm

- Anvil—where rods screw together

- Reference point for scale

- 16 mm Ø steel rod

- Meter scale

- Cone
DCP - CBR Relationship
## Subgrade Strength Classes for Design Catalogue

<table>
<thead>
<tr>
<th>Quality of Subgrade</th>
<th>Class</th>
<th>Range (CBR%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Poor</td>
<td>$S_1$</td>
<td>2</td>
</tr>
<tr>
<td>Poor</td>
<td>$S_2$</td>
<td>3 – 4</td>
</tr>
<tr>
<td>Fair</td>
<td>$S_3$</td>
<td>5 – 6</td>
</tr>
<tr>
<td>Good</td>
<td>$S_4$</td>
<td>7 – 9</td>
</tr>
<tr>
<td>Very Good</td>
<td>$S_5$</td>
<td>10 – 15</td>
</tr>
</tbody>
</table>

* Where the CBR of subgrade soil is less than 2, the economic feasibility of replacing 300 mm subgrade with suitable soil needs to be explored and, if found feasible, the pavement should then be designed based on the CBR value of the improved subgrade. Alternatively, a capping layer of thickness not less than 100 mm of modified soil (with CBR not less than 10) should be provided.
Limitations of the IRC SP 20 2002 Methodology

- Minimum base course thickness of 150mm for curves A & B and of 225mm for curves C & D.
- The sub base course thickness have been arrived at by subtracting the minimum base course thickness from the total pavement thickness requirement.
- Mostly bituminous surface treatment
- The Unsealed Gravel Roads, as wearing course, do not have explicit design guidelines.
Recommended Design Approach

- Categorization of roads:
  a) Gravel/Aggregate Surfaced Roads (Unpaved and Unsealed) – 10,000 to 100,000 ESAL (Below 10,000 ESAL applications, even Earth Roads are suitable)
    - Gravel is defined as mix of stone, sand and fine-sized particles used as sub-base, base or surfacing on a road
  b) Flexible Pavements (Paved Roads) (50,000 to 1 million ESAL applications)

- Serviceability rating on 5 point scale with terminal serviceability index as 2.0.
Design Criteria

For Unpaved Roads

- Serviceability over the design life is limited to 2, when rehabilitation will be due with or without overlay.
- Allowable rut depth under a 3 m straight edge is generally not more than 50 mm.

For Paved Roads

- The thickness of Flexible Pavement (Paved) is based on Structural Number (SN) recommended by AASHTO for Low Volume Roads at 50% reliability level.
Steps in the Design Process

For New Roads & Upgradation

- Estimation of traffic in terms of ESAL.
- Assessment of subgrade strength and identification of uniform stretches.
- Determination of pavement thickness and composition based on the design catalog.
### Cumulative ESAL Applications

<table>
<thead>
<tr>
<th>Subgrade Strength (CBR)</th>
<th>10,000 to 30,000</th>
<th>30,000 to 60,000</th>
<th>60,000 to 1,000,000</th>
<th>1,000,000 to 2,000,000</th>
<th>2,000,000 to 3,000,000</th>
<th>3,000,000 to 6,000,000</th>
<th>6,000,000 to 1,000,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Poor</strong> (CBR = 2)</td>
<td>200</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Poor</strong> (CBR = 3 to 4)</td>
<td>200</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>275</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Fair</strong> (CBR = 5 to 6)</td>
<td></td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>275</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Good</strong> (CBR = 7 to 9)</td>
<td></td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>275</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Very Good</strong> (CBR = 10 to 15)</td>
<td></td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>275</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Note:** In situations where locally available/suitably processed gravel base material fulfills all requirements and the engineer is satisfied that the gravel base material is well compacted, the top 75 mm WBM layer may be dispensed with, for cumulative traffic up to 1,000,000 ESAL applications.

For the aggregate - surfaced gravel roads, the thickness requirement of base gravel (conforming to MRO Specifications, Table 400.2) have been shown. The gravel base shall be covered with surface gravel (conforming to MRO Specifications, Table 400.3). The thickness of surface gravel layer will generally vary from 40 to 50 mm depending on traffic and quality of material.

**Legend:**
- Bituminous Surface Treated WBM / CRMB
- Base of Gravel / CBR / WBM, CBR not less than 150, Where 100 mm thickness is recommended, may be modified to 75 mm thickness for WBM construction with corresponding increase of 25 mm in subbase thickness.
- Gravel Base (CBR not less than 80, in exceptional cases may be relaxed suitably)
- Gravel Sub-Base (CBR, not less than 20, in exceptional cases may be relaxed to 15)
- Modified Soil/Improved Subgrade (CBR, not less than 10)
Gravel roads perform satisfactorily up to about 60,000 ESAL applications during design life of 10 years for any subgrade CBR above 2%.

If the subgrade CBR is above 5%, gravel roads can perform satisfactorily up to about 100,000 ESAL applications during the design life of 10 years.
Black-topped flexible pavements need to be designed for a minimum ADT of 200 or design traffic of 100,000 ESAL applications, during the design life of 10 years.

A minimum 150mm thick base course should be provided in the flexible pavement designs for ESAL applications from 100,000 to 10,00,000
Pavement Composition

- **Subgrade** should be compacted in two layers to 100% MDD achieved by Standard Proctor Test. Minimum dry density is 16.5 k N/m³.

- **Subbase course**: As per MoRD Specifications Clause 401, 403 (lime treated sub base), 404 (cement treated sub base), 409 (lime & flyash stabilisation), 410 (industrial waste).

- Materials passing 425 micron sieve should have LL and PI of not more than 25 and 6 respectively.

- The soaked CBR value should not be less than 20%.

- The thickness of subbase, where provided, shall not be less than 100mm
Pavement Composition

- **Base Course**: For Rural Roads designed for cumulative ESAL more than 100,000, unbound granular bases like WBM, WMM, CRMB, soil cement base as per MoRD Specifications Clauses 405, 406, 411 & 404. Where it is difficult to get hard stone within economic leads, cement stabilized based can be provided as per Clause 404.

- For less than 100,000 ESAL, a gravel base is recommended, except for a very poor subgrade strength under traffic categories 30,000 to 60,000 and 60,000 to 100,000 and for poor subgrade strength under the traffic category of 60,000 to 100,000 ESAL.

- Grading, Plasticity and other requirements for Gravel base are as per Clause 402.
**Surfacing:** For roads with ESAL more than 100,000, a bituminous surface treatment of 2 - coat surface dressing or 20 mm PMC is recommended.

For traffic less than 100,000 ESAL non bituminous gravel surfacing is recommended, except for very poor subgrade under traffic categories T₂ & T₃ and for poor subgrade strength for traffic category T₃, where a bituminous surface treatment is recommended.
Warrants for Bituminous Surfacing

- Fast Moving Vehicles like Commercial vehicles, Damage unprotected granular bases and create dust nuisance.
- The operating cost of such vehicles is highly influence by the smoothness of the road pavement.
- Bituminous surfacing will be advantages where subgrade is poor (CBR < 4) and the design traffic exceeds 60,000 ESAL and annual rainfall generally exceeds 1000 mm.

Guidelines for providing bituminous surface treatment.

<table>
<thead>
<tr>
<th>Annual Rainfall</th>
<th>Type of Surfacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Traffic Category</td>
</tr>
<tr>
<td></td>
<td>$T_1$ (ADT&lt;100)</td>
</tr>
<tr>
<td>Over 1500mm/year</td>
<td>Gravel</td>
</tr>
<tr>
<td>1000-1500mm/year</td>
<td>Gravel</td>
</tr>
<tr>
<td>Less than 1000mm/year</td>
<td>Gravel</td>
</tr>
</tbody>
</table>
Grading Requirements for Sub-base course

- **Sub-base course:** As per MoRD Specifications Clause 401 (Granular Sub-base), 403 (Lime Treated Soil for Improved Subgrade / sub-base), 404 (Cement treated soil sub-base / base)

<table>
<thead>
<tr>
<th>IS Sieve</th>
<th>Grading I</th>
<th>Grading II</th>
<th>Grading III</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.0 mm</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>53.0 mm</td>
<td>-</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>26.5 mm</td>
<td>55-75</td>
<td>50-80</td>
<td>100</td>
</tr>
<tr>
<td>9.50 mm</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>10-30</td>
<td>15-35</td>
<td>25-45</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.425 mm</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>Less than 10</td>
<td>Less than 10</td>
<td>Less than 10</td>
</tr>
</tbody>
</table>

The material passing 425 micron sieve for all the three gradings shall have LL and PI not more than 25 & 6 percent respectively.
Grading Requirements for Base course

As per MORD specification 402: Gravel / Soil-Aggregate Base and Surface Course (%gravel 50-70%; % sand 25-40%; %silt & Clay 5-10%)

<table>
<thead>
<tr>
<th>IS Sieve</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>53 mm</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>97-100</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>26.5 mm</td>
<td>-</td>
<td>97-100</td>
<td>100</td>
</tr>
<tr>
<td>19 mm</td>
<td>67-81</td>
<td>-</td>
<td>97-100</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>-</td>
<td>56-70</td>
<td>67-79</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>33-47</td>
<td>39-53</td>
<td>47-59</td>
</tr>
<tr>
<td>0.425 mm</td>
<td>10-19</td>
<td>12-21</td>
<td>12-21</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>4-8</td>
<td>4-8</td>
<td>4-8</td>
</tr>
</tbody>
</table>
## Grading Requirements for Surface Course

As per MORD specification 402: Gravel / Soil-Aggregate Base and Surface Course (%gravel 50-70%; % sand 25-40%; %silt & Clay 8-15%)

<table>
<thead>
<tr>
<th>IS Sieve</th>
<th>% by mass passing designated sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.5 mm</td>
<td>100</td>
</tr>
<tr>
<td>19 mm</td>
<td>97-100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>41-71</td>
</tr>
<tr>
<td>0.425 mm</td>
<td>12-28</td>
</tr>
<tr>
<td>.075 mm</td>
<td>9-16</td>
</tr>
<tr>
<td>PI</td>
<td>4-10</td>
</tr>
</tbody>
</table>

3/16/2012

CSRK PRASAD NIT WARANGAL
Dust Control & Stabilisation

- Chlorides (Calcium chloride, Magnesium chloride & Sodium chloride)
- Resins (lignin sulfonate – byproduct of pulp milling industry)
- Natural clays
- Asphalts (cut back liquid asphalt, emulsified asphalt)
- Soybean oil
Bituminous Surfacing Types

- Sand seal (prime, binder, sand)
- Single chip seal (prime, binder, stone)
- Double Chip Seal (prime, binder, large stone, binder, small stone)
- Cape Seal (prime, binder, stone, slurry)
- Single Otta Seal (No prime, binder, graded aggregate)
- Double Otta Seal (No prime, binder, graded aggregate)
- Asphalt Concrete (prime, asphalt premix)
### Expected Service Lives for some of the Typical Surface Seals

<table>
<thead>
<tr>
<th>Type of Seal</th>
<th>Typical Service Life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Seal</td>
<td>2-4</td>
</tr>
<tr>
<td>Slurry seal</td>
<td>2-6</td>
</tr>
<tr>
<td>Single chip seal</td>
<td>4-6</td>
</tr>
<tr>
<td>Double sand seal</td>
<td>6-9</td>
</tr>
<tr>
<td>Double chip seal</td>
<td>7-10</td>
</tr>
<tr>
<td>Single otta seal + sand seal</td>
<td>8-10</td>
</tr>
<tr>
<td>Cape seal (13mm+Single slurry)</td>
<td>8-10</td>
</tr>
<tr>
<td>Cape seal (19mm+double slurry)</td>
<td>12-16</td>
</tr>
<tr>
<td>Double Otta Seal</td>
<td>10-14</td>
</tr>
</tbody>
</table>
Thank you!