Pavement Design Practice in India and Comparison with other Guidelines, with Special Reference to the U.S. Practice

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Road length in India (as on March, 2016)

<table>
<thead>
<tr>
<th>Category of road</th>
<th>Length of road (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National highways</td>
<td>101,011</td>
</tr>
<tr>
<td>State highways</td>
<td>176,166</td>
</tr>
<tr>
<td>District roads</td>
<td>561,940</td>
</tr>
<tr>
<td>Rural roads</td>
<td>3,935,337</td>
</tr>
<tr>
<td>Urban roads</td>
<td>509,730</td>
</tr>
<tr>
<td>Project roads</td>
<td>319,109</td>
</tr>
<tr>
<td>Total</td>
<td>5,603,293</td>
</tr>
</tbody>
</table>

http://morth.nic.in/showfile.asp?lid=3100
* Bureau of Indian standards
* Indian Roads Congress (IRC)
* Ministry of Road Transport and Highways
* Academic institutions
* Central Road Research Institute (CRRI) and regional laboratories
* IRC: 37  2012
* IRC: 58  2015
* IRC: 81  1997
* IRC: 115 2014
Design parameters...

- **Pavement section properties**
  - Stiffness modulus and Poisson’s ratio values
    - Surface layer
    - Base layer
    - Sub-base layer
    - Subgrade

- **Traffic Characteristics**
  - Axle load distribution
  - Present traffic volume
  - Lane distribution
  - Lateral distribution
  - Tyre contact pressure
  - Wheel and axle configuration
  - Traffic growth rate

- **Environmental parameters**
  - Temperature
  - Rainfall

- **Design period**
Analysis

Static analysis of undamaged pavement structure

[Das 2014]
Design approach

- Expected traffic (axle and wheel configuration, axle load, distribution, volume, growth rate)
- Design period
- Material properties of individual layers
- Environmental factors (temperature, moisture)
- Assume thickness values

- Allowable traffic that the pavement can sustain
- Pavement analysis
- Computed stress/strain at critical locations
- Adjust thickness

- Are the values comparable?
  - Yes
  - No

Design finalized
Design of bituminous pavement
Rutting...

Fatigue...

Asphalt pavement

Top down cracking

Asphalt Surfacing

Granular Base
or Subbase

Subgrade

τ

ε_t - Horizontal tensile strain at the bottom of bituminous layer

ε_z - Vertical compressive strain on the top of subgrade

Dual wheel system
20.5 kN each, 0.56 tyre contact pressure

310mm
Field calibrated fatigue curve...
* Granular base and sub-base

* Cementitious bases and sub-bases with a crack relief layer of aggregate interlayer below the bituminous surfacing

*RAPM with or without addition of fresh aggregates treated with foamed bitumen/bitumen emulsion

* long life bituminous pavement
Pavement design charts (Asphalt Institute, Austroads, Shell, IRC)
Designing a pavement with a given reliability

- Probability density
- Expected traffic
- Repetitions pavement can sustain

Number of repetitions

Probability density
Integrated mix design – structural design system...

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Thickness Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open graded friction course</td>
<td>40 to 75 mm</td>
</tr>
<tr>
<td>High modulus rut resistant mix</td>
<td>100 to 175 mm</td>
</tr>
<tr>
<td>Fatigue resistant bottom rich mix</td>
<td>75 to 100 mm</td>
</tr>
</tbody>
</table>

Subgrade

Bituminous layer

Granular base/sub-base

*Pavement with recycled mix
*Long life (perpetual) bituminous pavement
Alternative-I

Alternative-II

Alternative-III

[Das and Pandey 2000]
The graph illustrates the relationship between bituminous layer thickness, $h_1$, and granular layer thickness, $h_2$, under different traffic conditions. The lines represent different traffic scenarios:

- $Traffic = A + B$
- $Traffic = A$
- $Traffic = B$

The points $o$, $p$, and $r$ correspond to specific values of $h_2$ for each traffic scenario. The point $q$ indicates where the $Traffic = A$ line intersects with the $Traffic = B$ line.

[Das 2015]
Phases of reduction of elastic modulus of cemented layer...

![Graph showing phases of reduction of elastic modulus of cemented base.](image)
Input E, Poisson’s ratio of Bituminous & cemented layer, CBR, traffic and tentative thickness of cemented layer

Initialize Bituminous and cemented layer layer thickness

Stage I
Calculate life of cemented base

Stage II
Calculate life of bituminous layer

Is total life is close to design life

No

Optimization of layer thickness

Yes

Print design thickness
Design of cement concrete pavement
$T_t > T_b$

- Fully constrained
- Un-constrained
- Partially constrained
* Cumulative fatigue damage during day-time is considered for bottom up cracking.

* Cumulative fatigue damage during day-time is considered for bottom up cracking.
Few more points...
* Use of environmental simulation (integrated climatic model) to predict distress propagation

* Use of better models for traffic prediction.

* Systematic collection of performance data

* Use of Miner's principle of linear accumulation of damage.

* Use of IRI for decision on rehabilitation.
New, alternative and innovative materials

Modified binder, bio-binder, recycled materials (RAP, RAS, ground tyre rubber, building rubbles), industrial and domestic wastes, reinforced material (steel, glass-grid, polyester), types of mixes (warm mix, half-warm mix, cold mix, foamed bituminous mix) and so on...

* Non-availability of good aggregates locally
* Depleting natural resources
* Disposal problem of industrial wastes
Recycled mix

Pavement design with recycled mix

Virgin binder

Aged binder

Old aggregates

New aggregates

RAP

Pavement design with usual mix

[Swamy and Das 2007]
Understanding pavement behaviour
Objective

is to build a safe, serviceable, economical, reliable and sustainable road infrastructure
References


IRC:58-2015, Guidelines for the design of plain jointed rigid pavements for highways, 4th revision, Indian Roads Congress, New Delhi, 2011.


Thank you!!

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