Comparative Design of Flexible Pavement using Different Countries Methodologies

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Abstract

AASHO road test conducted by American Association of State Highway and Transportation Officials in the late 1950’s is the first systematically conducted test data on pavement performance with different pavement layer compositions and different axle load repetitions. Based on AASHO road test results AASHTO-1961 was released with empirical design formulae for pavement structural design for both flexible and rigid pavements which was subsequently updated and released in 1972 and 1993. For many years this remained the source/inspiration for majority of the pavement design manuals across the world, until the recent times when most of these codes/manuals were updated and rewritten to suit the weather, axle load composition and performance characteristics of pavements in respective countries. Indian Roads Congress’s code IRC-37 for design of flexible pavements was based on AASHTO. In this project an attempt has been made to study the differences/variations in the pavement layer thicknesses as designed from IRC-37 and AASHTO-1993. To make the comparisons useful in assessing the level of up-gradation of IRC, pavement designs were made with design codes of AUSTROADS (Australia) and DMRB (UK). Pavement structures were designed for 4 different sub-grade CBR values and 5 different expected traffic loadings (in MSA) using IRC-37. Keeping the Base and sub-base thicknesses same as obtained in IRC-37, top layer thicknesses were designed using AASHTO-1993, AUSTROADS-2010 and DMRB-2006 and these values were compared to see how much economical our IRC design is. It is observed that IRC designs were very much optimized and updated that in most cases IRC gave most economical section compared to AASHTO-1993, and these designs were very close to those given by AUSTROADS and DMRB too showing the level of upgradation of IRC-37 based on research and field performance studies.

Keywords: AustRoads, AASHTO, DMRB, IRC-37, pavement structure, comparative design

I. INTRODUCTION

Most part of the highway network in India constitutes flexible pavements. The design of flexible pavement is a challenging task as the behavior of bituminous mix is temperature dependent and seasonal variations in temperature are high in India. In addition to that the subgrade strength varies with seasons and locally available materials. Properties to vary substantially from one place to another. This makes the prediction of pavement service life uncertain. This is type of uncertainty is present in many countries. When it comes to pavement structural design or prediction of pavement service life. This uncertainties or lack of concrete data on the behavior of flexible pavements lead to the development of empirical design procedures from AASHO road test in early 1950’s. AASHO road test is one of the first complete pavement study to be conducted in the world. The data and results from the AASHO road test lead to the development of AASHTO-1993, code for structural design of flexible and rigid pavements. This is the source of inspiration for majority of pavement design codes in the world. IRC: 37 was originally based on the AASHTO-1993 empirical design charts later on like many developed countries, India too started research on pavements and improved the original design charts based on the mechanistic design procedures. The failure criteria chosen for mechanistic design were fatigue of asphalt layer and rutting of subgrade. And almost all countries adopted these same criteria.

Here a small attempt has been made to compare the thickness of flexible pavement designed using all four methods and check which method relatively gives a conservative design and which one will provide the economical design.
II. METHODOLOGY

The methodology adopted was presented here.

1) Consider a CBR value and traffic in MSA and design the flexible pavement thickness using IRC- 37:2001
2) Then keep the base and sub-base thicknesses constant obtain the surface layer thickness required by other methodologies
3) Compare the surface course thickness obtained by IRC, AASHTO, AustRoads and DMRB

This methodology was adopted for different CBR values of subgrade and Different MSA values of traffic. All the surface layer thickness values obtained were compared to understand the thickness variations.

III. SCOPE OF THE WORK

1) In this work only four design codes were considered: IRC: 37-2001 for Indian roads, AASHTO-1993 for American roads, AUSTROADS for Australia & New Zealand roads and DMRB for U.K roads.
2) 4%, 6%, 8% and 10% CBR values of subgrade are considered.
3) 10, 20, 30, 50 and 100 msa cumulative standard axle loads are considered for the design of pavement.
4) Base and sub base thickness are directly taken from IRC 37; only top layer thickness were compared.
5) Surface course mix is considered to be DBM 60/70 Bitumen at 20°C.
6) Base course CBR is assumed to be 350 MPa and sub base CBR is assumed to be 175 MPa.
7) Directly design equations (SN) were taken and calculations were done from the nomographs of AASHTO, AustRoads and DMRB. The thickness of one layer is converted into the thickness of another layer using the equation given in IRC-37 and

\[ \frac{E_1 H_1^3}{(1-\mu_1^2)} = \frac{E_2 H_2^3}{(1-\mu_2^2)} \]

CBR value is converted to Elastic modulus of sub-grade using

\[ E (\text{MPa}) = 10 \times \text{CBR} \quad \text{for CBR} \leq 5 \]

\[ = 17.6 \times (\text{CBR})^{0.64} \quad \text{for CBR} > 5 \]

The surface layer thicknesses obtained by different methodologies for different subgrade CBR value and Traffic in MSA combinations were calculated and presented here pictorially in the form of graphs.

For Example CBR of 8% and traffic of 20 MSA will get the following thicknesses of surface layer in mm by different methodologies:

<table>
<thead>
<tr>
<th>Methodology</th>
<th>125</th>
<th>220</th>
<th>110</th>
<th>133</th>
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<tbody>
<tr>
<td>IRC</td>
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<td>AASHTO</td>
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<td>DMRB</td>
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<td>AUSTROADS</td>
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</tbody>
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![Graph](image)

Fig. 1:

IV. RESULTS

The other comparative graphs are presented here.

For all the following graphs traffic in MSA is presented on horizontal axis and surface layer thickness is presented on vertical axis for different CBR values.
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Fig. 2: CBR @ 4%

Fig. 3: CBR @ 6%

Fig. 4: CBR @ 8%
V. CONCLUSIONS

1) The design thickness of surface layer from IRC: 37-2001 was found to be lying between that obtained from AUSTROADS and DMRB for 6%, 8%, 10% at all CSAs considered, keeping the base and sub-base constant.
2) At 4% CBR, IRC: 37-2001 is suggesting a higher pavement thickness compared to AUSTROADS & DMRB, which may be a conservative design but not economical.
3) AASHTO-1993 design thickness was 50% to 80% higher compared to IRC: 37-2001 for a projected traffic of more than 30 msa and for traffic less than 30 msa it is almost 100% higher. The reason could be that AASHTO-1993 gave conservative design based on empirical equations.
4) DMRB design thickness was the lowest among IRC, AUSTROADS, DMRB & AASHTO at all CBR values.

VI. FUTURE SCOPE

1) There is a scope for comparison of different mechanistic methods, as in this work design charts were directly used
2) There is scope for a lot of work to be done to understand why different mechanistic design gave different thickness values, and also to understand the influence of local environmental conditions.
3) Cost comparisons can be made and economical section can be found.
4) A unified mechanistic design can be developed by the combination of different mechanistic design for all countries.
5) AASHTO-2002 can be used for comparison to check the updates and changes
6) Work can be done for other available CBR values too to understand at which CBR value the trend is changing for design thickness.

REFERENCES

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