3.5 Design of Flexible Pavement- C.B.R METHOD (IRC:37-2001)

- The flexible pavement is built with number of layers. In the design process it is to be ensured that under the application of load none of the layers is overstressed.
- The maximum intensity of stresses occurs in the top layer of the pavement .The magnitude of load stresses reduces at lower layers.
- In the design of flexible pavements, it has yet not been possible to have a rational design method wherein design process and service behavior of the pavement can be expressed by mathematical laws.
- Flexible pavement design methods are accordingly either empirical or semi empirical. In these methods, the knowledge and experience gained on the behavior of the pavements in the past are use fully utilized.

Flexible Pavement Design Method:

California bearing ratio method:

- ✓ California division of highways in the U.S.A. developed CBR method for pavement design. The majority of design curves developed later are base on the original curves proposed by O.J.Porter.
- ✓ One of the chief advantages of CBR method is the simplicity of the test procedure. The CBR tests were carried out by the California state highway department on existing pavement layers including sub grade, sub base and base course.
- ✓ Based on the extensive CBR test data collected on pavement which behaved satisfactory and those which failed, an empirical design chart was developed correlating the CBR value and the pavement thickness. The basis of the design chart is that a material with a given CBR required a certain thickness of pavement layer as a cover.
- ✓ A higher load needs a thicker pavement layer to protect the sub grade. Design curves correlating the CBR value with total pavement thickness cover were developed by the California state highway department for wheel loads of 3175kg and 5443 kg representing light and heavy traffic.

It is possible to extend the CBR design curves for various loading conditions,using the expression:

$$t = \sqrt{p}\left[\frac{1.75}{CBR} - \frac{1}{p\pi}\right]^{\frac{1}{2}}$$

$$t = \left[\frac{1.75p}{CBR} - \frac{A}{\pi}\right]^{\frac{1}{2}}$$

Hence,

T= pavement thickness, cm

P= Wheel load,kg

CBR= California bearing ratio,percent

P=tyrepressure,kg/cm^2

A=areaofcontact.cm^2

IRC Recommendations:

- ✓ The CBR tests should be performed on remoulded soils in the laboratory. The specimens should be prepared by static compaction wherever possible and otherwise by dynamic compaction.
- ✓ For the design of new roads, the sub grade soil sample should be compacted at OMC to proctor density whenever suitable compaction equipment.
- ✓ The CBR test samples may be soaked in water for four days period before testing .the annual rainfall is less than 50 cm and the water table is too deep to affect the sub grade and imperable surfacing is provided to carrying out CBRtest.
- ✓ If the maximum variations in CBR value of the three specimens exceed the specified limits, the design CBR should be average of at least six samples.
- ✓ The top 50 cm of sub grade should be compacted at least up to 95 to 100 percent of proctor density.
- ✓ An estimate of the traffic should be carried by the road pavements at the end of expected in view the existing traffic and probable growth rate of traffic.
- ✓ The traffic for the design is considered in units of heavy vehicles per day in both directions and is divided into seven categories A to G.The design thickness is considered applicable for single axle loads up to 8200 kg and tandom axle loads up to 14,500kg.
- ✓ When sub base course materials contain substantial proportion of aggregates of

size above 20mm, the CBR value of these materials would not be valid for the design of subsequent layers above them.

The CBR method of pavement design gives the total thickness requirement of the pavement above a sub grade and thickness value would remain the same quality of materials used in component layers.

Recommended method of design (IRC 37-2001):

1. Context
2. Design Approach and Criteria
3. Estimation of design traffic
4. Data requirements
   - No. of vehicle commercial per day
   - Traffic growth rate during design life
   - Design life in number of years
   - Vehicle damage factors: VDF is the number of standard axles per truck. So determination of VDF can be made through the determination of the load equivalency factor (LEF) for each axle of the truck and then taking the sum total of the equivalent standard axles for all the axles in the truck.
   - Distribution of commercial traffic over a carriage way
5. Computations of design traffic
6. Sub grade
   - Compaction requirements for different class of roads
   - Dry density and moisture content

PAVEMENT DESIGN:

1.A two-lane carriage way carries a traffic 150 cv/ day. Rate of traffic growth is 5% pa. Pavement design life is 15 years. VDF = 2.5. Soil CBR is 6%. Calculate cumulative number of standard axles to be catered for, in the pavement design.

(i) Two lane carriageway

Initial traffic in the year of completion of construction = 300 CVPD (sum of both directions)

Traffic growth rate = 7.5%

Design life = 15years

Vehicle damage factor based on axle load survey = 2.5 standard axle per commercial.

(ii) Distribution factor = 0.75

Total pavement thickness for CBR 6% and traffic 4.4 msa from IRC:37 2001 chart1 = 580 mm

Pavement composition can be obtained by interpolation from Pavement Design Catalogue (IRC:37 2001).

Bituminous surfacing = 20 mm PC + 50 mmBM

Road-base = 250 mm Granular base

sub-base = 280 mm granular material.

(iii) Certain additives or blend of additives called as bitumen modifiers can improve properties of Bitumen and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen. Polymer modified bitumen (PMB)/ crumb rubber modified bitumen (CRMB) should be used only in wearing course depending upon the requirements of extreme climatic variations.

It must be noted that the performance of PMB and CRMB is dependent on strict control on temperature during construction.

Advantages of using modified bitumen are:

- ✓ Lower susceptibility to daily and seasonal temperature variations
- ✓ Higher resistance to deformation at high pavement temperature Better age resistance properties
- ✓ Higher fatigue life for mixes
- ✓ Better adhesion between aggregates and binder Prevention of cracking and reflective cracking

2.Design the pavement for construction of a new bypass with the following data: Twolanecarriageway,Initialtrafficintheyearofcompletionofconstruction=400CVPD(sum of both directions), Traffic growth rate = 7.5 %. Design life = 15 years, Vehicle damage factor based on axle load survey = 2.5 standard axle per commercial vehicle and Design CBR of subgrade soil = 4%.

Two lane carriage way

Initial traffic in the year of completion of construction = 300 CVPD (sum of both directions) Traffic growth rate = 7.5 %

Design life = 15 years

Vehicle damage factor based on axle load survey = 2.5 standard axle per commercial

Total pavement thickness for CBR 4% and traffic 7.2 msa from IRC:37 2001 chart1 = 660 mm

Pavement composition can be obtained by interpolation from Pavement Design Catalogue (IRC:37 2001).

1. Bituminous surfacing = 25 mm SDBC + 70 mmDBM
2. Road-base = 250 mm WBM
3. sub-base = 315 mm granular material of CBR not less than 30%

Design procedure for rigid pavements.

Design procedure

Step 1: Find the length of the dowel bar embedded in slab by equating Eq.

Step 2: Find the load transfer capacities ,and of single dowel bar with the

Step 3: Assume load capacity of dowel bar is 40 percent wheel load, find the load capacity factor f as

Step 4: Spacing of the dowel bars.

- ✓ Effective distance upto which effective load transfer take place is given by , where is the radius of relative stiffness.
- ✓ Assume a linear variation of capacity factor of 1.0 under load to 0 at.
- ✓ Assume dowel spacing and find the capacity factor of the above spacing.
- ✓ Actual capacity factor should be greater than the required capacity factor.
- ✓ If not, do one more iteration with new spacing.