

DESIGN AND ANALYSIS OF FLEXIBLE PAVEMENT IN AMARAVATI GOVERNMENT COMPLEX

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Abstract - The development of the cities/towns with heterogeneous (different types) of vehicles are increasing day by day. As we know that the prime factor influencing the structural design of a pavement is the load carrying capacity.

This project presents the **Design and Analysis of Flexible Pavements in Amravati Government Complex**, for Amravati Capital City. In our project utilities are being provided along the side of the pavement. In line with the vision and goals set with objectives of National Urban Transport Policy, Amravati is targeted to become a highly urbanized city in India within a stipulated period. The pavement is designed taking the year 2050's forecasted traffic into consideration. The design is analyzed by using **IIT Pave** software. Road network selected in Amravati Government Complex area with Right of Way - 25M, Length of road - 6.38kms. The road network which we studying is of **Super block-C** in Amravati Government Complex of Amravati city. This pavement contains Cycle track, Pedestrian path, multi-functional zone, Carriage way and median. **Drones** and **DGPS** (Differential Global Positioning System) are being used for Surveying. Cycle track is laid by using **Flexible pavement**. Pedestrian walking zone is being laid by using **25mm Pre-cast concrete tiles**.

1. INTRODUCTION

The transportation by road is the only one which could give maximum service to all. The transportation by road has also the maximum flexibility for travel with reference to route, direction, time and speed of travel. Door to door service is possible only through road transportation

1.1 Pavement:

Pavement is a designed structure laid on an area, intended to sustain vehicular traffic. The function of pavement is to transmit loads to the sub-base and underlying soil. Now a day's Flexible pavements contain sand and gravel or crushed stone compacted with a binder of bituminous material, such as asphaltic tar or asphaltic oil. Such a pavement has enough plasticity to absorb shocks.

1.2 Types of pavements:

Pavements are broadly classified into two types based on their structural performance. They are:

- Flexible pavement.
- Rigid pavement.

JUSTIFICATION FOR SELECTING FLEXIBLE PAVEMENT:

LOAD DISTRIBUTION

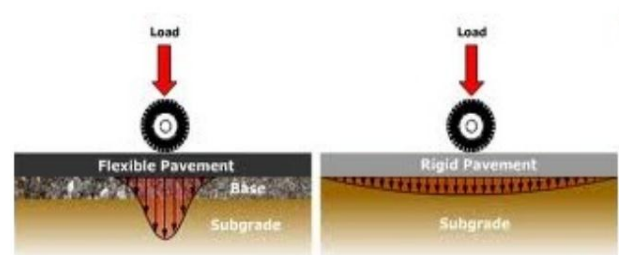


Figure 1: Rigid and Flexible Pavement Load Distribution

Figure Showing the Load Distribution in Flexible Pavement and Rigid Pavement

As per the above justification we've opted **FLEXIBLE PAVEMENT** because of its advantages.

➤ Design procedure for Flexible Pavement:

There are many methods across the globe for designing the flexible pavements. But we are following the method adopted in **IRC: 37-2012**.

1.3 Design procedure of Flexible pavement using IRC method

1.3.1 Survey

There are many types of Surveying. Some majorly used types are stated as follows:

- Land Survey.
- Engineering Survey.
- Geodetic Survey.
- Photogrammetric and Remote Sensing.

The type of survey opted for laying a pavement is mainly **engineering survey**. The stages of Engineering Survey are as follows:

- Map study.
- Reconnaissance.

- Preliminary Survey
- Final location and detailed Survey.

As there is advancement in technology, we have also used **Drones** and **DGPS** for surveying the area.

Total Station:

A **Total Station** is an electronic instrument used for surveying. It is a combination of **Electronic Theodolite** with **Electronic Distance Measurement (EDM)** to measure both vertical and horizontal angles and the slope distance from the instrument to a particular point. Data collected is processed with microprocessor to compute.

Total Station works on co-ordinate system:

- ✓ North co-ordinate – X.
- ✓ East co-ordinate- Y.

Total Station is used for many purposes. Some of the uses are mentioned here:

- ✓ Taking of levels.
- ✓ Taking of arcs.

Total Station gives height from ground and angular distance with respect to the reference point. It gives us the layout of an area. It can survey up to a distance of 3.5km without shifting the instrument. The error is + or – 5mm.

Advantages of Total Station:

The advantages of using Total station over conventional surveying instruments:

- Surveying is carried out very fast and Accuracy of measurement is high. Human errors in recording observation are eliminated.
- Calculation of elevations and co-ordinates are accurate and fast. Even the corrections for temperature and pressures are made automatically.
- The collected Data can be directly transferred to computers for further processing like plotting contours.

1.3.2 Soil Tests:

Introduction:

For civil engineer, soil is a material that can be:

- Built on- Foundation of building, bridges etc.,
- Built in- Basements, culverts, tunnels.
- Built with- Embankments, roads, dams.
- Supported- Retaining walls.

The following tests conducted on soil before designing the pavement. The tests are as follows:

• Free swell index:

- **Grain size analysis:**
- **Atterberg's Limits:**
- **Moisture content:**
- **California Bearing Ratio (CBR):**

1.3.3 Traffic & Loads acting on pavement

Traffic & Loads acting on pavement are taken into consideration while designing a pavement. Loads cause stresses, deformations, and displacements in structures. Analysis of their effects is carried out by the methods of structural analysis. Overloading may cause structural failure, and hence structural failure should be either considered in the design or strictly controlled. The different types of loads acting on roads are as follows:

- Contact pressure.
- Repetition of loads.
- Wheel load.
- Axle configuration.

Contact pressure:

The tyre pressure is an important factor, as it determines the contact area of the wheel to the pavement surface. Even though the shape of the contact area is elliptical, a circular area is often considered for sake of simplicity in analysis.

Wheel load:

The next important factor is the wheel load it determines the depth of the pavement required to ensure that the sub grade soil is not failed. The stress distribution and deflection within a pavement are effected by wheel configuration.

Axle configuration:

The Standard Axle taken into consideration is Single Axle with Dual wheel 80 KN, where Single wheel load is 20 KN.

Repetition of loads:

The effect of traffic on pavement, not only depend on the magnitude of the wheel load, but also on the frequency of the load application. Each load application cause some deformation and the total deformation is the summation of all these. Therefore, modern design is based on total number of standard axles.

The process we have adopted for designing this road is by following IRC: 37-2012. The code states that 2MSA is

sufficient for designing local city road. But as our road will also be used for commercial purposes so traffic up to 5MSA (MSA-Million Standard Axle) is taken into consideration as standard.

Computation of Design Traffic:

The design traffic in terms of the cumulative number of standard axles to be carried during the design life of the road should be computed using the following equation:

$$N = 365 * [(1 + r)^n - 1] / r * (A * D * F)$$

Where,

N = Cumulative number of standard axles to be catered for in the design in terms of MSA.

A = Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles per Day (CVPD).

D = Lane distribution factor.

F = Vehicle Damage Factor (VDF).

n = Design life in years.

r = Annual growth rate of commercial vehicles in decimal (e.g., for 5 per cent annual growth rate, r = 0.05).

The traffic in the year of completion is estimated using the following formula:

$$A = P (1 + r)^x$$

Where,

P = Number of commercial vehicles as per last count.

x = Number of years between the last count and the year of completion of construction.

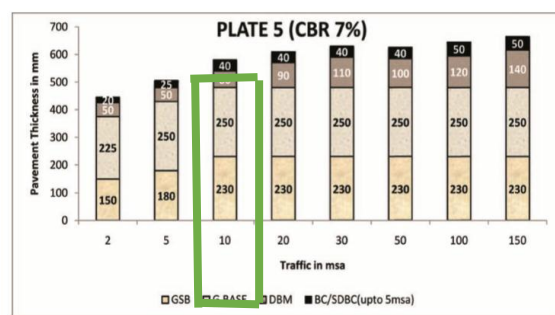
As the Amravati Government Complex is a Green filed city, the traffic suggested from code for any new city is 2MSA as standard. But after laying the roads construction work will be still on progress. So, the transportation for construction materials to the site will be transferred by using these roads, keeping this into consideration the traffic is increased to 5MSA.

➤ **Design of Flexible Pavement:**

Designing means finding out the thickness of the layers and the amount of other materials which will be sufficient to withstand different types of loads and forces applied on the pavement, at the same time and it should be economical and

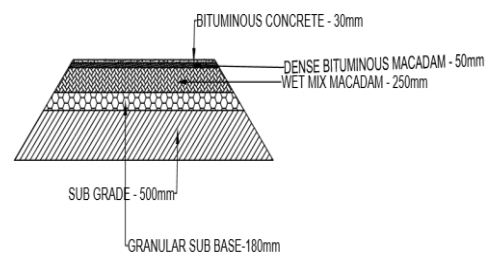
also providing serviceability. The design process for laying a pavement is as follows:

- Based on the obtained CBR value and the estimated traffic, the thickness of pavement layers is designed by following the code IRC: 37-2012.
- Plates are already designed, in the code just by verifying the values the thickness of pavement layers are obtained and then execution process goes on.
- Based on value obtained from CBR test and Traffic in MSA, the following graph is adopted for designing the Flexible pavement of traffic 5MSA and CBR Value of 7.46 %.



As 25m Right Of Way is Four-lane single carriage way the design should be based on 40% of the total number of commercial vehicles in both directions.

Cross Section of Flexible pavement:



MATERIALS

According to MORTH 5th edition, the following materials are adopted for the following layers.

Bituminous Concrete: Grading – 2 of table 500-17 of MORTH, 5 TH edition.
Dense Bituminous Concrete: Grading – 2 of table 500-10 of MORTH, 5 th edition.
Wet Mix Macadam: As per table 400-12 & 400-13 of MORTH, 5 th edition.
Granular Sub base: Grading – 5 of table 400-1 & 400-2 of MORTH, 5 th edition.

Prime Coat: With SS-1 Grade Bitumen emulsion as per table 500-3 of MORTH, 5 th edition.
Tack Coat: With RS-1 Grade Bitumen emulsion as per table 500-5 of MORTH, 5 th edition.

Sub grade:

The desirable properties of sub grade soil as a highway material are

- Stability.
- Incompressibility.
- Permanency of strength.
- Minimum changes in volume and stability under adverse conditions of weather and ground water.
- Good drainage.
- Ease of compaction.

Pavement Crust for Cycle track:

The pavement crust for Cycle track is recommended as 20mm premix carpet, 75mm WMM, 150mm GSB and 300mm subgrade. The layer as premix carpet mixed with color pigment shall be got approved from the Authority or Authority representative before execution of the same.

Pavement Crust for Sidewalk:

25 mm Precast Concrete Tiles are to be used for sidewalk placed over 25 mm Cement Concrete of M15 grade and 150 mm GSB.

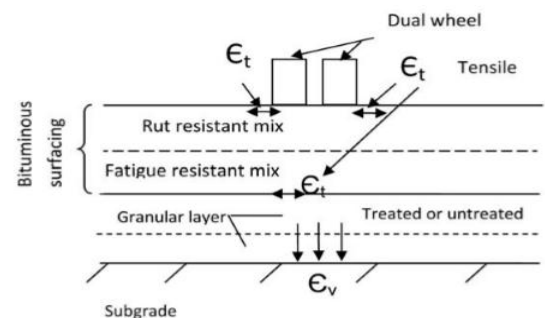
Pavement Crust for Multifunctional Zone:

80 mm paver blocks shall be used for Multifunctional zone. Paver blocks are to be placed over sand bed of 150 mm and subgrade of 300 mm. The pattern /style/color of paver block shall be got approved from the Authority or Authority representative before execution of work.

➤ **ANALYSIS OF FLEXIBLE PAVEMENT USING IIT PAVE**

The method used in data analysis is Mechanistic Empirical method which considers the design life of pavement to resist the fatigue cracking in bituminous surface to 20% of the pavement surface area or rutting in the pavement reaches the terminal rutting of 20mm, which happened earlier. The mechanistic empirical software called IIT-PAVE is used in analyzing the pavement responses. The analysis of flexible pavement for IIT PAVE is based on multi-layer theory. Using linear layered elastic model Stresses and strains at critical locations are computed. Tensile strain, ϵ_t ,

at the bottom of the bituminous layer and the vertical subgrade strain, ϵ_v , on the top of the subgrade are conventionally considered as critical parameters for pavement design to limit state of cracking and rutting in the bituminous layers and non-bituminous layers respectively. This computation also indicates that tensile strain near the surface close to the edge of a wheel can be sufficiently large to initiate longitudinal surface cracking followed by transverse cracking much before the flexural cracking of the bottom layer if the mixed tensile strength is not adequate at higher temperatures.



The pavement design and analysis has been carried out for different pavement components materials as per IRC 37-2012.

Calculations of Flexible Pavement by using IIT PAVE:

Calculations	
Critical Tensile Stress (E_t)	3.71E-04
Critical Compressive Strain (E_z)	-5.03E-04
Fatigue criteria: Max allowable traffic, MSA	8.534534
Rutting Criteria: Max allowable traffic, MSA	37.54584

Check:

Fatigue Criteria – Safe

Rutting Criteria – Safe

RESULTS

Showing the results obtained from soil tests:

S.No	Tests Conducted	Result Obtained
1	Free Swell Index	40%
2	Grain Size Analysis	
	Gravel Content	0.0%
	Sand Content	6.78%
	Silt and Clay Content	93.22%

3	Atterberg's Limits	
	Liquid Limit	19.3%
	Plastic Limit	15.23%
	Plasticity Index	4.07
4	Water content - Dry Density relation	
	Maximum Dry Density	1.80 gm/cc
	Optimum Moisture Content	14%
5	California Bearing Ratio Test	7.46%

➤ **Utilities:**

Utilities are the essential services that play a vital role in economic and social development of an area. A public utility is that maintains the infrastructure for a public use. Management of utilities in the right-of-way is the responsibility of the road authority and it has become increasingly complex in recent years.

The following are the utilities that are provided in Amravati Government Complex:

- Strom water drains
- Potable water supply pipes
- Sewer pipes
- Reuse water supply pipes
- Power and Information & communication technology lines
- Gas pipes

3. CONCLUSIONS

The Road network selected in Amravati Government Complex area:

- Right of Way - 25M.
- Length of road - 6.38kms.
- The road network which we studied is of **Super block-C** in Amravati Government Complex of Amravati city.
- The California Bearing Ratio (CBR) test obtained for the experimented soil is **7.46%** from which the thickness of pavement is being designed.
- The thickness of Flexible Pavement as per IRC 37-2012 are as follows:
 - **Sub grade - 500mm**
 - **Granular Sub base - 180mm**
 - **Wet Mix Macadam - 250mm**
 - **Dense Bituminous Macadam - 50mm**
 - **Bituminous Concrete - 30mm**
- The following results are analyzed by using **IIT PAVE** software.
 - **Critical Tensile Stress (E_t) - 3.71E-04**

- **Critical Compressive Strain (E_c) = - 5.03E-04**
- **Fatigue criteria: maximum allowable traffic, MSA - 8.534534**
- **Rutting Criteria: Maximum allowable traffic, MSA - 37.54584**
- It is necessary to accommodate utility services along and across the roads. The laying design of utilities has to be done to ease maintenance and operations but keeping in mind that it will affect the traffic flow and conflict with other services to the minimum location should be taken up so that minor or no adjustments are required with road works taken up later.
- Here, the utilities are not provided under the carriage way. But, they are provided under the sideways. **The load of axle get diminishes to maximum extent when the load comes closer to SUB-GRADE.** The potable water line is placed at a depth of **1.0 Meter** from the **F.R.L. (Finished Road Level)**. Sewer is being placed at a depth of **1Meter** from the **F.R.L. (Finished Road Level)** and sometimes varies based on the applied **gradient**. Storm water is being provided beside the **carriage way**.

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