Design of Rigid Pavement for an Existing Road

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Abstract - Pavements, which are typically referred to as flexible and unyielding Pavements, are meant to facilitate the safe, orderly, and smooth entry of traffic. The most commonly used terms for adaptable and unbending pavements are adaptable pavements. Low flexural strength and adaptability in their principal function under stresses are characteristics of adaptable pavements. Pavements that are unbending have minimal flexural strength and are flexible in their principal function as opposed to those that have both essential flexural strength and flexural inflexibility. In order to reduce the expense of vehicles, the huge improvement in auto versatile innovation has led to heavy moving burdens on the existing motorways. The current streets, which were constructed based on general guidelines, cannot adequately support heavy wheel loads, causing them to collapse. According to the specifications of a pavement plan, an effort is made in the venture report to plan a roadway in Paratwada. In order to ensure the soil's properties, such as consistency limit, strainer examination, CBR values, and others, soil tests are conducted on the street's current layout. The thickness of the flexible pavement is then planned. By researching and working out, the street layout is also developed and established. The total length of the roadway is 497 metres, divided into three segments of 247 metres, 200 metres, and 50 metres.

1.1 Index Terms - Methods

1. Collection of Samples
2. Types of Soil Test
3. Construction procedure
4. Graduation test
5. Compaction

II. INTRODUCTION

1.1 General

When applying the same and equivalent traffic load to the pavement, rigid pavements require less thickness than bituminous pavements, making its construction financially feasible.:-

[1]. The biggest drawback of inflexible pavement is that it is more expensive to repair than bitumen roads because the entire concrete slab must be rebuilt when it is damaged. Additionally, because the neighbouring slab panel construction joints serve as a weak plane throughout the portion, the rigid pavement often fails there. Furthermore, it takes 28 days for concrete to reach its maximum compressive strength, which delays the opening of newly built rigid pavements to regular traffic.

[2]. Since it is crucial to ensuring the structural capacity and ride quality of all types of pavements, care should be taken in the design and construction of subgrade and sub-base. Subgrade and sub-base have a significant impact on how well a pavement performs in terms of bearing strength, consolidation, and moisture susceptibility.

[3]. In rainy weather, bituminous surfaces suffer degradation more quickly than concrete surfaces, whereas in dry weather, gravel surfaces become extremely dusty, posing safety and health risks. By building concrete roads, it is simple to solve the issues of dust production and rainy weather damage to roads.

[4]. Unlike bituminous pavement, which has a life span of only ten years, rigid pavements have a lifespan of more than forty years.

[5]. Since concrete is 100% recyclable, rigid pavements require less maintenance than bituminous roads, which frequently need to be repaired after being damaged by weather and traffic. Rigid pavements also have a high surface that is resistant to fuel spills from cars.

Pavements that have notable flexural strength or rigidity are considered rigid. As opposed to flexible pavement layers, there is no grain-to-grain stress transfer to the lower levels. Concrete constructed of Portland cement is used to create rigid pavements. This concrete can be plain, reinforced, or prestressed. A base course between the stiff pavement and the subgrade may or may not be present. Due to its rigidity and high tensile strength, a rigid pavement tends to disperse the load across a somewhat greater area of soil, while the slab itself provides the majority of the structural capacity

III. Literature survey

Vishwakarma, R.J. and R.K. Ingle (2018)- 'Effect of panel size and radius of relative stiffness on critical stresses in concrete pavement' Any country's total development depends on its transportation system. Only transport by road can offer everyone the greatest level of service flexibility from point of origin to point of destination. It works best for moving goods and people to and from rural areas when there are no other transportation options. India has a road network that spans more than 57 lakh km, making it the second-largest network in the world. With 66.2 lakh km of roads, the United States has more. In India, there are 1.69 km or more of roads for every square kilometre of land. This is greater than the United States (0.66 km) and Japan (0.89 km). India also has a higher road density than China (0.45 km) and Russia (0.07 km) [1]. R-56 Roads Wing Design CBR Research Schemes (1999) Guidelines for IRC: 37 are based on fatigue cracking in

bituminous layer, irreversible deformation in the subgrade, and rutting [5]. It gives the mathematical models for determining the permitted vertical compressive strain over the subgrade for rutting failure of the and the allowable horizontal tensile strain at the bottom of the bituminous layer for fatigue failure.asphalt [6]. The actual stresses at these crucial sites are discovered using the IITPAVE software that is included with IRC: 37.

Shaban A. Cosentino P. (2017) , Using a miniature pressure metre and the California bearing ratio Test, we can examine the structural performance of unbound pavement materials. It was decided to evaluate jointed plain concrete pavements using a 3D finite element model. Thus, utilising Ever FE software, the impacts of pavement foundation materials on bending strains were investigated and assessed. From the findings of this work, the following conclusions were formed.

1. Although the compression stresses remain unchanged, the correct pavement thickness can dramatically lower the maximum tension strains at the concrete pavement slab's bottom layer.

2. While compression pressures at the top and bottom layers remain constant, increasing the thickness of the concrete pavement gradually increases the tension stress at the top layer in the base course layer to a thickness of 300 mm.

3. Although the base layer itself showed a minor rise in tension stresses with increases in its thickness, the bending stresses in the concrete layer did not alter as the base layer's thickness increased.

4. The tensile stresses in the base layer for both surfaces rose as the value of the base course materials' modulus of elasticity increased.

5.The tension bending stresses in the pavement and base layers were significantly reduced by the inclusion of a subbase layer, while the compression stresses in both layers remained unchanged.

6. The research revealed that lowering the tension stress at the bottom layer of pavement resulted from raising the modulus of subgrade reaction, whereas all compression stresses and tension stress at the top layer remained unaltered.

IV. METHODOLOGY

4.1 Methods

Because of its better quality and strength, concrete roads, sometimes referred to as rigid pavements, are the option that engineers favour for the longevity of the roadways. Concrete roads built correctly in accordance with codal regulations typically last for more than 25 years. Concrete roads' flexural strength allows them to sustain strong traffic loads and high traffic volumes. For transportation, it offers some of the best highways available. While the entire cost of building and maintaining concrete roads is very affordable over the course of its design life, it has a significant upfront cost. For concrete road construction to attain design strength, the highest level of quality control is necessary at all stages.

In India, concrete roads are constructed in accordance with the IRC codes, which are –

1. **IRC:15 -2002** - “Standard Specifications and Code of Practice for Construction of Concrete Roads”
2. **IRC: 61-1976 -** “Guidelines for construction of concrete pavements in hot weather”
3. **IRC: 91-1985 -** “Guidelines for construction of concrete pavements in cold weather”

4.2 Collection of Samples:

In the area of the site (of the job), three soil samples had been gathered.

4.3 Types of Soil Test:

The various tests carried out on the samples include;

1. Index characteristics
2. Specific gravity
3. Compaction traits
4. The California bearing ratio

1. Proctor's thickness test for mild compaction is used to obtain soil samples with their optimal moisture still in the air.
2. After the soil test is compacted in CBR shape for the proper thickness, the form is submerged in water for three days.

Table-1. Various Tests

Type of Material	Suggested CBR Value (%)
Gravel	25
Road Metal	55

3. To obtain the CBR values for the dirt sub grade, the CBR test is then carried out.

Construction procedure:

Since the prepared subgrade is what the GSB layer is built on top of, the subgrade's surface must first be examined, and any grass or plant that may be present must be taken out. When necessary, the subgrade's top surface's grade and cross slope are rectified. The building procedures are listed below:

• Using a mortar grader, the subbase material is spread to the desired cross slope and uniform thickness by adjusting the grader's blade.

• The material's moisture content is evaluated, and the additional water needed to bring it up to the ideal moisture content is sprinkled at a consistent pace using a truck-mounted sprinkler.

• Using equipment like disc harrows and rotavators, the water material is appropriately blended.

• Using a mortar grader with hydraulic controls for the blade, the mixed material is spread to the required thickness, grade, and camber.

• If the loose GSB layer's compacted thickness is 100 mm or less, a regular smooth-wheeled roller may be used to compact the layer. Vibratory rollers with a static weight of 10 tonnes or more provide compaction for compacted thicknesses up to 225 mm and over 100 mm.

• With at least a third of an overlap between each run of the roller, rolling is carried out from the lower edge of the undivided carriageway inward or from the top edge of the divided carriageway outward. Less than 5kmph is the maximum rolling speed allowed.

• Rolling continues until at least 98% of the material's maximal density has been archived.

• There will be a 6 mm (+ or -) surface level tolerance. **Quality control tests:**

• Graduation test: one test for every 400 m3

• Limits of Atterburge: 1 test per 400 m3

Before compacting, test the moisture content of 400 m3 using 1 test.

• CBR test: as necessary.

• Negative constituents: necessary**.**

Materials:

a. Cement: Portland Slag Cement, Portland Pozzolana Cement, and OPC 43. If there are more than 0.5% of sulphates in the subgrade, cement must be sulphate-resistant.

b. Aggregates:

a. Coarse aggregate:

• Abrasion value for Los Angeles should be less than 35%.

• Less than 35% should be the combined elongation and flaking index.

Less than 2% of the body should absorb water.

• Soundness for 5 cycles: Magnesium and sodium sulphates should both be under 18% and less than 12%, respectively.

b. Fine aggregate: crushed stone sand/natural sand.

Gradation:

Table-2. Gradation

IS Sieves	% passing by weight
26.50mm	100
19mm	75-95
9.50mm	50-70
4.75mm	30-55
2.36mm	17-42
600micron	8-22
300micron	7-17
150micron	2-12
75micron	0-10

Construction procedure:

Batching and mixing: The batching plant must have the ability to weigh out the material for proportioning. In comparison to the suggested laying patterns, the plant should have a 25% higher capacity.

Transporting: Plant mixture Lean concrete must be removed from the mixer as soon as possible. Tipping trucks must transport the concrete. Additionally, there must to be an ongoing supply of the substance. to supply the necessary energy for the laying machinery to operate continuously and at a constant tempo.

Placing: A paver equipped with an electronic sensor must lay dry lean concrete over the drainage layer. The equipment must be able to lay the material evenly and in one layer without segregation. Concrete that is dry and brittle must be spread out and compacted evenly.

Compaction:

• The material should be laid out and levelled, then quickly compacted. Rolling should continue across the entire width.

• A minimum dry density of 98% cannot be achieved.

• 90 minutes maximum for spreading, compacting, and finishing at 250 to 300 °C. If less than 250 c, 120 minutes as well.

When the temperature exceeds 350 c, it is advisable to cease pouring concrete.

• For rolling dry, lean concrete, double drum smooth-wheeled vibratory rollers with a static weight of at least 80 to 100 KN are appropriate. Joints: Longitudinal and structural joints must be offered.

V. RESULTS AND DISCUSSION

Case I: Using the Kenpave software, stress values for moving load conditions and the site of critical loading were discovered.

Table-3. stress values at different load positions

Location of loading		Stress in y direction (KN/m^2)	Stress in y direction (KN/m^2)	Principal stress (KN/m^2)
1)Load at starting condition	Min	-9583.5	-650.83	1.4559
	Max	123.33	670.20	10276
2)Load at middle condition	Min	-5522.8	-390.75	1.2962
	Max	56.869	387.82	6025.4
3)Load at end condition	Min	-5623.0	-387.89	0.35333
	Max	60.904	435.16	6193.3

Because the stress values are higher in the first example, the critical load is taken into account for the situation where moving loads begin to move on the pavement (i.e., case 1).

Case II Pavement Section Supported by Variable Lengths The negative bending moment, positive bending moment, and primary stress values are compared for all pavement sections supported on different lengths. And the support requirements range from L/5 to L/ (i.e., complete area). I.L./5 II.L./10 III.L./20 IV.L./ (complete area) Stress value in various situations

1) Using ANSYS 12.1

Table 4-variation in principle stress analysis

Pavement Thickness(m)	0.16	0.20	0.24	0.28	0.32
Principal stress(KN/M2)	60.76	48.91	40.23	35.23	31.9

2) Using KENPAVE

Table 5- variation in principle stress Kenpave

Pavement thickness (m0	0.16	0.20	0.24	0.28	0.32
Principal stress (KN/M2)	49.242	47.47	44.084	38.994	32.332

VI. CONCLUSION

• An effort is made in this project work to include cutting-edge geometric design and pavement design approaches for an existing road. The IRC requirements are founded on logical reasoning, and the proposed road is safe in terms of both geometry and pavement design.

• Designing a flexible pavement using the Group Index and CBR methods is also suggested. California resisting value methods. Only the GI approach and CBR method are used due to time and scope constraints.

• To have a concrete understanding of estimation analysis, an attempt is made to calculate the quantities of flexible pavement's earth work.

• Tri axial approach costs more than group index, California resistance value, and California bearing ratio methods.The following are some of the key conclusions that this study came to:

1. The FEM approach can find the critical load site with greater accuracy. When designing, essential loads are taken into account for the situation where moving loads begin to move across pavement.

2. When the DLC layer and Subgrade layers are compacted properly, the stresses will be at their lowest and the spacing between supports will decrease in an inversely proportionate manner to the increase in stress.

3. PQC layer and DLC layer thickness are inversely correlated with stress levels. The stresses in the pavement are inversely correlated with the temperature, Poisson's ratio, and elastic modulus.

4. Among all the instances The PQC layer's 320 mm thickness is the ideal thickness for the standard class.a loading for the circumstances you've specified above.

VII. REFERENCES

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