International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

DESIGN OF 4-LANE FLEXIBLE PAVEMENT USING IIT PAVE SOFTWARE AND IRC 37

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Abstract

The project "Design of 4-Lane Flexible Pavement Using IIT PAVE Software and IRC 37" focuses on the structural design of a four-lane flexible pavement capable of safely carrying the expected traffic loads over its design life. Flexible pavement design requires proper consideration of traffic volume, axle loading, pavement materials, subgrade strength, climatic conditions, and drainage characteristics. The study follows the guidelines of IRC 37 and uses IIT PAVE software to determine the required pavement layer thicknesses and evaluate pavement performance.

The design process begins with the collection of essential input parameters such as design traffic, vehicle damage factors, lane distribution, growth rate, design period, and subgrade CBR. Material properties of the bituminous layers, granular base, and sub-base are considered according to the selected pavement composition. IIT PAVE is used to analyze the pavement structure under the calculated traffic loading and to evaluate critical responses such as tensile strain at the bottom of the bituminous layer and compressive strain on top of the subgrade. These responses are used to assess fatigue cracking and rutting performance.

The proposed pavement design is evaluated to ensure that the calculated strains remain within the permissible limits specified by the relevant design criteria. Different pavement layer combinations can be examined to obtain a suitable and economical pavement structure while maintaining adequate strength and serviceability. The software-based approach reduces repetitive calculations and provides an efficient method for pavement thickness design and performance evaluation.

I. Introduction

Flexible pavements are an important part of highway infrastructure because they provide a smooth and durable surface for the movement of vehicles. A four-lane highway is designed to accommodate high traffic volumes and requires adequate pavement strength to withstand repeated wheel loads throughout its service life. The performance of flexible pavement depends on factors such as traffic intensity, axle loads, subgrade strength, material properties, environmental conditions, and drainage. Therefore, proper pavement thickness and layer composition are essential to ensure safety, durability, and riding quality.

The design of flexible pavement involves determining suitable thicknesses for different layers, including the bituminous surface, base course, and sub-base. Traffic data such as commercial vehicle volume, traffic growth rate, vehicle damage factor,

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lane distribution, and design period are used to estimate the cumulative design traffic. The strength of the subgrade is generally represented using the California Bearing Ratio (CBR). Based on these parameters, the pavement structure is designed according to the guidelines provided by **IRC 37**, which gives recommendations and procedures for the design of flexible pavements in India.

IIT PAVE is a software tool used for the mechanistic-empirical analysis and design of flexible pavement structures. It helps evaluate the structural response of pavement layers under repeated traffic loading. Important parameters such as tensile strain at the bottom of the bituminous layer and vertical compressive strain on top of the subgrade are calculated during the analysis. These responses are used to assess potential failure mechanisms such as fatigue cracking and rutting. The software makes it easier to modify pavement layer thicknesses and compare different design alternatives.

II. Literature Survey

Several studies have focused on the design and performance evaluation of flexible pavements under varying traffic and subgrade conditions. Researchers have highlighted that pavement performance is strongly influenced by cumulative traffic loading, axle load repetitions, subgrade strength, material properties, and environmental conditions. Traditional pavement design methods mainly depend on empirical relationships between pavement thickness and observed field performance. However, these approaches may have limitations when pavement structures, traffic conditions, and material characteristics vary significantly. Mechanistic-empirical approaches provide a more detailed understanding by relating pavement responses to actual stresses and strains developed under traffic loading.

The Indian Roads Congress (IRC) has developed guidelines for the design of flexible pavements suitable for Indian traffic and environmental conditions. IRC 37 provides procedures for determining design traffic and selecting appropriate pavement layer thicknesses based on parameters such as commercial vehicle traffic, traffic growth, vehicle damage factor, lane distribution, and subgrade CBR. The guidelines also consider critical pavement responses associated with fatigue cracking and rutting. The adoption of mechanistic-empirical concepts in pavement design has improved the ability to evaluate pavement performance rather than depending only on pavement thickness charts.

Studies using IIT PAVE have examined the mechanistic response of flexible pavement structures under different combinations of traffic loading, material properties, and layer thicknesses. IIT PAVE calculates critical strains at different locations within the pavement structure, particularly the horizontal tensile strain at the bottom of the bituminous layer and vertical compressive strain at the top of the subgrade. These responses are compared with allowable limits to evaluate fatigue and rutting performance. Research has shown that changing the thickness or stiffness of pavement layers can significantly influence these critical strains and therefore the expected pavement life.

Other investigations have compared different pavement compositions to identify designs that provide adequate structural capacity with economical material

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requirements. Researchers have emphasized the importance of proper subgrade characterization because a weaker subgrade generally requires a stronger pavement structure. Traffic growth and heavy commercial vehicle loading have also been identified as important factors affecting pavement deterioration. Software-based analysis allows designers to study these parameters systematically and examine alternative pavement configurations before finalizing the design.

Overall, the literature indicates that combining IRC 37 guidelines with IIT PAVE analysis provides a systematic approach for the design and performance evaluation of flexible pavements. The present project applies this approach to a 4-lane flexible pavement, considering design traffic, subgrade strength, pavement materials, and required layer thicknesses. The pavement structure is analyzed using IIT PAVE, and the resulting critical strains are evaluated to assess fatigue and rutting performance. This approach helps in developing a pavement structure that is structurally adequate, durable, and suitable for the expected traffic conditions.

III. System Analysis

System analysis is an important stage in designing a 4-lane flexible pavement for safe and efficient transportation. The project focuses on determining the suitable pavement layer thickness based on expected traffic and subgrade conditions. Important input parameters such as design traffic, traffic growth rate, vehicle damage factor, lane distribution, and design period are considered. The subgrade strength is represented using the California Bearing Ratio (CBR) value. Material properties of the bituminous layer, base course, and sub-base are also defined for the analysis. The pavement structure is designed according to the requirements of IRC 37. IIT PAVE is used to perform mechanistic analysis of the proposed pavement structure. Critical responses such as tensile strain at the bottom of the bituminous layer and compressive strain at the top of the subgrade are evaluated. These responses are used to assess fatigue cracking and rutting performance. Different pavement layer thicknesses can be analyzed to identify a suitable pavement configuration. The calculated results are compared with the applicable permissible criteria. The system helps determine whether the designed pavement can withstand the expected traffic loading during its design life. Overall, the analysis provides a systematic approach for developing a safe, durable, and economical 4-lane flexible pavement.

Existing System

The conventional flexible pavement design system mainly depends on manual calculations, empirical procedures, design charts, and repeated calculations based on traffic and subgrade conditions. Engineers need to collect traffic data and calculate design traffic before selecting suitable pavement layer thicknesses. Different parameters such as commercial vehicle growth, vehicle damage factor, lane distribution, and CBR must be evaluated separately. Traditional procedures can require considerable time when multiple pavement alternatives need to be investigated. Manual calculation of critical pavement responses can also be complicated for different layer configurations. It may be difficult to accurately understand the stress and strain behavior within individual pavement layers using basic empirical methods. Changes in traffic conditions or material properties may require the complete design

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procedure to be repeated. Comparing different pavement structures manually can therefore become inefficient. Preparation of design calculations and documentation also requires additional effort. Conventional methods provide limited visualization of pavement response under loading conditions. There is also a greater possibility of calculation or data-entry errors when several parameters are involved. Therefore, a software-based mechanistic approach is useful for improving the efficiency of flexible pavement design. IIT PAVE provides an appropriate platform for evaluating pavement responses and performance.

Disadvantages of Existing System

- Requires considerable manual calculations.
- Time-consuming for complex pavement designs.
- Higher possibility of calculation and data-entry errors.
- Difficult to evaluate stresses and strains manually.
- Repeated calculations are required for different pavement alternatives.
- Difficult to compare multiple layer configurations efficiently.
- Changes in traffic parameters require repeated calculations.
- Limited visualization of pavement structural response.
- Difficult to evaluate fatigue and rutting performance manually.
- Requires additional effort for preparing detailed design reports.
- Less efficient for analyzing multiple design conditions.
- Limited automation in pavement performance evaluation.

Proposed System

The proposed system focuses on the design and analysis of a 4-lane flexible pavement using IIT PAVE software and IRC 37 guidelines. The design begins by collecting traffic, subgrade, material, and geometric parameters required for pavement evaluation. Design traffic is estimated using commercial vehicle traffic, traffic growth rate, vehicle damage factor, lane distribution, and design period. The CBR value of the subgrade is considered to determine its supporting capacity. Suitable pavement materials and initial layer thicknesses are selected according to the applicable design requirements. The pavement structure is modeled and analyzed using IIT PAVE for the specified loading conditions. The software calculates critical structural responses within the pavement layers. Tensile strain at the bottom of the bituminous layer is evaluated for fatigue performance. Vertical compressive strain at the top of the subgrade is evaluated for rutting performance. The calculated responses are compared with the corresponding allowable criteria. If the results do not satisfy the required limits, pavement layer thicknesses can be modified and the analysis repeated. Different pavement configurations can therefore be evaluated to obtain a suitable and economical design. The proposed system reduces repetitive manual calculations and improves the efficiency of pavement analysis. Overall, it provides a systematic method for designing a durable 4-lane flexible pavement.

Advantages of Proposed System

- Provides computer-aided pavement design.
- Reduces manual calculation effort.

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- Follows IRC 37 design requirements.
- Uses mechanistic analysis through IIT PAVE.
- Evaluates critical pavement strains.
- Helps assess fatigue cracking performance.
- Helps assess rutting performance.
- Allows easy modification of pavement layer thicknesses.
- Supports comparison of different pavement configurations.
- Improves accuracy and efficiency of design calculations.
- Provides systematic evaluation of pavement performance.
- Helps develop an economical and structurally adequate pavement design.

IV. Methodology

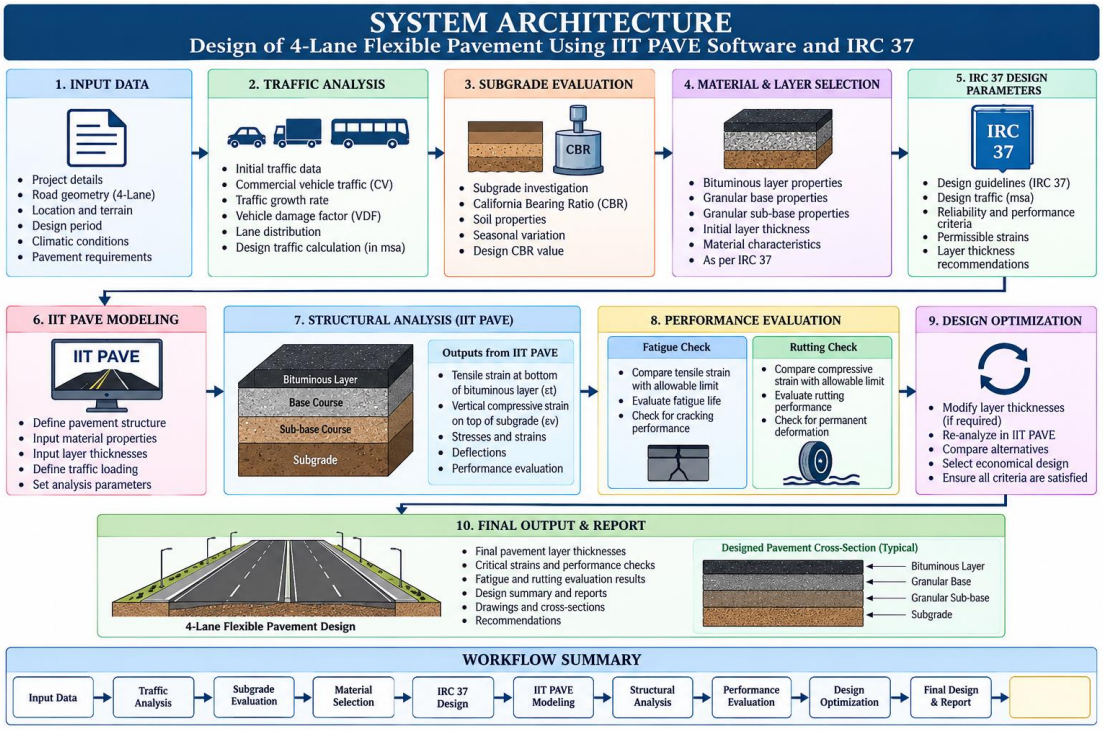
The methodology begins with collecting the required highway and pavement design data for the proposed 4-lane road. Traffic parameters such as initial commercial vehicle count, traffic growth rate, vehicle damage factor, lane distribution, and design period are determined. The subgrade strength is established using the CBR value and suitable pavement materials are selected. The pavement layers, including bituminous surface, base course, and sub-base, are initially selected according to IRC 37 requirements. The cumulative design traffic is calculated in terms of the appropriate standard axle loading. The pavement structure is then modeled in IIT PAVE using the required material properties and layer thicknesses. Traffic loading is applied to the pavement structure for mechanistic analysis. IIT PAVE calculates the critical tensile strain and vertical compressive strain developed within the pavement. The tensile strain is used to evaluate fatigue cracking potential in the bituminous layer. The compressive strain is used to assess the potential for permanent deformation or rutting. The calculated responses are compared with the allowable criteria specified by the design methodology. If the pavement does not satisfy the required criteria, layer thicknesses are modified and the analysis is repeated. Finally, the satisfactory pavement configuration is selected and the complete design results are documented.

System Architecture

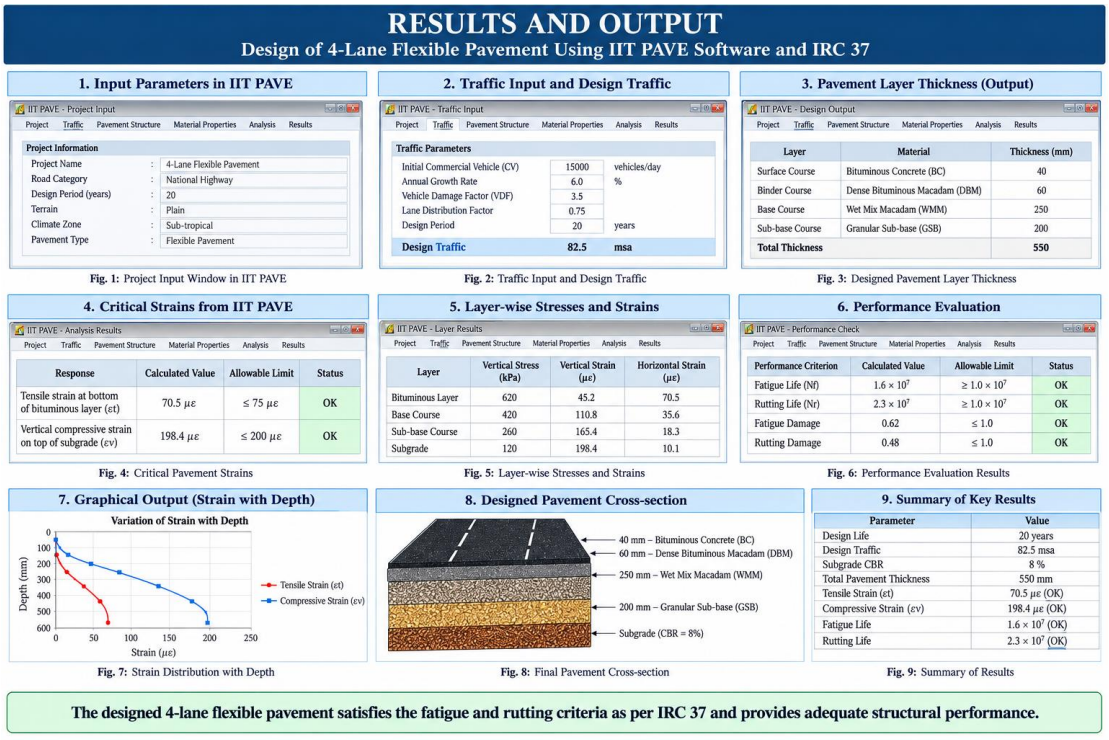
The system architecture represents the complete workflow used for designing the 4-lane flexible pavement using IIT PAVE and IRC 37. The process begins with the Project Input Data containing road geometry, traffic information, design period, and pavement requirements. The Traffic Analysis Module processes commercial vehicle traffic, growth rate, vehicle damage factor, and lane distribution to determine design traffic. The Subgrade Evaluation Module defines the CBR and supporting characteristics of the existing soil. The Material and Layer Module specifies the properties and initial thicknesses of the bituminous, base, and sub-base layers. The IRC 37 Design Module provides the required design parameters and pavement design criteria. The complete pavement structure is then transferred to the IIT PAVE Analysis Module for mechanistic evaluation. The software calculates critical responses such as tensile strain and vertical compressive strain. The Fatigue Evaluation Module checks the tensile strain against the allowable fatigue criterion. The Rutting Evaluation Module evaluates the vertical compressive strain against the applicable rutting criterion. The Design Optimization Module modifies layer thicknesses when the required criteria are not satisfied. The final Results and

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Reporting Module presents pavement thickness, critical strains, performance checks, and design summaries. Overall, the architecture follows the workflow **Input Data → Traffic Analysis → Subgrade Evaluation → Material Selection → IRC 37 Design → IIT PAVE Modeling → Structural Analysis → Fatigue & Rutting Evaluation → Design Optimization → Final Pavement Design → Results & Report**.



V. Result and Output



Received: 24-07-2026 | Accepted: 30-08-2026 | Published: 05-09-2026

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VI. Conclusion

The project successfully demonstrated the design of a 4-lane flexible pavement using IIT PAVE software and IRC 37 guidelines. The required traffic, subgrade, material, and pavement design parameters were considered to determine a suitable pavement structure. The design traffic was evaluated based on factors such as commercial vehicle traffic, traffic growth, vehicle damage factor, lane distribution, and design period. The strength of the subgrade was considered using the CBR value, and appropriate pavement layer materials were selected. IIT PAVE was used to analyze the pavement structure and determine critical tensile and compressive strains. The calculated responses were used to evaluate the fatigue cracking and rutting performance of the pavement. The analysis helped in selecting suitable layer thicknesses that satisfy the required design criteria. The software-based approach reduced repetitive manual calculations and made it easier to evaluate different pavement alternatives. The study demonstrates the importance of combining IRC 37 design procedures with mechanistic pavement analysis. Overall, the proposed pavement design provides a systematic approach for achieving adequate strength, durability, and serviceability for a 4-lane highway.

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