IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 4, May 2024

Study of Concrete Pavement at Chichpalli, Jambharla

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Abstract: *Concrete pavement is a type of road surface made from a mixture of cement, water, and aggregates such as sand and gravel. It is a durable and long-lasting option for roads, highways, and parking lots due to its strength and resistance to wear and tear.*
The process of constructing concrete pavement involves preparing the subgrade, placing a base layer of aggregate material, and then pouring and finishing the concrete mixture on top. The concrete is typically reinforced with steel bars or fibers to improve its tensile strength and prevent cracking.
Once the concrete pavement has been poured and cured, it provides a smooth and even surface for vehicles to travel on. It is also easy to maintain and repair, as damaged sections can be easily replaced or patched. Concrete pavement is a popular choice for infrastructure projects due to its durability, longevity, and low maintenance requirements.

Keywords: Concrete Pavement, Pavement Maintenance, Durability, Sustainability

I. INTRODUCTION

Cement concrete pavement has distinct initial advantage over hitumen pavement in this regard, as surface texturing forms integral part of the normal construction practice for such pavements. They also have superior night visibility by virtue of their lighter colour. Poorly designed and constructed concrete pavements are known to have very long service life. The cement concrete road constructed in the country in the past, though extremely limited in length, have an excellent service track, having given good service under condition much sever than those for which they are originally intended. Cement concrete develops very fine, small, discontinuous micro-cracks in initial stages due to bydrothermal changes.

Construction of rigid pavement is also financially viable as rigid pavements require less thickness than the bituminous pavements when same and equal traffic load is applied to the pavement.

The main disadvantage is rigid pavement requires a high initial cost for rectification compare to bitumen roads as the entire concrete slab needs to be replaced when it darnages. In addition, the rigid pavement tends to fail across the construction joints provided between the adjacent slab panels as it acts as a weak plane across the section. Furthermore, there is a delaying for allowing normal traffic to newly constructed rigid pavements. Since concrete requires 28 days for achieving utmost compressive strength.

Attention should be taken to design and construct of subgrade and sub base since it is essential to ensure the structural capacity and ride quality of all types of pavements. Pavement performances with respect to bearing strength, consolidation and moisture susceptibility are strongly influenced by subgrade and sub base.

During rain storm the damage to bituminous surfaced roads are faster than concrete roads, while gravel roads become very dusty in dry weather condition causing safety and health problems. Problems of dust formation and wet weather damage to roads can be easily overcome by constructing concrete roads.

Rigid pavements have a life span of more than 40 years compared to the bituminous which has 10 years life span.

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DOI: 10.48175/IJARSCT-18306

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Rigid pavements require little maintenance; whereas bituminous roads need frequent repairs due to damage occurred by traffic and weather, high surface resistant to automobile fuel spillage and environmentally friendly since concrete is 100% recyclable.

II. LITERATURE REVIEW

1. Concrete Pavement Design and Materials" by the Portland Cement Association (PCA):

This poblication focuses on the design and material aspects of concrete pavements. It discusses topics such as pavement thickness design, joint design and construction, sub base considerations, and concrete mix design for pavements. It also provides guidelines for troubleshooting and maintenance.

This comprehensive textbook covers the fundamentals of concrete mix design, including the selection of materials, mixture proportioning, and durability considerations. It provides valuable information for designing concrete mixtures for pavements.

The Portland Cement Association (PCA) provides guidelines and recommendations for the design and material selection of concrete pavements. Here are some key considerations and recommendations:

1. Traffic Loads: Determine the expected traffic loads on the pavement, including vehicle types, axle loads, and traffic volume. This information helps in determining the pavement thickness and design parameters.

2. Strength and stability of the subgrade soil where the pavement will be constructed. A weak or unstable subgrade may require additional measures such as subgrade stabilization techniques or the use of thicker pavement sections.

3. Thickness Design: PCA provides guidelines for determining the appropriate thickness of concrete pavements based on traffic loads, subgrade support, and other factors. The thickness design accounts for factors such as the modulus of subgrade reaction, concrete strength, joint spacing, and climate conditions.

4. Joint Design: Proper joint design is essential for controlling cracking in concrete pavements. PCA recommends the use of both transverse and longitudinal joints. Transverse joints, typically spaced at regular intervals, allow for thermal expansion and contraction. Longitudinal joints are used to control cracking due to shrinkage

5. Concrete Mix Design: The concrete mix used for pavements should have suitable properties to ensure durability and long-term performance. Factors such as aggregate gradation, water-cement ratio, cementitious materials, and admixtures need to be considered. PCA provides guidelines for achieving the desired strength, workability, and durability of concrete mixes.

6. Surface Texture and Finishing: The surface texture of concrete pavements influences skid resistance and ride quality. PCA provides guidance on achieving the desired surface texture through appropriate finishing techniques, such as brooming, tinning, or diamond grinding

It's important to note that while the PCA provides guidelines and recommendations, specific design and material selection should be carried out by qualified engineers and in accordance with local design standards and codes.

2. Design of Concrete Pavements" by T.Y. Lin, N.IH. Burns, and H.R. Tang:

This classic book focuses specifically on the design aspects of concrete pavements. It covers topics such as traffic analysis, pavement performance prediction, thickness design methods, joint design, and construction considerations

Subgrade Evaluation: The first step in concrete pavement design is evaluating the strength and stability of the subgrade, which is the underlying soil or material beneath the pavement. Factors such as soil type, moisture content, and load-bearing capacity are considered.

Traffic Analysis: The anticipated traffic load and volume are essential for designing concrete pavements. This analysis helps determine the thickness and structural requirements of the pavement to withstand the expected traffic loads over its design life.

Pavement Thickness Design: The thickness of the concrete pavement is determined based on the traffic analysis, subgrade strength, and desired service life. Mechanistic-empirical methods, such as the AASHTO (American Association of State Highway and Transportation Officials) guide, are often used to calculate the required thickness.

Joint Design: Concrete pavements incorporate joints to control cracking caused by shrinkage. temperature variations, and traffic loads. The spacing, type (e.g., contraction, expansion, or construction joints), and sealing of joints are important design considerations to ensure pavement durability and minimize maintenance.

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Reinforcement Design: In some cases, steel reinforcement may be used in concrete pavements to enhance their performance. Reinforcement helps control cracking and provides additional strength and load distribution capacity. The design of reinforcement, such as steel bars or fibres, involves determining the appropriate placement and quantity of reinforcement based on the pavement's requirements.

Concrete Mix Design: Designing the concrete mix involves selecting the appropriate proportions of cement, aggregates (such as sand and crushed stone), water, and admixtures. The mix design aims to achieve desired strength, durability, workability, and other performance characteristics.

Construction and Quality Control: Proper construction techniques and quality control measures are vital to ensure the constructed pavement meets the design specifications. This includes proper subgrade preparation, concrete placement, finishing, curing, and testing for strength and thickness
compliance.

3. AASHTO Guide for Design of Pavement Structures:

Published by the American Association of State Highway and Transportation Officials (AASHTOL, this guide provides detailed design procedures for various types of pavements, including rigid (concrete) pavements.

The AASHTO guide provides design methodologies, recommendations, and procedures for the design of various types of pavement structures, including flexible (asphalt) and rigid (concrete) pavements. It covers a wide range of design considerations, such as traffic loads, materials, climate conditions, and construction practices.

Key components and design considerations covered in the AASHTO guide include:

Traffic analysis: This involves evaluating traffic volume, vehicle types, and axle loads to determine the design traffic that the pavement structure needs to withstand.

Subgrade and sub base design: The guide provides guidelines for evaluating the strength and support characteristics of the underlying subgrade soils and determining the need for sub base layers to improve pavement performance.

Pavement materials: The guide offers recommendations for selecting appropriate materials, such as asphalt binders, aggregate types, and concrete mixes, based on factors like climate, traffic loads. and availability.

Structural design: The AASHTO guide presents design methodologies for determining the appropriate thicknesses of pavement layers to ensure adequate structural capacity and resistance against distresses like rutting, cracking, and fatigue.

Drainage considerations: Proper drainage is crucial for the long-term performance of pavements.

The guide addresses the design of drainage systems, including surface drainage, sub-surface drainage, and pavement slopes.

Environmental considerations: The AASHTO guide also emphasizes environmental sustainability and provides guidance on incorporating eco-friendly practices in pavement design, such as using recycled materials and optimizing energy efficiency.

It's important to note that the AASHTO guide undergoes periodic updates to reflect advances in pavement design technology and research. Therefore, it is recommended to consult the most recent edition of the guide, which will provide the most accurate and current information for pavement design.

4. Mechanistic-Empirical Pavement Design Guide.

A Manual of Practice" by the National Cooperative Highway Research Program (NCHRP): This manual presents a mechanistic-empirical (M-E) design approach for concrete pavements. It incorporates advanced modelling techniques to predict pavement performance under various conditions, allowing engineers to optimize designs for specific project requirements

The "Mechanistic-Empirical Pavement Design Guide: A Manual of Practice" published by the National Cooperative Highway Research Program (NCHRP) is a comprehensive manual that outlines a mechanistic-empirical (M-E) design approach specifically tailored for concrete pavements. This design guide is intended to assist engineers in optimizing pavement designs based on project-specific requirements.

The mechanistic-empirical design approach integrates advanced modelling techniques to predict pavement performance accurately. Unlike traditional empirical methods that rely on historical data and statistical relationships, the M-E

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approach considers the underlying mechanisms and behaviours of the pavement structure and its response to various loads and environmental conditions.

The manual provides guidance on how to apply the M-E design methodology effectively. It includes detailed information on the key components involved in the design process, such as material properties, traffic inputs, environmental factors, and structural analysis methods. By considering these factors, engineers can develop more reliable and cost-effective pavement designs.

Additionally, the manual addresses the incorporation of performance-related specifications and criteria into the design process. It highlights the importance of considering factors such as pavement roughness, ride quality, and durability when developing designs. By integrating performance-based requirements, the M-E design approach aims to enhance the long-term performance and sustainability of concrete pavements.

In summary, the "Mechanistic-Empirical Pavement Design Guide: A Manual of Practice" by the NCHRP presents an advanced design approach for concrete pavements. By incorporating mechanistic-empirical principles and modelling techniques, engineers can optimize pavement designs based on project-specific requirements and improve the overall performance of concrete pavement

Research Papers And Technical Reports:

Numerous research studies have been conducted on various aspects of concrete pavement design, including load transfer mechanisms, joint performance, reinforcement techniques, load transfer efficiency, long term performance evaluation and the use of innovative materials. These papers provide insights into the latest advancements and can be found in journals such as the Transportation Research Record, Journal of Transportation Engineering, and Cement and Concrete Research. Searching academic databases like IEEE Explore, Google Scholar, or the Transportation Research Board's website can provide access to a wealth of research papers and technical reports. on concrete pavement design.

Variation, defined for this research as the time difference between what was planned and what actually happened, is important as it can affect the productivity performance of construction tasks. The construction process is complex and consists of a large number of interdependent tasks. When the starting time and/or duration of one task varies, it can affect other downstream tasks and result in disruptions to the schedule and/or decreased productivity. This research examined the effect of using a risk assessment matrix in conjunction with the Last Planner System (LPS) method to reduce and/or eliminate task duration variation. A case study was conducted involving a mechanical contractor who specializes in plumbing, heating, ventilation, and air conditioning. The company compared the performance of two separate, but similar projects. The LPS method was used with one of the projects and the company's traditional planning system was used with the other (i.e., not using the LPS system).

A total of 16 weeks' worth of data was collected for each project. Variation, productivity, and cost savings were analysed using a risk assessment matrix and benefit-cost procedures. The project that used the LPS method had a 35% higher productivity performance than the traditionally planned project and resulted in a benefit-cost ratio of 13:113:1. The research findings fill a gap in the body of knowledge by analysing how planning can reduce variation with real project data. The results of this research illustrate the effect the LPS method can have on reducing variation and improving project productivity performance. The findings also serve as an example of an effective planning strategy for project managers and field managers in their efforts to improve project performance.

6. Design and Construction of Concrete Pavements" by the National Concrete Pavement Technology Center (CP Tech Center):

This guide focuses specifically on concrete pavements and provides practical recommendations for their design and construction. It covers topics such as pavement types, joint design, thickness design, reinforcement, and construction techniques.

The National Concrete Pavement Technology Center (CP Tech Center) has been instrumental in advancing the design and construction of concrete pavements. Their publication titled **"Design and Construction of Concrete Pavements"** serves as a comprehensive guide for engineers, designers, and contractors involved in the construction of concrete pavements. While I don't have access to the specific content of the publication, I can provide you with a general overview of the key aspects typically covered in such a resource.

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Introduction: The publication likely begins with an introduction that outlines the importance of concrete pavements and their benefits compared to other types of pavement materials.

Design Considerations: This section covers the fundamental design principles for concrete pavements. It may include topics such as traffic analysis, pavement performance requirements. design methods (including mechanistic-empirical design), and considerations for various types of concrete pavements (e.g., jointed plain concrete, continuously reinforced concrete, precast concrete).

Materials: Concrete pavements require specific materials to ensure durability and long-term performance. This section discusses the selection and properties of materials, such as aggregates, cementitious materials, admixtures, and reinforcement.

Construction Techniques: The publication likely covers various construction techniques for concrete pavements, including subgrade preparation, formwork, concrete placement and consolidation, jointing systems, curing methods, and finishing techniques. It may also touch upon specific considerations for different construction scenarios, such as urban areas or heavy traffic zones.

Quality Control and Quality Assurance: Concrete pavement construction requires strict quality control measures. This section might address testing and acceptance criteria for materials, in-situ quality control procedures, testing of fresh and hardened concrete, and methods for ensuring uniformity and durability.

Maintenance and Rehabilitation: Concrete pavements require regular maintenance and occasional rehabilitation to extend their service life. The publication might discuss maintenance strategies, common distresses and their causes, rehabilitation techniques (e.g., slab replacement, joint resealing, diamond grinding), and guidelines for maintaining and repairing concrete pavements.

Sustainability and Innovation: Given the growing emphasis on sustainability, the publication may touch upon eco-friendly practices, such as using recycled materials, incorporating energy-efficient technologies, and exploring innovative pavement design and construction techniques.

It's worth noting that the specific content and depth of information provided in the publication may vary. The **"Study and Construction of Concrete Pavements"** publication by the CP Tech Center should serve as a valuable resource for those involved in the design and construction of concrete pavements, providing guidance based on industry best practices and the latest research and advancements.

7. Pavement Analysis and Design" by Yang H. Huang:

While not specific to concrete pavements, this book covers the principles of pavement analysis and design, including tflexible and rigid pavements. It offers a theoretical understanding of pavement behaviour, koading analysis, structural design principles, and pavement evaluation techniques that are applicable to concrete pavement design.

The book covers various aspects of pavement engineering, including the characterization of pavement materials, pavement performance evaluation, traffic analysis, and design methodologies for flexible and rigid pavements. It offers a systematic approach to pavement analysis and design, integrating theoretical concepts with practical applications.

Here are some key topics covered in the book:

Introduction to pavement engineering: This section provides an overview of the importance of pavements, their functions, and the factors influencing their performance.

Pavement materials characterization: It discusses the properties and behavior of different pavement materials such as aggregates, asphalt binders, and concrete. The characterization of these materials is essential for designing durable and resilient pavements.

Pavement performance evaluation: This chapter focuses on methods for assessing the performance of pavements, including the measurement of roughness, skid resistance, and structural condition. It also covers techniques for collecting data on pavement distresses and evaluating their severity.

Traffic analysis: Understanding traffic characteristics is crucial for designing pavements that can withstand the expected traffic loads. This section explores various aspects of traffic analysis, including traffic volume estimation, axle load spectra, and traffic growth projections.

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Flexible pavement design: The book provides a detailed explanation of the design methodologies for flexible pavements, considering factors such as traffic loads, material properties, and ironmental conditions. It covers concepts such as layer thickness design, pavement structural malysis, and the use of mechanistic-empirical methods.

Rigid pavement design: This section focuses on the design principles for rigid pavements, including the determination of slab thickness, joint spacing, and reinforcement requirements. It discusses the different design methods used for jointed plain concrete pavements and continuously reinforced concrete pavements.

Throughout the book, Yang H. Huang emphasizes the importance of considering sustainability, environmental impacts, and life-cycle costs in pavement design decisions. The text is supported by numerous examples, case studies, and exercises that help readers apply the concepts learned.

"Pavement Analysis and Design" by Yang H. Huang is widely regarded as a valuable reference for engineers involved in the design, construction, and maintenance of pavements. It provides a comprehensive foundation in pavement engineering principles and equips readers with the knowledge and tools necessary to develop safe, efficient, and durable pavement structures.

"Mechanistic-Empirical Pavement Design Guide: A Manual of Practice" by the Federal Highway Administration (FHWA): This manual introduces a mechanistic-empirical (M-E) design approach that considers both the structural and environmental factors affecting pavement performance. It provides detailed procedures, software tools, and design examples for concrete pavements.

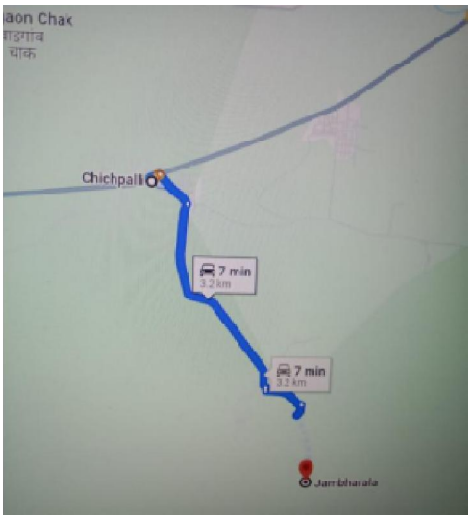
III. METHODOLOGY

MAP STUDY

Present study consisting of designing a rigid pavement from CHICHPALI to JAMBHARLA is prime services road of Chandrapur study. As a part of a study, the map showing the features of existing road is acquired. Fig no. 3.1 shows the relevant maps,

After acquiring the map the physical features are studied

Length :-5 km Width :4m



The first necessary of preparing a plan and section of area to cover by the project. From these prepared maps and sections the best possible alignment, te amount of earthwork and other necessary details depending upon the nature of the project can be calculated. Surveys make sure that protected environment isn't adversely affected, that the structure is safe, and that the project is overall as efficient as possible. The object of map survey is to locate the alignment of road which provides maximum transportation facilities with a minimum cost of construction and maintenance map

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survey is used to determining the positions of points on the surface of the earth and measuring the distances directions and angles and elevation between them this can be used a variety of tools and techniques such as GPS aerial photography and ground based measurements map surveys can also provide information on the topography and natural features of the land such as trees bodies of water and slopes which can be important for environment assessment and planning they can also be used to identify any hazards or risk and help to inform about land use and development a map survey provides a crucial information about the existing topography land features and infrastructure. Map survey before road construction ensures the project is well planned complies with legal requirements considers environmental factors avoid utility conflicts and accurately estimates costs.

IV. TRAFFIC SURVEY

Traffic Intensity Survey:-

Table :Intensity Survey

DATE	VEHICLE	VEHICLE/DAY
22/12/23 TO 23/12/2023	TRUCK	2
	TRACTOR	16
	AUTO	6
	BIKE	50
	BULLCART	14
TOTAL=		88 CVD

SOIL SURVEY

Soil Sample Collection

We were collected 30kg soil sample from 3 different spots at depth of o.5m below the ground surface where the rigid pavement will be design

Gate Of Jambharla

chor gate

hanuman mandir

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IV. TESTING OF SOIL SUBGRADE

As a part of study, disturbed soil surface are collected along the mad in order to know the characteristics of the soil surface. The test to be carried out on soil surface will be is per the following list.

Specific Gravity: Specific gravity is a fundamental property of soils and other construction materials. This dimensionless unit is the ratio of material density to the density of water and is used to calculate soil density, void ratio, saturation, and other soil properties

Table :Result of Specific Gravity

Sr.no	Soil Sample Collection	Result
1.	30M	2.75
2.	60M	2.25
3.	90M	2.714
4.	120M	2.625
5.	150M	2.857

Sieve Analysis: - Sieve analysis helps us in finding the different particle sizes present inside a given soil mix. It helps us in deciding about the Gradation i.e. the soil is well graded or poorly graded.

Table: Result of Specific Gravity

Sr. No	Soil Sample Collection	Result
1	30M	2.96 0/0
2	60M	2.57 0/0
3	90M	2.558 0/0
4	120M	2.754 0/0
5	150M	3.242 0/0

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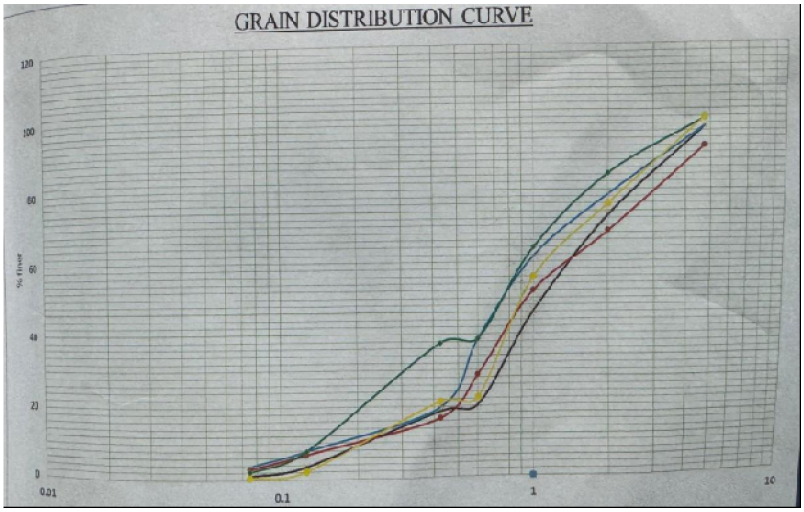

Fig: Graph Of Grain Distribution Curve

Consistency Limit

A] Liquid Limit (LL): - If the natural moisture content of soil is higher than liquid limit, the soil can be considered as soft and if the moisture content is lesser than liquid limit, the soil is brittle and stiffer. The value of liquid limit is used in classification of the soil and it gives an idea about

Table: Result of Liquid Limit (LL)

Sr. no	Soil Sample	Result
1	30M	34 $^{0}/_{0}$
2	60M	38 $^{0}/_{0}$
3	90M	32 $^{0}/_{0}$
4	120M	39 $^{0}/_{0}$
5	150M	64 $^{0}/_{0}$

LIQUID LIMIT CURVE

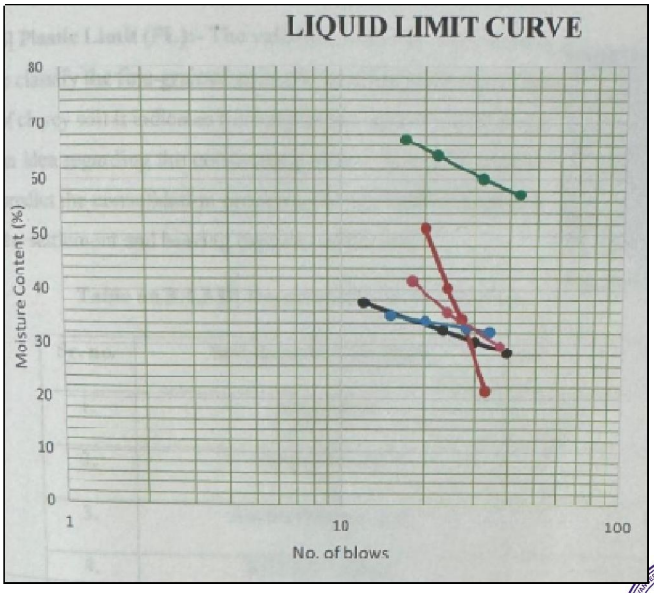

Fig: Graph of Liquid Limit Curve

ISSN 2581-9429 IJARSCT

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BI Plastic Limit (PL)

The value of the plastic limit is used classify the fine-grained soils and evaluating the activities of clayey soil it indicates the toughness index of soil. It gives anides regarding the consistency of soil. It can be used to predict the consolidation properties of soil while computing the settlement and bearing capacity of the soil

Table: BI Result of Plastic Limit (PL)

Sr. no	Soil Sample	Result
1	30M	$20^0/_0$
2	60M	$24^0/_0$
3	90M	$14^0/_0$
4	120M	$25^0/_0$
5	150M	$24.71^0/_0$

Shrinkage Limit (SL):-

This limit is needed for studying the swelling and shrinkage properties of cohesive soil. The shrinkage factor helps in the design problems of structure made up of this soil or resting on such soil. It helps in assessing the suitability of soil as a construction material in foundations, roads, embankments, and darns.

Table :Result of Shrinkage Limit (SL)

Sr. no	Soil Sample	Result
1	30M	$20.5^0/_0$
2	60M	$10.29^0/_0$
3	90M	$14.05^0/_0$
4	120M	$12.9^0/_0$
5	150M	$6.7^0/_0$

Maximum Dry Density (MDD) :

Sample No	1	2	3	4	5
Water Added	10.1 %	13%	16%	19%	22%
Volume of mould(v)	1000	1000	1000	1000	1000
Empty Weight	4637	4637	4637	4637	4637
Wt. Of Mould + Compacted soil (w_2)	6687	6669	6601	6541	6533
4.Wt. Of compacted soil	2050	2032	1964	1904	1896
Wet density	2.05	2.032	1.964	1.904	1.896
Water content	4.77%	5.97%	8.88%	14.09%	14.42%
Dry density	1.42 g/cc	1.50 g/cc	1.53 g/cc	1.45 g/cc	1.28 g/cc

Optimum Moisture Content (OMC):-

Sample No	1	2	3	4	5
Empty Wt (W1)	10278	10.836	10.676	10.267	11.067
Wt of Container+ wt of soil (W2)	39.85	43.64	40.69	42.25	38.32
Wt of Container + dry soil (W3)	38.503	41.79	38.24	38.67	34.79
Wt of wet soil (W2-W1)	38.572	32.804	30.014	31.983	27.997
Wt of dry soil (W3-W1)	28.225	30.954	27.564	25.403	24.467
Wt of water(ww) (W2-W1)	1.347	1.85	2.45	3.58	3.53
Water content (WW/WD)	4.77%	5.97%	8.88%	14.09%	14.42%

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CBR:-

Normally the CBR value at 2.5 mm penetration which is higher than that at 5.0 mm reported as the CBR value of the malarial. However, if the CBR value obtained from the test at 5.0 mm penetration is higher than that at 2.5 mm, then the test is to be repeated fur checking if the check test again gives similar results, the higher value obtained at 50 mm penetration is reported as the CHR value. The average CBR value of three test specimens is reported to the first decimal place, as the CBR value of the material If the variation in CBR value between the three specimens is more than the prescribed limits, lists should be repeated on additional three samples and the average CBR value of a specimens is accepted

Table :Result of CBR

Sr. no	Soil Sample	Result
1	30M	2.42%
2	60M	3.23%
3	90M	4.04

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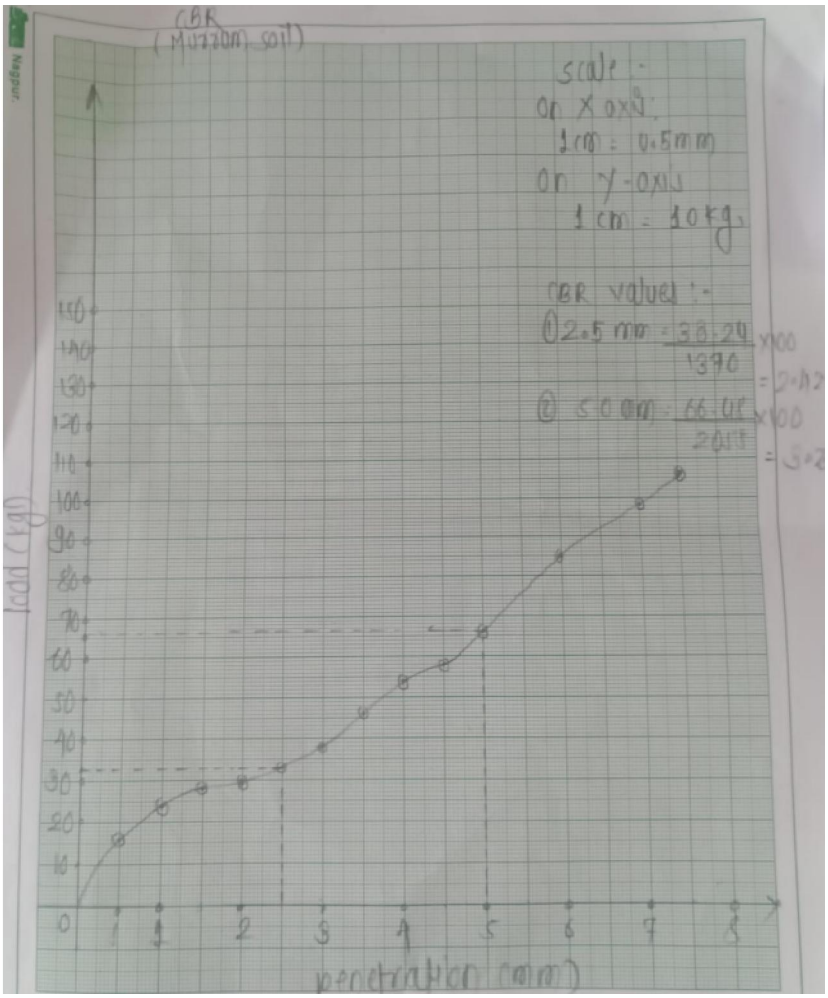

Soil Classification:

Soil sampling and analysis can provide oveful information about the chemical and physical conditions of soil in a specific location Soil survey is an inventory of the properties of the soil such as texture, internal drainage, parent material, depth to groundwater, topography, degree of erosion, stoniness, pil, and salinity and their spatial distribution over a landscape

Table :soil classification from above result

Sr. no	Soil Sample	Classification
1	30M	MI
2	60M	CI
3	90M	CL
4	120M	CL
5	150M	CI

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Volume 4, Issue 4, May 2024

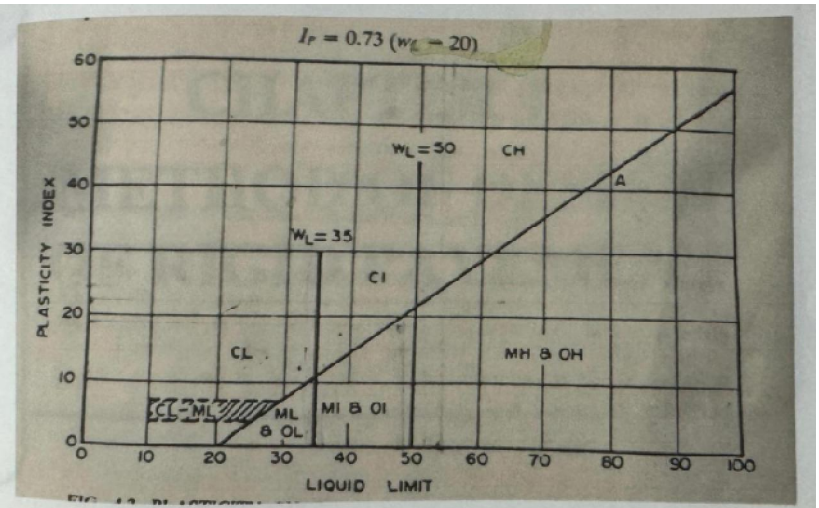


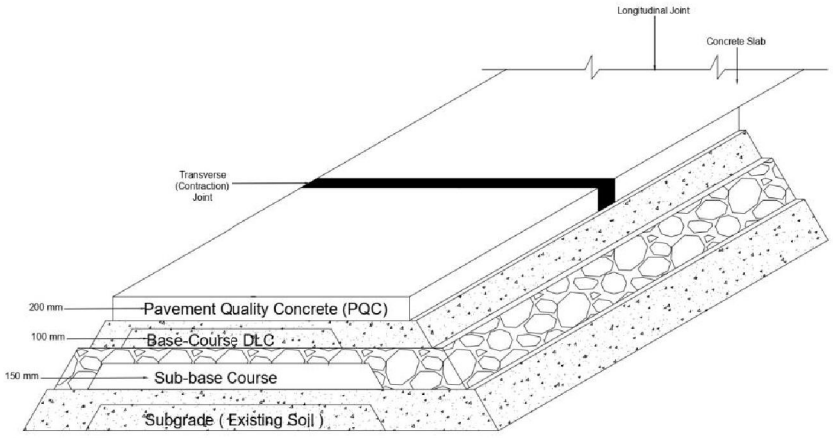
Fig. 3.4.5. b) : Plasticity chart (IS Soil Classification System)

V. CONCLUSION

We have concluded that we can replaced flexible pavement by concrete pavement due to the problem that were occurring frequently.

Cement concrete pavement is costly but if we taught about long life, it is economical because of low cost maintenance and utility more.

In the present study of attempt is made to replace the flexible pavement is design as per IRC: 58-2002. The final thickness of PCC pavement found to be**18 cm.**



Design of Concrete Slab

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 4, May 2024

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