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STUDY ON A SUSTAINABLE CONCRETE FOR LOW VOLUME ROADS

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ABSTRACT:The number of roads and cars in a country is a positive measure of its economic health. A huge portion of India's population still lives in rural areas and relies on agriculture for their livelihood. Villages are also becoming more important centers for industrial expansion. Each of these activities needs better communication, and well-maintained roads may help. Agricultural tractors and trailers, light cargo vehicles, buses, animal-drawn vehicles, motorized two-wheelers, and bikes make up the vast majority of traffic on village roads, which have an extremely low volume of traffic overall. Some rural routes may also see light and medium trucks transporting sugarcane, timber, quarry materials, and other items. Village connectivity programs currently use flexible pavements due to their inexpensive initial construction costs. The condition of village roads deteriorates quickly due to high maintenance costs, sensitivity to water logging, and a lack of institutional infrastructure for their upkeep. This is particularly true in expansive soil regions, where plain cement concrete pavement fails to hold due to inadequate subgrade soil strength. Expansive soil presents unique challenges for highway engineers as a result of its swelling and shrinkage properties; the former can experience pressures ranging from zero to two thousand KN/m2, while the latter can only withstand 150 KN/m2. Every year, expansive soil causes billions of rupees' worth of damage in India. Plain cement concrete pavements undergo deterioration at an early stage in their design life. The swelling pressure, typically measuring 500 Kn/m2, is the primary factor that causes damage to C.C. concrete. The expansion of the subgradesoil during rainy seasons results in a surcharge weight of 3.0 KN/sqm for granular subbase and 4.80 KN/sqm for cement concrete across the entire subgrade. The shoulder soil confines both the subbase and CC pavement, resulting in a consistently higher net uplift pressure in the middle of the pavement compared to its edges. Due to the fact that subgrade soil drying always begins at the pavement's margins and works its way to its centers, the swell pressure is consistently highest in the pavement's centers. The early draying of black cotton soil near the pavement edge and maximum swelling pressure in the middle of the pavement are the reasons behind this. Cracks running the length of the road appeared near the center. The c.c. pavement begins to settle as the subgrade soil shrinks and the black cotton soil dries up. In this scenario, the crocodile transverse cracks disrupt the length-to-breadth ratio of the cement concrete pavement, which impacts its design because the subbase settles before the pavement quality concrete (PQC). This leaves a space between the two. On the Deccan lava plateau and Malwa plateau, where there is moderate rainfall and underlying basaltic rock, lies the Bundelkhand region, which comprises seven districts of Andhra Pradesh and twenty districts of Madhya Pradesh. Expansive soil covers approximately 20% of our country's total area, which is 32,87263 square kilometers. Existing regulations estimate the design life of cement concrete pavement to be 20 years, but early longitudinal and transverse cracks cause damage sooner, and the subgrade soil strength in this area is quite weak. Rigid pavement, consisting of numerous joints intended to reduce thermal stresses, frequently causes inconvenience to users and traffic. IRC SP:58-2002 and IRC SP:58- 2015 recommend using reinforcement in concrete slabs to counteract the tensile stresses caused by temperature and moisture changes, which cause the slabs to shrink and contract. Although the quantity of steel used in pavement as dowel bars, tie bars, and temp steel affects the cost of rigid pavement, it is not intended that this reinforcement in the concrete slab contributes to its flexural strength. Therefore, we can use this reinforcement to enhance the flexural strength of the pavement based on actual stress estimations. The International Road Code (IRC) provides standards for the design and construction of low-volume traffic roads with a minimum concrete grade of m-30 for rigid pavement. The public works departments of Uttar Pradesh and Telangana enthusiastically endorse this recommendation for village road construction, pointing out that dual wheel load calculations or the use of 75 mm thick WBM III over 100 mm thick granular subbase cause traffic stresses of less than 50 CVPD on most of these roads. Mr. C.A. After 4 to 5 years of construction on pavements built on existing codal provisions in expansive soil regions, early fissures became visible in the pavement surface. In this work, we try to solve these problems by studying the expansive soil's subgrade properties in depth and obtaining subgrade response modules according to the IRC:SP:62-2014 standards. We conducted an analysis of the performance of the current plain cement concrete and collected construction data and specifications from the relevant agency. High traffic may damage or crack some roads, necessitating a traffic survey of the existing roads to identify the root cause of these CC pavement failures. This project uses the current CC. Poor design may also lead to road collapse, thus necessitating a redo of the pavement to confirm the specified design and provisions.

Based on the field study results, the current road design and pavement are suitable for low-volume traffic, according to the existing guidelines of IRC:SP:62-2014. It is evident that the current road design is inadequate for C.C., even though the quality of some roads may be below average. The roadway is constructed on expansive land in a specific geographical location. We use a finite element model to calculate the stresses caused by swell pressure. We place steel at the top and bottom of the pavement to counteract these stresses. We increase the joint spacing from 2.5–4.0 m (as per IRC SP:62–2014) to 20 m for smooth riding. The proposed section, which removes CNS layes ranging in thickness from 150 to 225 mm, will evaluate the savings compared to current design practice. The average CBR of the expansive soil subgrade in the Bundi Khand region is approximately 3.0 percent, but in a small area of the Bundi Khand region, the subgrade is quite poor, with a CBR value of only 2.0 percent. This study's proposed R.C.C. pavement

design takes into account CBR values of 2.0 and 3.0 percent for the granular and cementation subbases, respectively. Since flexable pavement deteriorates at a rapid rate, particularly in this area, it is necessary to do special repairs on these roads periodically. Therefore, we recommended replacing the existing flexible pavement with plain cement concrete to assess its potential for salvage. Town roads, expanding soil zones, swell pressure, stiff pavement, reinforced concrete pavement, and finite element model. The current study has led to the creation of publications that provide a sustainable substitute for rigid pavement in areas with expanding soil. We are investigating the RCC village road pavement in the expanding soil region as a long- term solution for subgrade soils with a CBR value of 2.0%, an average CBR value of 3% for expansion soils with granular subbase and cementations, and as a replacement for existingflexible pavements that are several years old.

A BRIEF OVERVIEW

1.1 Main roads function as the primary thoroughfares for vehicles. Road services have been necessary for humans ever since they discovered how wheels worked in prehistoric times. The primary mode of transportation shifted to bullock carts and chariots. These days, people all over the world rely on motor vehicles as their primary mode of transportation. The number of roads and cars in a country is a positive measure of its economic health. According to Encyclopaedia Britannica Inc. in Chicago (1999), Table 1.1 shows the relative positions of road length and road density for a number of developed nations, including India.

The majority of India's population (about 70%) resides in rural areas, where farming is the primary economic activity. A lot of factories are moving to rural areas because of all the new environmental regulations. Better communication is necessary for each of these pursuits, and well-maintained roadways may supply just that. The majority of the traffic on rural roads used to be agricultural tractors and trailers, light cargo vehicles, buses, vehicles pulled by animals, motorized two-wheelers, bikes, and other similar vehicles. Some rural roads see the haulage of sugarcane, lumber, quarry materials, and other items by light and medium trucks. In their case study of the Jaipur district in India, Kumar et al. (1998) examined rural travel characteristics and stressed the role of access roads in rural development. We currently recommend flexible pavements for village connectivity due to their low initial construction cost and traffic type. Nevertheless, village roads, particularly in alluvial regions, deteriorate rapidly due to high maintenance costs, susceptibility to water logging, and the absence of an institutional framework for the work. Waterlogging and floods erode the numerous kilometers of these roads annually.

Additionally, industrialization in the surrounding regions is altering the character of traffic. Political leaders, urban designers, and transportation engineers will inevitably consider other, better pavement options for rural roads. Worldwide, a number of groups are responsible for establishing and maintaining road standards and specifications. One of the most prominent Indian groups concerned with road standards is the Indian Roads Congress (IRC), which hasbeen around since 1934. To determine the course of future road building, chief engineers from each of India's states gathered in Nagpur in 1943. The group classified the roads under discussion as follows:

1.2 Road Classification: National Highway The National Highway serves to connect two or more capitals or significant towns across multiple states. In India, the Ministry of Road Transport and Highways owns the network of trunk roads known as the National Highways. The National Highways Authority of India (NHAI), with assistance from the National Highways and Infrastructure Development Corporation (NHIDCL) and the public works departments (PWD) ofeach state, is the governing body responsible for building, upgrading, and maintaining most of India's national highways. The Ministry of Highways and Road Transport oversees its operations. A massive endeavor to improve and extend the roadway system is the National Highways Development Project (NHDP). Public-private partnerships frequently handle construction, upkeep, and toll collection on NHAI highways. Unlike national highways, which are at-grade roads, Indian motorways are controlled-access highways designed with ramps to regulate entrance and departure. A state highway connects two or more major cities in the same state. The Indian government is responsible for maintaining the country's road network, which is known as the state highways. The state's Public Works Department is in charge of its

construction and maintenance. State highways typically connect major urban areas, smaller towns, and district headquarters within a state, as well as to routes in neighboring states or to New Hampshire. The total length of SH was 176,166 km as of March 31, 2016. The overall length of SH highways in Maharashtra was 22.14% as of March 31, 2016, with Karnataka at 11.11%, Gujarat at 9.76%, Rajasthan at 8.62%, and Tamil Nadu at 6.67%. State governments have initiated several SH projects since 2000. By 2010, state governments had completed $1.7 billion worth of highway projects, and they were currently working on additional projects worth

$11.4 billion. In 2018, the India Government initiated a sponsored road and highways project, Bharatmala, which aims to construct 83,677 km (51,994 mi) of new roadways. The first stage of the Bharatmala project is set to commence in 2021–22 and will entail the building of 34,800 km of highways, with an anticipated expenditure of

5.35 lakh crore (US$75 billion).

1. A major district road connects two or more districts of a state by connecting their most important locations.
2. Additional District Roads: for linking multiple locations within a district.

3. The purpose of village roads, often called link roads, is to connect rural areas to major thoroughfares.

In 1950, the Central Road Research Institute (CRRI) was founded in New Delhi to conduct studies and investigations related to highway engineering. To build important roadways and connect the state capitals via well- maintained roads, the National Highway Act was created in 1956. Nagpur stated in 1943 that it would build 529,600 km of various types of roads over a 20- year period, from 1943 to 1963, to meet socio-economic and agricultural needs. In 1961, Bombay announced its second 20-year plan, the Bombay Plan (1961–81), with the goal of building 10,59,200 kilometers of roadways in various categories. In 1985, Lucknow announced

the third plan, aiming to construct 2770,000 km of roads within the next 20 years to meet the nation's needs. Vision 2021 is the current road development plan. Table 1.2 displays the road standards determined by the Indian Roads Congress. Link and rural roads are critical because they serve a large section of the population, but long-distance roadways like national highways, state highways, and important district roads can't meet everyone's needs. The Indian government endeavored to connect all villages and cities across the country through roadways, a move that brought

1.3 road policies to the forefront. This is a summary of the correspondingly developed vision plans.

1.3.1 Progress has been made towards road development goals until 2021. The Indian Roads Congress has drafted a document outlining their goals for road development in India. Table 1.4 shows the set targets for the year 2021 for the construction of various types of roads, which will lead to an expansion of the road network. In particular, the plan calls for the following: (i) a four- or six-lane national highway for half of its length, and a two-lane road with hard shoulders for the other half. (ii) Of the state highways, 10,000 km should be four-lane, and the rest should be two-lane. iii) Install two-lane carriageways on forty percent of the main district routes. (iv) The following should be the objectives for basic village access: (a) villages with a population of 1000 or more in 2003; (b) villages with a population of 500 to 1000 in 2007; (c) villages with a population of 500 or fewer in 2010; (d) villages with a population of 250 or fewer in 2022. (v) Adequate maintenance of existing assets is crucial. (vi) It is important to prioritize research and development efforts in the road sector.
(vii) Non-traditional means of financing, such as increasing gasoline taxes or instituting tolls,

could be considered. (viii) The construction industry could introduce new methods to improve technology. (ix) Engineers should take steps to make roads safer. (x) We need to consider the environmental consequences of roads and traffic. (xi) We should prioritize the education and development of engineers. (xii) We recommend implementing road projects through public- private partnerships (PPP).

1.4 : The Indian Roads The Congress has developed Vision 2025, a strategy for improving ruralroads. This plan's most notable aspects are:

(i) The main network that provides access to each hamlet should be depicted in master plans forrural roads. In the future, all programs must adhere rigidly to this network.

(ii) All urban areas with 100 or more residents will be linked by all-weather pathways.

(iii) Blacktop is expected to cover an estimated 290,000 km, while graveling will cover the remaining 250,000 km.
In addition to the 66,000 crores currently allocated, an additional 26,000 crores are needed.

(iv) The estimated cost is 1,64,000 crores, and it should be used to upgrade existing rural roads, which span around 1,237,000 km.

(v)The rural road network will need an annual budget of 7,500 crores to be maintained.

(vi) Methods for reducing the expense of rural roads should be devised. These include making the most of locally sourced materials, stabilizing the soil, using 8-gravel roads and low-cost stream crossings, and implementing stage-construction concepts.

(vii) Using tractor-bound technologies for building and maintenance shall be prioritized. In addition to all of this, on December 25, 2000, the Indian government began a nationwide initiative called the Pradhan Mantri Gramme Sadak Yojana (PMGSY) to improve connectivity in

586,00 villages across the nation. As part of this initiative, all-weather roads will be built to link communities with populations up to 500 that are located within half a km of the main route. As part of the Chhuti Kari Yojana, the public works departments of various states are currently connecting a number of village roads that are less than half a kilometer from the trunk road. The rural engineering department, Mandi Parishad, Samaj Kalyan Nirmarn Nigam Limited, Project and Tube Well Company Limited, several agencies financed by the global bank, and the state of Uttar Pradesh are among the many that build the tiny link roads. State Awas Vikas Parishad, etc.

1.5 Different Types of Road Pavements Most road pavements are engineered to withstand traffic loads as well as environmental stresses (e.g., variations in temperature, moisture, etc.). It is important that the pavement be structurally sound and that its thickness is adequate to evenly distribute loads and stresses to the subgrade. The surface should be moderately hard-wearing so that cars can move smoothly and damage-free. Additionally, the road's quality should be such that riders may travel at high speeds in comfort. In addition to having a long lifespan and requiring little in the way of maintenance, the pavement should be impermeable to water so that it does not seep into the subgrade. The three most common varieties of pavement are semi-rigid, stiff, and flexible. Rigid pavements, i.e., there are a lot of benefits to using cement concrete pavements instead of more pliable options. The slab can be laid directly on top of the subgrade in rigid pavements; however, a base course is required in situations where the soil is not sufficiently strong. In order to create a flat, even surface for vehicles to travel on, the surface course is the primary structural component of a pavement. Water cannot seep into the pavement and subgrade because of this. Although the upfront cost of building a cement concrete road is substantial, its lifespan is far greater than that of flexible pavements. Seehra (2006) lists the following as the most common varieties of rigid pavements:

1.5.1 Plain Concrete Pavement (PCP): This is the most common kind of concrete pavement, and it mimics the behavior of a long concrete slab without joint control by using joint spacing that is set to mimic that condition. The standard spacing for the contraction joints is 4.5 m, and they are given undo welling. The aggregates in these pavements interlock at the cracks, allowing the joints to distribute the stress. To avoid having both wheels of the vehicle collide at the sametime, the joints are usually angled at a slope of 1 in 10.

1.5.2 Joint Reinforced Concrete Pavement (JRCP) One distinguishing feature of JRCP over plain concrete is the wider spacing of the transverse contraction joints. This pavement style often has joints 8–12 m c/c, perpendicular to the roadway. Cracks form in the middle of the slab with this pavement type, and reinforcement mesh is used to keep them together. In addition, the longitudinal joints have the tie bars, and the terminal ends have the anchors. 1.5.3 CRCP, or Continuously Reinforced Concrete Pavement, is an alternative to plain concrete pavement that reduces maintenance costs, improves riding comfort, and allows for much longer slab lengths by minimizing the need for expansion and contraction joints. The CRCP-EJ method of construction allows for a significant decrease in the quantity of steel; it uses steel that accounts for around 0.4% to 0.5% of the concrete cross section. Also, unlike traditional continuously reinforced concrete pavements, it doesn't develop cracks at random. Aggregate interlocking facilitatesweight transfer over CRCP's closely held fissures, which also block water from penetrating the material.

1.5.4 SFRCP, or Steel Fiber-Reinforced Concrete Pavement, is a type of plain concrete that has been reinforced with a random distribution of short steel fibers with particular geometries. These fibers limit the growth of cracks by acting as crack arresters. The flexural, fatigue, impact, and other strengths of SFRC are higher than those of regular cement concrete. Numerous highway pavements, bridge deck surfaces, and airport pavements have made use of SFRC, with fiber contents ranging from 0.75 to 1.5 percent by volume. One possible benefit of using SFRC as a composite matrix is its increased stress resistance. Reduced excavation, fewer construction joints, shorter construction times, and less material consumption are all possible outcomes of significantly decreasing the pavement thickness while maintaining the same loading conditions.

1.5.5 RCCP, or Roller Compacted Concrete Pavement, is a technology that is seeing fast global growth in the field of rigid pavement. For national highways and motorways, RCCP technology allows for the use of slip-form paver machines to lay pavement-quality concrete (PQC) as the wearing surface and dry lean concrete (DLC) as the sub- base layer. The paver machine will improve the riding condition of the RCCP and almost eliminate wear and tear. The durability of cement concrete pavements outlasts that of flexible pavements, which is one of the main benefits of rigid pavements (1.5.6). Low maintenance costs result in a lower overall cost (as measured by life cycle analysis), even though the initial building cost is high. Due to quicker vehicle movement, which allows for a significant reduction in travel time and greater load-carrying capacity in large vehicles, rigid pavements contribute to the economy by adding about 14% fuel savings for load carriers (Prasad, 2007). Not only are they weatherproof, but they are also immune to water. When compared to flexible pavements, rigid pavements offer superior performance over poor soil subgrade and offer improved nighttime vision. During the monsoon, it is able to traverse waterlogging and marshy, lower-grade environments. Cement concrete roads, as an alternative to bituminous roads in western countries, have remained popular in the international scenario of 1.5.7 Rigid Pavements. According to Meerha (2006), out of the total motorway network, over 40% in the US, 30% in Germany, 20% in Switzerland, and 40% in Belgium are composed of hard pavements.

1.5.8 Rigid Pavements: National Scenario With a desired growth rate of approximately 10%, the Indian economy is in a critical stage of development. Maintaining a high standard of road infrastructure across the nation is crucial to meeting this growth ambition. In 1930, the Great Southern and Western Trunk Highways, as well as city highways in Hyderabad, Delhi, Mumbai, and Calcutta, were built using cement concrete in India. Later on, when cement became scarce, flexible pavements became the norm. Roads made of bituminous material deteriorated during rainy seasons in several large cities, including Nagpur and Mumbai, but cement production has recently increased, leading to a preference for hard pavements. According to Meera (2006), approximately 20% of the 13,146 km of highways planned for four lanes under the National Highway Development Project (NHDP) in India will be constructed using cement concrete. With its 84 kilometers of concrete pavement, the Mumbai-Pune motorway cuts down on travel time, fuel consumption, pollution, and fatalities and injuries on the road, all of which contribute to the economy. The motorway begins at NH-4 near Panvel near Kon and ends at Dehu Road on the westem bypass outside of Pune. The new cement concrete pavement carriageway extended from km 42 to km 94, widening and upgrading the Delhi- Mathura (NH-2). Cement concrete roads are recommended in populous areas and streets to address the challenge of maintenance due to poor drainage and other factors. The Indian Road Congress (IRC) has produced a rural road manual for roads with low traffic volumes, such as village roads and streets. The Pradhan Mantri Gramme Sadak Yojna (PMGSY) was implemented nationwide in 2000 to address people's socioeconomic needs. Rigid pavements are the only long-term solution due to the lack of resources and ineffective institutional framework for maintaining rural roadways. Cement concrete pavement has already been used in the state of Punjab for village roads and streets. The citizens of Ambedkar villages in the Indian state of Andhra Pradesh began having their village roads and streets paved with rigid pavement in 2008. Rigid pavements may soon be a necessity in the northern Indian states located in alluvial plains, where problems such as poor subgrade, waterlogging, floods, and population explosions are common. IRC: SP: 20-2002 provides details on the planning, design, and building of rural roads; IRC: 58-2002 and IRC: 15-2002 are the current standard specifications and codes of practice for the design and construction of cement concrete pavements used in village roads. Guidelines for the design and construction of cement concrete pavement for rural roads, IRC: SP: 62-2004, were introduced to encourage the use of these pavements on low-volume roads. With an axle load of 102 kilonewtons, the roads can be constructed to support a wheel load of 50 kilonewtons, according to IRC SP: 62-2004. However, a 30 Kn design wheel can be considered for minor link roads built for single dwellings where the sole traffic is that of agricultural tractors, trailers, and light commercial vehicles. (i) If the wheel load is 51 Kn, the tire pressure can be thought of as 0.7 MPa, and if it's 30 Kn, it can be thought of as 0.5 MPa. A sub-base of 150 mm thickness of water-bound macadam, granular sub-base, gravel, solidcement, soil-lime, or 53-22.4 mm aggregates can be used for pavements that are intended to withstand a wheel load of 51 kN. The sub-base thickness can be lowered to 75 mm for moderate traffic and wheel loads of 30 kN. It is possible to assume a 'k' value 20% higher than the subgrade's 'k' value when dealing with granular subbases. To prevent the sub-base and concrete slab from touching, it is advised to place a 125-micron-thick plastic sheet over the sub-base. 13. Since traffic growth occurs over a longer period of time, it is advisable to construct rural roads with 90-day flexural strength rather than 28-day flexural strength. It is reasonable to assume that the 90-day flexural strength is 20% greater than the 28-day flexural strength of concrete. There needs to be a three-month ban on heavy commercial trucks. The suggested characteristic 28-day compressive strength for pavement construction on country roads is 30 MPa, whereas the minimum characteristic 28-day flexural strength is 3.8 MPa. Concrete has a Poisson's ratio of 0.15 and a modulus of elasticity (E) of 3.0 x 10^4 MPa. One possible value for the coefficient of thermal expansion 'κ' of concrete is 10 x 10-6 per °C. Alluvial village roads typically sit on weak soil and are prone to flooding, two of the 1.7 shortcomings of concrete pavement design. When it comes to building rural roads, there is a severe shortage of both skilled workers and heavy machinery. It is also possible that during the rainy season, water will seep into the subgrade from the surface. Making flexible pavement, which takes a lot of maintenance, is the current method for building village road pavements in alluvial zones. Not only is there not enough money, but the institutional framework for maintaining these roads is inadequate. Another concern is the potential shortage of building materials, which are essential for the creation of flexible pavements. Another obstacle to building flexible pavements is environmental considerations. Rigid pavements are a better and more long-term solution for connecting villages because of this. Many revenue villages still lack all-weather pavement, despite numerous attempts since independence. We are working hard to make up for this shortfall. The current effort focuses on discussing and implementing adjustments to the current provisions of plain cement concrete roads in order to account for swell pressure, which is an average of 500 Kn/m2 in expansive soil areas. There are a lot of strains on concrete pavements from a number of sources, and designers still haven't taken swell pressure into consideration. The worst-case scenario is when you have strains from a single wheel load, stresses from the temperature difference between the slab's bottom and top surfaces during the day, and frictional stresses from the temperature difference overall. Because the top layer of concrete gets hotter during the day and cooler at night, the temperature differential between the two surfaces changes in a daily cyclical pattern. Because of the pavement's self-weight acting as a constraint on the slabs' warping propensity, which causes stresses in the pavement called temperature stresses, the pavement tends to warp upwards (top convex) during the day and downwards (top concave) at night. Flexural in nature, these exhibit tensile stress during the day and shear stress at night. There won't be much resistance to warping at the corners since it depends on how much weight the slab has up to that point; the resistance is highest in the middle of the slab and slightly lower at the edges. Pavement temperature stresses, which are greatest within, are almost nonexistent in the corner area. When analyzing stresses in a slab pavement, it is important to distinguish between the three distinct areas: the corner, the edge, and the inside. These three areas have different reactions to temperature differentials and loads applied to them. When the impacts of temperature differentials are significant enough to be added to the load effects, the maximum total tensile stresses in three sections of the slab will be caused. When the temperature differential in the slab is at its highest— around midday—critical stress conditions are reached at the edge region, where neither the load nor the temperature stresses are at their lowest—this is when it would develop during the day in the interior and edge regions. Research into the practicality of the stiff pavement for rural roads recommendations made in IRC SP: 62-2004 is necessary. It is advised to use a thickness of 15.0 cm of grade M-30 concrete for the pavement. In more remote places, using concrete of grade M 30 just doesn't make sense. Additionally, there are two reasons why it is not practical or convenient to remove all current pavements, such as bituminous roads, gravel, or brick on the edge, before building the new concrete roads according to the plan. There are two potential issues with the proposed pavement: first, it could end up being higher than the plinth level of the buildings, and second, it could cause traffic problems while the project is underway. It was determined that concrete of grade M20 was more practical in the field. It is necessary to analyze potential changes to the provisions because the strains induced by temperature variation do not reflect real-world situations. It is necessary to reevaluate the number of joints since they cause traffic problems, whether they are expansion, contraction, or construction joints. It is possible for fractures to form in the concrete pavement because heat stresses are reversible.

Nothing is in place at this time to deal with these tensile strains.

1.8 Purpose and Scope of the Current Work Through the use of design calculations for varying moduli of subgrade reaction and other parameters, a comprehensive investigation is necessary to ascertain the most appropriate and cost- effective solution. The study's goals are as follows: ¬ To propose, taking structural factors into account, the most appropriate design of rigid pavements for village roads in expanding soil, with reinforcement provided. In order to accomplish the goals, the current project is classified as follows: ¬ Analyzing the current state of stiff pavements. In expansive soil regions, particularly in Andhra Pradesh and Telangana, the majority of village roads are built on WBM-painted roads that have been damaged by lack of maintenance, floods, or other causes. To collect basic data on CBR values, we consulted various departments and organizations, including the Quality Promotion Cell and Research Institute, the UP PWD, and the IRC (SP 62, 2014). The project aims to determine the optimal traffic load by studying the traffic intensity of village roads in certain areas of Andhra Pradesh and Telangana and by offering firm pavements as a solution for these types of roads. Examining the current pavement's design through the lens of IRC SP: 62-2014, a PQC study was conducted. An analysis and finite element model (FEM) were conducted using the ANSYS software to determine the actual stresses caused by soil swell pressure and load. The goal was to find a sustainable solution for village roads in expansive soil areas, as well as for existing flexible pavements, by reducing the number of joints in reinforced cement concrete pavements and counteracting tensile stresses.

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TABLE - 1.1 : Length of Road & Road Density Country Wise

S. No.	Country	Road Length (km)	Road Density (km/sq km)
1.	USA	6,85,3024	0.67
2.	INDIA	5,90,3293	0.63
3.	CHINA	4,84,6500	0.12
4.	JAPAN	1,21,5000	3.77
5.	GERMANY	6,44,480	5.97
6.	UK	3,97,039	1.50

TABLE - 1.2 : Road Length in India

Category	Ownership	Total Length (km)	Length share
NH	MORTH	101,011	1.80%
SH	PWD of different states and union territory	176,166	3.14%
Other Public Works Department roads	PWD union territory	561,940	10.03%
Village roads	PWD, PMGSY, Rural engineering Deptt, State Mandi Parishad	3,935,337	70.23%
City Roads	Municipal corporations and municipalities	509,730	9.10%
Project roads	Various government departments of states/union territories, and Steel authority of India Ltd, NMDC and Border Road organization, NTPC, Power grid, GEL etc.	319,109	5.70%
Total		**5,603,293**	**100%**

TABLE - 1.3 : Standards of Roads as per IRC

S. No.	Category of Road	Top Width of Embankment (m)	Pavement Width (m)
1.	National Highway Two lane	12.0	7.0
2.	State Highway Two lane	12.0	7.0
3.	Major District Roads Two lane Single lane	12.0 -	7.0 3.75
4.	Other District Roads Two lane Single lane	10.0-12.0 -	7.0 3.75
5.	Village Roads/LR Through Roads Dead End Road	6.0-8.0 6.0-8.0	3.75 3.0
6.	Streets	As available	As available

TABLE - 1.4 : Target of Road (Road Development Plan, Vision 2025)

S. No.	Type of Road	Achievement in Km till 2000	Achievement in Km. for 2021
1.	Express Way	-	15766
2.	National Highway	57700	80000
3.	State Highway	124300	160000
4.	Major District Roads, Other district roads, Village roads.	2994000	No target suggested.

TABLE - 1.5 : 'k' Value Corresponding to Soaked CBR %

Soaked CBR (%)	2	3	4	5	7	10	15	20	50	100
'k' (N/mm^2/mm)10^{-3}	21	28	35	42	48	5	62	69	140	220

LITERATURE REVIEW

2.1 A large amount of the Earth's surface is covered by generally fertile soil, which is typically found in semi-arid and dry regions. Nearly the whole maritime plateau is contained within its roughly 16.6% land area. West Coast This includes the Indian states of Maharashtra, Andhra Pradesh, Telangana, Andhra Pradesh (particularly the Bundel Khand region), and Karnataka. A lot of people use the phrase "expansive soils" to describe soils that can expand. Soil that retains the same quantity of water is considered mostly unsaturated. The unsaturated topsoil swells when wet and contracts when the water content decreases. Soils like these have extraordinary drying properties because of the montmorillonite clay that is in them.

2.2 Evaluation of Expensive Soil Black cotton soil, or expansive soil, has dramatic volume fluctuations when wet. During the summer, the soil cracks a lot, and during the winter and rainy season, its volume changes twice or thrice. Minerals like montmorillonite and bentonite are the main culprits for these transformations. That soil acts like a balloon because of its high sodium (Na) and calcium (Ca) content. Swelling pressures of black soil, when exposed to water, range from zero to two thousand Newtons per square metre, or two megapascals (Mpa). The primary source of the damage to structures and road surfaces is the rise in pressure induced by this wave.

Soil stratification occurs here, with strata anywhere from one to fifteen metres thick. Buildings placed on this soil should, therefore, be supported by piling foundations. When building roads, the Indian Road Congress suggests stabilising the soil and modifying the subgrade. The maximum swell pressure is 2000 KN/m2, but the soil's bearing capacity is 150 Kn/m2. On average, the swell pressure in the Bundel Khand region (UP & MP) is 500 Kn/m2. In order to address this, the Indian Roads Congress (IRC) suggests applying a CNS layer over the subgrade dirt that is 150 mm to 225 mm thick.This soil is famous for its swelling and shrinking properties. The widespread occurrence of early cracks and damage in this location highlights the necessity for a sustainable alternative method to build roads in expansive soil. Soil tests show high water absorption and a clayey texture. Especially in the heat or when it's dry, it shrinks after expanding and becoming very sticky when wet. Soil plasticity indexes vary between 20 and 65%, liquid limits between 50 and 100%, and pH values between 7 and 9. Of our nation's total landmass of 3,287,263 square kilometres, 546,000 square kilometres are solid ground. This comes out to 16.6% of the country's overall landmass. The majority of these soils may be found in a few specific locations in India, including seven districts in Andhra Pradesh, twenty-two districts in Telangana (including Bundel Khand), Maharashtra, Andhra Pradesh, Tamil Nadu, and Gujarat. The soil shrinks and forms fissures 10–15 cm wide and 1–2 m deep when the water in it evaporates during the wet season. The soil can be oxygenated to an adequate depth through these fissures. And because of its extraordinary fertility, this soil is ideal for growing cotton, sunflower, jowar, bajara, gramme, tobacco, castor, millets, banana, rice, sugar cane, and so on— as long as there are sufficient irrigation facilities. As indicated before, these soils are good for some cash crops, but they provide major problems for highway engineers and other construction engineers. Pavements made of cement concrete on these soils usually fall apart after four or five

years, whereas pavements made of flexible materials disintegrate quickly. In 2012, 2.3 billion dollars were lost due to expansive soil in the US. The problematic soil in Andhra Pradesh has caused considerable losses, which I have personally experienced. Pavements made of cement and concrete valued about 400 lakh were built in the Jalaun district by the Andhra Pradesh Rural Roads Department. Cracks started showing up in the pavements after two or three years of construction, even though their quality was up to par. The expansion and contraction characteristics of the soil are the only causes of this loss. Damage to highways, village roads, dwellings, and structures amounts to billions of dollars per year due to black cotton soils, which is a major national concern in India. Natural disasters like floods and earthquakes can't compare to these damages.

FIGURE - 2.1 : Texture of expansive soil (showing wide & deep cracks)

2.2. Expansive soil in our country

Karnataka, Gujrat, Tamil Nadu, Telangana, and Maharashtra are the states where you're most likely to come across expansive soil, which occupies more than 5.46 lakh square kilometers—or about 16.6% of the total land area in the nation. The ICAR established the All India Survey committee and divided the soil into eight categories: sod types categorised as follows: (a) Alluvial, (b) Black cotton, (c) Red, (d) Laterite, (e) Forest

and mountain, (f) Arid and desert, (g) Alkaline, and (h) Peaty and marshy. In India, thiscategorization is generally acknowledged. A model that takes into account the combined effect of wheel load and temperature distribution on the concrete pavement was presented by Lee and Darter (1994). To forecast how rigid pavement will react under heat and wheel loads, Mahboub et al. (2004) used an ANSYS-based 3- dimensional finite element pavement model based on field observations. They found that pavement reactions to thermal loading were more pronounced than those to traffic-induced stress. In order to assess the effects of temperature on concrete pavement, Kamyar et al. (2004) created a three-dimensional finite element pavement model and found that these effects are more noticeable than those caused by traffic. The KGPSLABWH 3-D finite element model was created by Srinivas et al. in 2007 to examine the combined and individual effects of wheel loads and linear temperature fluctuation throughout slab thickness. Curling causes the subgrade to lose support, and adding the wheel load and warping stresses algebraically is not the right way to do it. Tensile stresses are lower during the day and higher at night due to a non-linear temperature gradient. According to research by Paridey (2005), the impact of warping strains on concrete pavement is negligible for slab lengths below 4.5 m.

I. When designing a pavement, it is important to take into account the potential loss of sub-grade support owing to erosion, permanent deformation, and seasonal moisture changes. This is because, as Kumar et al. (2006) pointed out, concrete pavements are mechanistically designed to withstand the combined action of axle loads and non-linear temperature distribution. It is recommended that k not exceed 200 MN/m3.

II. In pavements with a thickness of 200 mm or above, flexural stresses are relatively unaffected by variations tyre pressures.

III.The flexural strains are greatest on wheels that are perpendicular to the pavement's edge, although the number of cars with this configuration is low. The combined effects of axle load and warping can cause cumulative fatigue damage. It is recommended to calculate this damage for axle load between 10 am and 04 pm and for warping between 00 am and 06 am, respectively. From 10:00 AM to 4:00 PM, the average temperature differential (ATD) accounts for approximately 70% of the peak temperature differential (PTD) during the day. roughly half of the daytime PTD occurs throughout the night, while roughly three quarters of the nighttime PTD occurs between the hours of 00 am and 06 am. Concrete slab thickness designs should take into account the non-linearity of the temperature gradient as it varies across the slab's depth (V).

VI. The effect of moisture fluctuation may be comparable to a temperature gradient of 0.011°C/mm, and warping caused by moisture gradient is the inverse of temperature gradient.

VII. The economic benefits of cement sub-base and concrete slab bonding should also be taken into account. Based on his research into cement concrete pavement design and construction, Seehra (2006) concluded that the IRC: 58-2002 standards for rigid pavement design provide the most realistic results. For highway pavements subjected to heavy traffic, the combination of vehicle load, temperature fluctuation across pavement thickness, and fatigue is an appropriate requirement according to IRC: 58-2002. Modernised equipment is the best choice for the aforementioned mixof loads and the minimum concrete grade that is prescribed, which is M 30. The stress equations provided in IRC: 58-2002 and IRC: SP: 62-2004 for rigid pavement are derived from the plate on elastic foundation theory, which was first proposed by Westergaards (1926) and subsequently refined by Teller and Sutherland (1943).

White topping was first proposed by Sinha et al. (2007) as a means of repairing damaged bituminous pavements; the authors noted that the practice will lead to cheaper, better roads that last longer. In 1938, Bradbury created an equation and a coefficient for thermal stresses that account for curling/warping stress. In IRC: SP: 62-2004, the conservative linear temperature gradient across the pavement layer is taken into account. Research shows that temperature changes do not follow a straight line, and that the stress readings produced using Bradbury's formula are on the lowside. It is acceptable to use 0.7 times the number specified in the IRC code as the stress value (Kumar etal. 2006).

2.3. IRC: SP: 72 – 2015 and IRC: SP: 72 – 2007-2008 The U.P.P.W.D., Rural Engineering Department, and other road construction agencies in Uttar Pradesh primarily utilise this IRC code when building village roads. It is advisable to conduct the traffic estimate for the new road survey on a road with similar traffic characteristics, ideally in the same zone with similar conditions.

Section 2.3.1: Subgrade Strength Evaluation Soil categorization tests necessitate the collection of at least three samples per kilometre of length. It is required to determine the C.B.R. value, soil category, etc., for every sample. Measurement of pavement compaction and thickness (2.3.2) Subgrade traffic curve parameters are utilised to ascertain the design thickness. This code suggests using locally accessible materials to keep project costs down.

2.3.3 Traffic Parameters Important data for calculating thickness composition are traffic characteristics. Vehicles with two or four wheels, tractors, trucks, buses, animals, and bicycles

Fewer medium-heavy commercial vehicles (MCVs) than heavy-duty ones are required.

2.3.4 Traffic Growth Rate

Calculated by formula –

$T_n = T_0 (1+ r)^n$ n = no. of year

T_n = Year Traffic

r = Groth rate of Traffic

Another technique to determine traffic density is to refer to the rules outlined in RC: 108, "Guidelines for traffic prediction on rural Highways." For roads with extremely low traffic volumes, defined as 0.1 msa or less, the suggested design life for gravel road stage construction is 10 years.Chapter 2.3.6 Estimation for ESAL Programmes Vehicles such as trucks, buses, and tractor trailers fall into this category if their combined weight is three tonnes or more, including axle loading. The traffic is determined using the 80 KN standard axle load and its equivalent standard axle load repeats.

Vehicle category	Laden	Unlade, Partially Laden
HCV	2.86	0.31
MCV	0.34	0.02

TABLE - 2.1 : Traffic Categories: For pavement design, traffic categorized into seven categories as under

Traffic Category	Cumulative ESAL Applications
T_1	10000-30000
T_2	30000-60000
T_3	60000-100000
T_4	100000-200000
T_5	200000-300000
T_6	300000-600000
T_7	600000-1000000

A representative sample should be acquired from the location to conduct the subgrade CBR value test. Code 2720 specifies that a minimum of three samples per solid are needed for C.B.R. calculations, and that there should be no more than three samples of every given variable. It is recommended to implement this

TABLE - 2.2 : Subgrade strength classes

Quality of Subgrade	Class	Range (CHR %)
Very Poor	Si	2
Poor	**S2**	3—4
Fair	**S3**	5—6
Good	S_4	7—9
Very Good	S_5	10—15

2.4. Observation from literature

Due to a lack of funding in U.P., the government is unable to maintain roads at O.D.R. and

M.D.R. levels, let alone the maintenance of village roads, which are notoriously problematic due to poor subgrade soil and the annual flooding of numerous such roads. Wheel load, temperature differential between the slab's upper and lower surfaces, and frictional stresses caused by a general rise or fall in temperature are only a few of the stresses that rigid pavements experience.
P.C.C. Pavement on black cotton soil experiences challenges during dry seasons as a result of swelling and shrinkage during wet seasons. The pressure from both phases causes tension at the surface, leading to cracks as a solution to these problems. Here are a few interesting points: Guidelines for the design, building, and maintenance of stiff pavements for village roads are provided by IRC SP: 62-2004 and IRC SP: 2014. All types of subgrade soil, including expansive, silty, and clay, should be applied with the same suggested thickness; no special considerationsare given for expansive soil.

2. When designing a pavement for a wheel load of 50 KN, it is necessary to install a 75 mm thick WBM Gr-III above a 100 mm thick GSB sub-base of water bound macadam to prevent mud pumping and operate as a capillary cut. This is in accordance with the provisions of IRC SP:2014. It is necessary to reexamine and revise several clauses.

3. The linear assumption of temperature variation is unrealistic, and the stresses estimated using boundary's equations are significantly greater than the actual values; these inaccuracies require corrections.

Field examinations into the performance of current pavements are necessary for the long-term viability of rigid pavement in vast areas.

5. In areas with expansive soil, it is important to pay attention to the subgrade soil type, detailed soil classifications, natural terrain, environmental factors, and traffic on the village road.

6. According to the guidelines provided by IRC : SP : 49-2014, all significant projects should use dry lean concrete with a thickness of at least 150 mm as a subbase for stiff pavements. A thorough case study examining the intersection of GSB and PQC, GSB and LC, and LC and PQC, as well as 100 mm thk for village roads, is required.

7. Reinforcing concrete slabs is advised by IRC: SP: 58-2002 and IRC SP: 58-2015 to counteract tensile strains produced by temperature and moisture variations. The flexural strength of the concrete slab is not going to be increased by this reinforcing. Rigid pavement costs are influenced by the amount of steel used as dowel bars, tie bars, and temp steel, however this steel does not contribute to flexural strength. Therefore, this reinforcement can be used to increase the flexural strength of pavement according to the actual stress estimations.

8. The rules for transverse contraction and construction joints, expansion joints, longitudinal joints, and other closely spaced joints are provided by IRC: SP: 62-2004 and IRC SP:62-2014. These joints are known to cause traffic difficulty. Designed. To improve traffic flow and passenger comfort, reinforcement concrete pavement can have joint spacing increased.

9. The highly expensive provision of a CNS layer that is 150 mm to 225 mm thick, as proposed by IRC: SP: 72- 2015. We need to keep an eye on this layer and see how it performs. When it rains or the earth shrinks in the summer, it can cause tension to build up on the pavement's top layer, which can lead to cracks. We shall make an effort to create low volume roads in black cotton soil based on the observations from literature. After reviewing the relevant literature and doing a site survey, we can make the necessary changes to the current codal provisions and design the rigid pavement

with structural considerations in mind, making sure to reinforce it appropriately to takeadvantage of flexure.

3. Surveys of the Realm

3.1 Background In this chapter, we offer the field observations that will be helpful for the rural road design in the Indian states of Andhra Pradesh and Telangana. Researchers have looked into how well preexisting cement concrete pavements work across expansive areas. Environmental factors and the type of subgrade are also investigated. The CBR values are used to determine the values of the subgrade's modulus of reaction k. The CBR values of roads in several districts of

Andhra Pradesh, India, are examined in depth. Modulus of sub grade reaction. In order to understand the nature and extent of the traffic load situations on rural roads, researchers conduct traffic studies on several routes in the Vijayanagaram district of Andhra Pradesh and the Mulugu district of Telangana, India. Ten roads in the community were selected for the purpose of observation.

Fig 3.1. Damaged flexible pavement

Average CBR Value of mulugu region On the Basis of survey of several roads of mulugu region and collection of CBR value from different divisions of PWD, PMGSY and Rural Engineering Department. The average shocked CBR Value of Districts are as per below

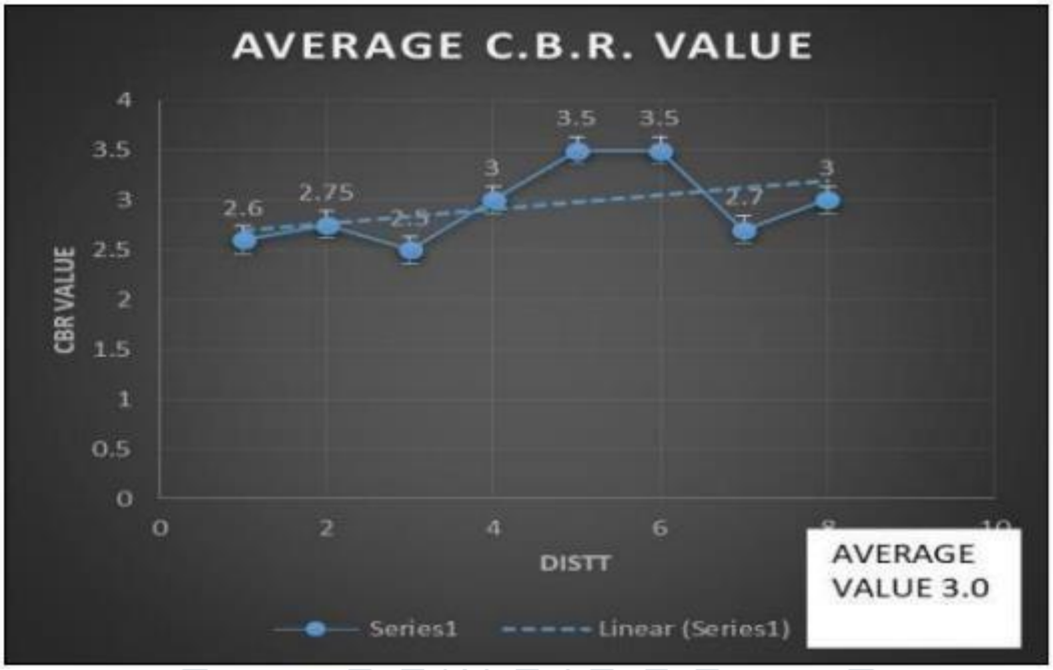

Fig 3.2. Showing average CBR value of Expansive soil region area

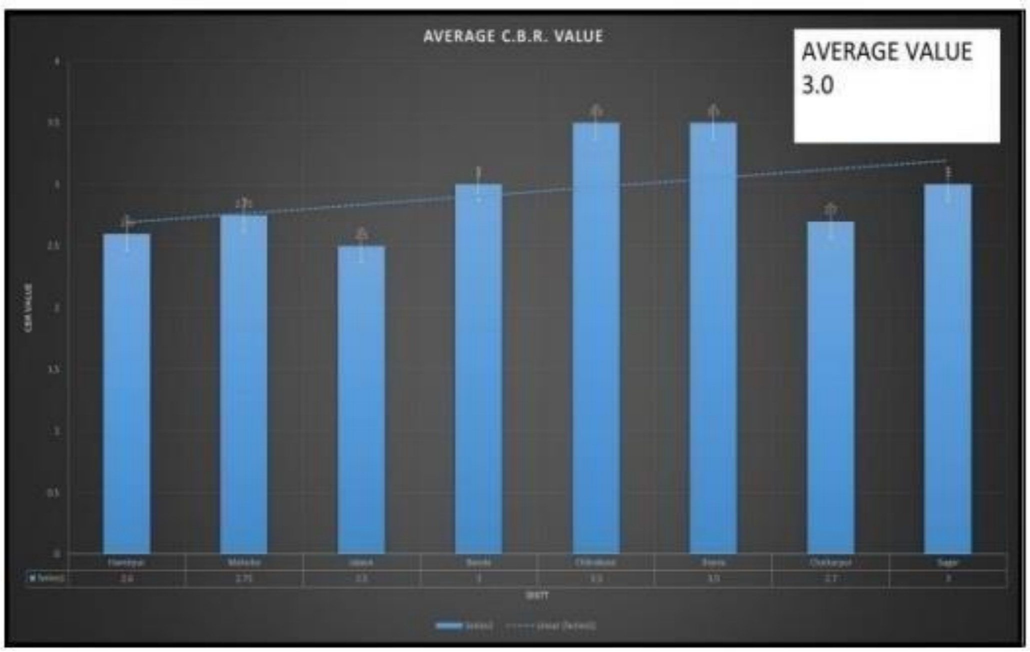

Fig 3.2. : Showing average CBR value of Expansive soil region area

4. ANALYTICAL ANALYSIS and FEM Modelling

4.1 Overview While there are several benefits to using plain cement concrete pavements over flexible pavements, traffic congestion is a common complaint about the numerous joints found on these roadways. Due to the nearly eliminated need for contraction joints in RCC pavement, it is an ideal alternative to plain concrete roads that suffer from joint difficulties. Compared to normal cement concrete pavements, RCC pavements might have a thinner layer. Although the riding quality will be compromised, the cost of the pavement can be further decreased by adding elastic joints to continuously reinforced cement concrete pavements in accordance with the provisions established in IRC: 101: 1988. In order to prevent cracks caused by shrinkage and fatigue, continuously reinforcing concrete pavements (CRCPs) are reinforced either in the centre of the slab or along the neutral axis, according to IRC 101- 1988. We do not take into account the usage of steel in flexure. For the purpose of using reinforcement against flexure as well, the reinforcement is moved to the top and bottom of the slab in an equal amount in this work. In an effort to streamline and save costs during the building of village roads, we also confirmed that the designed portions with M 30 had a minimum grade of concrete of M 20. In this chapter, we see how to use the finite element method to create a field-ready model in ANSYS software and then use that model to verify the actual stresses created in the RCC pavements that are designed for use on village roads on expanding soil. According to IRC: SP: 62-2004, the country roads' simple cement concrete pavement Additionally, M 30 is the minimum grade of concrete required in 2014. Additionally, 150 mm is the lowest allowable pavement thickness. There is a 4.0 m limit on the spacing between contraction joints. In order to keep the CBR below 5%, UPPWD has also embraced the idea of cement treated pavements, with a thickness of 24 cm for CTB Pavement. Price of C.T.B.. Higher than the typical flexible pavement with a crest of 27.5 cm, these pavements are more substantial. Due to a village's sole connection, it's difficult to create cement

stabilised roods without causing traffic backups, and achieving a compressive strength between

4.0 and 7.0 Mpa is no picnic. So, the cement-treated base road experiment for a single- connectivity dwelling failed. Additionally, according to IRC: SP: 62-2004, rural roads that terminate should be designed to support a single wheel load of 30 kN with a tyre pressure of 0.5 Mpa, whereas rural roads that pass through should be designed to support a single wheel weight of 51 kN with a tyre pressure of 0.7 Mpa. While through roads might be 3.75 metres wide, dead ends can only be 3.0 metres wide. According to the plans, the pavement thickness for dead end roads is 15.0 cm and for through roads it is 20.0 cm, with M 30 concrete spread out over 10 cm of dry lean concrete. Because the stresses caused by temperature variation are nonlinear, the design based on the IRC code is conservative and uneconomical. A minimal thickness of 27.5 cm has been achieved in the design of flexible pavement for the same combination of variables. Since most village roads fall within this range and a detailed survey of existing plain cement concrete revealed that it was less than 50 cvpd, the thickness of the concrete was maintained at

15.0 cm for traffic up to 50 cvpd. Also computed and compared are the one-kilometer costs of reinforced cement concrete pavement and ordinary cement concrete pavement. Flexible pavement, in comparison to RCC and ordinary cement concrete, has a reduced starting cost. However, when considering the whole cost and the lifespan of the design, RCC pavements seem to be more cost-effective. Hence, instead of using ordinary cement concrete or flexible pavement, RCC is the way to go for village roads on expansive soil. Onest Stage: Modelling The model does not incorporate intricate geometrical features. You can avoid wasting a tonne of time on rework by starting with this crucial step in any investigation. So, notice the geometry and try to figure out why you're simulating this part. If you want to save time and avoid complexity in the long term, this will teach you how to remove extraneous features from your geometry. Remember that less is more in every situation. Because their primary purpose is to accurately portray the intended outcomes of final designs, computer-aided design (CAD) models sometimes omit supplementary features that are essential for accurate simulation. Ansys Design Modeller offers a variety of useful simulation capabilities, including dividing surfaces for load application, weld definition, and the ability to build areas around models to represent flow volumes for fluid flow analysis.Ansys Design Modeller also supports shell/surface modelling. Improved meshes and quicker solutions are the results of using face and edge merging techniques to simplify model reduction by removing unnecessary features and boundaries. Sew and connect approaches could be used to make sure that models with gaps and overlaps have enough connectedness.

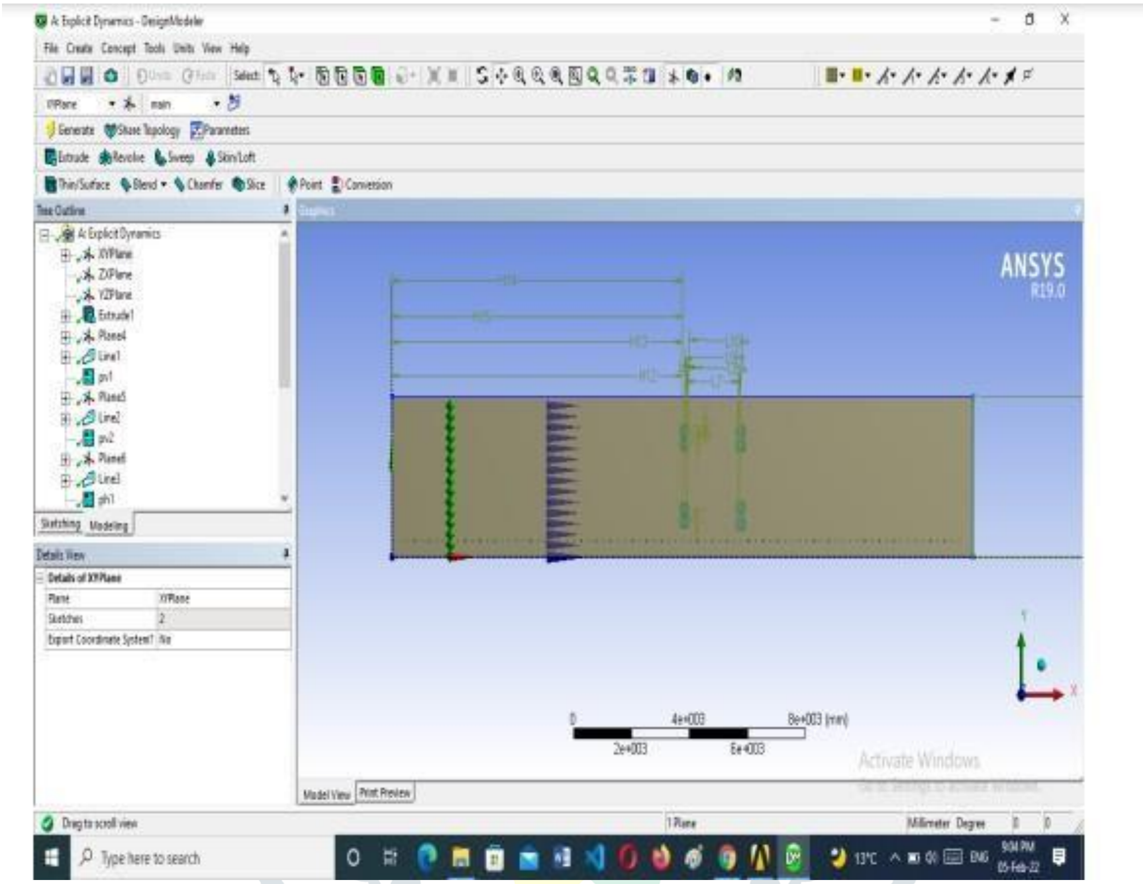

FIGURE - 4.1 : Creating model in ANSYS® Design Modeler

Step 2 : Definition of material At this point, the material attributes are defined. Depending on the kind of analysis needed, certain material properties are defined. It may be helpful to complete this phase by searching the literature for similar problems. Luckily, you're almost there if the material you wish to use in your simulation is already in the material library of your FE tool. Importing the material qualities you've chosen from the library is the last step. Ansys is compatible with a wide variety of material property data types. These data types are grouped together into "functional groups" with a common material name in order to provide all the pertinent information for a certain study.

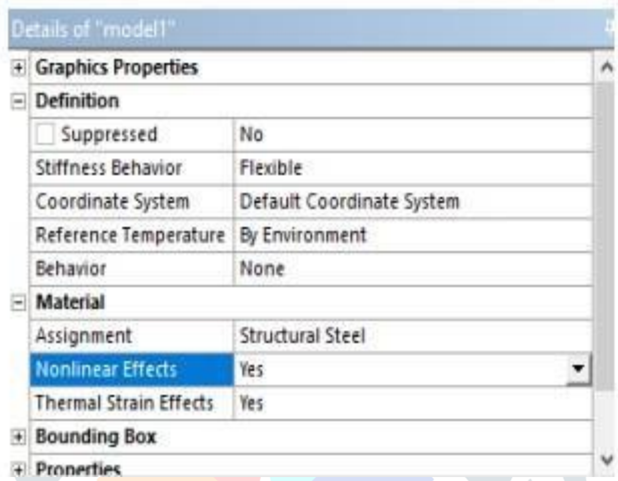

FIGURE - 4.2 : Selection of materials in ANSYS® Mechanical

Step 3 : Understanding loads At this point, you should have a good idea of the component's weight and any external forces acting on it. You need to exercise caution when dealing with the force definition type to prevent issues like singularities. Acceleration, gravity, rotational velocity, pressure, force, hydrostatic pressure, distant force, bearing load, and other forms of loads are all available in ansys.

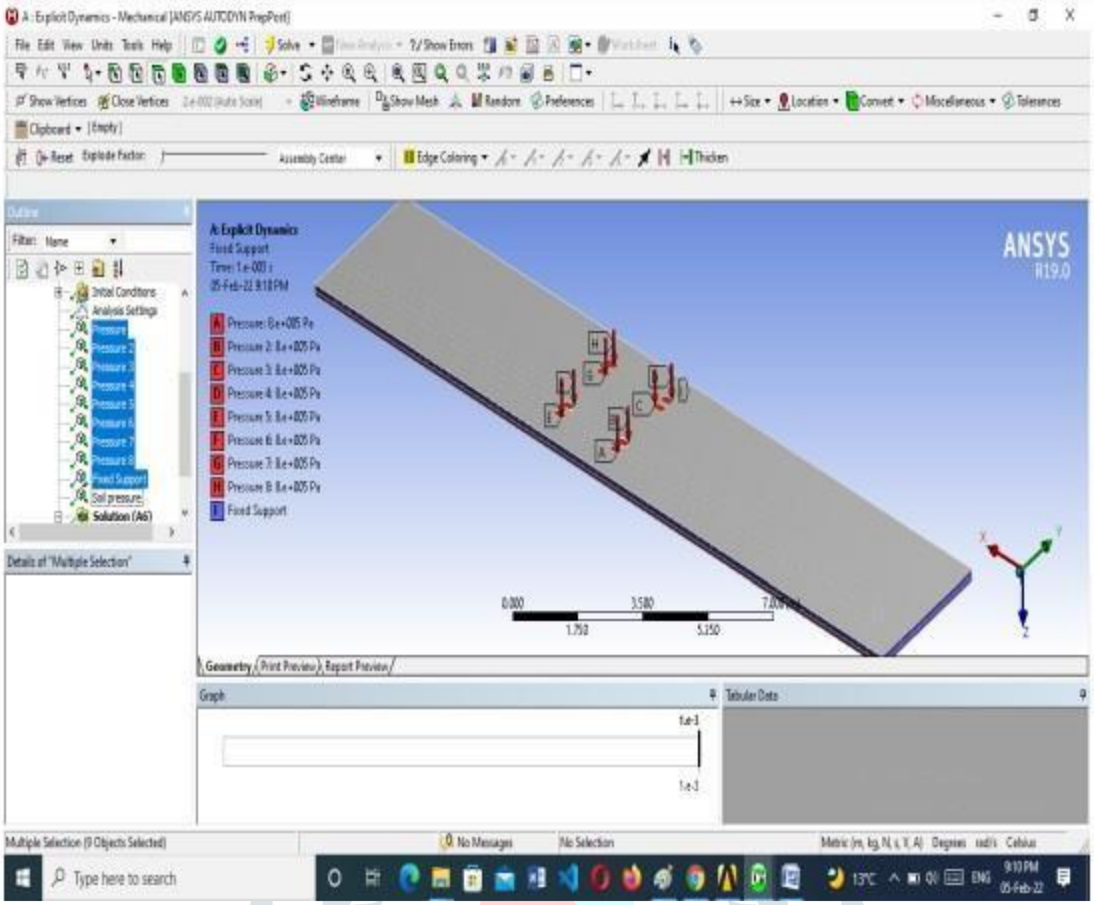

FIGURE - 4.3 : Applying Loading at different section in ANSYS® Mechanical

Step 4 : Conditions at the boundary From an engineering perspective, the main reason to conduct this stage is to simplify the problem. Before starting an analysis, the user may know certain basic conditions, such as the displacement of a point in the geometry. "Initial value problems" describe these kinds of scenarios. We offer displacement support, fixed edges, and more in Ansys. Stage 5: Connecting Miniature and less complex shapes, called finite elements, make up your geometry. Any introductory numerical analysis (FEM) textbook will cover the several element kinds and their respective uses. In order to save the user time and effort, a lot of software has recently begun to automate this step. Depending on the geometry, elements can have a cubical, tetrahedral, or two- dimensional shape.

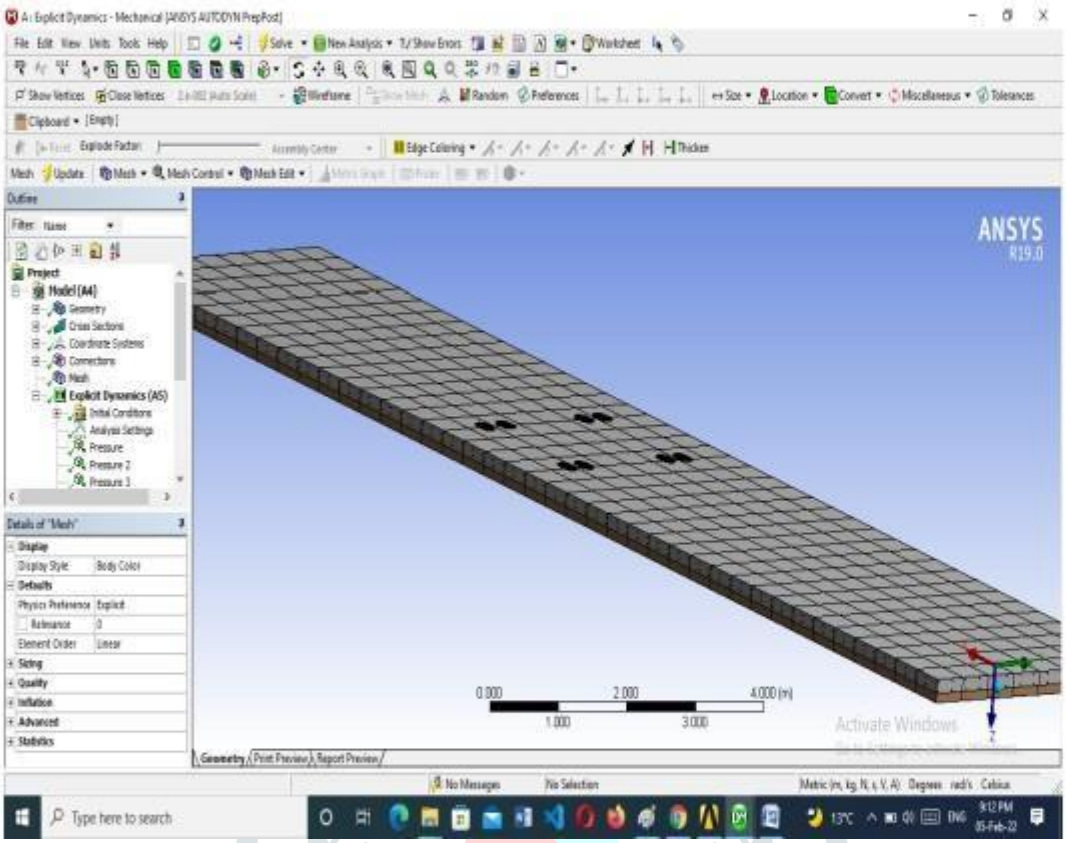

FIGURE - 4.4 : Meshing of geometry section in ANSYS® Mechanical

Step 6: Solution After the simulation properties have been defined, this stage takes place in the backend. It involves converting partial differential equations to algebraic equations. This makes it easier for the code to represent equations as matrices. Individual element matrices are combined to form global matrices for the entire geometry, which are then solved using unknown variable solvers.

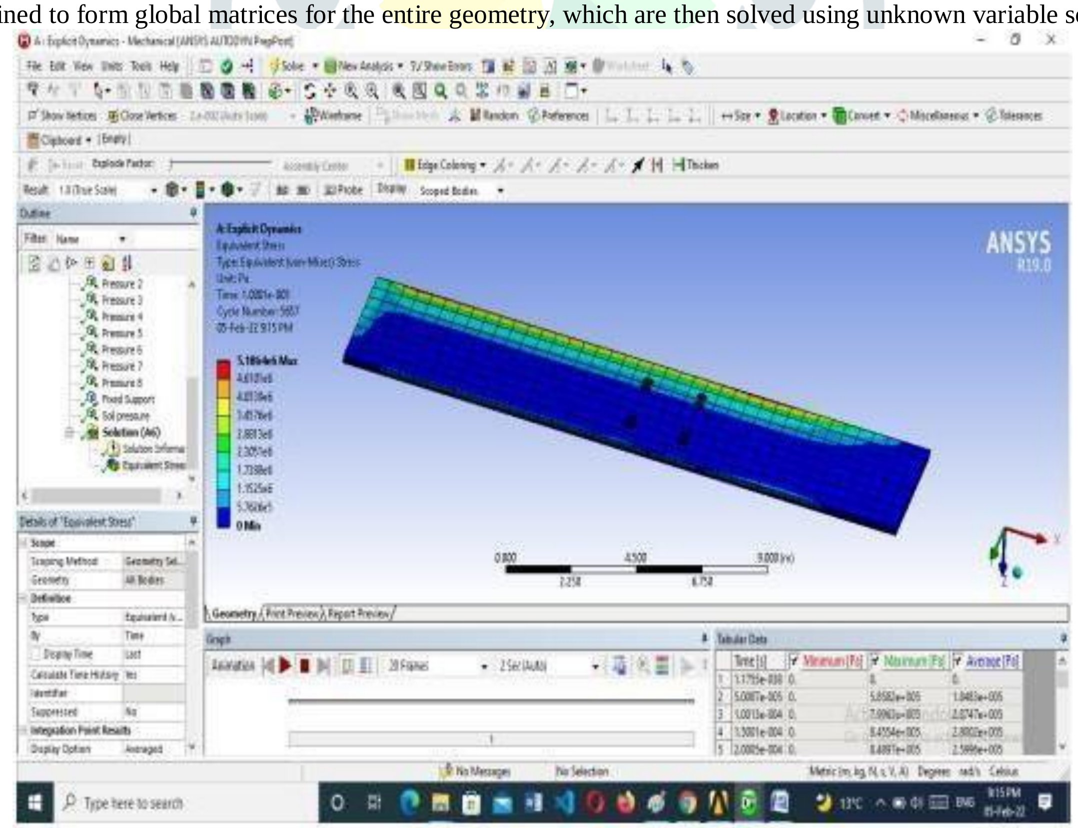

FIGURE - 4.5 : Solution in ANSYS® Mechanical

In order to determine the true pavement stresses caused by swell pressure alone and by swell pressure and wheel load together, a realistic model is built using the ANSYS-19 software. Referring back to the procedure described earlier, the following design parameters were derived from IRC: SP: 62–2014: wheel load, temperature difference, concrete modulus of elasticity, poisons ratio, design load, corresponding modulus of subgrade reaction (K) value, and tyre pressure for both single and dual wheels. With the current I.S. code in mind, this effort aims to modify some provisions in order to offer a sustainable alternative to R.C.C. pavement onexpansive soil.

Table - 4.1 : Elastic modulus, passion ratio for different layers

layer	Elastic modulus (Mpa)	Passion ratio	Density (Kg/m^3)
C ement concrete	30000	0.15	2400
Water bound macadam	150	0.30	2200
Granular sub base	25 - 170	0.35	2200
Sub grade	21 – 140	0.40	1800

Using the finite element method in conjunction with the ANSYS software, we were able to verify that the actual stresses created in the proposed R.C.C. pavement were within the permissible range in every section.Reinforced cement concrete pavements, as proposed, are more cost-effective than plain cement concrete pavements and have a longer expected lifespan (up to 20 years) because the stresses caused by swell pressure—a factor ignored by the conventional method but a major cause of pavement failure—are better managed with the appropriate amount of top and bottom reinforcement. By incorporating these parts into the expansive soil region, significant cost savings can be made. Additionally, this environmentally friendly construction alternative will significantly reduce maintenance costs, which typically pay for themselves in

five to six years for plain cement pavement. Tension at the slab's top and bottom could be caused by changes in moisture and temperature. Because cracks start at the top and bottom faces and work their way into the interior region, the centre reinforcement that is required by the CRCP is not very effective. Placing steel at its neutral axis precludes its flexural application. Adding steel to both sides of the proposed RCC pavement takes care of these issues, and increasing the spacing of the contraction joints makes the pavement even more comfortable to ride on. A longer panel also has the benefit of increasing compressive frictional stresses, which lower the critical tensile stress at the end. The proposed R.C.C. pavements are more cost-effective and provide better accessibility compared to the current plain cement concrete pavements.

5. CONCLUSION

Tractors, animal-drawn vehicles, light cargo carriers, buses, and the like make up the relatively small percentage of traffic on rural roads. When it comes to expansive regions, the subgrade of soft soils is a particular issue for the village roads. In areas with expansive soil, most of the village roads get flooded every time it rains. Additionally, the institutional framework for the upkeep of village roads is inadequate, and there is a lack of funding. Long monsoon seasons cause the flexible pavements used for village roads—typically with a granular subbase and a

base with a thin bituminous carpet as the wearing course—to deteriorate, necessitating expensive annual maintenance. This has prompted the investigation of different types of pavements. One solution to this important problem is rigid pavements, but the current plain cement concrete pavements in expanding soil regions cannot be maintained. By reinforcing the pavement on both the top and bottom, this study suggests rigid pavements for rural roads in areas with expansive soil. The quantity of steel is nearly identical to that of CRCP. Some roadways in the Indian state of Uttar Pradesh have been the subject of field observations. Researchers have looked into how well preexisting cement concrete pavements work across expansive areas. To learn about the kind and level of traffic load circumstances on rural roads, a comprehensive study of CBR values of various roads in India is also conducted. The following are a few of the findings andobservations:

(i) For new village roads, the modulus of subgrade response (k) can be determined using the following values: 28 Mpa/m for expansive soil, 34 Mpa/m for granular sub base support, and 56 Mpa/m for cementitious sub base, all in accordance with IRC: 62-2014.

(ii) In accordance with IRC: 62-2014, when building new village roads on extremely poor subgrade soil, the modulus of subgrade reaction k can be 22 Mpa/m for granular sub base support, 25 Mpa/m for cementitious sub base, and a general value of expansive soil CBR 2.0 for very poor subgrade soil.

(iii) According to the traffic census, it is quite unusual for village roads to experience both maximum wheel load and maximum

temperature change in the pavement at the same time.
iv) In areas with expansive soil, reinforced cement concrete pavement is more cost-effective than ordinary cement concrete pavement. With the design life duration and annual maintenance taken into account, RCC pavements are incredibly cost-effective. Thus, it is more prudent to use Reinforced Rigid Pavements for rural roads in large areas.

(v) Reinforced concrete pavement (RCC) has reinforcement at both the slab's top and base. The expense is significantly reduced. To ensure a comfortable ride for drivers, we widened the gap between the contraction joints. The compressive frictional stresses are increased and the tensile stress is reduced as the panel length grows, which is a benefit. Through the use of the finite element approach in conjunction with the ANSYS software, the performance of the RCC pavements suggested in this study has been determined to be satisfactory.

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