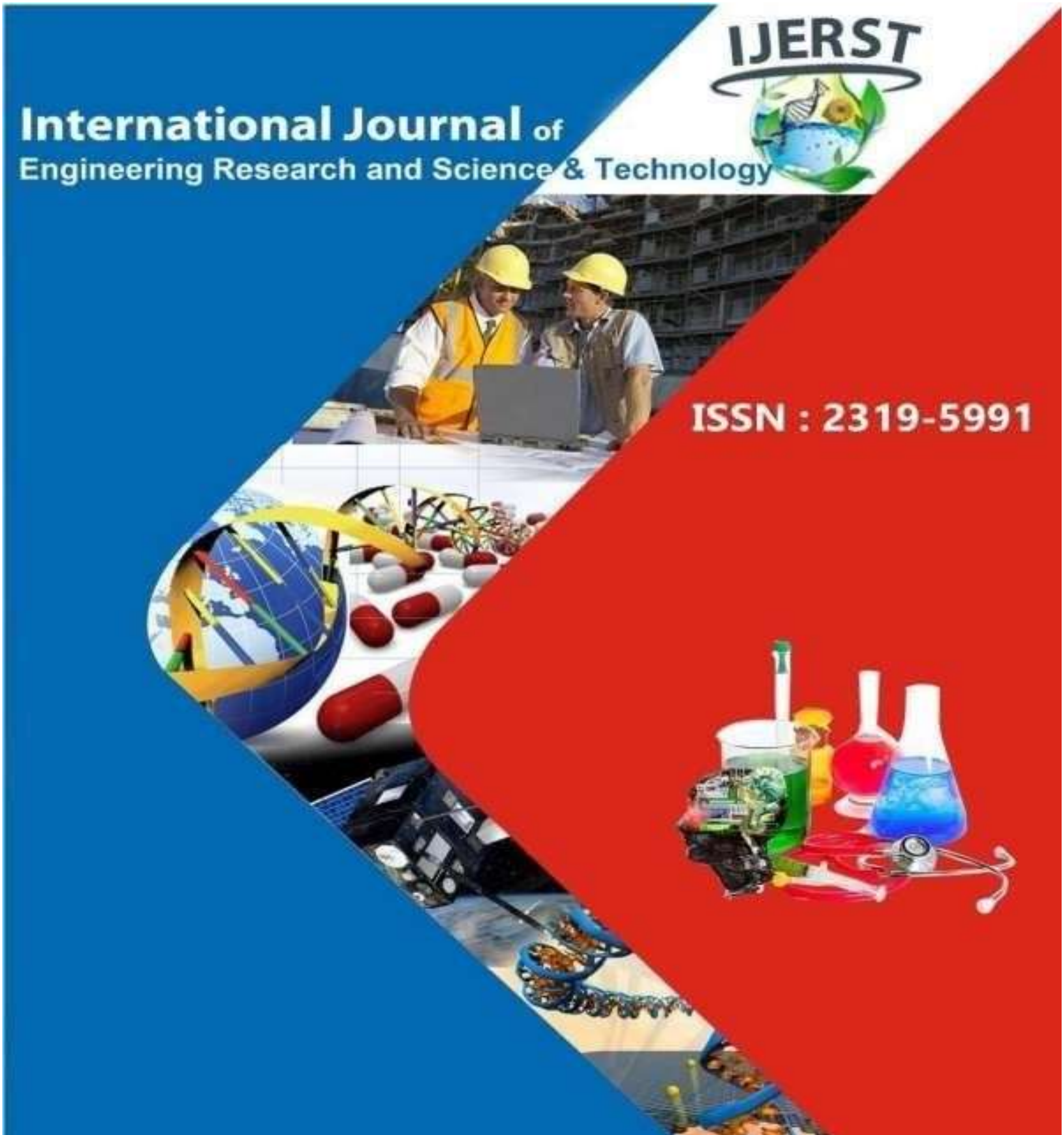

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QUALITY CONTROL MANAGEMENT IN FLEXIBLE PAVEMENT DESIGN: A COMPREHENSIVE APPROACH

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Abstract:

The connectivity between towns, urban clusters, and distinct regions plays a crucial role in a nation's development Roads and railways form the backbone of this connectivity Among them, expressways have been pivotal in the overall economic transformation of countries An expressway, or freeway, is a structured system consisting of multiple layers of engineered materials over natural soil or sub-base Its primary function is to efficiently distribute vehicle loads while ensuring a surface that offers satisfactory ride quality, adequate skid resistance, good light reflection properties, and minimal noise pollution Understanding the benefits and advancements in flexible asphalt, we can assert that roadways significantly contribute to community development, economic prosperity, and overall national progress

Keywords: pavement design, management systems in pavement design

I.INTRODUCTION

Hyderabad Growth Corridor Limited (HGCL), a Joint Venture of Hyderabad Metro Development Authority (HMDA) and Infrastructure Corporation of Andhra Pradesh (INCAP), has entrusted the project titled "Consulting Services for Construction Supervision of Eight-lane Access Controlled Expressway as Outer Ring Road to Hyderabad City in the State of Andhra Pradesh, India, from Shamirpet to Pedda Amberpet - Northern Arc (Km61700 to Km95000)" to NIPPON KOEI – aarvee associates (JV), in collaboration with Nippon Koei India

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Vol. 20, Issue 3, 2024

Pvt Ltd This initiative is supported by the Japan International Cooperation Agency (JICA) under Phase 2 Programme and Loan Agreement No ID-P:198, with the agreement signed on 29th March 2010

The monthly progress report, in compliance with the Terms of Reference (TOR) outlined in the agreement between Nippon Koei of Japan and Aarvee Associates of India, in association with Nippon Koei India Pvt Ltd, provides comprehensive updates It encompasses project background, key features of civil works, the scope of consulting services, and ongoing progress against the approved Work Programme as per Clause 11 of the General Conditions of Contract Additionally, the report details the mobilization efforts of both the Consultant and Contractors, ensuring transparency and adherence to project timelines and milestones This project underscores a significant collaboration aimed at enhancing infrastructure and connectivity crucial for regional development and economic growth

II.PAVEMENT DESIGN

Pavement is the durable surface material laid down on an area intended to sustain vehicular or foot traffic, such as a road or walkway In the past cobblestones and granite sets were extensively used, but these surfaces have mostly been replaced by asphalt or concrete There are two types of pavements:

- Flexible pavement
- Rigid pavement

A. Flexible Pavement Flexible pavements are those, which on the whole have low flexural strength and are rather flexible in their structural action under the loads The flexible pavement layers reflect the deformation of the lower layers on to the surface of the layer as shown in Fig1 A typical Flexible pavement consists of four components:

- surface course
- base course
- sub base course
- soil sub grade

Fig.1. A view of Flexible pavement components.

B. Rigid Pavement

Rigid pavements are those posses note worthy flexural strength The stresses are

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Vol. 20, Issue 3, 2024

not transferred from grain to the lower layers as in case of flexible pavement layers The rigid pavements are made of Portland cement concrete-either plain, reinforced or prestressed concrete The plain cement concrete slabs are expected to take up to about 40 kg/cm2 flexural stress The rigid pavement has the slab action and is capable of transmitting the wheel load stresses through a wide area below Figs2 and 3

Fig.2. A view of rigid pavement.

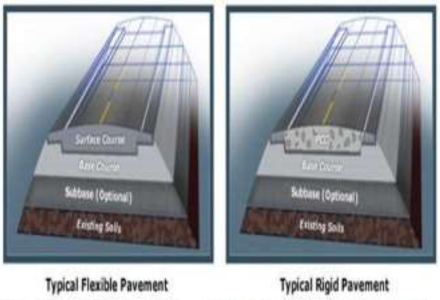

Fig.3.The difference between flexible and rigid pavement.

C. Functions of Pavement Components

- Soil Subgrade
- Sub-base and Base Course
- Wearing Course

Soil Subgrade: The soil subgrade is a layer of natural soil prepared to receive the layers of pavement materials placed over it The load on the pavement is ultimately received by the soil subgrade for dispersion to the earth mass It is essential that at no time, the soil subgrade is overstressed It means that the pressure transmitted on the top of the subgrade is within the allowable limit, not to cause excessive stress condition or to deform the same beyond the elastic limit It is necessary to evaluate the strength properties of a soil subgrade This helps to designer to adopt the suitable values of the strength parameters for design purpose and in case this supporting layer does not cum upto the expectations, the same is treated or stabilized to suit the requirements

Sub-base and Base Course: These layers are made of broken stones, bound or unbound aggregate Some times in sub-base course a layer of stabilized soil or selected granular soil is also used In some places boulders stones or bricks are also used as sun-base or soling course When the subgrade consists of the grained soils and when the pavement carries heavy wheel loads, there is a tendency for these boulders stones or bricks to penetrate into the wet soil, resulting in the formation of undulation and uneven pavement surface in flexible pavement

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Vol. 20, Issue 3, 2024

Grain Size Analysis (GSA): P This test is performed to determine the percentage of different grain sizes contained within a soil The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles

Significance: The distribution of different grain sizes affects the engineering properties of soil Grain size analysis provides the grain size distribution, and it is required in classifying the soil

Equipment: Balance, Set of sieves, Cleaning brush, Sieve shaker, Mixer (blender), 152H Hydrometer, Sedimentation cylinder, Control cylinder, Thermometer, Beaker, Timing device

Test Procedure:

Sieve Analysis:

- Write down the weight of each sieve as well as the bottom pan to be used in the analysis
- Record the weight of the given dry soil sample
- Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom) Place the pan below #200 sieve Carefully pour the soil sample into the top sieve and place the cap over it
- Place the sieve stack in the mechanical shaker and shake for 10 minutes
- Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil

III FREE SWELL INDEX (FSI)

Object: To determine the free swell index of soils

Apparatus:

- 425 micron IS sieve
- Glass graduated cylinders – 2 nos 100ml capacity
- Distilled water and kerosene

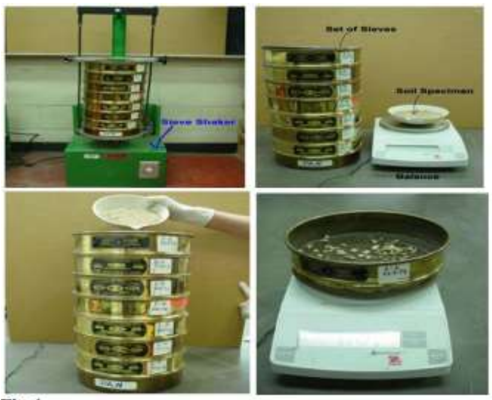

Fig.4.

Procedure:

ISSN 2319-5991 www.ijerst.com
Vol. 20, Issue 3, 2024

- Take two 10 grams soil specimens of oven dry soil passing through 425-micron IS sieve Each soil pecimen shall be poured in each of the two glass graduated cylinders of 100ml capacity
- One cylinder shall then be filled with kerosene oil and the other with distilled water up tothe 100ml mark
- After removal of entrapped air the soils in both the cylinders shall be allowed to settle Sufficient time (not less than 24 hours) shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils
- The final volume of soils in each of the cylinders shall be read out

III.METHODOLOGY

Alignment of the road is determined through meticulous road surveying, with comprehensive details documented in the report Technical specifications of the project, including right-of-way details, number of lanes, carriageway width, and shoulder width, are clearly defined according to pavement design standards All necessary dimensions of the road's cross-sectional elements are meticulously calculated and specified

A traffic survey report for KKY road is conducted through manual counting of traffic movements, establishing a design period of 20 years based on the gathered data Tests on bitumen, aggregates, and subsoil for the pavement are planned at a nearby treatment plant, with results meticulously analyzed The road design data for KKY road is subsequently computed and the design procedure is outlined in detail A comprehensive report on KKY road is included in this project

Additionally, the project entails several focused assessments:

- **Surveillance Review**: Seven major roads (RD1-RD7) within the study area are selected for detailed inspection Visual examinations of the asphalt surface, including photography to document location, severity, distress level, road width, wearing course details, drainage specifications, asphalt thickness, and shoulder width, are conducted
- **Asphalt Condition Survey**: Manual surface distress surveys are regularly conducted during detailed inspections, aimed at candidate rehabilitation projects These surveys involve geotechnical examinations, quality and laboratory testing, coring,

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Vol. 20, Issue 3, 2024

and detailed analysis to assess asphalt deterioration The methodology includes walking the section, identifying and categorizing distress features, and mapping them at 10-meter intervals Severity and thickness ratings are assigned based on manual guidelines and photographic references

- **Drainage Condition Assessment**: Evaluation of both surface and subsurface drainage is undertaken, as these elements significantly impact overall pavement performance Surface drainage assessment focuses on the asphalt's ability to efficiently drain water and prevent pooling on both the bituminous surfacing and shoulder areas
- **Test Collection/Laboratory Tests**: Thirteen trial pits are dug at depths ranging from 05m to 07m across failed and unfailed sections of seven roads in the Ifelodun Local Government area Laboratory tests including particle size distribution (sieve analysis), Atterberg limits (consistency limits), specific gravity, compaction, and California Bearing Ratio (CBR) are performed according to British Standard Institute (BS 1377, 1990) guidelines All tests are conducted in the geotechnical laboratory of the Department of Civil Engineering at Osun State University (UNIOSUN), Osogbo.

IV.MODELLING

An expressway, designed as a controlled-access facility, aims to facilitate the efficient and rapid movement of high volumes of motorized traffic while prioritizing safety, comfort, and cost-effectiveness The alignment and physical dimensions are carefully chosen to allow for future expansion without unnecessary expense, acknowledging the challenges of predicting traffic growth in a dynamic economy Geometric elements are tailored to meet the specific needs of both individual vehicles and the overall traffic flow Design parameters such as carriageway widths, capacities, design speeds, and other geometric features are determined based on thorough consideration of predominant vehicles, including trucks and passenger vehicles This ensures that the expressway not only meets current demands but also anticipates future requirements, thereby supporting sustainable and adaptable infrastructure development

ISSN 2319-5991 www.ijerst.com

Vol. 20, Issue 3, 2024

ROAD DESIGN

1Terrain Classification:

The general slope of the country classifies the terrain across the area The terrain is an important parameter governing the geometric standards and the criteria given in the table 1 as shown below, are used in classifying terrain under these categories While classifying a terrain, short isolated stretches of varying terrain were not taken into consideration

Table 1: Terrain Classification Recommended by IRC

Terrain Classification	Cross slope of the country	
Plain	0 – 10	More than 1 in 10
Rolling	10 -25	1 in 10 to 1 in 4
Mountainous	25 -60	1 in 4 to 1 in 1.67
Steep	>60	Less than 1 in 1.67

2Design Speed:

Design speed is the basic criterion for determining all geometric features of horizontal and vertical alignments The design speeds for various terrain conditions are given in the table 2 as shown below Design speed is mainly be used to determine the following parameters:

• Horizontal alignment radii

• Length of Vertical Curves / K factors

• Geometric layout of the interchanges (specifically layout of the accesses, including length of taper and merging areas, and of weaving zones)

• Layout and characteristics of signs

Table 2: Design Speeds to be adopted for Different Terrain

Sl No	Road Classification	Design Speed (Km/h)					
		Plain Terrain		Rolling Terrain		Mountainous Terrain	
		Ruling	Minimum	Ruling	Minimum	Ruling	Minimum
1	Expressway	120	100	100	85	80	60
2	Link Road	100	80	80	65	50	40

In fact, in urban areas, even in plain terrain, there could be geometric constraints and controls similar in their effects to mountainous terrain Thus, design speed should be adapted in areas with densely built environment having important facilities and other environmental constraints Also, considering the above, in areas with close accesses to the project corridors exists, the design speed should be adapted to suit the site conditions This can be achieved by either decreasing design speed on the main carriageway, or by providing an auxiliary lane physically separated from main carriageway, with a different design speed from main carriageway Design speed should also include provision for the approaches of adjacent road sections (State Highways, National Highways, and Local Roads) This will require speed to be reduced when approaching these sections

ISSN 2319-5991 www.ijerst.com
Vol. 20, Issue 3, 2024

Normally, ruling design speed was taken as the guiding criterion for the purpose of the geometric design Minimum design speed was however adopted where site condition and cost does not permit a design based on "Ruling Design Speed" In the link road section, the design speed was taken as 100 Kmph and for the rest of the ORR the design speed is taken as 120 Kmph

HORIZONTAL ALIGNMENT

3Horizontal Curve:

Horizontal curve consists of circular portion flanked by spiral transition at both ends Design speed, super elevation and coefficient of side friction affect the design of circular curves The provision of transition curves enhances the safety of the road users, as it will allow a smooth change in the rate of change of superelevation, and also reduces the centrifugal forces on the vehicle Length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of super elevation The rate of change of super elevation is considered to be 1:200, as prescribed in AASHTO, and the same rate has been adopted in this project

4. Superelevation:

Superelevation is generally considered to counteract only a fixed percentage of the centrifugal force developed, so that the slow moving traffic will be aided The radii beyond which super elevation is not required is shown in table 8 below The value of super elevation, which should not be less than the camber, is restricted to 7% It is calculated by the following formula

$$e = \frac{V^2}{225\,R}$$

Where

'e' is Superelevation

'V' is the design speed in Km/h

'R' is the radius in meters

Table 8: Radii beyond which superelevation not required

Design Speed (Km/h)	Radius of Curve (m)
100	1800
120	2600

5. Traffic Surveys:

Introduction:

An accurate estimate of the traffic that is likely to use the project road is very important as it forms the basic input in

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ISSN 2319-5991 www.ijerst.com
Vol. 20, Issue 3, 2024

planning, design, operation and financing A thorough knowledge of the travel characteristics of the traffic likely to use the project road as well as other major roads in the influence area of the study corridor is, therefore, essential for future traffic estimation Hence, detailed traffic surveys were carried out to assess the present day traffic and its characteristics

Table 1: Present and Projected traffic volume (PCUs) along the Project Corridor

Leg	2006	2011	2016	2021	2026	2031	2036
Leg-1	34,931	49,271	69,123	96,126	129,534	172,687	225,540
Leg-2	35,450	49,959	70,112	97,636	131,723	175,936	230,206
Leg-3	34,672	49,053	68,990	96,126	129,709	173,103	226,264
Leg-4	52,136	73,043	101,663	140,201	187,741	248,553	322,651
Leg-5	57,655	80,801	112,350	154,619	206,695	272,957	353,470
Leg-6	58,305	80,936	111,911	153,769	205,433	271,819	352,899
Leg-7	38,276	52,340	71,260	96,491	127,501	166,864	214,624
Leg-8	58,761	79,977	108,461	146,443	193,112	252,380	324,302
Leg-9	64,463	87,702	119,014	160,945	212,526	278,330	358,380
Leg-10	37,924	51,184	69,225	93,747	124,017	163,264	211,411
Leg-11	32,589	44,342	60,433	82,371	109,487	144,719	187,993
Leg-12	31,861	43,366	59,150	80,721	107,397	142,137	184,856

* Legs as detailed in Table 4.

Flexible pavement design has been carried out using the IRC: 37-2001 and AASHTO design methods IRC: 37-2001, a modification to IRC: 37-1984 has been revised to incorporate the mechanistic design approach In the new code pavement designs have been extended to cover up to traffic loading of 150 Msa Design was also carried out using the AASHTO pavement design guidelines

The scope of pavement design in this project can be divided into the following sections

• Design of Flexible Pavement for the Main carriageway

• Design of Flexible Pavement for Service roads

In the design of flexible pavements, a subgrade CBR of 10% has been considered Wherever the CBR of existing soils was found to be less than 10%, select subgrade material, with a thickness of 500mm, having a CBR of 10% or more has been considered in the design If the CBR of the existing sub grade is more than 10% it will be loosened and re-compacted and then the new pavement layers will be laid on it The availability of the soils with CBR more than 10% has been thoroughly investigated and is found to be in sufficient quantity

V.CONCLUSION

Pavements form the essential supportive framework in highway transportation. Each layer of asphalt serves numerous critical functions that must be carefully considered during the construction process. Various types of asphalt can be chosen based on specific traffic

ISSN 2319-5991 www.ijerst.com
Vol. 20, Issue 3, 2024

requirements. Poor construction practices can lead to premature asphalt failure, adversely affecting ride quality. Quality control of materials used in flexible pavement construction is paramount. The selection of materials is primarily governed by the National Highway Authority of India (NHAI), ensuring adherence to stringent standards and specifications for durability and performance.

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