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Comparison Between Cement Concrete Road and Bitumen Road

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Abstract: ***This study discusses the relative comparisons between concrete and bitumen (asphalt) roads with respect to structural performance, cost effectiveness, durability, maintenance and environmental performance. Cement and aggregates roads (or simply concrete roads also known as rigid pavements) have high strength and long life as compared to bituminous/asphalt roads and hence are suitable for high-traffic areas and extreme climatic conditions. By contrast, bitumen roads are more adaptable and cheaper in the short term due to shorter construction times and easy riding. But they generally speaking need to be maintained and maintained. Through this study, it is intended to give stakeholders and engineers an insight into advantages and constraints of each type of road to help in decision making while executing road work. Concrete pavement design has been increasingly important over the years for the development of concrete roads. The benefit of a pavement with low maintenance over the longest design life must be demonstrated to justify high initial investment.***
Key words: Durability, Maintenance, Strength, Appearance, Longevity,etc.

I. INTRODUCTION

Choosing materials for road construction impact greatly the performance and maintenance of the road network in terms of strength and cost. The roads often used consist of concrete and bitumen which have their own pros and substantial cons as well. Most modern concrete roads are constructed with cement mixtures containing aggregates and water, plus they're easier to make. They are common in the case of highways, urban streets and industrial areas because of their exceptional strength and resistance to the environment. Bitumen roads are built quite haphazardly with aggregates bound together using bitumen nowadays. These roads continue to be preferred due to their lower initial costs, rapid construction, and smooth driving surface. A comparative study assesses both road types based on important factors such as construction cost, lifespan, and multiple other considerations. Knowing these differences help engineers and public policymakers when dealing with designing road projects, thus achieving some level of optimal economic efficiency.

1) *Cement Concrete Road:* -Concrete roads are a type of highway surface made from Portland cement, sand, coarse aggregate, and water in a mixture that is poured and compacted to make a more durable and long-lasting surface. Unlike flexible pavement surfaces such as asphalt, concrete roads are not easily damaged by cracks, ruts, and potholes. Thus, concrete roads are more durable and longer lasting, which means less disruption of traffic flow and less need for maintenance and repair.



FIG 1.1 CEMENT CONCRETE ROAD

2) *Bitumen Road:* -Bitumen roads can also be referred to as flexible pavements or asphalt roads. They are built with a mixture of aggregates mixed together with bitumen as the by-product of petroleum refinery processes.

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They have become widely used due to their low initial costs, speedy construction, and smooth driving surfaces that provide pleasant and quiet driving. The bitumen road's flexibility allows it to tolerate small changes in terrain and ambient temperatures without cracking. This feature makes it an ideal choice for areas with moderate traffic loads and weather conditions. Bitumen roads have lower life expectancies compared with concrete roads. They may need more frequent maintenance, especially during hot climates where bitumen may soften and deform. But due to their ease of repair, recyclability, and affordability for short-term projects bitumen remains the most commonly used pavement system around the world, particularly in developing countries.



FIG 1.2 Bitumen Road

II. LITERATURE REVIEW

A comprehensive literature review comparing Cement concrete road and bitumen (asphalt) roads reveals distinct advantages and limitations associated with each, particularly concerning mechanical performance, cost-effectiveness, sustainability, and applicability in various contexts

Ellie H. Fini et al. (2015) "The European standard defines bitumen as an adhesive and waterproofing substance that is obtained from crude oil or found in natural asphalt, is fully soluble in toluene, and is extremely viscous or almost solid at room temperature. It is widely acknowledged that bitumen's initial properties heavily depend on how it is produced and processed, as well as the properties of bitumen crude oil. Proper distillation procedures and high-quality petroleum oils can improve bitumen's characteristics. Higher bitumen outputs are typically produced by heavier petroleum oils. Therefore, it is crucial to have a thorough understanding of the bituminous features from all angles. This information becomes even more crucial when producing and using bituminous materials for some bitumen uses becomes problematic due to issues like phase discontinuity and improper polymer dispersion [(1).]

Michele Porto et al. (2019) "The data for this research were compiled after a careful examination of the most recent papers in the literature on modified bituminous materials, technologies, and advancements. The report is organised into two main parts for this reason. The bitumen itself is examined in the first section in terms of its molecular composition and microstructural structures. The second section of the paper concentrates on bitumen alteration from various angles in order to evaluate the efficacy of the added additives and polymers in improving the technical characteristics of bitumen in both paving and industrial applications. The findings of this research have demonstrated the significance of the chemical makeup of bitumen as a foundation for change. While some polymers and compounds may enhance some characteristics of pure bitumen, they may also cause compatibility issues during manufacturing and storing. In this regard, numerous studies demonstrated the efficacy of waxes for enhancing the compatibility of polymers with bitumen as well as some advantages regarding the creation of warm mix asphalt (WMA). [(2)]

Peyman Baba Shamsi et al. (2016) has commented the Use of LCCA must be carried out appropriately and data utilized must be from existing records that are accurate in terms of initial costs, salvage value, rehabilitation timing and costs. [(3)]

Hamidreza Abbasianjahromi (2019) has evaluated the regression method has better performance than the time series model and the second, the implementation of concrete pavement has less economic risks in Iranian freeways and highways The pavement is one of the most important components of roads since it directly contacts with the vehicles. [(4)]

Amy R. Riley-Powell "Concrete pavements or rigid pavement is distributed stress over a large area it divided it in all horizontal direction therefore base layers undergo less pressure from axle loading as shown in figure.[(5)]

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III. OBJECTIVE OF THE STUDY

The basic aim of this study is to analyse and compare the performance, cost, sustainability and practical applications of bitumen roads and cement-concrete road. There are two main road surfaces of which bitumen road is being commonly used in urban and rural infrastructures. Both have various advantages and disadvantages. This comparison is aimed at evaluating major parameters such as construction techniques, initial and long-term costs, durability, load-bearing capacity, maintenance requirements, weather resistance, aesthetics, and environmental impact. Bitumen roads are widely used for their smooth finish and relatively quick construction time hence can be used on highways and major road networks.

1) *Cement Concrete Road:* -The aims and purposes primarily of consideration in the study of cement concrete roads are enhancement in the performance, durability, cost effectiveness and environmental sustainability. These objectives are crucial to the success of infrastructure development and especially in regions such as India where the climate and traffic loads are highly variable.
2) *Bitumen Road:* - Bitumen Road Through the attainment of these objectives, bitumen road research contributes to the development of durable, cost-effective, environmentally friendly infrastructure that meets the changing needs of society.

IV. METHODOLOGY

A. Comparison: Cement concrete road Vs Bitumen Road:

Cement concrete road construction methodology and bitumen road construction methodology: A comparison There are differences between the methods of cement concrete and bitumen road construction, with respect to process, materials, labor intensity and structural behavior which can be considered when developing a method of choice depending on the specific project requirements, site conditions and intended use.

B. Cement Concrete Road: -

1) Site Preparation (Common for Both)

- Inspecting for any vegetation, debris, or existing ground cover.
- Topsoil dredging to the depth required, depending on the expected traffic load.

2) Materials Used:

- Ordinary Portland Cement (OPC) or blended cement
- Fine aggregates (sand)&Coarse aggregates (gravel/stone)
- Water& Admixture

3) Preparation of Sub-grade:

- Excavation and compaction of sub-grade to the required level.
- Laying of sub-base (if required) and compacting it properly.

4) Formwork Setting:

- Steel or wooden forms are set along the pavement edges.

5) Batching and Mixing Concrete:

- Concrete is mixed using a batching plant or on-site mixer as per the M40/M30 grade or design mix.

6) Placing Concrete:

- Concrete is placed manually or using slipform pavers over the prepared base.

7) Compaction and Finishing:

- Vibrators or vibratory screeds are used for compaction.
- Surface is levelled and finished using screeds, floats, or trowels.

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8) Curing:

- Kept moist for at least 7–14 days using water or curing compounds to achieve strength.

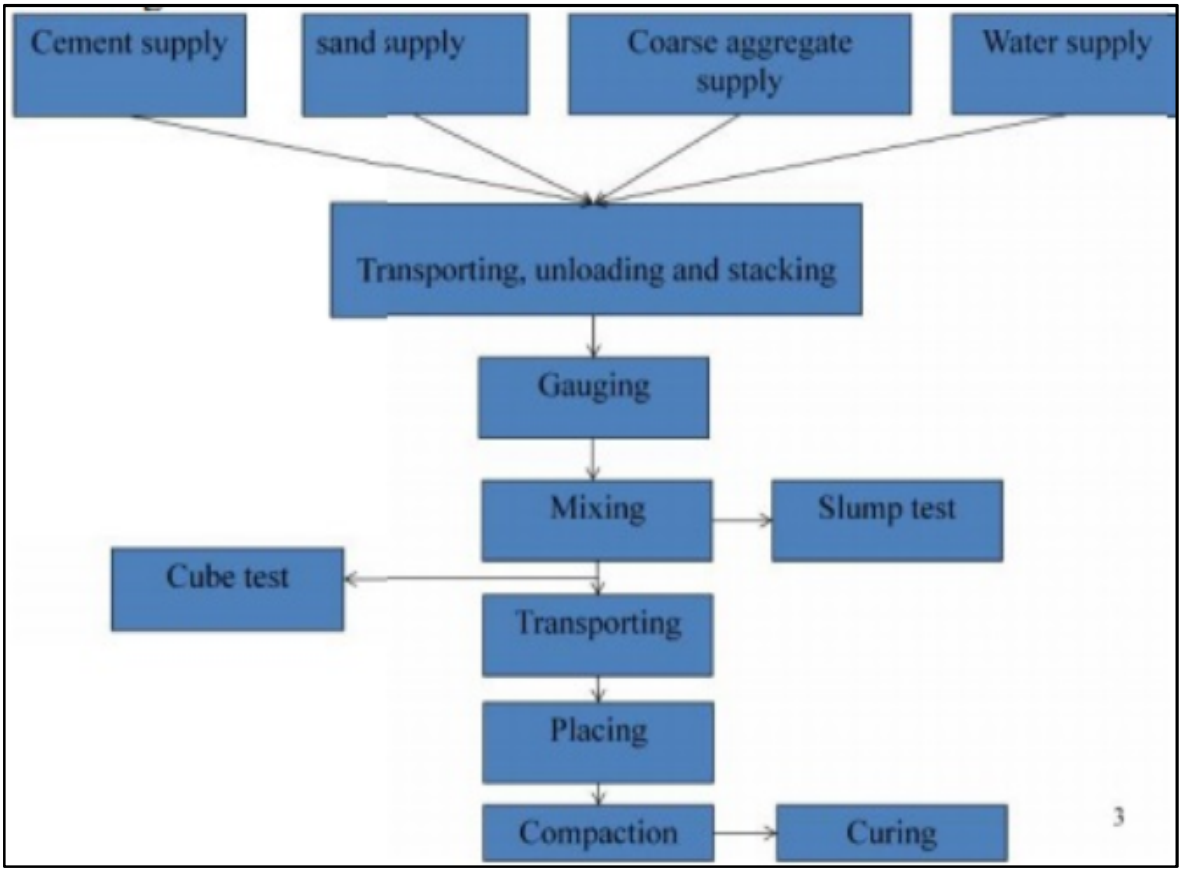


Fig-3.2Methodology steps

9) Joint Cutting and Sealing:

- Transverse and longitudinal joints are cut after initial setting and sealed with joint filler.

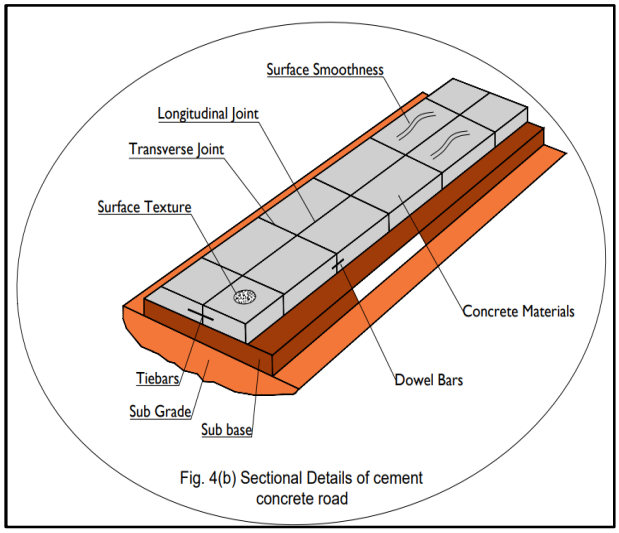


Fig-3.2.9Joint Cutting and Sealing

C. Bitumen Road (Flexible Pavement)

1) Materials Used:

- Bitumen (VG-30, VG-40, or modified binders)
- Aggregates (coarse and fine)
- Filler (stone dust, cement, etc.)

2) Preparation of Sub-grade:

- Same as concrete road; excavation and compaction.

3) Laying Sub-base and Base Course:

- Granular Sub Base (GSB)
- Wet Mix Macadam (WMM) or Dense Graded Aggregate (DGA)

4) Tack Coat Application:

- Bituminous emulsion is sprayed on the base course for bonding with the surface layer.

5) Laying Bituminous Layers:

- Binder Course (e.g., Bituminous Macadam, DBM): Compacted layer of bitumen and aggregate.
- Wearing Course (e.g., Bituminous Concrete or Asphalt Concrete): Final surface layer.

6) Compaction:

- Rollers are used to compact the bituminous layers.

7) Finishing and Opening to Traffic:

- Once temperature falls below a set point, the road can be opened within a few hours.

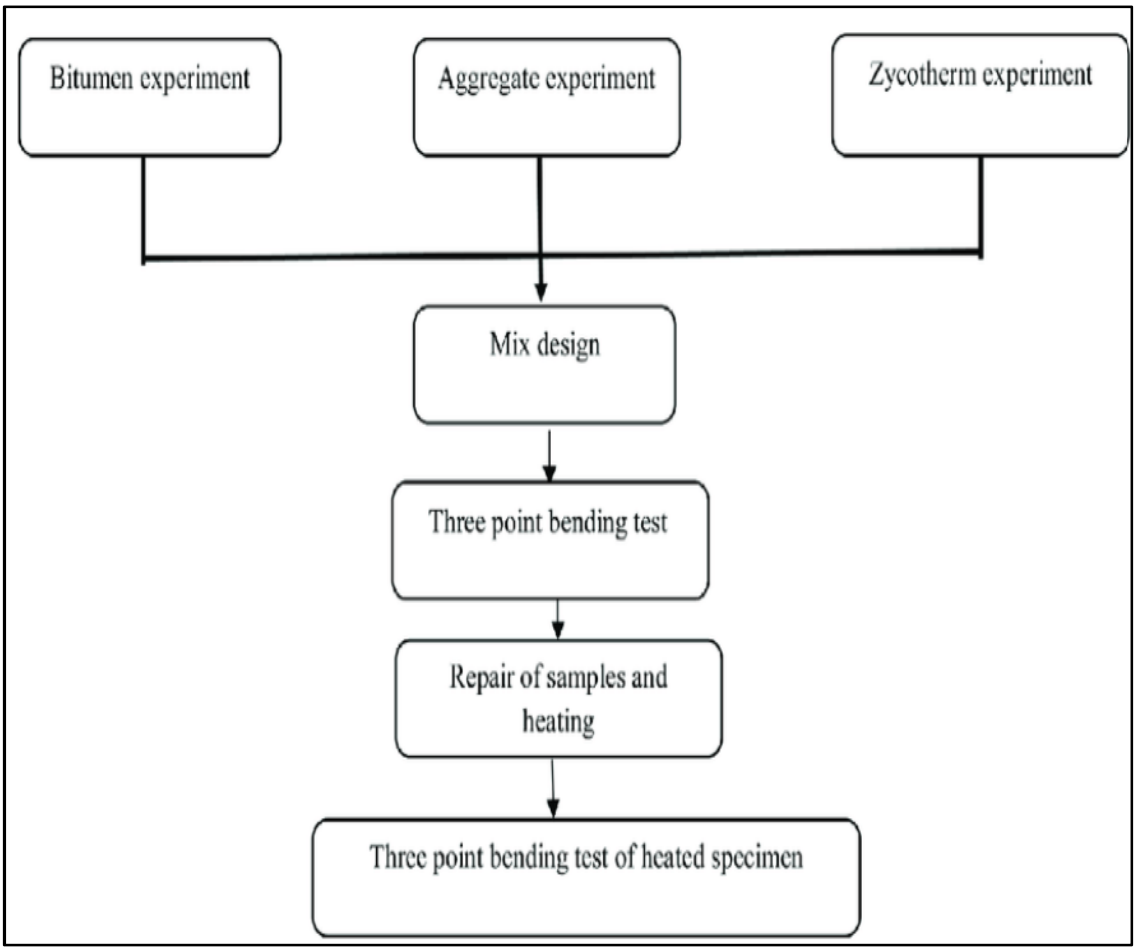


Fig-4.3(a) Methodology steps

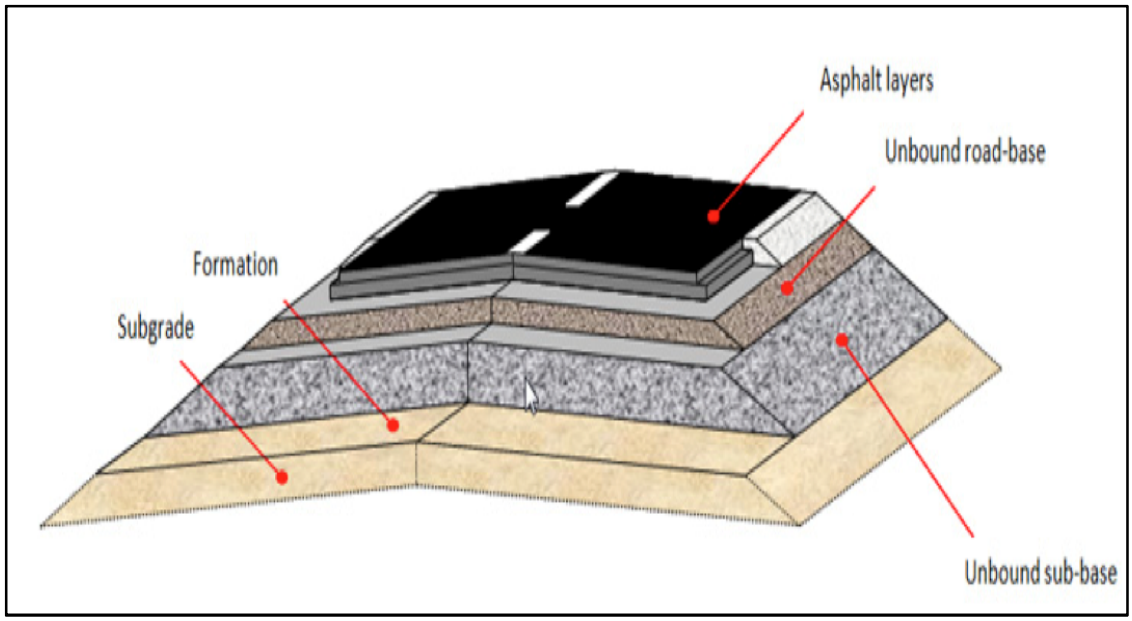


Fig-4.3(b) Layers and section details

V. RESULT& DISCUSSION

A. Cement Concrete Road Tests:

1) Density Test

Density of Cement/Concrete Road to be used as a reference measure to ensure that the concrete has been compacted properly and meets design strength and durability requirements D=M/V.

2) Impact Value Test

In spite of the fact that the impact value test is not performed directly on hardened concrete concrete, impact value test is carried out on aggregates used in the preparation of concrete, to ensure that aggregates used for cement concrete road are sufficiently tough for impact load during their service life.

IMPACT VALUE= (W2/W1)*100

Weigh the material passing through the sieve (W_2)&Weigh the total sample before test (W_1).

3) Crushing Value

To identify Aggregate Crushing Value (ACV) = The resistance of aggregate to crushing under gradual compressive load (ACV) is an important test for rigid pavements such as cement concrete roads. ACV = (W2/W1)*100

W2 = weight of fines passing 2.36 mm sieve&W1 = total weight of sample

4) Flakiness & Elongation Index Combined Test

- To quantify both flaky and elongated particles total proportion in coarse aggregates used for cement concrete roads (Good shaping of aggregates must be done to achieve good packing, minimal void content and effective interlocking).
- **FI** = (Weight of flaky particles/total weight of sample) *100

5) Cost Impact

1 square meter (m2) of cement concrete road project cost would depend on mix design, concretes, materials, labor and equipment. Let 's say you 're making: - M30 grade concrete.

Area: **1 m^2,** if cost of concrete is ₹6,500/m^2

Total Cost per m^2 = ₹6,500/m^2

B. Bitumen Road Tests:

1) Density Test

- The **density test** of a bitumen (asphalt) road is a critical **quality control measure** to ensure proper compaction of the pavement. Inadequate density leads to early **rutting**, **cracking**, and **potholes**.
- Acceptable bulk density for dense bituminous layers: ~2,300 to 2,450 kg/m³ (varies by mix design)D=(M/V)

2) Impact Value Test

- The **Impact Value Test** is conducted on the **coarse aggregates used in bituminous (flexible) pavements**, not directly on the bitumen layer. It measures the **toughness** of aggregates — their ability to resist sudden shock or impact — which is essential for surfaces subject to **repeated traffic loads**.
- IMPACT VALUE= (W_2/W_1)*100

3) Crushing Value

- The **Aggregate Crushing Value (ACV)** test is performed on **coarse aggregates** used in **bituminous (flexible) pavements** to assess their **resistance to crushing under gradually applied compressive load**
- ACV=(W_2/W_1) *100

W2 = weight of fines (passing 2.36 mm sieve & W1 = total sample weight

4) Flakiness & Elongation Index Combined Test

- These tests measure the **shape characteristics** of aggregates, which directly affect **workability, compaction, and strength** of the flexible pavement.
- **FI** = (Weight of flaky particles/total weight of sample) *100

5) Cost Impact

- The cost of 1 square meter ($1m^2$) of a bitumen road can vary significantly depending on the type of road, materials used, and location. However, a rough estimate for the cost of bituminous concrete (used in many road types) can be around ₹4,000per square meter
- Area: **1 m^2,** if cost of concrete is ₹4,000/m^2

Total Cost per m^2 = ₹4,000/m^2

COMPARISON BETWEENCEMENT CONCRETE AND BITUMEN ROAD

Table -1 (IS Code)

S.NO	TEST PERFORMANCE	IS CODE	LIMITS
1.	DENSITY	-	-
2.	Impact Value%	IS 2386 (P-4)	Less than 30%
3.	Crushing Value%	IS 2386 (P-4)	Less than 30%
4.	Flankiness & Elongation Index combined %	IS 2386 (P-4)	Less than 40%
5.	Estimated Value per Sq metre	-	-

Table -2 (Test)

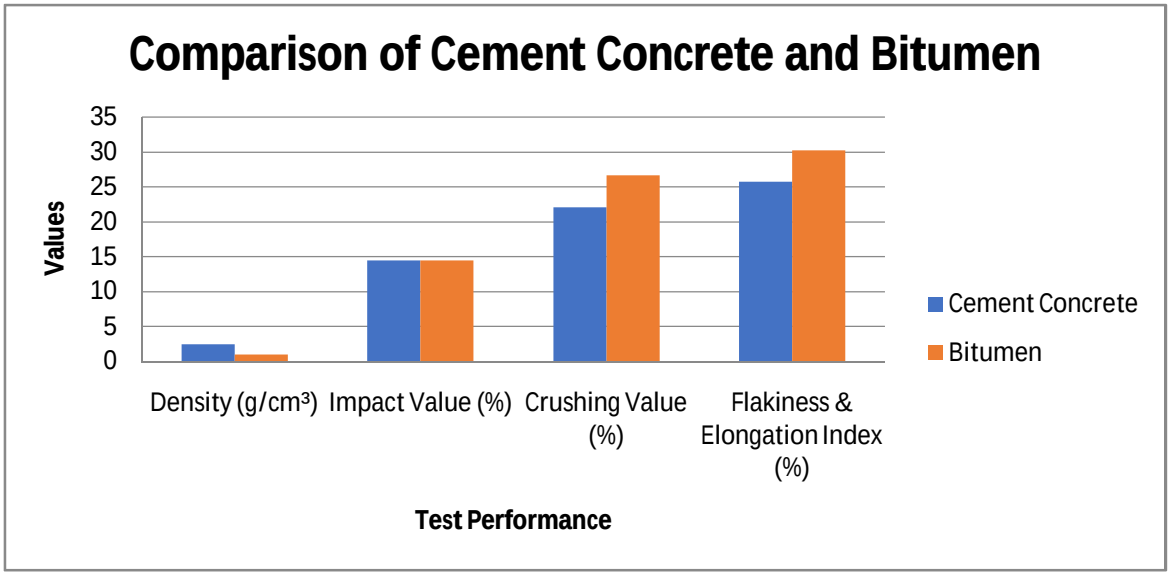
S.NO	TEST PERFORMANCE	CEMENT CONCRETE	BITUMEN	LIMITS
1.	DENSITY	2.45g/cm^3	1.04g/cm^3	-
2.	Impact Value%	14.5%	14.5%	LESS THAN 30%
3.	Crushing Value%	22.1%	26.7%	LESS THAN 30%
4.	Flankiness & Elongation Index	25.79%	30.2	LESS THAN 40%

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	combined %			
5.	Estimated Value per Sq metre	Rs 6,500 to Rs 7.500	Rs 4,000 to Rs 5,000	-

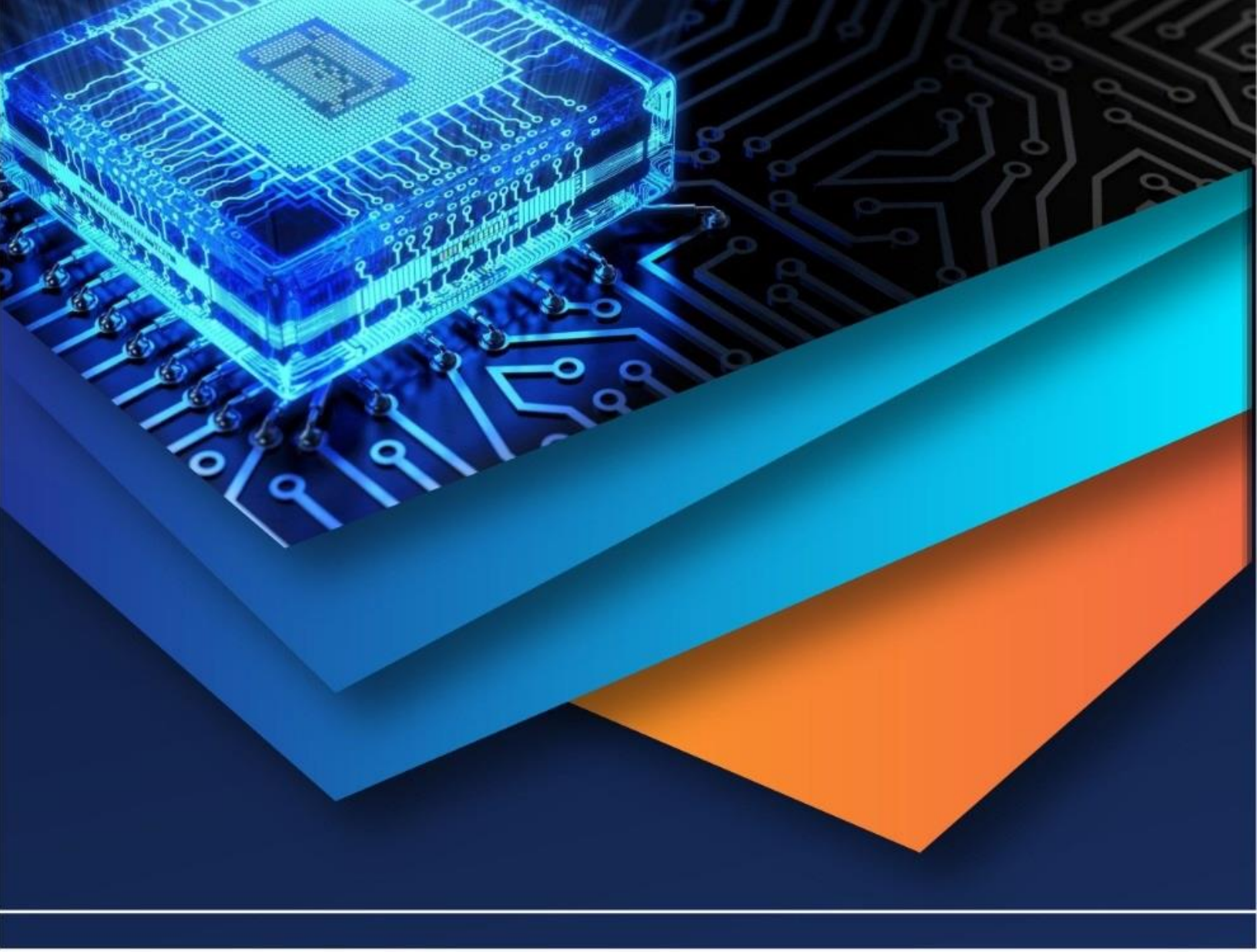
VI. CONCLUSION

Cement concrete road costs more initially but on the long run it is more durable, needs minimum maintenance and has higher economy. So, they are best suited for high traffic areas and heavy load regions. Bitumen road costs a lot less initially but is quite quicker to make. They provide smooth ride quality and are excellent for medium traffic roads. However, they need less frequent maintenance and are less prone to weathering. They are best suited for low traffic or pedestrian areas. So overall, concrete road is a practical and sustainable type of road that one can lay, when longer term durability and low maintenance is important and one wants to have more efficient installation.



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