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COMPARATIVE STUDY OF REBOUND HAMMER STRENGTH OF PCC RURAL ROADS

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ABSTRACT

The beginning of road construction could be dated to the time of the Romans. With the advancement of technology from carriages pulled by two horses to vehicles with power equivalent to 100 horses, road development had to follow suit. The construction of modern highways did not begin until the late 19th to early 20th century. Developed countries are constantly faced with high maintenance cost of aging transportation highways. The growth of the motor vehicle industry and accompanying economic growth has generated a demand for safer, better performing, less congested highways. The growth of commerce, educational institutions, housing, and defense have largely drawn from government budgets in the past, making the financing of public highways a challenge. The multipurpose characteristics of highways, economic environment, and the advances in highway pricing technology are constantly changing. Therefore, the approaches to highway financing, management, and maintenance are constantly changing as well. This comparative study presents compressive strength of cement concrete rural roads obtained using rebound hammer apparatus. In this study total 15 roads are considered. Three sections were taken in each road and at each section five positions were taken for applying Non-Destructive test using Rebound hammer. Strengths are compared with design strength.

KEYWORDS: PCC Rural Roads, Non-Destructive test, Rebound Hammer, Comparative Study.

INTRODUCTION

Rural India relies on transportation services, both passenger and freight, to provide connections to the regional, national, and global economy. We commute to work, go shopping, run errands, visit family and friends, and go on vacation. To do this, we travel by automobile, airplane, train, boat, bus, bicycle, and on foot. Products and services also need to be delivered from place to place. Oil, machine and electronic components, agricultural products, special deliveries, and other goods arrive by truck, train, and airplane. The quality of life and economy in rural India depends on an efficient, effective, comprehensive, and coordinated multimodal transportation system that provides choices for the movement of people and goods and allows quick transfers between modes when and where they are needed. The need to maintain transportation linkages between rural and urban areas is very important to the economy, public health and safety, and the social structure of rural India. Effective rural transportation planning improves the multimodal and intermodal transportation system and helps to ensure that the quality of life and economy in rural India is maintained and enhanced. It does so by providing a strategic perspective on system investment over an extended period of time. Good rural transportation plans consider a wide range of investment, operational, and technology options that can meet the multimodal transportation needs of transportation system users. Most importantly, effective rural transportation planning provides the users and stakeholders of the transportation system with ample opportunity to participate in the planning process, thus ensuring maximum input into the desires, visions, and directions for transportation system investment.

Rural development has become a matter of growing urgency for considerations of social justice, national integration, and economic up lift and inclusive growth. For rural development, the provision of rural road network is a key component to enable the rural people to have access to schools, health centres and markets. Rural roads serve as an entry point for poverty alleviation since lack of access is accepted universally as a fundamental factor in continuation of poverty. As India launched the era of planned development in 1951, she had a reasonably good

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railway system, a few ports and around 400,000 kms of serviceable road network. Accessibility to villages was poor as only about 20 percent of them had all-weather road links. The Government laid down a framework for accelerated growth through investments in irrigation, power, heavy industry and transport. Side by side, stress was laid on provision of social infrastructure (education and health) and integrated rural development including agriculture. Rural roads act as a facilitator to promote and sustain agricultural growth, improve basic health, provide access to schools and economic opportunities and thus holds the key to accelerated poverty reduction, achievements of Millennium Development Goals (MDG), socio-economic transformation, national integration and breaking the isolation of village communities and holistic and inclusive rural development. A major thrust to the development of rural roads was accorded at the beginning of the Fifth Five Year Plan in 1974 when it was made a part of the Minimum Needs Programme. In 1996, this was merged with the Basic Minimum Services (BMS) programmes. The works of village tracks were also taken up under several employment creation and poverty alleviation programmes of the Central and State Governments. There is growing empirical evidence that links transport investment to the improved well being of the poor. A study carried out by the International Food Policy Research Institute on linkages between government expenditure and poverty in rural India has revealed that an investment of Rs. 10 crore (at 2009-10 prices) in roads lifts 16,500 persons above the poverty line. Some of the latest literature on the topic are as follows -

Jhonson (2008) discussed about current issues facing roads managers. He discussed new methods to stabilize dirt and gravel roads, reclamation process for full depth of the roads. He provided information to support decision making of when to upgrade gravel roads and also discussed cost safety improvements, farm to market road issues, best practices and resources in pavement design methods for roads. **Kittelson and Roess (2001)** reported that the current methodology of determining LOS is not based upon user perception. **Flannery et.al (2008)** reported that incorporated user perception to estimate LOS of urban street facilities using a set of explanatory variables that describe the geometry and operational effectiveness. **Zhang et al. (2013)** discussed about the development of a new pavement network management system that helps analysis and optimization. This LCCA optimization was implemented to regulate the optimum conservation scheme for a pavement network and to reduce supportability metrics within a given analysis period. They discussed about pavement deterioration, which is a main aspect to focus future pavement conservation procedures and is extremely difficult to focus faultlessly.**Ndoh and Ashford (1994)** developed a model to evaluate airport passenger services quality using fuzzy set theory techniques. The authors tried to incorporate user perception in evaluation of service quality instead of just considering traffic parameters for this purpose. **Ferhat Aydin and Mehmet Saribiyik (2010)** developed a relationship associated between non-destructive testing (NDT) named as Schmidt rebound hammer test and concrete destructive compression test. The Schmidt rebound hammer is chiefly a surface hardness analyzer with an evident hypothetical relationship between the strength of concrete and the rebound number of the hammer. Keeping in mind the end goal to adjust the Schmidt Hammer with the different aged concretes, cube samples of 28 - 90 days and various core specimens from distinctive reinforced concrete structures have been tried. This calibration has been done to get the related constant acquired from Schmidt and compression tests. The best fit amendment variables for the concrete compressive strength Schmidt rebound hammer relationship are acquired through preparing connection among the data sets. The remedy variables can be effectively applied to in situ concrete strength and also existing solid structures.

METHODS

OBJECTIVES OF STUDY

The objective of this investigation is as given below:

1. To study the behaviour of PCC rural roads.
2. Strength Comparisons at the time of laying and the strength at present using Rebound Hammer.
3. Reasons behind the occurrence of failure of PCC rural roads.

PROCEDURE

1. ***Selection of Roads:*** **-** The rural street system required for giving the 'essential access' to all towns/homes is termed as the Core Network. Fundamental access is characterized as one all-climate street access from every town/residence to the adjacent Market Center or Rural Business Hub (RBH) and key social and financial administrations. The 15 provincial streets which we have taken for examination has a place with Block Obedullaganj District Raisen (M.P).

2. ***Visual Inspection of Roads:*** - Visual testing is likely the most imperative of all non-destructive tests. It can regularly give important data to the all around prepared eye. Visual elements may be identified with workmanship, basic serviceability, and material weakening and it is especially imperative that the designer can separate between the different indications of trouble which may be experienced. These incorporate for example, splits, pop-outs, spalling, crumbling, shading change, weathering, recoloring, surface imperfections and absence of consistency.
3. ***NDT of Roads:***- In Non-Destructive testing of roads the surface must be cleaned, smoothened and dried.
Following are the steps involved in NDT of roads

a) Firstly five positions are slected in transverse direction of roads which is in the shape of square of size (30x30) cm. Each square is in the form of grid having 9 small squares of size (10x10) cm.

Fig.1: Grid markings on road

b) The first grid is at the left hand corner, second grid is in between centre and left hand corner, third grid is at centre, fourth grid is in centre and right hand corner and the fifth grid is at right hand corner shown in Fig. 2

Fig.2: Positions of grids on road

c) The strength of each grid is taken by rebound hammer holding the plunger perpendicular to the surface of concrete and applying pressure on a body towards the test object shown in Fig. 3

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Fig.3: NDT of Roads

RESULTS AND DISCUSSION

Average Rebound Hammer Strength at Different Positions of Roads

The average rebound hammer strength at different positions of roads are given below

Average Rebound Hammer Strength at Right Hand Corners of Roads

Compression testing was carried out using Rebound Hammer machine. The Average Rebound Hammer Strength (MPa) of each road is given in Table 1 and shown in Fig. 4

Table 1: Average Rebound Hammer Strength (MPa) at Right Hand Corners of Roads

S.No.	Names of Road	Rebound Hammer Strength (MPa)
1.	NH-12 to Itaya Kala Road	30.6
2.	Itaya Kala Road	38.8
3.	Itaya Khurd Road	23.9
4.	Itaya Khurd to Hamiri Road	31.5
5.	Hamiri (Point-2) Road	22.3
6.	Mandkasiye to Patharkasiya Road	21.9
7.	Patharkasiya to Babadhiya Gondi Road	29.3
8.	Diwatiya Road	26.4
9.	At Harrai to Dhawala Road	24.5
10.	Harrai to Kumariya Road	22.5
11.	Rojra Chak to Gokul Kundi Road	28.3
12.	Murari Chopna Road	39
13.	Kasrod Hajli to Salkani Road	35.3

14.	Goharganj to Ambai Road	29.7
15.	Champaner to Garha Road	33

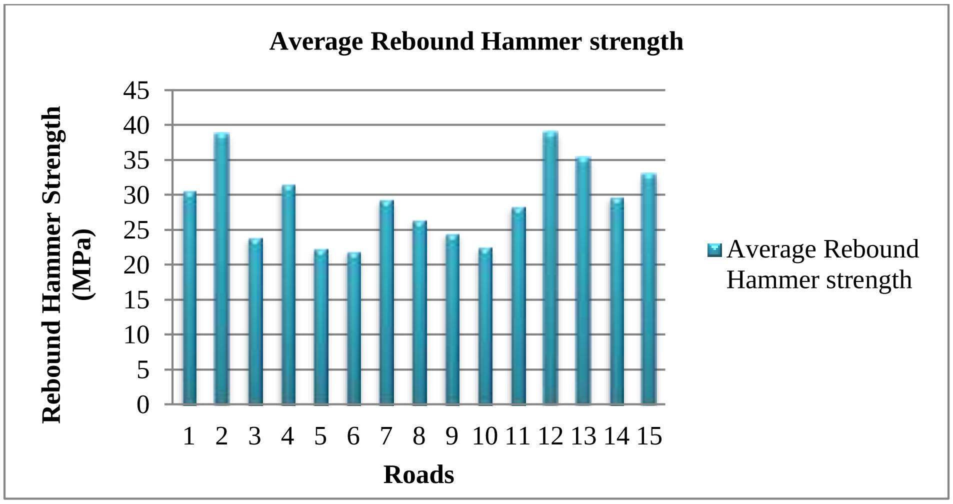

Fig.4: Average Rebound Hammer Strength (MPa) at Right Hand Corners of Roads

It is observed that the maximum rebound hammer strength is 39 MPa at Murari Chopna Road and minimum rebound hammer strength is 21.9 MPa at Mandkasiye To Patharkasiya Road.

Average Rebound Hammer Strength between Centre and Right Hand Corners of Road

Compression testing was carried out by using Rebound Hammer machine. The Average Rebound Hammer Strength (MPa) is given in Table 2 and shown in Fig. 5

Table 2: Average Rebound Hammer Strength (MPa) between Centre and Right Hand Corners of Roads

S.No.	Names of Road	Rebound Hammer Strength (MPa)
1.	NH-12 to Itaya Kala Road	39.6
2.	Itaya Kala Road	35.8
3.	Itaya Khurd Road	31.6
4.	Itaya Khurd to Hamiri Road	29.7
5.	Hamiri (Point-2) Road	25.2
6.	Mandkasiye to Patharkasiya Road	20.3
7.	Patharkasiya to Babadhiya Gondi Road	31
8.	Diwatiya Road	29.9
9.	At Harrai to Dhawala Road	26.1

10.	Harrai to Kumariya Road	24.4
11.	Rojra Chak to Gokul Kundi Road	28.3
12.	Murari Chopna Road	41.7
13.	Kasrod Hajli to Salkani Road	33.2
14.	Goharganj to Ambai Road	30.4
15.	Champaner to Garha Road	32.7

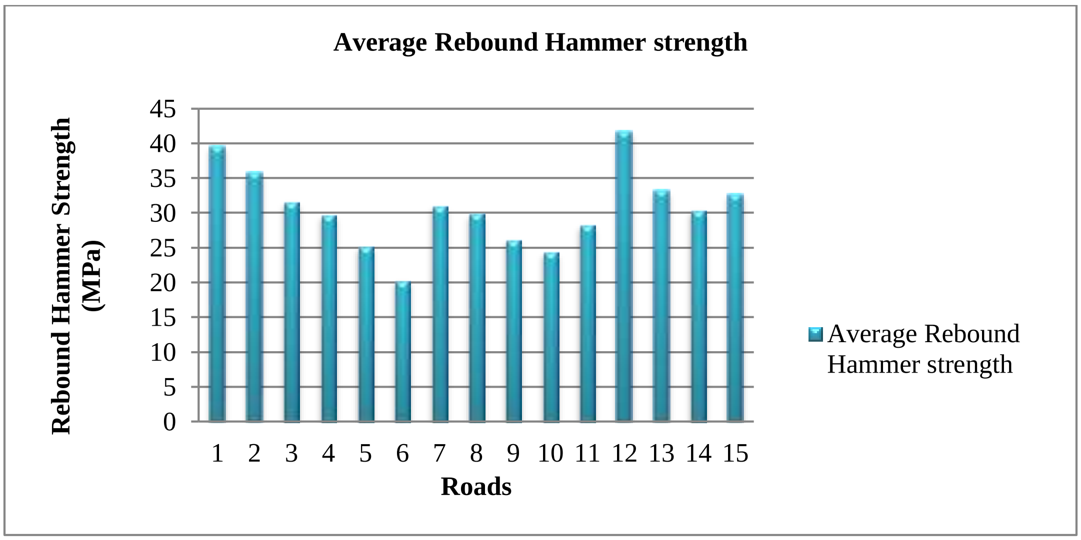

Fig. 5: Average Rebound Hammer Strength (MPa) between Centre and Right Hand Corners of Roads

It is observed that the maximum rebound hammer strength is 41.7 MPa at Murari Chopna Road and minimum rebound hammer strength is 20.3 MPa at Mandkasiye to Patharkasiya Road.

Average Rebound Hammer Strength at Centre of Road

Compression testing was carried out by using Rebound Hammer machine. The Average Rebound Hammer Strength (MPa) is given in Table 3 and shown in Fig. 6

Table 3: Average Rebound Hammer Strength (MPa) at Centre of Roads

S.No.	Names of Road	Rebound Hammer Strength (MPa)
1.	NH-12 to Itaya Kala Road	37.7
2.	Itaya Kala Road	34.7
3.	Itaya Khurd Road	34.4
4.	Itaya Khurd to Hamiri Road	27.4

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5.	Hamiri (Point-2) Road	25.4
6.	Mandkasiye to Patharkasiya Road	23.9
7.	Patharkasiya to Babadhiya Gondi Road	25.5
8.	Diwatiya Road	31.3
9.	At Harrai to Dhawala Road	31.4
10.	Harrai to Kumariya Road	24.8
11.	Rojra Chak to Gokul Kundi Road	31.8
12.	Murari Chopna Road	37.2
13.	Kasrod Hajli to Salkani Road	35.9
14.	Goharganj to Ambai Road	29.8
15.	Champaner to Garha Road	30.5

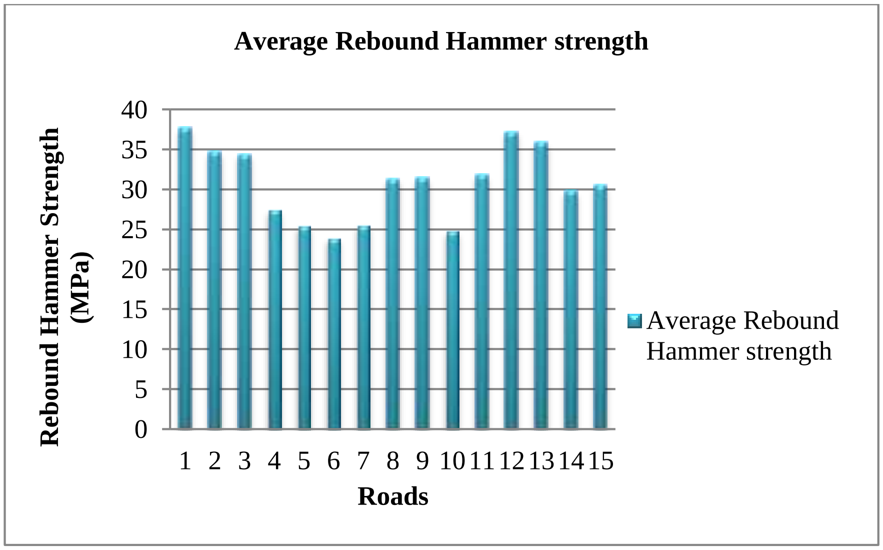

Fig.6: Average Rebound Hammer Strength (MPa) at Centre of Roads

It is observed that the maximum rebound hammer strength is 37.7 MPa at NH-12 to Itaya Kala Road and minimum rebound hammer strength is 23.9 MPa at Mandkasiye To Patharkasiya Road.

Average Rebound Hammer Strength between Centre and Left Hand Corners of Road
Compression testing was carried out by using Rebound Hammer machine. The Average Rebound Hammer Strength (MPa) is given in Table 4 and shown in Fig. 7

Table 4: Average Rebound Hammer Strength (MPa) between Centre and Left Hand Corners of Roads

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

S.No.	Names of Road	Rebound Hammer Strength (MPa)
1.	NH-12 to Itaya Kala Road	36.7
2.	Itaya Kala Road	36.9
3.	Itaya Khurd Road	34.8
4.	Itaya Khurd to Hamiri Road	29.2
5.	Hamiri (Point-2) Road	23.7
6.	Mandkasiye to Patharkasiya Road	23.9
7.	Patharkasiya to Babadhiya Gondi Road	27.7
8.	Diwatiya Road	34.4
9.	At Harrai to Dhawala Road	31.8
10.	Harrai to Kumariya Road	24.1
11.	Rojra Chak to Gokul Kundi Road	26.5
12.	Murari Chopna Road	40.5
13.	Kasrod Hajli to Salkani Road	33.3
14.	Goharganj to Ambai Road	31.6
15.	Champaner to Garha Road	30.9

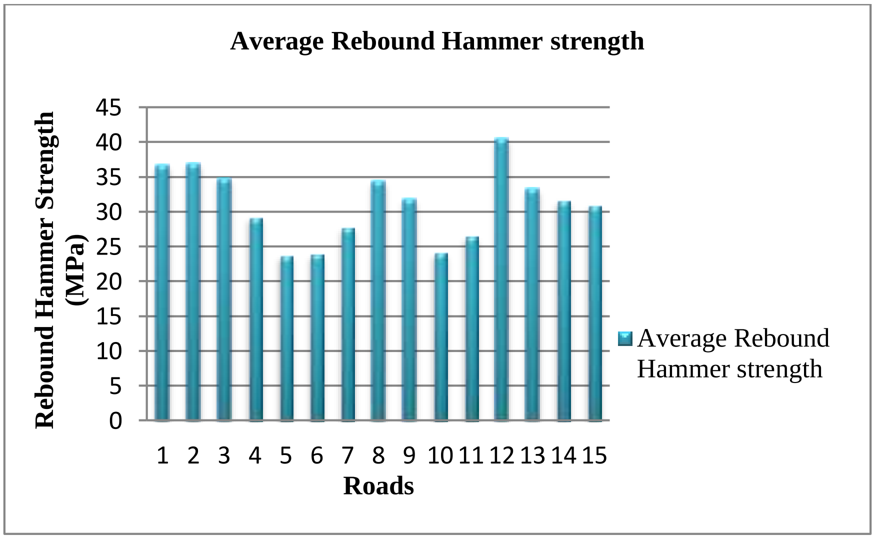

Fig.7: Average Rebound Hammer Strength (MPa) between Centre and Left Hand Corners of Roads

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It is observed that the maximum rebound hammer strength is 40.5 MPa at Murari Chopna Road and minimum rebound hammer strength is 23.7 MPa at Hamiri (Point-2) Road.

Average Rebound Hammer Strength at Left Hand Corners of Road

Compression testing was carried out by using Rebound Hammer machine. The Average Rebound Hammer Strength (MPa) is given in Table 5 and shown in Fig. 8

Table 5: Average Rebound Hammer Strength (MPa) at Left Hand Corners of Roads

S.No.	Names of Road	Rebound Hammer Strength (MPa)
1.	NH-12 to Itaya Kala Road	36.8
2.	Itaya Kala Road	33.1
3.	Itaya Khurd Road	26.4
4.	Itaya Khurd To Hamiri Road	27.1
5.	Hamiri (Point-2) Road	26.9
6.	Mandkasiye to Patharkasiya Road	22.6
7.	Patharkasiya to Babadhiya Gondi Road	25.8
8.	Diwatiya Road	30.6
9.	At Harrai to Dhawala Road	31.2
10.	Harrai to Kumariya Road	22.1
11.	Rojra Chak to Gokul Kundi Road	24.7
12.	Murari Chopna Road	45
13.	Kasrod Hajli to Salkani Road	32.6
14.	Goharganj to Ambai Road	27.7
15.	Champaner to Garha Road	30.2

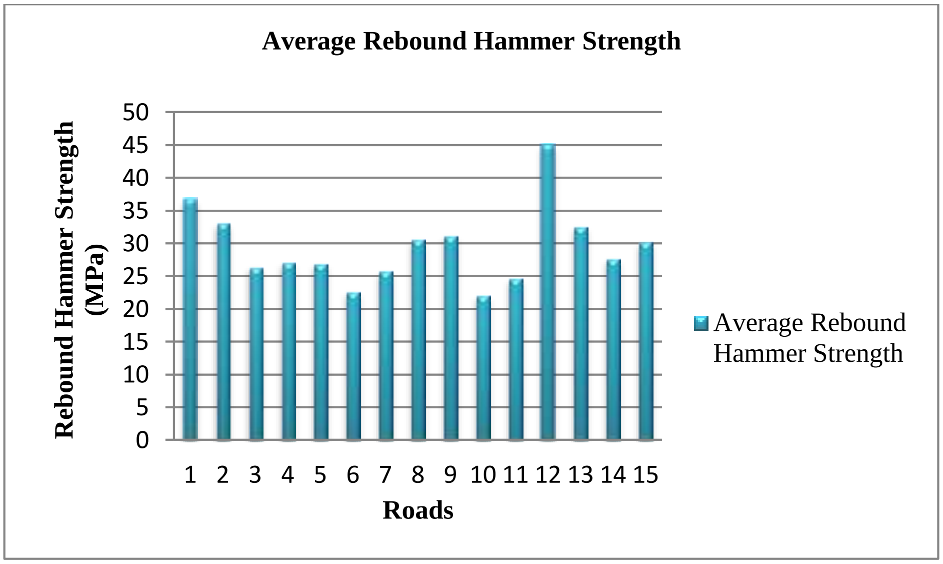

Fig.8: Average Rebound Hammer Strength (MPa) at Left Hand Corners of Roads

It is observed that the maximum rebound hammer strength is 45 MPa at Murari Chopna Road and minimum rebound hammer strength is 22.6 MPa at Mandkasiye to Patharkasiya Road.

Maximum and Minimum Average Rebound Hammer Strength at Different Positions of Roads

The maximum and minimum average rebound hammer strength at different positions of roads is given in Table 6

Table 6: Maximum and Minimum Average Rebound Hammer Strength

Positions on Roads	Minimum strength (MPa)	Maximum strength (MPa)
Right Hand Corner	21.9	39
Between Centre and Right Hand Corner	20.3	41.7
Centre	23.9	37.7
Between Centre and Left Hand Corner	23.7	40.5
Left Hand Corner	22.6	45

It is observed from the Table 6 the minimum strength is at the centre position of the roads i.e 23.9 MPa and 37.7 MPa and the reason behind the weak strength is the running of multi-axle heavy vehicles because of this maximum wheel load of vehicle comes on the centre position of the roads.

CONCLUSION

Following are the salient conclusions of the study:

1. Rebound Hammer strength of NH-12 to Itaya kala road is higher than the design strength which is 30 MPa which proves that strength of concrete increases in its whole life.
2. Rebound Hammer strength of Itaya kala road is higher than the design strength which is 30 MPa which proves that strength of concrete increases in its whole life.
3. Rebound Hammer strength of Itaya khurd road is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa the reason behind the low strength is compaction of road is not done properly and the strength can be increased by compaction grouting.

4. Rebound Hammer strength of Itaya khurd to Hamiri road is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa the reason behind the low strength is the running of multi axle heavy commercial vehicles and the strength can be increased by providing reinforcement in the rigid pavement.
5. Rebound Hammer strength of Hamiri road point -2 is less than the design strength which is 30 MPa the reason behind the low strength is inadequate subgrade support and poor subgrade soil having low CBR value the strength can be increased by soil stabilization or soil replacement upto a known depth .
6. Rebound Hammer strength of Mandkasiye to Patharkasiya Road is less than the design strength which is 30 MPa the reason behind the low strength is scaling of cement concrete and the strength can be increased by resurfacing of concrete slab by using Portland cement.
7. Rebound Hammer strength of Patharkasiya to Babadhiya Gondi is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa which is due to the compaction of road is not done properly and the strength can be increased by compaction grouting.
8. Rebound Hammer strength of Diwatiya road is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa the reason behind the low strength is the running of multi axle heavy commercial vehicles and the strength can be increased by providing reinforcement in the rigid pavement.
9. Rebound Hammer strength of Harrai to Dhawala road is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa the reason behind the low strength is the presence of Black cotton soil having low bearing capacity and the strength can be increased by soil stabilization.
10. Rebound Hammer strength of Harrai to Kumariya Road is less than the design strength which is 30 MPa which is due to presence of cracks in longitudinal as well as in transverse direction and the cracks should be filled by using different materials (such as cement concrete mortar, epoxy material, fibre reinforced concrete etc.) so that the strength can be increased.
11. Rebound Hammer strength of Rojra Chak to Gokul Kundi Road is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa the reason behind the low strength is the running of multi axle heavy commercial vehicles and the strength can be increased by providing reinforcement in the rigid pavement.
12. Rebound Hammer strength of Murari Chopna Road is higher than the design strength which is 30 MPa.
13. Rebound Hammer strength of Khasrod Hajli to Salkani Road is higher than the design strength which is 30 MPa.
14. Rebound Hammer strength of Goharganj to Ambai Road is higher than the design strength which is 30 MPa in various positions but in some positions it was found that the strength is less than the design strength which is 30 MPa the reason behind the low strength is scaling of cement concrete and the strength can be increased by resurfacing of concrete slab by using Portland cement.
15. Rebound Hammer strength of Champaner to Garha Road is higher than the design strength which is 30 MPa.
16. The longitudinal and transverse cracks are developed in Itaya kala road and in Itaya khurd to Hamiri road which is due to poor sub grade soil we suggests that in place of PCC rural roads the RCC rural roads should be constructed so that the life of rigid pavement will increase.
17. The minimum average strength obtained at centre position of roads and the reason behind the weak strength is the running of multi-axle heavy vehicles because the maximum wheel load of vehicle comes on the centre position of the roads and the strength can be increased by providing reinforcement in the rigid pavement.

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