

## Understanding Highway Failure and Recommending its Maintenance: A case study of Delhi – Kolkata highway

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### Abstract

*For the development of a country, transportation infrastructure plays a very important role. The purpose of this paper is to examine the pavement failure types and to select the best maintenance to overcome it for Delhi – Kolkata highway earlier known as (old NH-2). There are many kind of failures that a pavement go through such as, potholes, raveling, rutting, shear failure etc. The main reasons for failure in flexible pavement are heavy loads, poor drainage facilities and heavy rainfall. Due to pavement failures people faces many problems in their day to day life. Pavement failures not only create problems to people but it also increases cost of maintenance. The present studies identifies that the classifications of faults in flexible pavements with their source along with the way to correct it with associated maintenance procedure.*

**Keywords:** Highway Failure, Highway Maintenance, Flexible Pavement, Rigid Pavement, Potholes, Cracks, Raveling, Rutting, Repair.

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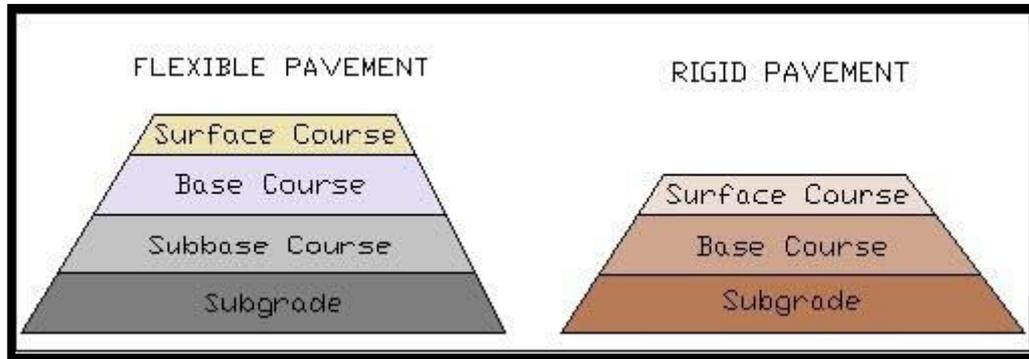
### 1. Introduction:

Transportation plays a vital role in social, economic and industrial development of a country. Because of this transportation is categorized in three ways such as, airways, waterways and roadways. The main aim of this paper is to examine the various failures in a flexible pavement along with their causes of formation and how we can tackle it with maintenance procedure guidelines. It is visible that people nearest transportation is the road transportation. This type of transportation is needed for the connectivity of villages to cities or cities to different parts of states, but if this transportation pavement is damaged then it could to leads to serious problems. Pavement damaged can results in cracks, potholes, depression, rutting etc. Causes of these failures in pavement may be due to poor drainage facilities, poor construction materials, or severe rainfall. [1]

Based on the requirement pavements are classified into two categories which are flexible pavement and rigid pavement. [4]

1. **Flexible pavement** – these type of pavement are mainly made up of various type of materials. Each layers receives the load from the upper layer and then the load is distributed equally to the rest of the layers. In this way stress is reduced in flexible pavement. Under the load of tyres these type of pavement bends.[7]

2. **Rigid pavement** – these type of pavement is constructed from cement concrete or slabs of reinforced concrete. These pavement are designed to provide sufficient strength to resist the vehicular loads from the traffic. It distributes the vehicular loads to wide area of subgrade as it has high modulus of elasticity and rigidity. [7]



**Fig.1- layers of flexible and rigid pavement**

In India mostly flexible pavement is considered for construction. When the roads are constructed, there is the high need of maintenance so that it could be used by people for longer period of time. Another reason is that in India there is a harsh climate so, maintenance is required to prevent these road from getting damage during single season.

A flexible pavement failures is by formation of potholes, cracks on the bituminous surface.

## 2. Literature review:

**Gollarama Kishore, KRamu, (2020)** suggested proper design, maintenance and proper drainage system should be made for the betterment of roads and with relevance to safety of the users. They also focus on frequency of maintenance. If there is a damage in the road so, road should be repaired. The methods in this paper includes highway planning and designing which involves the stages such as highway development, geometric design and factors which affects these designs. Apart from that they also discussed about the various types of highway pavement failures along with their maintenance. They also talked about the various types of maintenance processes that should be taken into consideration while applying these processes on maintenance works which include shoulder, bridge, traffic control devices and so on. **Shivam Khare Tanuj Verma, (2018)** presented decrease in serviceability results in the pavement failures which cause cracks, ruts etc. If these issues are not taken into consideration then it could leads to serious problems. Main objective of their paper is to provide good maintenance to the pavement so that it could be in good condition for future use. Objective of their paper includes, identification of the defect along with its causes and type of maintenance to be used for the smooth movement of traffic. The limitation or research gaps in the research manuscript is that they don't focus on the practical part as they only considered theory as the base of their study. **Ashpaq Majeed Naik, (2018)** have proposed three tasks for the pavement failure analysis. First task is to check the pavement visually and investigate the types of failure. Second task is to determine the cause for the failure and third task is the solution for the problem. Factors that are considered are traffic volume, environmental issues etc. **Mehedi Hasan, Mohd. Abdus Sobham, (2020)**, as Rajshahi city has about 186.64 km of paved roads according to 2011 census but only 23% of road length are in failure condition. In this paper they had investigated the failures that are present in the flexible pavement along with their causes and

maintenance. They also emphasis on the various causes which results in pavement defects, that includes heavy traffic, poor mix and so on. This study also proves that maintenance procedure is 60% similar to the conventional procedure. Data is collected by field investigation. As a result, from their field investigation they have spotted various types of failure in different areas of Rajshahi City. They also categorized their maintenance types according to their failure conditions. As per their conclusion Rajshahi city which is situated in Bangladesh is followed by urgent and routine maintenance. The limitation or research gaps in the research manuscript is that they focus on types of maintenance but they don't focus on the methods that can be used to solve these failure problems. **Hnin EiEiKhaing, Dr. Tin Tin Htwe, (2014)** described proposed the various methods to improve the pavements life. According to him routine maintenance, periodic maintenance and urgent maintenance are the various ways that can improves the life of a pavement. The work is focusing on failure patterns, visual maintenance by using various types of methods such as IRC Formulas, Soil Mechanics of three layered system. Visual maintenance works includes routine, periodic, urgent maintenance along with this, visual maintenance also includes maintenance regarding bituminous and asphalt pavement. As a conclusion their main objective is to improve the pavement of Magway-Yangon highway (Myanmar). They also evaluated thickness overlay by using IRC formula. As a result the maximum overlay can be achieved is 6 in and 12 in as maximum overlay for granular. **Parveen et al.** emphasis that sides of the roads should not be neglected from things such as, hidden signs, potholes, and damaged edges, improper design etc. as it could leads to the serious accidents sometimes. In this paper they had investigated the failures that are present in the flexible pavement along with their causes and maintenance. In their investigation they had taken an alignment of 10 km which includes 8 km of flexible pavement and 2 km of rigid pavement in Fatehpur district, Uttar Pradesh. They also emphasis on the causes of defects in pavement which includes heavy traffic, poor mix and so on. This study also proves that maintenance procedure is 60% similar to the traditional procedure. Data is collected by field investigation. As a result, from their field investigation they have spotted various types of failure in different areas of Fatehpur district. They also categorized their maintenance types according to their failure conditions. As per their conclusion Fatehpur district which is situated in Uttar Pradesh is followed by urgent and routine maintenance. The limitation or research gaps in the research manuscript is that they focus on maintenance type but they don't focus on the methods that can be used to solve these failure problems. **Praveen Kumar, Ankit Gupta et al, (2010)** provides the remedies to minimize the pavement failure. There are many reasons responsible for pavement failure. Applying the maintenance procedure on the pavement can results in enhancing the life of a pavement This paper describes the pavement failure and their problems experienced in India. Based on the experience various prevention technique were described in this paper for enhancing the life of a pavement. The work is focusing on pavement performance modals for the maintenance work. They also highlights the importance of pavement modals for forecasting service life of pavement and their strength. Pavement modals includes surface characteristic models, models based on environmental factor, pavement rating models and so on. The limitation or research gaps in the research manuscript is that there is not a specific constant as it changes according to need. These types of models are not suitable during seasonal traffic.

### 3. Factor affecting & causes of pavement failure: [2]

1. Materials used are defected
2. Defects in quality control and construction method during construction
3. Improper drainage system
4. Movement of heavy load vehicles or increase in load repetition because of rise in traffic volume
5. Improper compaction of pavement layer during early stages of construction
6. Factors such as rainfall, increase in table of water etc.

For fixing the problems related to the pavement failure following procedure is carried out such as: sealing, cutting, filling etc. maintenance of the pavement is classified into three heads: [5]

1. **Routine repair:** which involves filling of potholes, patch repair work, shoulder repair, repairing of road signs etc.
2. **Periodic maintenance:** which are renewals of wearing course of pavement surface and maintenance of various items.
3. **Special repair :** which are widening of roads, damage caused by environmental factors, reconstruction of pavements etc.

Flexible pavement is the pavement which has low flexural firmness and flexible response when loaded. In flexible pavement distortion can be seen in final layer. (Figure -1) shows the different layers of flexible and rigid pavements

**4. Methodology:**

Due to heavy rain or moving of heavy loaded vehicles on the pavement Delhi – Kolkata highway damaged at various places which developed pavement distress in the highway. Many failures such as potholes, cracking etc., were formed. To overcome this problem maintenance is carried out with high frequency. Some of the pavement failure along with their maintenance are discussed below.[4]

**Table -1 Pavement failures and their maintenance**

S.no	Type of Failure	Description	Remedial Measure
•	<b>Potholes</b>	This type of failure is the most common failure that a pavement has. This type of failure is present everywhere in the pavement. Structural failure and roughness of the road were created. Rainwater and the movement of heavy load vehicle were the causes of formation of these types failure.	Filling are some operations that are considered into action for potholes having low depth. Otherwise premix filling is considered if the potholes frequency is more
•	<b>Alligator cracking</b>	This type of failure is commonly seen on the pavement which occurs due to pavement layer materials relative movements. Repeated use of heavy vehicles results in fatigue failure or moisture variation can cause swelling or shrinkage in pavement. Another causes for this failure is due to improper construction of base course, that results in the cracking of the surface course.	For different types of alligator cracking different type of maintenance is required such as, for normal alligator cracking carpeting is use but for the effective alligator cracking patching is required.
•	<b>Block cracking</b>	Another type of failure than can be seen in pavement is block cracking. Unstable base and poor construction are the causes of formation of these kind of failure.	Seal coat can be used to prevent from these kind of failure
•	<b>Slippage cracking</b>	This type of cracking created roughness on the road. Unstable wearing surface and bad drainage are the causes of formation of these cracking.	For repairing these types of cracking carpeting and sealing coat methods are taken into consideration.
•	<b>Transverse cracking</b>	This type of cracking is mainly forms due to poor mix design or movement of heavy load vehicle on the pavement	For the solution surface dressing such as carpeting is used for repairing these types of cracks

• <b>Longitudinal cracking</b>	This type of cracking is mainly forms due to poor mix design or movement of heavy load vehicle on the pavement	For the solution surface dressing such as carpeting is used for repairing these types of cracks.
• <b>Raveling</b>	This type of failure in pavement is responsible for creating roughness. It happens when the pavement binder doesn't have the strength to hold the aggregate and process of compaction is not done properly at the time of construction.	For solving these types of issue surface treatment is required.
• <b>Corrugation and Shoving</b>	These types of failure are responsible for creating roughness and elevated portion in the pavement. It is caused due to improper design mix, severe traffic and unsuitable binders etc.	These types of failure may be repaired by premix filling, rolling and sealing.
• <b>Depression</b>	Another type of failure is the depression in the pavement which is caused by severe rainfall and poor drainage facility.	This type of failure is cured by removing affected portion from the surface layer and replacing it with the premix filling material.
• <b>Rutting</b>	This type of failure is occurred due to movement of heavy load vehicles and the poor construction procedure, which results in the filled water ruts that causes vehicle hydroplaning.	The affected portion should be replaced with premix. Later on sealing is applied on the premix for repairing the pavement.

**5. Strengthening of pavement [1]:**

For the successful maintenance of pavement, it is essential that they have adequate stability to withstand the design traffic under prevailing climatic and subgrade conditions. Strengthening may be done by providing additional thickness of the pavement adequate thickness in one or more layers over existing pavement, which is called **overlay**.

**Types of overlay [7]:**

- Flexible overlay over flexible pavement
- Rigid overlay over rigid pavement
- Rigid overlay over flexible pavement
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1. **Flexible overlay over flexible pavement** – for the design traffic and the existing condition of subgrade total pavement thickness is required. For finding the total design thickness CBR method of pavement design is considered by IRC. The existing thickness of the pavement is found from the test pits dug on the pavement.

$$h_o = h_d - h_e$$

**where,**  $h_o$  = overlay thickness required

$h_d$  = total design thickness required

$h_e$  = total thickness of existing pavement

2. **Rigid overlay over rigid pavement** – when a rigid pavement is constructed on old rigid pavement, it acts as a monolithic one, as the slabs of both old and new pavement don't make a perfect bond. This problem can be solved by making the old surface rough or by placing thin layer of bituminous material between the slabs.

For calculation of overlay:

**Table 2 – Rigid overlay design factors**

Agency	Existing Pavement Condition	X		
Crops of Engineers and, PCA	I. Good Condition	1.00		
	II. Initial Cracking	0.75		
	III. Badly Cracked	0.35		
Agency	Construction Method	a	b	c
1. Crops of Engineer	• Poured directly on Old Pavement	1.40	1.40	1/1.4
	• Levelling Course	2.20	2.00	1/3
2. PCA	6. As (1) above	1.87	2.00	1/2
	7. As (2) above	2.00	2.00	1/2

$$h_o = (h_d^a - x h_e^b)^n$$

**where,**  $h_o$  = overlay thickness required  
 $h_d$  = total design thickness required  
 $h_e$  = total thickness of existing pavement

values of a,b,x and n depends on the type of pavement and method of overlay

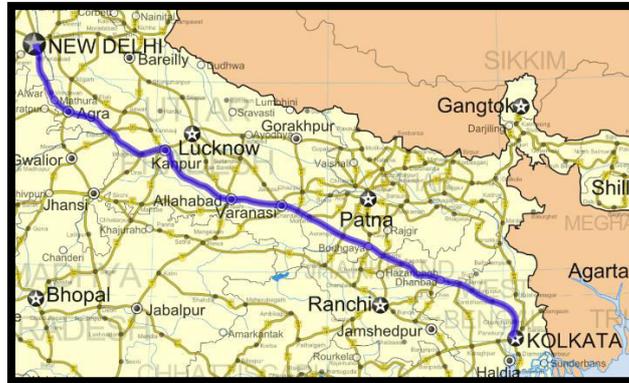
- Rigid overlay over flexible pavement** – calculation of thickness for rigid overlay is done by rigid pavement which is laid down. Therefore, K value is obtained by conducting plate bearing test on flexible pavement.
- Flexible overlay over rigid pavement** –when we provide flexible overlay on rigid pavement, the wheel load is distributed to larger area. Further due to bituminous overlay a temperature differential is decreased in rigid pavement. The life of a rigid pavement may be increased considerably by a suitable designed and constructed bituminous overlay placed at the right time.

$$h_f = 2.5 ( F h_d - h_e )$$

**where,**  $h_f$  = overlay thickness required  
 $h_d$  = design thickness of rigid pavement  
 $h_e$  = total thickness of existing pavement  
 F = factor depending upon modulus of rigid pavement

**6 Study area:**

Delhi – Kolkata highway is the busiest highway in India. It starts from the Delhi and ends in Kolkata. Length of the highway is around 1645 km. A survey of 20 km is done for determining the various types of failure that are present in pavement and their maintenance procedure to overcome it.



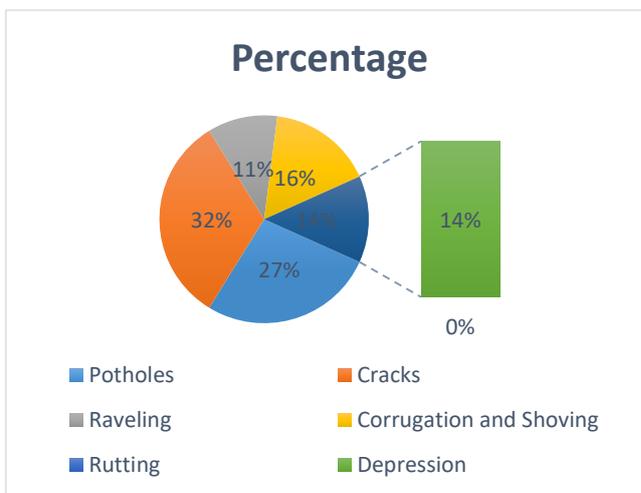
**Fig.2 – Map of study area**

**7. Results and Analysis:**

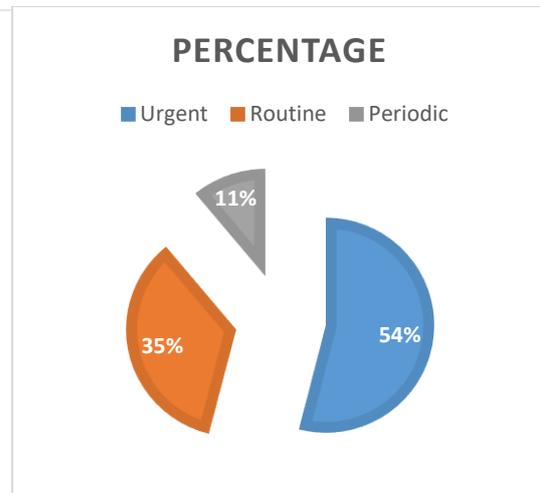
All the maintenance processes are sorted in the maintenance categories from the data obtained from the various form of failures. All the maintenance data is obtained from the authorities.

**Table-3 shows the failure category with their frequency of maintenance**

Failure	Failure occurrence (location)	Maintenance
Potholes in pavement	12	Urgent maintenance
Cracks in pavement	14	Routine maintenance
Raveling in pavement	6	Periodic maintenance
Corrugation and shoving in pavement	8	Urgent maintenance
Rutting in pavement	8	Periodic maintenance
Depression in pavement	7	Urgent maintenance



**Fig.3 – Occurrence of failure**



**Fig.4 – Frequency of maintenance**

## 8. Conclusion:

Based on the study for different types of faults in pavement Following conclusions are made:-

1. The main reasons which causes failure in a flexible pavement is due to the weather conditions such as heavy rainfall, quality of material used, heavy traffic load on the pavement and air in subgrade which causes dampness.
2. The study shows that the maintenance is to be carried out is routine but at some areas it should be urgent. In Delhi – Kolkata Highway, urgent maintenance should be carried out for the flow of traffic, otherwise it could leads to traffic jam as it is the one of a busiest highway of India.
3. Therefore, for good life of a pavement proper maintenance, standardization as well as strengthening is required but if these things are not controlled properly, then it could result as a repeated road maintenance again and again for the same road.

## References:

1. Khaing, H. &Htwe, T., 2014. Study on Failures and Maintenance of Flexible Pavement. *International Journal of Scientific Engineering and Technology Research*.3(14). P. 2984-2990.
2. Khare, S. &Verma, T., 2018. Defect and maintenance of road. *International journal of advanced research in science and engineering, Volume 07*.
3. Kishor, G. &Ramu, K., 2020. Evaluation of highway failure and their maintenance. *International research journal of engineering and technology*.
4. M, H. &Sobham, M., 2020. Highway failure and their mainteance. *International journal of sustainable transportation technology, Volume 03*.
5. Naik, A. & Gupta, D. R., 2017. Defect in flexible pavement and its maintenance. *International journal of advanced research in education and technology, Volume 04*.
6. Dipannita Thakur, Dr.Prafull J Wadhai, Dr.Bhalchandra V Khode, 2022. Design of a swarm intelligence model for redesign & upgradation of highways. *International conference on recent advancement in infrastructural development, water management and climate change (IC-RAIWC-22)*.
7. Dipannita Thakur, Dr.Prafull J Wadhai, Dr.BhalchandraKhode, Parametric evaluation of highway redesign models for traffic flow from a statistical perspective. *International conference on recent advancement in infrastructural development, water management and climate change (IC-RAIWC-22)*
8. YogeshBibinahake, PrafullWadhai, NaliniVaidya. Comparative stufy on smart road technology. *International conference on recent advancement in infrastructural development, water management and climate change (IC-RAIWC-22)*.
9. IshitaGusain, Amit Kumar Sharma, Nitin Mishra, Bhalchandra V Khode. Experimental analysis of concrete replaced by different percentage of demolished concrete in a concrete mix. *International conference on recent advancement in infrastructural development, water management and climate change (IC-RAIWC-22)*.
10. prajwal D Mendhe, Dr.Sujesh D Ghodmare, Dr. P J Wadhai, Prof. Abhijit S Titarmare. Sustainable Transportation using automated highway system for intercity connectivity. *10<sup>th</sup> intrrnational conference on emerging trends in engineering and technology – signal and information processing (ICETET-SIP-22), 2022, PP. 1-6*,
11. SujeshGhodmare, Dr.BhalchandraKhode, Sachin Ladekar. The roll of artificial intelligence in industry 4.0 and smart city development. In: Gupta LM, Ray M.R., Labhassetwar P.K. (eds) *advance in*

- civil engineering and infrastructural development lecture notes in civil engineering, vol 87. Springer, Singapore.*
12. Kaivalya Metre, Gaurav Kumar, HarshitBaghel, MohitBatra, SujeshGhodmare. *Compact city and related impact on sustainable development in urban areas. In: Gupta LM, Ray M.R., Labhasetwar P.K. (eds) advance in civil engineering and infrastructural development lecture notes in civil engineering, vol 87. Springer, Singapore.*
  13. Sujesh D Ghodmare, Dr.Preeti Bajaj, Dr. B V Khode. *Application of the multiattribute utility techniques with its for sustainability evaluation of emerging metropolitan city of Nagpur. International journal of civil engineering and technology (IJCIET) volume 10, issue 01. January 2019, pp. 942-950. ISSN Print: 0976-6308. ISSN Online: 0976-6316.*
  14. M P Bhorkar, AMarwade, S Piprade, S Khutafale, V Gadhave. *Reduction of particulate matter on road using dust accumulator. International conference on advances in civil engineering (ICACE-2021), IOP Conf. series: materials science and engineering 1197 (2021) 012025, IOP Publishing,*
  15. Subbaraju B. H., Gokhale Y. C. *An investigation of concrete pavement failure. Journal, Indian Roads congress. Vol. XXIII-2, 1965.*
  16. Subbaraju B. H., Nanda R. L. *Investigation of some roads failures in north western India. Journal, Indian Roads congress. Vol. XXIV-2, 1950.*