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Comparative Study on Failure and Maintenance of Flexible Pavement

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ABSTRACT: Since 1947, India has started its work on building itself. The main component which play very important role in this process has been connectivity. In this 21st century we know there are many ways connectivity. At the end, physical form of connectivity always was the road. A very much created transportation framework is imperative for monetary, mechanical, social and social improvement of a nation. Now a day highway construction is done rapidly in our country, but highway pavement damage and creates different types of failure. The different types of failure which are seen on bitumen highway pavement are alligator failure, depression, corrugation, shoving, shear failure, longitudinal cracking, potholes and slippage, bleeding and pumping. To overcome such type of failure it is most important, as due to failure of pavement defects are created to road users and create maximum road accident. Prior to going into the maintenance strategies, we should investigate the reasons for the failure of Flexible pavement. Keeping focus on Failure seen on flexible pavement, try to provide a solution on their maintenance front to prolong the life of the existing roads.This research paper deals with investigating different types of failure on road surfaces and providing the required solution for each type of failure and the best maintenance option for Flexible Pavement.

KEYWORDS: Connectivity, Road Connectivity, Flexible Pavement

I. INTRODUCTION

With 32,000,000 km² of land mass India have a large area to cover with this physical connectivity. India's is still a developing nation and we have most of our population located in rural areas. To provide facilities and increase standard of living, India needs to provide good road connectivity to increase opportunities to rural areas. About 72.97% of total road network in India until March 2020 belongs to rural roads. (Annual report 20–2021, Ministry of Road Transport and Highways). Since year 1990 India has invested immensely in development and maintenance of new rural roads. Increasing their capacity to serve people in all-weather condition. Primary type of road connectivity to rural section of India has been a flexible payment. Which in some part is already existing and some parts of India it is in development. In any case development upgradation of road has its own set of challenges which play vital role in time to complete project and objectives which were considered for project. In India especially the enthusiasm which is shown in conceptualization and execution of road project is tremendous. This positivity goes down once the project ends its execution face and offered to public for utilization. The main component of lifelong benefit of a good rural Road connectivity goes down due to negligence in maintenance. The total cost to the nation which comes due to badly maintained road works is huge in terms of monetary physical and mental attributes. The parameters on which a specific area can be treated regarding its maintenance and challenges which need to be tackled while doing maintenance work not very much into mainstream. The type of failure which occurs in one part and their solution may not be same for other part of the country.

In India, the evaluation process of pavement failures is often done in a relatively informal manner. The main reason for this choice of action is that the cost associated with the evaluation is not justified by the importance of the road on which the failure is occurring, or the magnitude of the failure. There may also be a reluctance to spend money on a pavement failure evaluation, instead of using these funds directly for maintenance work. Because of these factors, there is a reliance on the past experience of the investigator in evaluating the failure, determining the testing required to be done, and making a final decision regarding the appropriate maintenance work. This means that the failure may be incorrectly diagnosed if the wrong testing is selected, or the investigator's experience is lacking.

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Maintenance of the road is a consequence of construction. A proper way of maintenance of the road not only helps in extending the life span of the road but saving the cost of maintenance in Highway. Maintenance management is a development as well as the construction and the development is sustainable. We shall pay more and more attention to the highway maintenance while the urgency and importance of maintenance management are neglected by road management department.

Road maintenance works are classified into three types: namely, routine, periodic and emergency. Routine maintenance is based on routine (daily) inspection of the condition of pavement, cut and fill slopes, drainage, bridges and other structures and facilities to monitor any defects and damage. The results of routine inspection will be promptly reported to the operation office for follow-up maintenance works to be undertaken either continually throughout a year or at certain intervals every year. The term "preventive maintenance" refers to repair that addresses causes of deterioration leading to the need for costly rehabilitation work in future. Periodic maintenance is based on detailed inspection performed at certain time intervals such as seasonally or yearly depending on the type and kind of facilities. It includes checking and testing the conditions of various structures and facilities. Defects and damage will be reported for repairs or remedies. Maintenance plans covering several years will be developed.
Emergency maintenance basically comprises works to restore road and road related facilities to their normal operating conditions after they are damaged by road accidents or natural causes. It is impossible to foresee the frequency, but such maintenance requires immediate action.
Routine maintenance activities, an appropriate mix of labor and equipment is required to provide works of adequate quality in a cost-effective manner. In a "labor-based" economy, the aim is to apply a labor/equipment mix that gives priority to labor, but supplements it with light/intermediate equipment where necessary for reasons of quality or cost. The term "labor-based" thus indicates that flexible and optimal use is made of labor as the predominant resource in so far as cost-effectiveness and quality aspects are ensured. It is important to distinguish between the optimal use of labor and maximum use of labor. The latter could degenerate into a "make work" approach where cost-effectiveness and quality aspects are ignored. Equipment-based is the opposite of labor-based in that most of the work is done by labor-replacing equipment, supported by a small labor force.

II. RELATED WORK

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil subgrade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light-reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced so that they will not exceed the bearing capacity of the subgrade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This chapter gives an overview of pavement types, layers, and their functions, and pavement failures. Improper design of pavements leads to early failure of pavements affecting the riding quality.
The development of a systematic and simplified method for evaluating pavement failures will help to ensure that even if the evaluation is carried out by inexperienced staff, there is a reasonable chance of success in diagnosing the problem and determining the best maintenance option. In addition, economic and practical factors involved in making a specific recommendation were discussed.

III. METHODOLOGY

Frequent inspection of the road is essential to identify the defects and their causes, determine priorities and take appropriate remedial measures.

1.Quality Assurance:- The quality assurance system should cover all aspects of road project starting from design, supply of maintenance right through the extreme process of construction and maintenance. It is suggested to observe the following:

- Bitumen and aggregates should be checked to assess the properties and behavior.
- Appropriate grade of bitumen depending on traffic intensity/climatic conditions should be used.
  Aggregates should be clean and dry.
- Bitumen and aggregates should be heated to the specified temperature under controlled conditions.
- After necessary correction, the surface to be paved should be cleaned thoroughly.

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Mechanized system should be preferred over the manual method of construction/maintenance. Laying and rolling temperature should be controlled.

2. Maintenance planning:-General One of the main philosophies behind the construction of a road is safe and easy operation so the performance of the road shall be maintained at a consultant's level. In order to do so a constant monitoring of the performance is required and accordingly maintenance activities are planned. The planning should be done for maintenance not only to do it in safe manner without causing disturbance to the traffic operation but also to do it in an economical way. This section of the 0 & M Manual, shall include the activities described here-in-under amongst other activities required for the regular and preventative maintenance of the equipment during the operations period, so that the project Highway is maintained in a manner that at all times it complies with the Specifications and Standards at the time of divestment of Right and Interests by the Concessionaire in terms of the Concession Agreement it is sound, durable and in functional condition.

It necessary to maintain the Project Highway in traffic-worthy condition and the Project's Ancillary Facilities in usable condition throughout the Concession Period or any extension thereof in terms of the Concession Agreement through regular maintenance and preventative maintenance of the various items and elements of the Project Highway, and also the existing 2 lanes of the Project highway during construction of new lanes in such a manner that the unevenness index of the pavement does not exceed 3,000 mm per km, or the present roughness value of the existing pavement, whichever is lesser.

3. Maintenance Operation:-

Maintenance operations have been divided into four categories as follows:-

a. Routine Maintenance

b. Preventive Maintenance

c. Periodic Maintenance

d. Emergency / Special Maintenance

a) Routine Maintenance:- Cleaning maintenance shall comprise of cleaning, sweeping, disposal and brushing off of all litters, debris, silt , rubbish, greasy and oily stains and removal of carcasses from carriageway and all other areas inclusive the mainline and Rest and Service Areas called as Routine maintenance. Following tasks are carried out in routine maintenance.

- Cleaning and Sweeping : Cleaning and sweeping of the Layout and Areas by sweeping and collection of debris and silt and collection of litters, wastes and rubbish strewn or deposit in bins and disposal of same from carriageways, medians, verges, rest and service areas along the mainline whether on paved areas inclusive of bridge decks and carriageway in tunnels. The disposal of such wastes shall be at the approved disposal sites.

- Removal of animal carcasses, dung and dropping within agreed working hours from the surfaces of pavement, Krebs, concrete aprons, concrete or any other surface within the Concession limits.

- Cleaning of Warning, Regulatory and Directional Signboards the cleaning of all signboards found in the Concession limits i.e. the medians and verges, slopes, loops and interchanges, rest and service areas.

b) Preventive Maintenance:- In that maintenance, regularly carry out the necessary preventive Maintenance activities for the Project Facilities to ensure adherence to the Design Requirements and Specifications throughout the Concession Period.
Preventive Maintenance shall include the activities related to each element and the system as a whole of the Project Highway to ensure that during the Concession Period and its end are in sound, durable functional conditions.

c) Periodic Maintenance:- Carriageway this activity shall be carried out as required and at least once every 5"' year (from COD) and in the last year of concession period. Road marking as specified and other road side features shall be restored to meet the relevant standards to the satisfaction of the Independent Engineer.

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The periodic maintenance activities shall also include profile corrective course of overlaid with the periodic renewal of the wearing course of the road pavement.
The paved shoulders shall also be treated in similar manner as applicable to the mainline traffic lanes.
The separator islands shall be restored to the design cross section. Road marking as specified and other roadside features wherever required shall be restored to meet the relevant standard specified. Any other repairs needed to the project will be attended to.
Crash Barriers & Pedestrian Guard Details The crash barriers should require minimum maintenance except in case of damage due to impact. Concrete Posts and Steel Beam crash barriers will require repairs or replacement from low to medium impact damage caused by vehicles.

d) Emergency and Special Maintenance:- These types of maintenance works are self-explanatory. This involves immediate repairs to roads affected by heavy rain, flooding, cyclone damage, landslides, sand dune formation and similar events affecting the project road where the main purpose is to restore the traffic viability of the corridor.

3.3 Maintenance Inspection:-

The inspections are vital for effective and efficient operations and maintenance of any Highway, structures and various Facilities. They are also needed to ensure safety of the road user. The emphasis in inspection is on the conditions of the road. They identify the locations where deterioration is occurring, measure the extent of the problem and define the action needed for rectification. The inspections are categorized into a) Visual, b) Close, c) Thorough; they differ in their nature, frequency, extent and use of tools and equipment. The inspections have been programmed and will be carried out by responsible, competent, and comprehensively trained inspectors/technicians/engineers, with predetermined checklists and formats for various elements of the Project. They are fully conversant with the inspection procedures and the safety requirements. The periodicity, timing and thoroughness of the inspections will be different and is described hereunder. The inspections have been classified into four categories — daily, monthly, quarterly, and before, during or after the rainy season. Maintenance inspection is required to evaluate the conditions, distress manifestation defects and deficiencies, etc. of the road and its components. These exercised shall be done through collection of all the relevant as-at-site data to apply appropriate maintenance measures. Inspection shall be of three categories.

1. Visual Inspections

2. Close Inspections

3. Thorough Inspections

1. Visual Inspection:- Visual inspections are broad general inspections carried out quickly and frequently. They bring out the defects/deficiencies which may cause obstruction to smooth flow of traffic as well as some of the regular maintenance requirements.

- Purpose: To report the obstacles to traffic from the point of view of safety, and fairly obvious deficiencies this could lead to accidents or maintenance problems. This will bring out deficiencies/defects of obstructions, signboards, blocked drains, expansion joints, kerbs, side slopes, turfing, vegetation, Painting on fences, handrails, guardrails, delineators; and cleanliness of Rest Areas, Bus Stops, underpasses, ROW and the like.

- Tools & Equipment: Usually no tools and equipment are necessary. Careful observation and visual assessment of the specific object/item of the Project are enough for identification and for quantification of the deficiencies or damages. By: The daily inspections will be done by maintenance gang men, supported/guided by Highway/bridge maintenance engineers having knowledge of highways and structures. In addition, Route Patrol staff will also report such needs.

2. Close Inspection: - Closed inspections are periodic inspections against a checklist, carried out for specific elements of the Project Highway.

- Purpose: To report the defects / deficiencies of all aspects of specific elements of the Project Highway and recommend appropriate remedial measures. These inspections will cover Riding quality on the pavement as well

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as on the expansion joints, kerbs, drainage facilities, all structures including headwalls and aprons, painting on the handrails, and others.

➢ Tools & Equipment: Close inspections may be visual and/or supplemented by standard instrumental aids for assessment of defects / deficiencies of the Project with careful observation of specific elements. These are more intensive and require detailed examination of element of the Project. It should cover all the aspects of the specific element of the Project against a checklist.

3. Thorough Inspection:- Thorough inspec;tions are comprehensive and detailed inspections carried out with detailed formats, to assess the condition of materials, structures, potential dangers to structures, drainage, etc.

➢ Purpose: To report condition of materials, structures, various elements, particularly with respect to the bridges, culverts, cross drainage structures, their silting or scouring, pavement during adverse weather conditions, drainage system including catch pits, drains, etc.

➢ Tools & Equipment: Thorough inspections will be done with comprehensive checklist/formats prepared meticulously in advance for various structures/elements, with aid of standard equipment and non-destructive testing where necessary.

IV. EXPERIMENTAL RESULTS

Traffic Census is the baseline of Transportation Engineering. All management as well as engineering operations are done on the basis of this only. There is a considerable variation in flow, so for the purpose of designing averaging of these counts is done into single volume count. There are four main methods of Traffic Census namely Manual Method, Automatic Method, Combination of Manual and Automatic Method and Photographic Methods. All these have their pros and cons. These have different preferences with respect to Accuracy, ease of Documentation, Versatility and economics. Three main methods of Traffic Analysis IRC, U.K method and U.S.A practices have been discussed along with IOWA Department of Transport guidelines for measurement of Congestion. For better management of Traffic, duration of Survey as per IRC has to be increased as urban areas are moving from Developed to developing. The traffic surveys in the state of Maharashtra for four lane divided carriageway from Km 100+000 to Km 166+700 (Talegaon – Amravati NH-53). The road starts at Chainage Km 100+000 and ends at Chainage Km 166+700. 4.2 Traffic survey and Analysis Detailed traffic surveys are conducted (from 01-08-2019 to 07-08-2019) along the project road based on the observations and discussion with contractor at following mutually agreed location: • 7- days, Continuous Classified Traffic Volume Count at one location. • The Average Daily Traffic (ADT) and Average Annual Daily Traffic (AADT) in 2019 on the Road section are shown in Table 1.0 and 2.0 below

Table 4.1: Location wise ADT and PC

Chainage at KM 150+500						
Description	**ADT(Vehicle)**			**ADT(PCU)**		
Direction	**UP**	**DN**	**Both**	**UP**	**DN**	**Both**
Two Wheeler	**1265**	**1285**	**2550**	**633**	**643**	**1276**
3 Wheeler(Passenger)	**39**	**43**	**82**	**39**	**43**	**82**

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Car, Jeep & Van Private		1146	1280	2426	1146	1280	2426
Taxi(Yellow board)		45	17	62	45	17	62
Local shared taxi/Chakda		16	9	25	16	9	25
Mini Bus		5	6	11	8	9	17
School Bus/Institution Bus		1	1	2	3	3	6
Govt. Bus		1	1	2	3	3	6
Pvt.Bus		103	107	210	309	321	630
Cycles		24	24	48	12	12	24
Cycle Rikshaw		0	0	0	0	0	0
Animal/Hand Cart		0	0	0	0	0	0
Toll Exempted	Car/Jeep	4	7	11	4	7	11
	Mini Bus	3	4	7	5	6	11
	Bus	0	0	0	0	0	0
Mini LCV		257	322	579	386	483	869
LCV (4 Wheels)		46	34	80	69	51	120
LCV (6 Wheels)		342	301	643	513	452	965
2 Axle Truck		234	268	502	702	804	1506
3 Axle Truck		317	340	657	951	1020	1971
MAV (4-6 Axle)		623	709	1332	2804	3191	5995
MAV (more than 6 Axle)		0	0	0	0	0	0

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Tractor		1	0	1	2	0	2
Tractor+Trailer		14	16	30	63	72	135
Toll Exempted	LCV	6	6	12	9	9	18
	TRUCK	0	0	0	0	0	0
Total Traffic		4492	4780	9272	7722	8435	16157
Total Tollable Traffic		3136	3395	6531	6955	7643	14598

Table 4.2: AADT (Annual Average Daily Traffic)

Chainage at KM 150+500						
Description	ADT(Vehicle)			ADT(PCU)		
Direction	UP	DN	Both	UP	DN	Both
Two Wheeler	1265	1285	2550	633	643	1276
3 Wheeler(Passenger)	39	43	82	39	43	82
Car, Jeep & Van Private	1146	1280	2426	1146	1280	2426
Taxi(Yellow board)	45	17	62	45	17	62
Local shared taxi/Chakda	16	9	25	16	9	25
Mini Bus	5	6	11	8	9	17
School Bus/Institution Bus	1	1	2	3	3	6
Govt. Bus	1	1	2	3	3	6
Pvt.Bus	103	107	210	309	321	630

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Cycles		24	24	48	12	12	24
Cycle Rikshaw		0	0	0	0	0	0
Animal/Hand Cart		0	0	0	0	0	0
Toll Exempted	Car/Jeep	4	7	11	4	7	11
	Mini Bus	3	4	7	5	6	11
	Bus	0	0	0	0	0	0
Mini LCV		257	322	579	386	483	869
LCV (4 Wheels)		46	34	80	69	51	120
LCV (6 Wheels)		342	301	643	513	452	965
2 Axle Truck		234	268	502	702	804	1506
3 Axle Truck		317	340	657	951	1020	1971
MAV (4-6 Axle)		623	709	1332	2804	3191	5995
MAV (more than 6 Axle)		0	0	0	0	0	0
Tractor		1	0	1	2	0	2
Tractor+Trailer		14	16	30	63	72	135
Toll Exempted	LCV	6	6	12	9	9	18
	TRUCK	0	0	0	0	0	0
Total Traffic		4492	4780	9272	7722	8435	16157
Total Tollable Traffic		3136	3395	6531	6955	7643	14598

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V. CONCLUSION

Following conclusions have been drawn based on the present study:

1. Proper plan, standard review and support of waste framework is of most extreme significance in protecting the speculation made on roadway framework and in giving solace and security to the street client.

2. The orders of a wide range of bothers have been distinguished. The reason and treatment is diverse for various seriousness levels of each misery.

3. The abandons in existing thruway framework and in upkeep rehearses must be unmistakably comprehended and annihilated.

4. The impacting parameters considered in this investigation are splits and breaking design, unpleasantness, groove profundity, pot openings and avoidances. The above parameters have been arranged by their seriousness levels.

5. Maintenance choice can be taken dependent on the models of arriving at any one or the entirety of the impacting parameters to their greatest worthy cutoff points.

6. The little pain (breaking, potholes, pushing, rutting, and so on.) must be fixed before any significant upkeep (overlay, restoration coat) is finished. Indeed, even diminished thickness of overlay will show better outcomes if minor imperfections are fixed before overlays are finished.

7. It is evident that earlier discussion regarding implementation of road operation maintenance has its challenges. The construction industry has shown necessity for change in order to create efficiency in future maintenance planning. However, there are an amount of challenges needed to be solved and sorted out in order to construct the implementation at a successful phase. Previous initiatives have been done, although it requires other solutions, even though the vision is shared between clients, consultants and contractors. The cohesiveness in vision creates an advantage to create a successful utilization of the checklist. Processes are easy to change compared to changing the mind-set of the personnel working with maintenance, and if they are open and aware of the need for changes, the implementation can therefore be successful.

8. A negative aspect resulted during the interviews, were the lack of reconciliation during and after ending a Basic Package of Routine Maintenance, even though there are problems recurring and known before for clients, consultants and contractors. To reduce the recurring damages costs, the key is feedback to consultants and contractors, in order to include the whole chain affecting future and current maintenance. The knowledge exists, however only out in the fields, which aggravates the learning possibilities for new examined students and also existing personnel. Scheduled meetings in the planning and design phase facilitates the overall lifetime of a road, including how to become more effective in implementing the road operation maintenance. A key perspective important to considerate is when a facility has unjustifiably high operational maintenance costs, which requires elevated maintenance work in order to meet the requirements stated in the maintenance contract, can be referred to the road is not designed accurately.

9. An important factor to make the checklist a successful tool for future maintenance is to modify the planning and design phase, meaning to reduce the influence from the aesthetics. The report states different solutions in finding a middle course to fulfil the requirements both from aesthetics and maintenance perspectives. Furthermore, the checklist is based on the interviewee's experience, which facilitates the implementation. Moreover, there are some materials used to highlight the aesthetics, however creates problems in accessibility and safety for both road users and the professional workers executing the road operation maintenance in Sweden. In these cases, it is crucial that the aesthetics does not take ascendancy over the planning and design phase. The checklist is easy manageable and divided into each activity discussed in this master thesis including comments on alternative methods or the effects on road operation maintenance, which contributes to simplicity of applying the checklist as effective as possible. Furthermore, when the checklist is based on the interviewees, the checklist creates a greater understanding of how to interpret the stated suggestions. Time and reflection should be asked concerning why new constructed roads often obtain damages with very large settlings, frost damage and other deformations compared to older constructed roads. An additional point should also be taken into consideration regarding why costs are constantly increasing, where an investigation should be carried out. Should the documents be revised, have the knowledge paused? Short communication lines, progress meetings, and feedback will create a successful implementation of the checklist.

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