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Pavement Condition Survey; A Compendium Of Distresses On NH 12 - Kota -Jhalawar India

[1] Tiza Michael, [2] Anand Kumar, [3] Avinash Kumar Patel
[1] M. Tech Scholar, [2] [3] B. Tech Scholar,
Department of Civil Engineering, Career Point University, Kota, Rajasthan, (India)
[1]tizamichael@gmail.com[2] anandamgodblessu@gmail.com[3] avidellpc@gmail.com

Abstract:- **NH - 12 Kota -Jhalawar was observed to be in a very bad state, the authors in quest of making this article worthwhile travelled along the stretch from Kota to Jhalawar and observed the general road condition, however, the stretch between Mandana and Dara was chosen for the purpose of this study. It was observed that the situation of the road is extremely bad with distresses exceeding the permissible value and at some points a total/ complete failure was observed, the authors used a measuring tape, and scale to make measurements of dimensions of the distresses as reported in this article. It was classified under the third and worst category.**

Index Terms:- **Pavement, Distresses, raveling, rutting, edge breaking, drainage, alligator cracking. Longitudinal cracking**

I. INTRODUCTION

The ever growing need for road maintenance by the Government or road maintenance agencies cannot be overemphasized, unfortunately negligence from the part of agencies saddled with the responsibility of maintaining the roads usually fail to do so in good time, thus leading to extreme kinds of failures which do not only increase the cost of maintenance but as well increases the cost of usage of such roads, the road users tend to have an undue increase in cost attempting to travel on such roads, as this leads to faster wearing away of tires, higher consumption of petrol, increase in journey time and in some cases travelers without personal means of travelling suffer a lot due to refusal of commercial vehicle drivers to ply such routes. According to Khanna et al (2015), It is estimated that repair cost rise to six times the maintenance costs after three years of neglect and to eighteen times after five years of neglected maintenance. From the backdrop, the constant structural evaluation of road condition should be prioritized, many highways fail to very high degrees due to negligence, Pavements are designed to serve a particular period before issues of failure will be noticed, however due to some reasons such as sudden increase in traffic volume which was not considered in the design process, poor drainage facilities along the road stretch, poor maintenance habits, heavy rainfall, frost action, high-water table, snow fall, poor compaction during construction, poor quality control, little defects in materials used in construction, excessive overloading of vehicles, high repetition of load etc. roads fail so quickly. NH 12 Kota Jhalawar was observed to have failed due to some of the reasons afore mentioned, while some points failed completely as the study shows that the permissible limits were far exceeded.

Khanna et al (2015) shows a simple table classifying road distresses and degree to which they are termed good, fair or poor. Below is the table.

Table 1. General classification of pavement condition.

Group Number	Classification	Pavement Condition
1	Good	No cracking, rut depth less than 10 mm
2	Fair	No cracking or cracking confined to single crack on wheel path with rut depth between 10mm and 20mm
3.	Poor	Extensive cracking and /or rut depth greater than 20mm.

Source; Khanna et al (2015)

From the above table and studies conducted, the national highway is classified under poor as the high way has failed and in very bad condition. This research was conducted with the major aim of surveying the condition of National Highway (NH-12) in order to estimate if the road stretch was still within permissible limits for use.

II. OBJECTIVES

The general objectives of this research is to
1. Assess the degree of damage of the road
2. Assess the extent or dimensions of distresses on the highway.

3. Study the possible causes and as well suggest the probable temporal and long lasting solutions to each distress.
4. Classification of road condition

III. SCOPE OF STUDY

The study is limited to investigating distresses on the site through use of measuring tape and scale, assessing the distresses, identifying and measuring their dimensions, suggesting the probable causes and solutions to each distress type and as well classifying the road condition in the appropriate category.

IV. LIMITATION

Due to lack of sophisticated modern machinery that are tested and proven as affective in evaluating road conditions such as Benkelman beam, Falling Weight deflectometer etc., non- sophisticated but effective civil engineering tools were used.

V. RESEARCH METHODOLOGY/ MATERIALS

The authors travelled from Kota to Jhalawar to first make a total observation of the entire road stretch, the stretch along Kota-Jhalawar precisely between Mandana and Dara was selected for the study. This is because it had a long stretch and by observation had almost all the distresses that could be studied. The stretch selected for study was divided into 5 major areas. The materials used in this work were 15M measuring tape, Global Positioning system and scale.

VI. LITERATURE REVIEW

Tsai and Mersereau (2010) studied the critical assessment of pavement distress segmentation, it was reported that though many researchers had come up with detection of distresses on pavements and as well recognition algorithms, Tsai and Mersereau were the first to publish an article incorporating the measures to objectively and quantitatively evaluate and estimate pavement performance of six varying segmentation algorithms. The six segmented methods were tested with the use of set of actual images of pavements on a highway in Atlanta. The article provides more reasonable guidance and insight into future algorithms, their development, as it is important in automating image distress classification and detection.

Muhammad (2016) studied highway subsurface assessment using pavement surface distress and roughness data, the research was aimed at obtaining the relationship between pavement damage (ravelling, cracking and rutting) and international roughness index (IRI). the research was conducted in Saudi Arabia on a section of a highway between Jeddah to Japan. road surface tester (RST) vehicle was used to collect appropriate data. the result showed that a good relationship exists between cracking and IRI and ravelling at a confidence level of about 95%. Salvatore et al (2016) evaluated pavement surface distress using digital image collection and analysis, the research involved two steps automated pavement image collection and distress detection, pavement distress analyser (PDA) was used to collect data on distresses. it was concluded that the study made it feasible to integrate the manual survey process with the road way pavement management systems.

Magdi (2015) did a study on distresses and suggested possible causes and remedies. Obeid Khatim road in Khartoum, Sudan was used as a case study for the research. the results were obtained from intensive field study with appropriate experimental procedures. basic soil tests were conducted at specific locations, these tests included basic Atterberg's limits and CBR to determine the subgrade strength of the soil. it was concluded that most of the distresses were cracking and rutting distresses.

Jamal & Peddapati (2013) investigated flexible pavement performance in relation to in situ mechanistic and volumetric properties using ltpp data. long term pavement performance database was the tool used for data collection, the analysis included about 116 highways in the United States. it was observed from the result that temperature had a significant effect on back calculation of modulus of hot mix asphalt layer. the research showed that fatigue life was a function of tensile strain at the bottom of hot mix asphalt layer, peak surface deflection, hot mix asphalt air voids and maximum specific gravity, and ambient air temperature.
Ouyang & Xu (2013) studied pavement distresses and came up with a 3D laser scan images for measurement of distresses such as cracking. result authenticates that the 3D system could obtain accurate images if pavements on surfaces of pavements under varying lighting and driving conditions.

Chang Et Al (2001) studied ravelling and cracking. the research estimated the reductions in service life of pavements due to cracking and ravelling. results showed that are with medium and heavy extents of segregation experience 73 % on average and 56% reduction in service life of pavement respectively, as a result of ravelling and 46 %as a result of segregation.

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Akhila & Preeja (2014) in the study automatic road distress detection and analysis suggested a new better, more environmental friendly way of measuring pavement distresses and as well classifying them. supervised training approach was used in the study.

Saad & Al-Geelawe (2016) developed a software that could be used to accurately determine the exact extent of distresses by inputting values obtained from the field into the software, the system presents the present condition rating index (PCRI) of the pavement. a decision tree of the system suggests the appropriate maintenance required based on available budget, road way classification, and expected design life change of the pavement.

Neero Et Al (2014) studied distresses of flexible pavements on NH-52A from Nirjuli to Itanagar in India, the study showed that the basic problem of increased distresses along the strectch was poor implementation of mix design and poor workmanship followed by lack of timely maintenance.

VII. TYPES OF FAILURES IN FLEXIBLE PAVEMENT.

Flexible pavements are susceptible to many factors that leads to varying types of distresses (damages), a compilation of the major distresses and description are mentioned in the table below.

Table 2. Types of failures in flexible pavement

No	Type of failure	Description
1	Fatigue (alligator) cracking	Series of interconnected cracks caused by fatigue failure under repeated traffic loading
2	Bleeding	Film of asphalt binder on the pavement surface
3	Block cracking	Interconnected cracks that divide the pavement up into rectangular blocks (approx. 0.1 m^2 to 9 m^2)
4	Corrugation on and shoving	A form of plastic movement typified by ripples(corrugation) or an abrupt wave (shoving) across the pavement surface
5	Depression	Localized pavement surface areas with slightly lower elevations than the surrounding pavement
6	Joint reflection cracking	Cracks in a flexible overlay of a rigid pavement which occur directly over the underlying rigid pavement joints
7	Longitudinal cracking	Cracks parallel to the pavement's centreline or laydown direction (a type of fatigue cracking)
8	Patching	An area of pavement that has been replaced with new material to repair the existing pavement
9	Polished aggregate	Areas where the portion of aggregate extending above the asphalt binder is either very small or there are no rough or angular aggregate particles
10	Potholes	Small, bowl-shaped depressions in the pavement surface that penetrate all the way through the HMA layer down to the base course
11	Raveling	The progressive disintegration of an HMA layer from the surface downward as a result of the dislodgement of aggregate particles
12	Rutting	Surface depression in the wheel path
13	Slippage cracking	Crescent or half-moon shaped cracks generally having two ends pointed into the direction of traffic
14	Stripping	The loss of bond between aggregates and asphalt binder that typically begins at the bottom of the HMA layer and progresses upward
15	Transverse cracks	Cracks perpendicular to the pavement's centreline or lay down
16	(Thermal) cracking	direction is usually a type of thermal cracking
17	Water bleeding and pumping	Water bleeding occurs when water seeps out of joints or cracks or through an excessively porous HMA layer. Pumping occurs when water and fine material is ejected from underlying layers through cracks in the HMA layer under moving loads.

Source: Neero (2014).

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VIII. GENERALISED TYPES OF DISTRESSES, CAUSES, AND PROBABLE TREATMENT.

Represented in the table below are defects or distresses by location or point in which they occur, the causes and probable treatment are as well mentioned below.

Table 3. Surface Defects:

Symptoms	Causes	Treatment
Fatty surface Bituminous binder collects as a film on the surface, becomes slippery and causes accidents.	Excessive binder in a per mix surfacing. Loss of cover aggregates. Poor quality aggregates. Excessively heavy axle loads. Too heavy prime or tack coat.	Sand blotting or sand blinding. Open graded per mix surface with low bitumen content can absorbs excess binder. A Liquid Seal Coat application.
Smooth Surface Low skid resistance value, slippery When wet.	Aggregates polished under traffic. Excessive binder.	Resurfacing with a surface dressing course or pre-mix carpet. Section of hard and angular aggregates should be selected.
Streaking Alternative lean and heavy bitumen lines appearance in longitudinal or transverse direction.	Non uniform bitumen application, bituminous distribution and improper and careless operation. Too low binder temperature.	Remove streaked surface and apply new surface. Careful bitumen spraying.
Hungry Surface Loss of aggregates from surface of fine cracks appearance.	Less bitumen in the surfacing or absorptive aggregates in the surfacing.	Use of slurry seal 2 to 5mm. As an emergency repair, a fog seal may be used.

Table 4. Cracks Symptoms and Causes:

Symptoms	Causes
1.Hairline creaks Short and fine at close intervals on the surface.	Insufficient bitumen content. Excessive filler; improper compaction.
2. Alligator Cracks Inter connected cracks forming series of small blocks Resemble skin of an alligator.	Excessive deflection of surface over unstable subgrade, sub-base, and base. Excessive overloads/heavy vehicles. Inadequate pavement thickness on sub-base and base course. Brittleness and overheating of bitumen.
3.Longitudinal Cracks Appear in a straight line along roads and at joints between pavements and shoulders.	Poor drainage-alternate wetting and drying beneath the shoulder surface. Water stagnation, seepage through joint. Trucks passing over joints. Weak lean joints between adjoining spreads.
4.Edge Cracks Formed parallel to outer edge of pavement – 0.3 to o.5m from inside edge. At time transverse cracks also branch out, from edge cracks.	Lack of lateral support from shoulders. Non-provision of extra winding on curves. Inadequate pavement width. Inadequate surface drainage. Frost heave.
5.Shrinkage Cracks Appear in transverse direction. Non deterioration or deformation of pavement but top surface becomes old and cracked.	Shrinkage of bituminous layer with age. Binder loses ductility as it ages and become brittle.
6.Reflection cracks Sympathetic cracks appear in the	Due to joints and cracks on pavement layers

bituminous surfaces over joint and crack on the pavement underneath. Pattern-longitudinal; transverse diagonal or block appear on overlays on concrete roads when pavement is widened and the entire pavement is surfaced	underneath.

Table 5. Deformation symptoms, causes and treatment.

Symptoms	Causes	Treatment
Slippage; Relative movements between surface layers and layer beneath and patch work with per mix material after tack point in the direction of thrust of wheels.	Unusual wheels thrust. Inadequate tack. Crescent shaped cracks on surface and lower courses.	Remove localized surface area. Lack of bond between coats.
Rutting; Longitudinal depression or groove. Water accumulates and cause skidding.	Heavy channelized traffic. Bullock cart traffic. Inadequate mix compaction. Improper mix design. Intrusion of sub grade clay into base course.	Tack coat and pre mix open or dense graded patching and compacting to the desired level.
Corrugations; Undulation (Ripples) across Bituminous surface. Spacing of waves around 3.0m.	Excessive binder. Too soft binder and high proportion of fines. Faulty laying of surface course.	Surface course scarified and the scarified material is re-compacted. A new surface layer is laid, sand bituminous pre mix is spread and thoroughly rolled.
Shoving;		
Localized bulging of pavement surface in points, where traffic starts or stops (Bus stop, hills, intersection sharp curves) or where vehicles accelerate. Crescent shaped cracks.	Excessive binder. Too soft binder. Lack of bond between bituminous surface and under lying layer. Heavy traffic movements of start and stop type.	Remove materials in the affected area and lay a stable premix patch.
Shallow Depression; Localized low area of about 25mm dipping. They may or may not be accompanied by cracks.	Poor settlement of lower pavement layers due to pockets of inadequate compaction of subgrade or pavement layers.	Fill with premix materials, open or dense graded and compact to the desired profile.
Settlement and upheaval; Larger deformations of the pavement followed by extensive cracks.	Inadequate compaction. excessive moisture in subgrade. Inadequate pavement thickness. Frost heave conditions.	Excavate defective fill and do embankments fresh. Under – drains may become necessary where there is no drainage. Properly designed pavements shall be provided.

Table 6. Disintegration symptoms, causes and treatment.

Symptoms	Causes	Treatment
Stripping; Separation of bitumen form aggregate particles in the presence of moisture.	Inadequate mix compaction. continuous water contact presence of dust or moisture on aggregates. Overheating of aggregates.	In case of surface dressing hot coarse sand, heated to 150 degrees Celsius is spread over affected areas and rolled. In other cases, existing

	presence of dust or moisture on aggregates when it comes in contact with bitumen occurrence of rain or dust storm after construction. opening roads on traffic before binder has set. improper bitumen grades.	bituminous mixes are removed and fresh one laid.
Loss of aggregates; Surface rough appearance. portions of aggregates are intact and in other portion aggregate are lost.	Aging oxidation of binder. Cold or wet weather after surface dressing. Wet or dust aggregates. Insufficient binder. Aggregates having no affinity to binder. Insufficient rolling.	Application of liquid seal or fog seal or slurry seals. If loss of aggregates is over large area, provide another surface dressing.
Ravelling; Characterized by progressive disintegration of the surface due to failure of the binder to hold materials together. Start from surface downward or from edge inwards. Begins with blowing off of fine aggregates, leaving behind pockmarks.	Inadequate compaction. Construction during wet for cold weather. inferior quality aggregates. Excessively open graded. Overheating of mix. Ageing of binder.	Add more binder quantity. If progressed for renewal coats with premix material is necessary.
Pot holes; Bowl-shaped holes of varying size in surface	Ingress of water into pavement. Lack of proper	Fill with premix open graded dense graded pitching.

layer or lacks extending into base course. Usually appear after rain.	camber aggravated by use of plastic filter in WBM. lack of bound between bituminous surfacing and WBM. In dense grade mixtures, it is caused by too much or too few fines. too thin bituminous surface	
Edge breaking; Bituminous surface irregularly breaks. If not reminded in time. Surfacing may peel off in large chunks at edges.	Infiltration of water. warn out shoulders. Inadequate compaction. Lower layer not being wider than the upper layer.	Affected area entirely removed to regular section. Pavement and shoulder built simultaneously .in sandy areas, bricks, paving to protect edges, to improve surface and side surface drainage. periodic inspection of shoulders.

Source; Subramaniam. (2010)

Fig. 1. Pot hole

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Fig 2. Combination of distresses

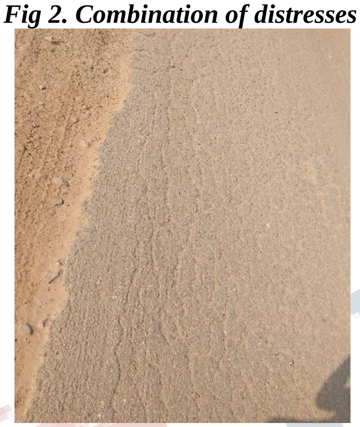

Fig. 3. Longitudinal Cracking

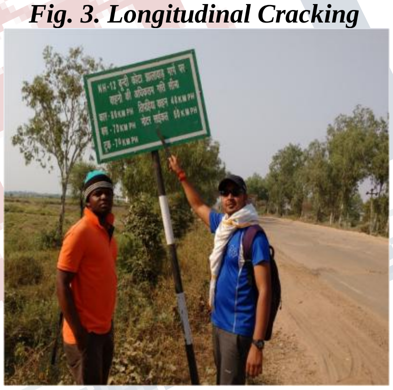

Fig. 4. NH-12 Sign post

FIg.5 Combination of distresses

Fig. 6 Alligator cracking

Fig, 7 Drainage Issues

Fig. 8 Heaved lump of soil at the edge of pavement

Fig. 9. Edge breaking/Pot holes.

XIV. RESULTS

The results obtained from measurement on the site are recorded in the table below, it was observed that virtually all types of distresses applicable to flexible pavements were found on the site visited. There were some stretches in which the pavement had a combination of

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different types of pavement distresses and was as well at long stretches.

Table 7. First Location-Mal-pani Godaam

Type of Distress	Length (m)	Width (m)	Depth (mm)
1.Rutting	1.27	0.85	3.9
2.Alligator cracking	7.62	1.77	
3.Depression	4.19	1.52	25
4.Total Failure(Combination)	1.90	Entire	32
5.Rutting/Depression	4.5	0.9	75
	1.21		53
6.Polishing	2.14	2.02	40
7.Rutting	1.32	1.38	72
8.Total failure	50		

Table 8. Second location-Dhanalal place

Type of Distress	Length(m)	Width(m)	Depth(mm)
1.Rutting	6.40	1.45	56
2.Rutting	12.80	1.40	29
3.Edge breaking		2.50	33
4.pot-holes	0.90	1.40	75
5.Rutting	1.9	0.7	4
6.Rutting	1.5	0.8	3
7.Edge breaking			129

Table 9. Third Location-Prathmik Madhyamika Vidalia Road, Pathakhera

Type of Distress	Length(m)	Width(m)	Depth(mm)
1. Edge breaking			3.9
2.Rutting	1.48	1.24	122
3.Total Failure(Combination)	60	Partial	Varying at different locations
4. longitudinal cracking	1.6	0.5	40
5.Rutting	1.9	0.7	3.5
6.longitudanal cracking	13.07	0.18	3
7. Rutting		0.29	
8.Patholes	1.17	1.03	70
9. Total Failure(Combination)	105	partial	Varying at different locations
10. Pot-holes	1.19	1.50	60
11. Heaving	Different places and long	0.75	4.9

Table 10. Forth Location-Sri Devnanarayan Street, Pathakhera

Type of Distress	Length(m)	Width(m)	Depth(mm)
1. Edge breaking			2.9
2.Rutting	6.83	1.38	113
3.Total failure (Combination)	70	Partial	Varying at different locations
4.longitudinal cracking	1.5	0.7	35
5.Rutting	5.83	1.98	110
6.longitudanal cracking	12.09	0.28	4
7.Total failure (Combination)	55	partial	Varying at different locations
8.Patholes	1.25	1.67	67
9. Total failure (Combination)	155	partial	Varying at different locations
10. Pot-holes	0.95	1.72	47
11. Heaving	Different places and long	0.85	3.95

Table 11. Location-Akalank Day Boarding Cum Residential School, Mandana

Type of Distress	Length(m)	Width(m)	Depth(mm)
1. Alligator cracking	7.62	1.77	
2.Rutting	5.76	1.23	109
3.Total failure (Combination)	70		
4.longitudinal	1.3	0.6	29

cracking			
5.Rutting	5.21	1.92	119
6.longitudanal cracking	11	0.29	
2.Rutting	5.62	1.31	102
7.Patholes	1.35	1.63	70
8. Total failure (Combination)	53		
9. Pot-holes	0.90	1.83	50
10. Heaving	Different places and long	0.85	4.25

CONCLUSION

Along the stretch, it is observed that the

1. Pavement thickness was so small, thus, the reason for the devastating rate of deterioration.
2. Very poor drainage is responsible for the rate of failure since flexible pavements have high vulnerability to failure when in contact with water.
3. The distance between distresses were very close.
4. At most points on the stretch selected for study, it was observed that the distresses could hardly be identified since there was a combination of many types of distresses
5. Due to poor road condition, too much dust is produced during the dry season, while too much water is found on the pavement in wet seasons.
6. Both depths and widths of the deterioration exceeds permissible limits 20mm to a great extent.
7. Increase in traffic load and load repetition could be a major contributing factor to the damages.
8. Poor maintenance culture of Highways contributed tremendously to the damages.

Recommendations

From the study, it is recommended that there should be a quick lasting solution to the highway by way of patching, proper design and construction of overlays and drainage channels.

Maintenance culture should be imbibed and maintained by agencies responsible for Highway maintenance.

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About The Authors

TIZA MICHAEL (B.Engr., BBS, MBA, Aff. M. ASCE, ASS.M. UACSE, M. IAENG. M.ITE).
He obtained B.Engr. (Civil Engineering) from Federal University of Agriculture Makurdi Nigeria, MBA (Construction Management) in India and Bachelor of Biblical Studies (BBS) from Canada, He is currently pursuing M. Tech (Transportation Engineering) from Career Point University Kota India. He has published many articles in accredited and recognised journals of national and international repute. He has presented his research in multiple International conferences. He is a member of different professional bodies across the globe.
Please click the link below to follow his research works https://www.researchgate.net/profile/Tiza_Toryila

ANAND KUMAR is a B. Tech student from Career Point University Kota, India. He has published in Journal of International repute and has presented in an International conference
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AVINASH KUMAR PATEL is a B. Tech student from Career Point University Kota, India.

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