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Study of Flexible Pavement Distresses on a Section of GT Road, Pakistan.

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Abstract— Better and efficient Transportation system is a key to success for a developing nation. But it is affected by large number of causes and one of them is the distresses develop on the pavement during its service and result in premature failure of the pavements. There are numerous distresses found in the road. In this research paper the common distresses are discussed in the light of a survey conducted on a road. A section of GT Road from Taxila to Gujar khan (north N-5) is surveyed and the distresses found on it are also discussed and their probable causes and remedial measures are also provided.

Index Terms— Transportation System, Distresses, Pavement, causes, remedial measures

1 INTRODUCTION

Transportation system is one of the most important factors affecting the national and public economy/development of any country. The better transportation system is the necessity for developing the nation and public economically.

Pakistan is one of the developing countries and roads are used mainly for transportation. Unluckily the flexible pavements in Pakistan undergo different types of distresses very soon after construction and the commuters suffer severely upto the application of some remedial measures. A number of times, the remedies engaged do not serve properly due to erroneous investigation of the distress cause and the funds/efforts used are wasted, sometimes repeatedly.

So deep study of these distresses is very necessary to find out and classify these distresses, their genuine reasons/causes and then to know what theoretical and practical solutions/remedies can be adopted for effective healing of these distresses.

1.1. Scope of Research

GT Road from Taxila to Gujar Khan (Section of N-5) has been visited and found exhibiting variety of distresses. Said section has been selected as sample section and distresses available physically have been studied, listed and matched with theoretical information already collected.

Remedies have also been collected from literature and engineering departments and report has been composed.

2. LITERATURE REVIEW

Nejad F. M. et al presented an automatic diagnosis system for detecting and classification of pavement crack distress based on Wavelet–Radon Transform (WR) and Dynamic Neural Network (DNN) threshold selection. The algorithm of the proposed system consists of a combination of feature extraction using WR and classification using the neural network technique. The proposed WR + DNN system performance is compared with static neural network (SNN). In test stage; proposed method was applied to the pavement images database to evaluate the system performance. The correct classification rate (CCR) of proposed system is over 99%. This research demonstrated that the WR + DNN method can be used efficiently for fast automatic pavement distress detection and classification. The details of the image processing technique and the characteristic of system are also described in this paper.

Brilakis I. et al presented a method for automated pothole detection in asphalt pavement images. In the proposed method an image is first segmented into defect and non-defect regions using histogram shape-based threshold. Based on the geometric properties of a defect region the potential pothole shape is approximated utilizing morphological thinning and elliptic regression. Subsequently, the texture inside a potential defect shape is extracted and compared with the texture of the surrounding non-defect pavement in order to determine if the region of interest represents an actual pothole. This methodology has been implemented in a MATLAB prototype, trained and tested on 120 pavement images. The results show that this method can detect potholes in asphalt pavement images with reasonable accuracy.

A.Georgopoulos et al through their research paper described and proposed a method developed jointly by the Laboratories highway engineering and Photogrammetric of the National Technical University of Athens. The method involves digital image processing techniques to provide suitable digital imagery as input to specialized software developed especially for this project. This software determines objectively and fully automatically the type, the extent and the severity of surface cracking for flexible road pavements. The proposed method presented substantial agreement, when compared with systematic visual ratings of existing pavement cracking carried out according to the internationally accepted requirements for airfield and road pavement of the Federal Aviation Administration (FAA).

Obaidat M. T. et al worked to investigate the potential of integration of geographic information system (GIS), global positioning system (GPS) and computer vision system (CVS) for the purpose of flexible pavement distresses classifications and maintenance priorities. The classification process included

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International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
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distress type, distress severity level and options for repair. A system scheme that integrated the above-mentioned systems was developed. The system utilized the data collected by GPS and a PC-based vision system in a GIS environment. GIS Arcview software was used for the purpose of data display, query, manipulation and analysis.

Nejad F. M. et al focused on comparing the discriminating power of several multi-resolution texture analysis techniques using wavelet, ridgelet, and curvelet-based texture descriptors. The approach consists of four steps: Image collection, segmentation of regions of interest (ROI), extraction of the most discriminative texture features, creation of a classifier that automatically identifies the pavement distress, and storage. Tests comparing the wavelet, ridgelet, and curvelet texture features indicated that curvelet-based signatures outperform all other multi-resolution techniques for pothole distress, yielding accuracy rates in the 97.9%.

Nejad F. M. et al proposed an expert system for pavement distress classification. A radon neural network, based on wavelet transform expert system is used for increasing the effectiveness of the scale invariant feature extraction algorithm. Wavelet modulus is calculated and Radon transform is then applied to the wavelet modulus. The features and parameters of the peaks are finally used for training and testing the neural network. Experimental results demonstrate that the proposed expert system is an effective method for pavement distress classification. The test performances of this study show the advantages of proposed expert system: it is rapid, easy to operate, and have simple structure.

H.D Cheng introduced a new pavement distress image enhancement algorithm, and a new analysis and classification algorithm. The enhancement algorithm corrects non-uniform background illumination by calculating multiplication factors that eliminate the background lighting variations. The new pavement distress classification algorithm builds a data structure storing the geometry of the skeleton obtained from the threshold image. This data structure is pruned, simplified, and aligned, yielding a set of features for distress classification: number of distress objects, number of branch intersections, number of loops, relative sizes of branches in each direction, etc. This skeleton analysis algorithm relies on two-dimensional geometrical parameters, which are understandable by both developers and users, unlike some methods that deal with abstract quantities not readily understood by ordinary users. The proposed analysis algorithm can precisely quantify geometrical and topological parameters, can quickly accept new classification rules for classification, and can estimate the distress severity from the threshold image.

3.ROADSIDE AREA FOR STUDY

3-1 Road stretch selected for study:

National Highway N-5 portion from Taxila to Gujar Khan has been selected, by this group, for studying the physical existence of different types of Flexible Pavement distresses. Said portion of GT Road consists of 70 Km between the chainages of Km 1493+000 and Km 1563+000. Location of the road stretch marked on Google Map is shown below in Fig. 1.

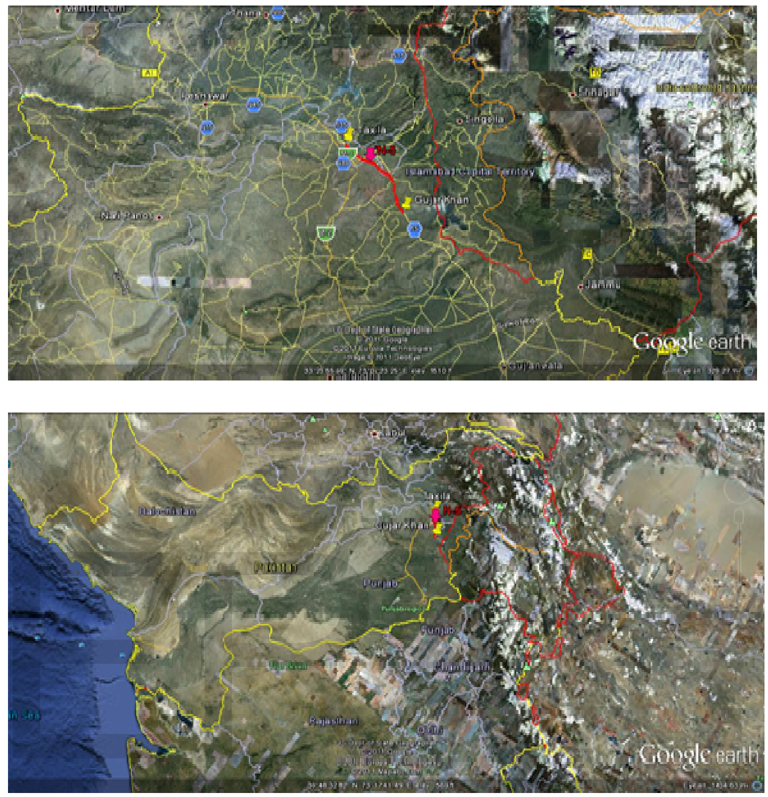

Fig. 1: Stretch of N-5, from Gujar Khan to Taxila, marked on Google Map

3-2 Climate of the selected section area:

The selected road portion passes through Rawalpindi and Islamabad which have a typical version of humid subtropical climate, with hot summers accompanied by a monsoon season followed by fairly cold winters. The hottest months are May and June, where average highs routinely exceed 38 °C (100.4 °F).The monsoon season is from June to September, with heavy rain falls and evening thunderstorms with the possibility of cloudburst. Winters are lasted from November to March with temperatures variable by location. In this area, temperatures vary from cold to mild, routinely dropping below zero. In the hills there is sparse snowfall. The weather ranges from a minimum of 3.9 °C (39.0 °F) in January to a maximum of 46.1 °C (115.0 °F) in June. The average low is 2 °C (35.6 °F) in January, while the average high is 40 °C (104.0 °F) in June. Climate charts/data of both the cities are given below

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
ISSN 2229-5518

a) Climate data of Rawalpindi

Rawalpindi

J	F	M	A	M	J	J	A	S	O	N	D
56	65	80	36	31	60	258	287	91	27	14	34
17	19	24	30	41	46	36	34	34	31	24	19
3	6	11	17	32	26	28	27	24	17	9	5

Average max. and min. temperatures in °C
Precipitation totals in mm
Source: World Meteorological Organization

b) Climate data of Islamabad

Climate data for Islamabad (1961–1990)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	17.1 (62.8)	19.1 (66.4)	23.9 (75.0)	30.1 (86.2)	35.3 (95.5)		35.0 (95.0)	33.4 (92.1)	33.5 (92.3)	30.9 (87.6)	25.4 (77.7)	19.7 (67.5)	28.5
Average low °C (°F)	2.6 (36.7)	5.1 (41.2)	9.9 (49.8)	15.0 (59.0)	19.7 (67.5)	23.7 (74.7)	24.3 (75.7)	23.5 (74.3)	20.6 (69.1)	13.9 (57.0)	7.5 (45.5)	3.4 (38.1)	14.1
Precipitation **mm (inches)**	56.1 (2.2)	73.5 (2.894)	89.8 (3.535)	61.8 (2.433)	39.2 (1.543)	62.2 (2.449)			98.2 (3.866)	29.3 (1.154)	17.8 (0.701)	37.3 (1.469)	1,142.1 (44.965)
Sunshine hours	195.3	189.3	201.5	252.0	313.1	300.0	263.5	251.1	261.0	275.9	249.0	195.3	2,947.0

Source: HKO

3-3 Geometry of road stretch

Geometric cross-section of the road has North Bound and South Bound Carriageways. Each carriageway consists of standard size (3.65 m) two lanes with 1meter and 3 meter wide inner s and outer shoulders respectively. Both the carriageways are separated by New Jersy Barrier (NJB) in urban areas and median in rural areas. Inner shoulder and two lanes have 2% cross slope and outer shoulder 4% cross slope. The road passes mostly through plain areas with zero or very small longitudinal grade. At few locations in Rawalpindi City, there is 3-4 % longitudinal grade. Typical cross-sectional details are shown below

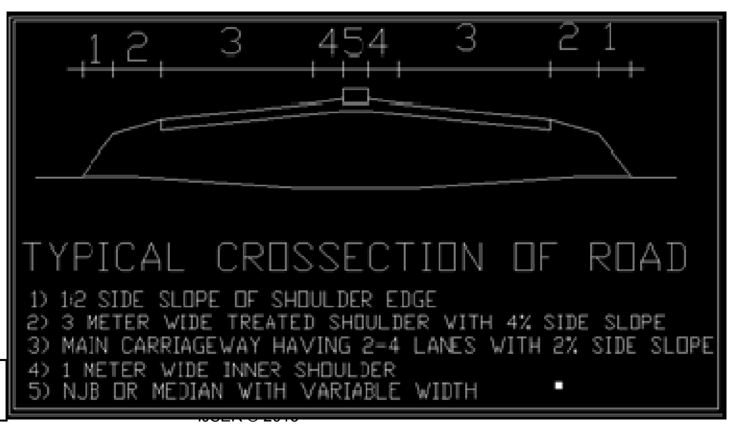

Fig 2. Typical Cross-section of the road

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
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The road has been constructed with both rigid and flexible pavement stretches at different locations. A linear plan showing details regarding rigid/flexible stretches, location of median/NJB, number of lanes, is given below

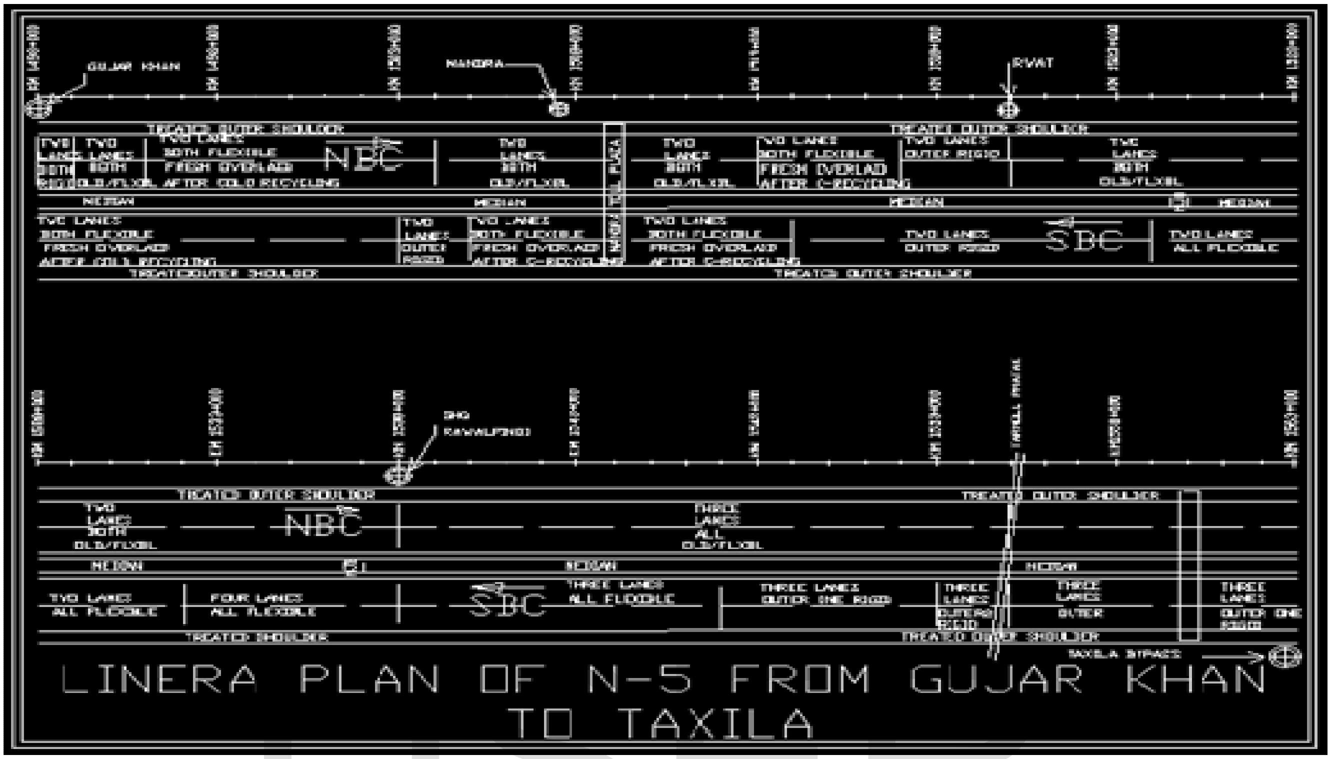

Fig 3. Linear Plan of the Road Section From Gujjar Khan to Taxila

3-4 Roadside population and traffic

The selected road portion passes through urban as well as rural areas. Urban areas occurring along the selected road portion are Gujar Khan, Mandra, Rwat, Rawalpindi and Tarnoll. In-between these urban areas are rural areas. Road is serving the fast moving vehicles i.e. motor cycles, cars, wagons etc. and slow moving vehicles i.e. tractor trollies, passenger busses, trucks and heavy logistic trailers.

4. IDENTIFICATION OF DISTRESSES IN SELECTED ROAD STRETCHES

After literature review (Unit 2 above) and theoretical study of flexible pavement distresses, the research team practically visited the GT Road (N-5) from Gujar Khan to Taxila Bypass. The road was found to be constructed in different stretches during different times. Some stretches, which are very old, are in very poor condition and have undergone a number of distresses whereas some stretches, which have been constructed recently, are in very good condition and exhibit almost no damage. During visit only the flexible stretches were seen and the distresses were identified visually. The status of the distresses observed is summarized in the table below

NBC Stretches where distress was observed

Sr. No.	Description of Distress	Stretch Chainage		
		KM 1493-94 Both lanes KM 1517-20 Outer lane	KM 1494-96 Both lanes KM 1504-13 Both Lanes KM 1517-20 Inner Lane KM 1520-38 Both Lanes KM 1538-55 Three Lanes KM 1555-63 Both Lanes	KM 1496-1504 Both Lanes KM 1513-17 Both Lanes
1	Fatigue (alligator) Cracking	-	√	√
2	Bleeding	-	√	√
3	Block cracking	-	√	-

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
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4	Corrugation and shoving	-	-	-
5	Depression	-	√	-
6	Joint reflection cracking	-	√	-
7	Lane/shoulder drop-off	-	√	-
8	Longitudinal cracking	-	√	-
9	Patching	-	√	-
10	Polished aggregate	-	√	-
11	Potholes	-	√	-
12	Raveling	-	-	-
13	Rutting	-	√	√
14	Slippage cracking	-	√	-
15	Stripping	-	√	-
16	Transverse thermal cracking	-	√	-
17	Water bleeding and pumping	-	-	-
Comments		Rigid pavement stretches, not Observed for distresses.	Old Flexible Pavement stretches. The distresses marked are seen at numerous locations and in all severity levels.	Stretches fresh overlaid after cold recycling. The distresses marked are giving minor appearance.

SBC Stretches where distress was observed

Sr. No.	Description of Distress	Stretch Chainage		
		KM 1555-63 Outer one Lane KM 1553-55 Outer two Lane KM 1547-53 Outer one Lane KM 1514-24 Outer Lane KM 1503-05 Outer Lane	KM 1555-63 inner 2-lanes KM 1553-55 inner 1- Lane KM 1547-53 Inner 2-Lanes KM 1538-47 All 3- Lanes KM 1532-38 All 4- Lanes KM 1524-32 Both Lanes KM 1514-24 Inner 1-Lane KM 1503-05 Inner 1-Lane	KM 1505-14 Both Lanes KM 1493-1503 Both Lanes
1	Fatigue (alligator) Cracking	-	√	√
2	Bleeding	-	√	√
3	Block cracking	-	√	-
4	Corrugation and shoving	-	-	-
5	Depression	-	√	-
6	Joint reflection cracking	-	√	-
7	Lane/shoulder drop-off	-	√	-
8	Longitudinal cracking	-	√	-
9	Patching	-	√	-
10	Polished aggregate	-	√	-
11	Potholes	-	√	-
12	Raveling	-	-	-
13	Rutting	-	√	√
14	Slippage cracking	-	√	-
15	stripping	-	√	-
16	Transverse thermal cracking	-	√	-
17	Water bleeding and pumping	-	-	-

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
ISSN 2229-5518

Comments	Rigid pavement stretches, not observed for distresses.	Old Flexible Pavement stretches. The distresses marked are seen at numerous locations and in all severity levels.	Stretches fresh overlaid after cold recycling. The distresses marked are giving minor appearance.

4.1. Distresses observed are visible on the road surface as shown by photographs below

1) Fatigue (alligator) Cracking

Low severity cracks
at KM 1529+800 SBC

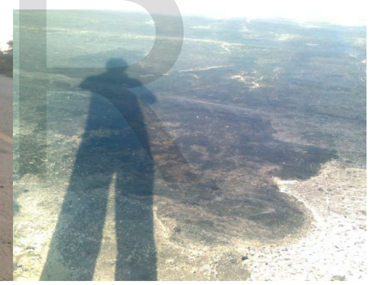
Moderate severity cracks
at KM 1526+300 SBC

High severity cracks
at KM 1525+300 SBC

2) Bleeding

At KM 1525+000SBC

at KM 1525+100SBC



at KM 1533+000NBC

3) Block cracking

Low severity cracks
At KM 1394+100 NBC

High severity cracks
at KM 1505+200 NBC

Low severity cracks
at KM 1394+150 NBC

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
ISSN 2229-5518

4) Depression


at KM 1537+000 SBC


at KM 1548+200 NBC


at KM1558+150 NBC

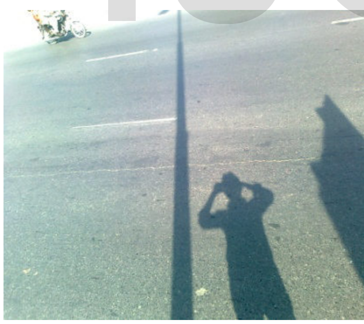
5) Joint reflection cracking


High severity reflection cracks
At KM 1503+200 SBC


High severity reflection cracks
at KM1503+275SBC


High severity reflection cracks
at KM 1493+350 NBC

6) Longitudinal cracking


Low severity cracks
At KM 1532+800 SBC


High severity cracks
at KM 1528+400 SBC


High severity cracks
at KM 1517+900NBC

7) Patching

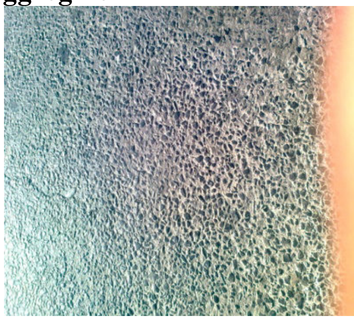

Low severity patch
At KM 1512+221NBC


High severity patch
at KM 1537+423 NBC


High severity patch
at KM 1543+175NBC

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
ISSN 2229-5518

8) Polished aggregate



Polished aggregates
At KM 1550+230 SBC

Polished aggregates
at KM 1550+300 BCS

polished aggregates
at KM 1550+425SBC

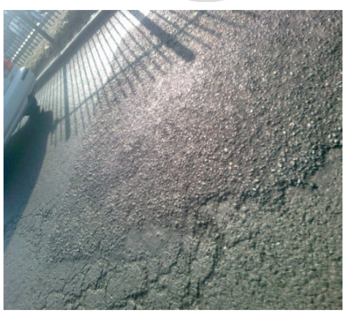
9) Potholes

Low severity pot holes
at KM 1542+950NBC

Moderate and high severity
Pot-holes
At KM 1533+125 SBC

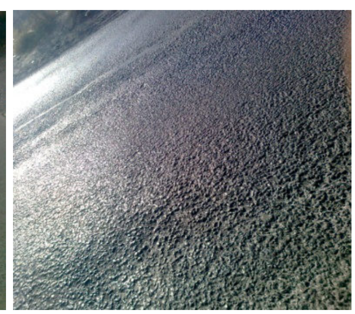
Moderate and high severity
Pot-holes
at KM 1533+219 SBC

10) Raveling



Low severity raveling
At KM 1514+700 SBC

Moderate severity raveling
at KM 1524+900 SBC



Moderate severity raveling
at KM 1538+550 SBC

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
ISSN 2229-5518

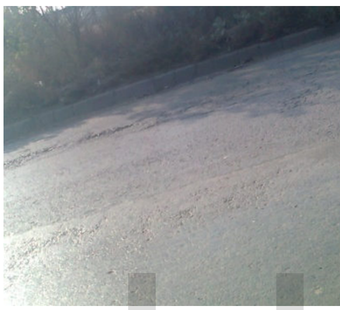
11) Rutting

Low severity rutting
At KM 1494+670 NBC

Moderate rutting
at KM 1511+150 NBC

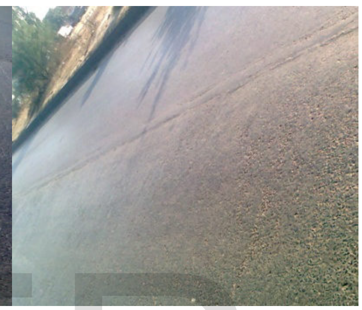
High severity rutting
at KM 1511+400NBC

12) Slippage cracking



At KM 1557+150NBC

at KM 1494+650 NBC



at KM1504+100NBC

13) Stripping

At KM 1531+280 NBC

at KM 1531+425NBC

at KM KM 1543+175 NB

14) Transverse thermal cracking

Low severity thermal cracks

At KM at KM 1531+425NBC

High severity thermal cracks

at KM 1524+800 SBC

High severity thermal cracks

at KM1527+700NBC

International Journal of Scientific & Engineering Research Volume 4, Issue 6, June -2013
ISSN 2229-5518

5. CONCLUSIONS/COMMENTS

(1) The study was carried out by the Group in three steps. Each step after completion gives a group of similar information about the Flexible Pavement Distresses as below

In Step-1 the literature study for having information about Flexible Pavement Distresses detection and classification was carried out. A number of research papers were studied and some very useful proposals regarding distress detection and classification were collected and have been placed in Unit-2 of this report. In Step-2 different reports giving details of flexible pavement distresses commonly observed on roads were studied. Seventeen number distresses, causes of their development and best possible remedies for their healing have been studied.

In Step-3 a 70Km long stretch of GT Road (N-05, from Gujar Khan to Taxila Bypass) was visited by the team. The distresses studied were visually identified on the road. Photographs of these distresses, the road stretches exhibiting these distresses along-with road location, road geometry, climate of this area and linear plan of the road are shown in Unit-4.

(2) The analysis of the contents of Unit-4 leads to the results

i) The distresses are common on old road stretches where no proper drainage system has been provided and relatively less on well drained portions.

ii) The distresses are rare on recently constructed portions.

iii) Rutting is common on truck lanes.

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