

IMPACT OF CLIMATE CHANGE ON THE PERFORMANCE AND MAINTENANCE OF THE FLEXIBLE PAVEMENTS IN DELHI

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Abstract- The climate of Delhi has major impact on the performance and maintenance of flexible pavements. Climate change is challenge for the design and management of roads in the future. Temperature, rainfall, sea level, ground water table and wind effect are the main factors which affect the performance of the flexible pavement. There is lot of variation in the temperature throughout the year. In summer temperature remains very hot and in winter the temperature dips down. Also the temperature throughout the world is increasing and is resulting to serious problems for the performance and maintenance of the flexible pavements. Rainfall and ground water table deteriorates the surface and causes major undulation of the pavement. The objective of this thesis is to find the impact of climate change on the flexible pavement. The study is done in the section from Karnal bypass to the Singhu border in Delhi. First of all the temperature and rainfall conditions of the Delhi are collected for the last fifty years and analysis is done on them. Combinations of climate change projections and local historical climate are adopted as climatic inputs for the prediction of pavement performance. To know the performance of the pavement the data of International Roughness Index (IRI) is calculated. Also the penetration test on the bitumen is done to know the impact of temperature on the pavement. The conclusions are drawn based on the scheme of maintenance that if flexible pavements are not maintained the cost of maintenance will increase by climate change due to an increase in road undulation. Due to climate change, road users may spend more for fuels, lubricants and tyre wear on flexible pavement sections that are not maintained well. Also by knowing the roughness value of the pavement the quantity of maintenance needed can be estimated.

Keywords: Climate change, temperature, deterioration, rainfall, precipitation, flexible pavement

INTRODUCTION

Climatic change has vast impact on the performance of flexible pavement. Performance of pavement can be generally defined as the change in their condition or function with respect to age. Temperature, rainfall, sea level, ground water table and wind effect are climatic elements which cause deterioration of flexible pavement. The investigation of climate change is aimed for local prediction of climate change in terms of climatic factors that can have influences on flexible pavements. The climate change projections can be combined with historical climate measurements to create likely future climate profiles that can be input into pavement performance. Climate change may have impact on a flexible pavement in direct and indirect way. The direct impact is from the change in the climatic environment of the pavement, including temperature and moisture. As an indirect impact, climate change may cause a demographic change, affecting traffic demand, and thus have an impact on pavement undulations. The temperature has increased since the latest ice age to high temperature peaks and will drop again after that, according to the temperature pattern that has occurred during the past four major ice ages. Besides this long-term trend, short-term variations in temperature always exist.

The study is done in Delhi which lies in the northern plains of Indian subcontinent. Delhi is the most populated state in India with high density of traffic on the roads. Delhi is highly influenced with climate change. In summer the temperature is very high and reaches up to maximum with about 45°C and above. Monsoon starts in late June and lasts until mid

September with about 797.3 mm rainfall also in winter the temperature dips very low about 12°C. Due to large population and high density of traffic, Delhi is highly polluted area and this effects the climatic condition of the area. The section of study is from Singhu border to Karnal bypass which is shown in the Figure 1.

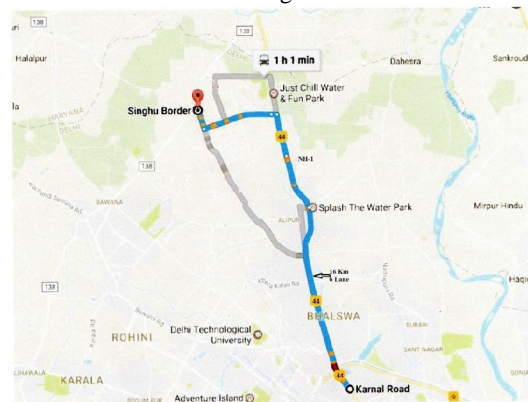


Fig. 1 Road section under study

Flexible Pavement Mechanism

The continuous effect of volume, composition, loading characteristics of traffic, environment, surrounding conditions and the maintenance inputs provided, changes functional and structural conditions of flexible pavements with time. The failure of the pavement occurs due to internal damage caused

by traffic loads within an operational environment, over a period of time; and is not an abrupt phenomenon. Studies conducted all over the world have reported that the deterioration pattern of pavements shows the same trend even though the design and construction techniques vary from country to country.

Methodology

The methodology of this study is to develop a detailed framework for the impact of climate change on flexible pavement. The detailed framework includes three tasks as mentioned below:-

- Investigation and analysis of climate change
- Pavement performance
- Pavement maintenance effects.

The performance of flexible pavements is affected by environmental factors, especially temperature and moisture. The prediction is based on climatic variations on the average increase or decrease in temperature and precipitation. This study is performed on the flexible pavements from the Karnal bypass to Singhu border in Delhi to demonstrate the methodology. The section has high impact of temperature on the pavement due to pollution caused by dumping of city waste near this section. Also the rainfall and ground water table influences the performance of the pavement

Temperature

The temperature has vast effect on flexible pavements. The effect of temperature on flexible pavements is different from that of concrete pavements. Due to temperature difference cracks get developed on the surface of the pavement and which cause the roughness of pavement. High temperature makes pavement more flexible and causes differential settlements on the surface. Figure 3.1 shows the softness of pavement due to temperature increase.



Fig.2 Pavement softness due to temperature

Precipitation

The precipitation from rainfall affects the quantity of surface water infiltrating into the subgrade and the depth of ground water table. Poor drainage may bring lack of shear strength and loss of support to the pavement. New Delhi earns an average of 790 mm of rainfall per year, or 65.8 mm per month. On average there are 57 days per year with more than 0.1 mm of rainfall (precipitation). The data of temperature and rainfall is collected from Indian meteorological department. Monthly average maximum temperature, average minimum temperature, record low temperature and record high temperature are recorded in the

Table 1. The mean rainfall of the month is also recorded. From the records it is clear that there is lot of variation of temperature throughout the year. The temperature is very high in the months from May to August and the temperature is low in the months November to February and also the there is temperature difference between day and night. Rainfall also varies throughout the year there is heavy rainfall during monsoon season.

Table 1 Monthly mean temperature and rainfall of Delhi

Month	MeanTemperature(°C)		Record High(°C)	Record Low(°C)	Mean Rainfall(°C)
	Max	Min			
January	20.8	6.7	31.0	2.2	18.9
February	23.9	9.1	35.7	1.6	16.6
March	30.0	14.1	41.3	3.4	10.8
April	36.9	20.5	45.3	8.6	30.4
May	40.5	25.1	48.4	14.6	29.0
June	40.3	27.6	47.6	19.8	54.3
July	35.4	26.4	45.7	17.8	216.8
August	34.7	25.6	43.2	20.2	247.6
Septembe	32.2	23.8	40.8	13.6	133.8
October	30.3	18.8	39.6	9.9	15.4
November	28.3	12.7	36.4	2.1	6.6
December	22.7	7.8	30	1.3	15.2

Roughness

Roughness of the pavement can be defined as an amount of irregularity in the pavement surface that affect the ride quality of a vehicle very badly. Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle delay costs, fuel consumption and maintenance costs. The roughness of the section (Singhu border to Karnal bypass) is calculated and graph showing variation of International Roughness Index is plotted as given in Figure 3.

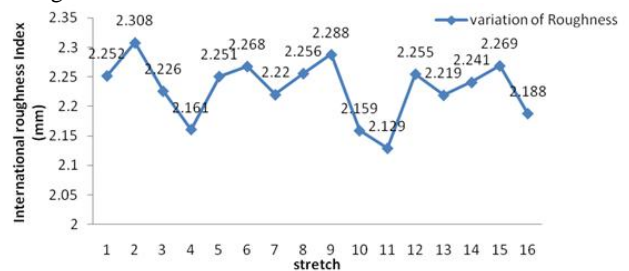


Fig 3 International roughness index values of the section

The Figure 3 shows the International Roughness Index (IRI) of the section. The value of the section is calculated for sixteen Kilometers and value of each Kilometer is calculated separately. This value of International Roughness Index helps to know that how much maintenance is required for the section. In fact, with the change in climatic condition the IRI value increases which will increase the maintenance cost of the pavement.

Surface distress

Surface distress is an indication of poor or unfavorable performance of pavement or signs of failure. The general surface distresses can be grouped under the following two broad groups.

- Fracture – Cracking
- Distortion - rutting (rut depth in mm)

Surface distress is associated to roughness (the more cracks, distortion and disintegration, the rougher the pavement will be) as well as structural integrity (surface distress can be a sign of impending or current structural problems). The values of cracks and ruts of the section are given in the Table 2.

Table 2 Distress measurement showing cracks and ruts per Km

S. No.	Location		Cracks (m ²)	Ruts (mm)
	From Km	To Km		
1	5.000	6.000	110.46	8.35
2	6.000	7.000	115.28	9.80
3	7.000	8.000	96.5	6.23
4	8.000	9.000	94.01	7.32
5	9.000	10.000	114.26	7.28
6	10.000	11.000	112.42	14.32
7	11.000	12.000	105	12.06
8	12.000	13.000	111.45	15.67
9	13.000	14.000	113.26	16.59
10	14.000	15.000	90.57	7.24
11	15.000	16.000	96.5	6.70
12	16.000	17.000	111.45	11.57
13	17.000	18.000	96.53	8.25
14	18.000	19.000	112.92	7.45
15	19.000	20.000	112.52	9.82
16	20.000	21.000	98.21	7.18

It is clear from the Table 2 that there is lot of variations in the cracks and ruts in throughout the section. These variations may be due to capillary rise, places where the ruts value is more is due to the reason that there may be high effect of capillary rise. Also the section near the water logged area has been found to have more ruts and cracks in the pavement surface. The main causes of ruts and cracks are temperature, rainfall, ground water table and sea level.

CONCLUSION

Based on the results of study and experimental investigation carried out on impact of climate change on flexible pavement following conclusion has drawn

- Globally the climate is changing and has vast effect throughout the world. The global temperature is increasing which melts the glaciers and sea level is

rising which is effecting the flexible pavements at a great extent.

- Based on the investigated climatic region in the Delhi the condition of flexible pavements is likely to be affected by climate change. Rutting/undulation will accumulate faster mainly due to the increase in temperature and water logging in a particular area due to higher ground water table or excessive capillary rise of ground water. Longitudinal and alligator cracking may increase or decrease as a result of a combination of increasing temperature and moisture.
- Regular maintenance of the pavement is required in accordance with the climatic conditions of the area. Without maintenance, the cost of a flexible pavement is likely to have an increase as a result of climate change and also decreases the life of the pavement.

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