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REVIEW PAPER ON IMPACT OF CLIMATE CHANGE ON THE PERFORMANCE AND MAINTENANCE OF FLEXIBLE PAVEMENTS

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Abstract: Flexible pavements are sensitive elements to environment and the performance of the pavement can be effected by climate change. Climate change poses a challenge to design and management of flexible pavements in the future. Climate change occur worldwide and thus all flexible pavements are exposed to the impact. Though an considerable framework is not available to calculate the impact of climate change on flexible pavements in terms of performance, maintenance and the subsequent cost of pavement. Pavement performance predictions are applied to schedule maintenance interventions. Maintenance effects of treatments are considered in maintenance decision-making. Pavement performance, intervention strategies, and life-cycle costs can be compared under various climate change and baseline scenarios. Maintenance effect models of Roughness Index (IRI) and rutting are validated using pavement condition survey data from NH 1 from Karnal Bypass to Singhu Border Delhi.

Keywords: Climate, Pavement, life cycle cost, flexible pavement, temperature ,moisture

INTRODUCTION

Flexible pavements are effected by their surrounding environment. The effects of temperature and moisture and their combination on pavement performance have been popular topics in pavement research for many decades. A typical flexible pavement may consist of wearing surface, base course, sub base and subgrade. Temperature and moisture can affect the stress-strain response in the full depth of a pavement. Temperature can affect the bituminous layers (including bituminous layer and bound base layer) because these layers are viscous and can show elastic and plastic response to loadings. Moisture can impact the resilient response of unbound layers, subbase, and subgrade. Furthermore, moisture can do damage in asphalt layers and causes distress such as stripping climate change is likely to make an impact on flexible pavements. The impact can be profound climate change occurs worldwide and so does its impact. Potentially, every flexible pavement may be influenced by climate change. also the life span of a flexible pavement (typically 20 – 40 years) is long enough to allow the impact of climate change to be revealed. The impact can accumulate and show its significance before or at the end of the service life. Change in temperature, rainfall, and pavement maintenance the social relations cost benefit of highways needs to be achieved by the balance in benefit between road authorities and users. Therefore, user costs and the social benefit of highways need to be taken into consideration.

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. Figure 1 shows the factors influencing the pavement performance.

Temperature

It was found by observation that the global average surface temperature has increased approximately 0.76 °C since 1850, in eleven years from 1995 to 2006 and ranks them among the most warmest years according to the record of global surface temperature. It is also been analyzed that the linear change of temperature growth over the most recent 50 years is almost twice that of the past 100 years.

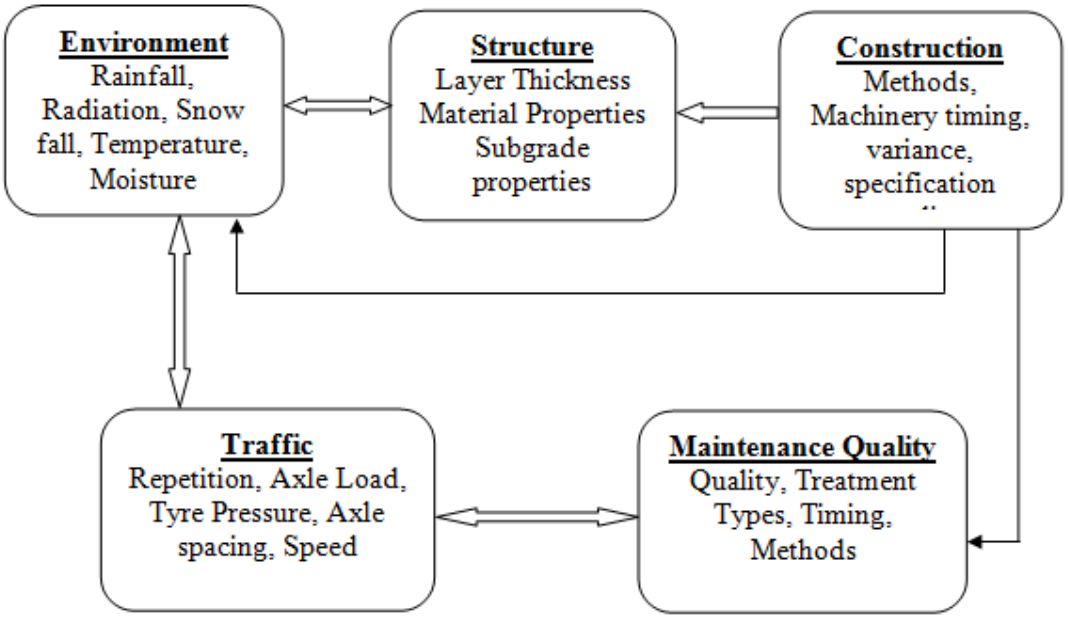

Fig 1 Factors Influencing Pavement Performance

Environmental Associated Factors

Environmental conditions are found to have significant impact on the performance of the flexible pavements. External factors such as precipitation, temperature, humidity and depth of water table are the main environmental factors that have exerted major influences on the pavement performance. Environmental conditions are effective in upper boundary of a pavement and the water is effective in the lower boundary of pavement. Precipitation, wind speed, air temperature, relative humidity, atmospheric pressure and solar radiation are six main climatic aspects in a coupled soil-climate model, the capillary rise also affects the resultant moisture content in the soil. Figure 2 shows the climatic parameters influencing soil surface.

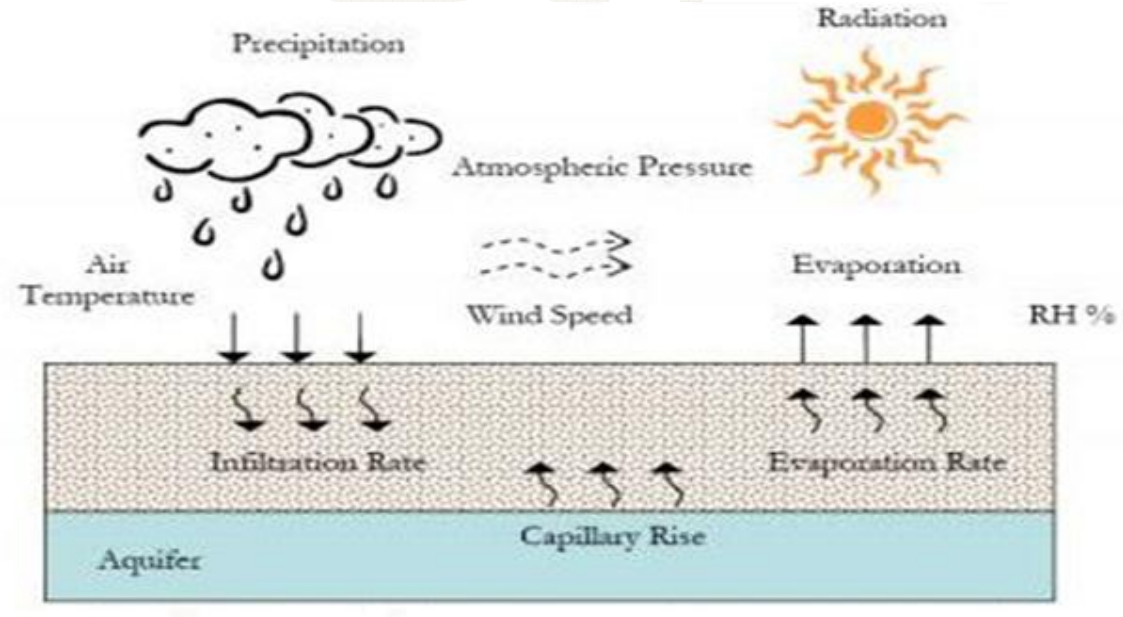

Fig 2 Climatic Parameter On Soil Surface

Global Warming Potential (GWP)

The ability of various green house gaseous to trap heat based on the absorbing ability of each gas in the atmosphere and defined over a specified time period is called global warning potential of the particular gas. The time period specified corresponds to the change in the relative damage of the gas over time and can be 20, 100 or 200 years; but for standard purposes, 100 years is taken as a base period. The basic purpose of using the green warming potential is to

convert individual greenhouse gaseous to carbon dioxide equivalent i.e., a standard format for reporting global emissions.

Cracking in Pavement

A crack is an unplanned break or discontinuity in the integrity of the pavement surface. Cracks may appear as small openings or partial fractures on pavement surfaces or bottoms of asphalt layers. Cracks can be affected by traffic loading, the climate, or the combination of both. Commonly, cracks can propagate in two ways which are top-down cracking and bottom-up cracking. Cracks are always a symbol of a pavement defect. Cracks allow for infiltration of water into the sub-layers of a pavement and thus, will accelerate pavement deterioration to some extent.

Longitudinal Cracking

Longitudinal cracking consists of linear cracks which generally develop in the direction of the pavement centre line. Longitudinal cracking can appear as single cracks or a series of nearly parallel cracks. The reason for longitudinal cracking is mainly because of shrinkage of the asphalt surface under low temperature or asphalt hardening. When temperature gets colder, asphalt concrete shrinks and tensile thermal stress will be induced. With asphalt hardening, asphalt becomes brittle and is more prone to cracking. Furthermore, longitudinal cracks can also be associated with subgrade movements due to moisture.

Transverse Cracking

Transverse cracking means linear cracks which predominantly develop perpendicular to the pavement centreline. Similar to longitudinal cracking, transverse cracking can occur as a single crack or a series of parallel cracks. The reason for the transverse cracking is believed to be environmentally associated. Common causes for

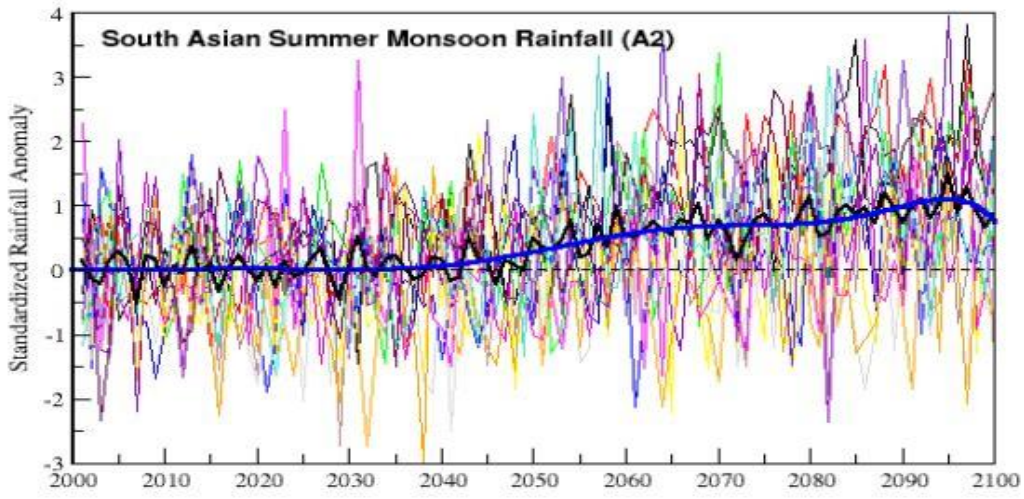

Fig 3 South Asia Summer Monsoon Rainfall

Effect of Rainfall in India

India is one of the world's most vulnerable country to climate change. Consequently, India is facing with the challenge of maintaining its economic growth while combating the threat of climate change as the economy is closely tied to natural resources-based and climate-sensitive sectors such as agriculture, highway etc. Further, India is vulnerable to extreme weather events, sea level rise, and potential climate change-induced shifts in precipitation patterns which may lead to increase the maintenance of the pavements. There have been significant increases in the frequency and intensity of extreme monsoon rain events over the past 50 years and the observed trend suggests an enhanced risk associated with extreme rainfall over India in the coming decades. The graph of monsoon rainfall of south Asia (2000 to 2100) is shown in figure 2 it shows the rainfall will increase with time.

Literature Review

Myhre et al. (1998) [1] analysed the heat of radiation can be significantly affected by the concentration of Greenhouse Gas (GHG) in the atmosphere. The concentration of green house gaseous in the atmosphere has a great impact on the absorption process because these gaseous absorbing the solar radiation. The natural balance of green house gaseous will be disturbed, when its concentration in the atmosphere exceeds the removal capability by the earth. Higher concentration of green house gaseous leads to more energy remaining in the earth, thus the globe is warmer

Knapp et al. (2000) [2] has predicted that the Climate change has bring more rains causing flooding which is amplified due to rapid urbanization leading to urban flooding of unexpectedly high magnitudes. Weather condition affect road safety especially precipitation which is believed to increase traffic accidents by 75%. However, due to reduction in speeds due to adverse weather, there is reduction in severity of accidents. Extreme weather events lead to speed reduction, congestion, traffic jams and uncertainty in traffic safety. The changes in traffic volume and flow also occur, reflecting the variation in travel demand, route choices and even cancellation of trips due to bad weather.

Suarez et al. (2005) [3] studied that certain segments of the road network are blocked due to flooding, riders need to take detours and on partially flooding roads, or congested roads, there could be stopped vehicles causing bottle necks, etc. These trips usually take much longer than regular trip time leading to increased travel time. The time cost even serves as an indicator of flood impact loss. The number of vehicles, both public and private, are also damaged due to partial or complete immersion in flooded sections as such vehicular damage also adds to overall loss.

. **Venugopal et al. (2006) [4]** concluded that There have been significant increases in the frequency and intensity of extreme monsoon rain events over the past 50 years and the observed trend suggests an enhanced risk associated with extreme rainfall over India in the coming decades. The graph of monsoon rainfall of south Asia (2000 to 2100) is shown in figure 3 it shows the rainfall will increase with time.

NAPCC (2008) [5] reported that India is one of the world's most vulnerable countries to climate change. Consequently, India is facing with the challenge of maintaining its economic growth while combating the threat of climate change as the economy is closely tied to natural resources-based and climate-sensitive sectors such as agriculture, highway etc. Further, India is vulnerable to extreme weather events, sea level rise, and potential climate change-induced shifts in precipitation patterns which may lead to increase the maintenance of the pavements.

IPCC (2013) [6] reported that it is almost certain that the observed climate change that has occurred in the past few decades is man-made. The green house gasses emission due to human activities has been increasing and thus increases the global temperature. The emissions of green house gaseous have increased by 75% between 1970 and 2004 and at an increasing rate which results in global warming. As a consequence of the warming, glaciers start to melt and the sea level will rise and by the result of this water circulation can be affected and thus precipitation is affected.

OBJECTIVE

The aim of this study is to assess the impact of climate change on the performance and maintenance of flexible pavements. The work should allow assessment of the impact of climate change on flexible pavements at either section or network level.

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

CONCLUSION

This study Provide a framework for the assessment of the impact of climate change on the performance, maintenance and decision-making flexible pavements. Based on predictions of pavement performance under climate change and baseline this framework goes a step further to discuss the subsequent changes in pavement maintenance and cost of pavement. Assess the sensitivity of environmental factors on pavement performance. The seasonal variation of temperature is considered by a sine function and its sensitivity will be discussed and compared to other environmental factors. Life cycle cost components that are related to climate change are identified. The components are related to climate change by international roughness index. A data selection process is developed to extract pavement performance indices from a Pavement Management System before and after a specific intervention.

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