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Modelling Impacts of Climate Change on Road Infrastructure at Regional Scale

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***Abstract* -Extreme climate events have major direct impacts on all road infrastructures. The consequences are mainly economic, but also concern safety. Climate change considerably modifies infrastructure's vulnerability to these impacts. Usually, infrastructure is designed on the basis of regulations and calculation codes which supply typical intensity values for climatic phenomena associated with a return frequency (e.g. a 10 year rainfall or a 100 year flood). While this reference event concept, based on return freq uency, has been extremely useful in the past, it is becoming dangerous lately as the underlying assumption that the climate of tomorrow will be similar to that of yesterday is no longer correct.**

According to the National Observatory of the Effects of Global Warming (ONERC), extreme meteorological phenomena will increase in number and degree in the years to come in the metro cities. In this paper we propose a prediction model to show the behaviour of road infrastructure in response to several weather related changes at a regional scale.

keywords: Weather impacts, Road infrastructure, , Spectrum sensing, wireless communication

I.INTRODUCTION

Pavement condition assessment and deterioration estimation is an integral part of all pavements and infrastructure management system. They are usually based on models which predict pavement performance based on present conditions. However, many difficulties are associated with the measurements and/or precise estimation of the inputs involved in the performance models, such as traffic flows, environmental condition etc. The uncertainty in the determination of these and other factors contribute to the difficulties encountered while developing pavement performance models. The implementing organizations have been pointing towards a need of developing an intelligent pavement performance models that can priotize pavement maintenance and rehabilitation works. Such models can forecast the pavement service life left and pavement rehabilitation needs and can help in the formulation of pavement maintenance and strengthening programs. Hence there is a need for development of performance of pavement in terms of deterioration.

The fatigue of the bituminous pavement materials under the repetitive action of traffic loading is one of the major mechanisms of structural weakening of the pavement. Since the fatigue is controlled by tensile strain which reaches maximum at the underside of the bituminous road base of a pavement under traffic loading, it is assumed that fatigue cracking would eventually initiate at the underside of the roadbase and propagates upwards till it reaches the surface. For a pavement structure containing a bituminous surfacing and a bituminous roadbase, this understanding of fatigue weakening means that the roadbase would suffer more fatigue damage than the surfacing, and the more heavily trafficked lane (the nearside lane) would suffer more cracking than the less trafficked lane (the offside lane).

We will be first analyzing the long term multi-source climate data (50-100 years) i.e temperature, rainfall, wind, humidity etc. over different geographical location (from coastal area to higher altitude area like hill station, from rural area to metro city) to study the trend pattern of the parameters. The road infrastructure data will be analyzed based on the available data (i.e soil type, road age, road type, etc.). The population data and the traffic information will be enabled to know the impact of climate on the road dynamics. All the above mentioned components will be analyzed using the different algorithms to be developed in the present work. Different data base will be developed and integrated in a cloud frame work in the high performance computing environment to analyze the big data. Finally the data mining approach, both statistical and dynamical modeling approach will be adopted for the prediction of the road behavior and the assessment of the impact of climate parameters and climate change on the transport system.

II LITERATURE SURVEY

There are different types of soil in different regions of earth. The moisture retaining property of different types of soils varies from each other. The moisture content of soil is a crucial factor which determines the pavement service life.

A. Soil type:Sandy

Sandy soil has the largest particles among the different soil types. It's dry and gritty to the touch, and because the particles have huge spaces between them, it can't hold on to water. Water drains rapidly, straight through to places where the

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roots, particularly those of seedlings, cannot reach. Plants don't have a chance of using the nutrients in sandy soil more efficiently as they're swiftly carried away by the runoff. The upside to sandy soil is that it's light to work with and warms much more quickly in the spring.

B. Soil type:Silty

Silty soil has much smaller particles than sandy soil so it's smooth to the touch. When moistened, it's soapy slick. When you roll it between your fingers, dirt is left on your skin. Silty soil retains water longer, but it can't hold on to as much nutrients as you'd want it to though it's fairly fertile. Due to its moisture-retentive quality, silty soil is cold and drains poorly.

C. Soil type:Clay

Clay soil has the smallest particles among the three so it has good water storage qualities. It's sticky to the touch when wet, but smooth when dry. Due to the tiny size of its particles and its tendency to settle together, little air passes through its spaces. Because it's also slower to drain, it has a tighter hold on plant nutrients. Clay soil is thus rich in plant food for better growth. Clay soil is cold and in the spring, takes time to warm since the water within also has to warm up. The downside is that clay soil could be very heavy to work with when it gets dry. Especially during the summer months, it could turn hard and compact, making it difficult to turn. (When clay soil is worked while it's too wet though, it's prone to damage).

D. Soil type: Peaty

Peaty soil is dark brown or black in color, soft, easily compressed due to its high water content, and rich in organic matter. Peat soil started forming over 9,000 years ago, with the rapid melting of glaciers. This rapid melt drowned plants quickly and died in the process. Their decay was so slow underwater that it led to the accumulation of organic area in a concentrated spot. Although peat soil tends to be heavily saturated with water, once drained it turns into a good growing medium. In the summer though, peat could be very dry and become a fire hazard. (peat is the precursor of coal.) The most desirable quality of peat soil, however, is in its ability to hold water in during the dry months and its capacity to protect the roots from damage during very wet months. Peat contains acidic water, but growers use it to regulate soil chemistry or pH levels as well as an agent of disease control for the soil.

E. Soil type: Saline Soil

The soil in extremely dry regions is usually blackish because of its high salt content. Known as saline soil, it can cause damage to and stall plant growth, impede germination,and cause difficulties in irrigation. The salinity is due to the build up of soluble salts in the rhizosphere—high salt contents prevent water uptake by plants, leading to drought stress.

III SYSTEM MODEL

A. Existing System

Some of the earlier studies as explained in the previous section indicate there are little exploration on the combination of climate-soil-human interaction directly. In the existing system the following important points are available.

- Some factors on climate trends over regions
- Few studies on the road studies mostly on mountainous region.
- Few database but at low resolution is available

B. Existing System Disadvantages

The main disadvantages are enlisted as follows:

- The climate studies at station scale i.e over a smaller area (Taluk level) needs to be studied
- Road infrastructure and climate interaction studies are missing
- Database needs to be organized in cluster way i.e location wise, climate zone wise, rural or urban etc.
- Mathematical modeling and computer simulation approach for road infrastructure is missing.

C. Proposed System

- An integrated modeling frame work for the studies of impact of the climate change on the road at a very regional scale will be developed in the highperformance computing environment.
- Several modules of algorithms for the study and modeling aspects will be developed.
- The case studies at different locations will be implemented and the validation and the verification of the modules will be presented.
- Finally the prediction of the impact of climate change on the road will be presented using the IPCC projected climate parameters.
- A robust data base management system will be developed.
- Integration with the GIS will be incorporated.
- A GUI will be developed and implemented for the impact studies by the common users.

The required Databases are presented below:

- Climate data and climate stress factors representative of the different problems considered (e.g. road soil properties, temperature, pavement temperature, and extreme precipitations).
- Road infrastructure and the Transport information for the city and rural area(transport infrastructure, network, and transport activity).
- Physical information (e.g. sea level rise, coastal information (e.g. sea storm heights database, hydrological data, soil types.
- Engineering data and information about the underlying deterioration & damage mechanisms, maintenance practices and costs.

IV DESIGN AND METHODOLOGY OF WORK

The objective of System Design is the specification of modules and the ways these modules are to be integrated to form a complete module fulfilling its design objectives in the system design, high-level abstraction of the whole module is provided using diagrams called dataflow diagram.

A. Climate Data Collection

Several climatic parameters like temperature, Rainfall, humidity are studied. The data is collected from Indian

Meteorological Department (IMD). Several years of temperature and rainfall data are collected from IMD for the study of the changes in climate over years. Also this data is utilized to project the future climate.

B. Study of the Anthropogenic Factors

The main anthropogenic factor is the growth in population with an exponential growth in the vehicle rate. The traffic data, the rate in the increase of vehicles are studied. The major roads with heavy traffic are listed and the rates of traffic flow on these roads are noted.

C. Road Infrastructure Analysis

Several road types, their construction materials, classification based on surface typa are studied. Basically there are two types of roads which are Surfaced roads and Unsurfaced roads. In surfaced roads further classification is made based on the s urface type. It is classified into Asphalt roads, Concrete roads and Water Bound Macadem roads. Unsurfaced roads are kacha roads with mud surface. There is no surfacing done for this type of roads. Concrete roads have several advantages over Asphalt roads in terms of durability and service life. But the construction cost of concrete road is very high compared to Asphalt roads. However, it is inevitable to build concrete roads in regions with heavy rainfall to overcome the maintenance expenses.

D. Climate and Data Processing

The raw climate data of several years collected from IMD is processed using HPC systems. Firstly, the data collected is filtered and data of our study region is obtained using our algorithms. Then, the annual average and monsoon average of rainfall is calculated. Also we make an analysis of temperature and calculate the averages of annual temperature and summer temperature. Then anomaly of temperature is also plotted. The graphs for these are shown in the results and discussions chapter. Traffic data of several regions of the city is collected from various sources. The roads with high traffic are studied. Several road parameters such as longitudinal depression, pothole area, and moisture content of the soil are studied. Commercial vehicles per day, Ratio of shoulder, Rainfall, Pot hole area of the roads are studied.

E. Development of Algorithms

Several existing algorithms are analysed and their disadvantages are listed. An efficient algorithm is developed for the analysis of the multi source multi-format climate data. Also the performance parameters of the roads are calculated in the algorithm. Input parameters such as rainfall, temperature, longitudinal depression, pot hole, dry density, bearing ratio, surface cracking, and commercial vehicles per day are considered. Performance parameters such as Drainage Rating, Cracking, Roughness, Edge drop and Rut Depth are calculated.

F. System Design

The system design of the prediction model of the pavement service life is represented in fig 1. There are totally five modules in the system which takes inputs such as rainfall, temperature, traffic and road type. These modules calculate drainage rating, rut depth, edge drop, roughness and cracking which are the performance parameters of pavement service life.

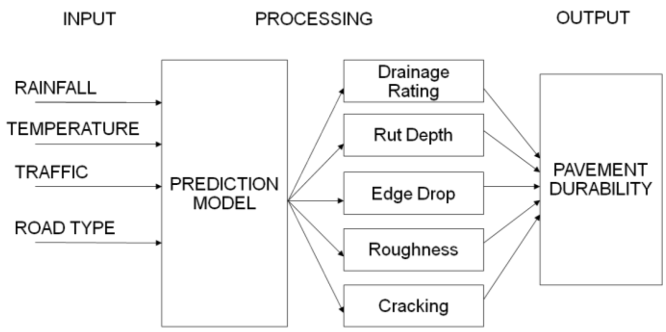

Fig.1 System Design

V RESULTS AND DISCUSSIONS

Several years of rainfall data is collected from various sources. Average of annual rainfall and monsoon rainfall is plotted. Also anomaly of rainfall is calculated and graph is plotted to determine the deviation of the rainfall from average rainfall. Temperature extremes have a lot of effects on the durability of the pavements. Temperature data is collected from various sources to analyse the annual temperature, monsoon temperature and summer temperatures. Fig 2 shows the graph plotted to show the trend of annual rainfall. Fig 3 shows the graph plotted to show the trend of annual temperature.

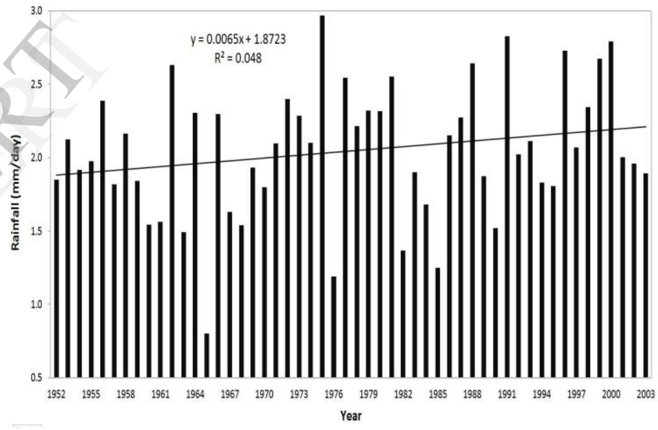

Fig. 2 Graph to show annual rainfall trend

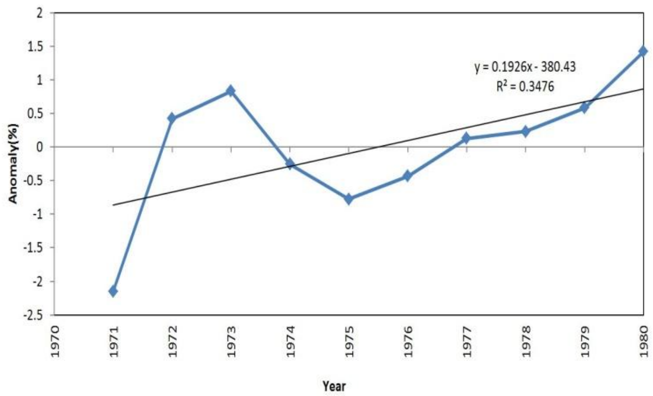

Fig. 3 Graph to show annual temperature trend

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VI CONCLUSION

The main distresses identified in the rural roads are Rutting, Edge drop, Cracking and Roughness. Ravelling was found to be absent on the selected sections. A few numbers of potholes are observed on some places of the road sections due to poor drainage and construction quality. MERLIN roughness is converted into International Roughness Index in m/km. For earth, gravel, surface dressed & asphaltic concrete roads, the IRI value is minimum 2.4 to maximum 15.9. Stretches A2 & A5 is showing roughness more than higher range. Performance parameters such as drainage rating, edge drop, rut depth, roughness and cracking have been taken in the study, which mainly depends upon drainage rating, field dry density of shoulder, pothole area, California Bearing Ratio of shoulder & subgrade, edge drop, commercial vehicle per day, rainfall, surface cracking, roughness, longitudinal depression and subgrade moisture content. Validation of performance equations has also been done for collected data which gives the validity of equations. The Performance equations developed for different distress types will be used in Pavement Maintenance Management System which will be helpful in prioritization of maintenance works.

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REFERENCES

1. Al-Suleiman (obedient) and Azm. S Al-Homound “A Model for Effect of Pavement Characteristics on Pavement Condition”, Journal of Indian Roads Congress, Vol. 57-1. September 1996.
2. Zi-Ping Chiang “The Study of Pavement Performance Index and Smoothness Prediction Model for Highway in Taiwan” (2000).
3. Prof. S.S. Jain, Dr. M. Parida and D. T. Thube “Optimal Strategies for Maintenance of Rural Roads in Uttaranchal” IRC International Seminar on Innovations in Construction and Maintenance of Flexible Pavements. Agra, 2-4, Sept. 2006, Pages 4-45 to 4-56.
4. R. Venkateswara Rao, C.S.R.K. Prasad “Performance Based Rural Roads Maintenance” IRC International Seminar on Innovations in Construction and Maintenance of Flexible Pavements. Agra, 2-4, sept.2006.
5. The MERLIN Low-cost Road Roughness Measuring Machine, Overseas Unit of the Transport and Road Research Laboratory, UK.