Integrating Climate Impact into Road Maintenance Planning in Developing Countries

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Abstract

Recently, there has been an increased frequency and intensity of extreme climate events such as flooding and landslides and this has significantly increased the vulnerability of road infrastructures to potential climate events. In practice, the measures to mitigate climate change need to be put prior to major events to yield maximum benefit. However, there is a lack of studies that incorporate climate impact into road maintenance and rehabilitation programs. This study addresses the urgent need to integrate the impact of climate change into road maintenance and rehabilitation programs to enhance the resilience of road infrastructures using a genetic algorithm (GA) based optimization approach. The approach involves developing a climate risk index (CRI) considering the criticality of the road, the probability of occurrence of a climate event, and the existing severity level of the pavement. Criticality level is defined by road functional class, availability of alternative routes and land use. Probability is determined by historical data and topography, while severity is defined by existing pavement conditions. The CRI is then incorporated as a generic constraint in the GA-based optimization model, which aims to maximize the average network condition under a given budget. The input data used in the optimization model includes road network data, calculated CRI values, existing roughness value measured in International Roughness Index (IRI), cost of adopted maintenance strategies. Moreover, three generic constraints deployed in the study namely CRI threshold value, rehabilitation threshold value and annual maintenance which limited to once in a year. Finally, the outputs generated in terms of a maintenance report and a cost report. The GA based system to optimize the proposed framework of climate impact was developed using Analytical Solver platform. A case study in Sri Lanka, involving a road network of 326.53 km, including class A and class B roads, demonstrates the effectiveness of the approach. The existing average network IRI value was 7 m/km while having 6 m/km for priority road's IRI. The GA model run with the optimum GA parameter which was found from several trials as; constraint convergence of 0.001, mutation rate of 0.8, population size of 100, random seed generation of 10 and the maximum iterations of 300. There are three maintenance strategies adopted in the case study such as routine maintenance, periodic maintenance and rehabilitation. The results shown that, the objective function versus budget plot depicts the decrease in IRI after raising the budget to select a maintenance plan. The total required budget was found as Rs. 2500 million to apply rehabilitation for all roads. The model results shown that in 25% and 50% of total budget conditions there is a clear separation between priority roads' IRI and non-priority roads' IRI due to the imposed generic constraint. This is an indication that the optimization model effectively prioritizes roads, particularly when there is a budget constraint. This concludes that the proposed approach can be utilized to make the most of the available budget for road maintenance by prioritizing highly vulnerable roads for climate events without compromising the overall network condition. Further, the proposed maintenance optimization approach can be extended to long term maintenance planning in an economical way especially for developing countries. At the initial maintenance stage, priority roads can be selected for maintenance by capping non-

priority road’s condition by utilizing available funds. Later, non-priority roads can be selected to maintenance program accordingly to available future funds.

Keywords: *Pavement management, Climate impact, Genetic algorithm, Optimization, International roughness index*

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