Functional and Structural Evaluation of Urban Road Sections in Rajkot City

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ABSTRACT **- Urban pavement sections are generally prioritized without taking pavement maintenance as a priority which leads to ineffectiveness in the cost of maintenance works. To achieve best results for the maintenance work parameters like Pavement Serviceability Rating (PSR), Road Class, Road Quality, Traffic Volume & Structural Adequacy are considered. Total five arterial sections for the 6 km length of stretch in both ways were considered. Parameters were functionally and structurally evaluated. The questionnaire has been prepared for the pairwise comparison of identified parameters and the weightage will be calculated using Expert Choice using AHP technique. A final priority index will be calculated and all sections will be ranked based on this index for maintenance prioritization.**

INTRODUCTION

Road Maintenance is one of the important components of the entire road system. The maintenance operations involve the assessment of road condition, diagnosis of the problem and adopting the most appropriate maintenance steps. Even if the highways are well designed and constructed, they may require maintenance; the extent which will depend on several factors including the pavement type. Various types of failures in pavements ranging from minor and localized failure to major and general failures do take place.

Pavement Maintenance is the preservation, repair and restoration of both the paved surface and the base of foundation. Roadway surfaces should be true to type, cross-section, alignment and grade, as originally constructed or subsequently reconstructed, or resurfaced in order to provide the highway user with a safe, convenient and smooth riding surfaces at all times.

LITERATURE REVIEW

1. Priority analysis is a multi-criteria process that determines the best ranking list of candidate sections for maintenance based on several factors. In this paper, two methods for priority ranking of road maintenance, viz. (a) ranking based on subjective rating and (b) ranking based on economic indicator are evaluated. The subjective ranking was done using maintenance priority index which is a function of road condition index, traffic volume factor, special factor and drainage factor. The second ranking method was based on economic indicator in which NPV/Cost ratio was calculated for each pavement section using the HDM-4 software.

The prioritization methods can be further divided as ranking methods, optimization methods, Artificial Intelligence Technique and Analytical Hierarchy Process method. In this paper first the study area was identified, then various field surveys were carried out in which inventory data, crust data and cost data are collected. After that traffic volume count, structural analysis by Benkelman beam deflection method and functional evaluation by fifth wheel bump integrator are carried out. From the evaluation, priority ranking by MPI method was done. Urgency Index (UI) was carried out by multiplying degree and extent. Weights were then analyzed to the assigned distresses. From the above analysis, Road Condition Index (RCI), Traffic Volume Factor (TVF), Special Factor (SF), Drainage Factor (DF) were carried out.

From the determination of MPI values, prioritization ranking using the HDM-4 software was done. HDM-4 application modules were prepared from which input parameters were collected and the HDM-4 model was adopted to the Indian conditions. After that further analysis and comparison of HDM-4 and MPI ranking method were done. From the above analysis it was concluded the complexity is added to the calculations in complex network optimization models as a prioritization methods. Ranking based methods requires less data than other methods. The main aim of this paper was to build knowledge about pavement maintenance prioritization methods.

2. The analytic hierarchy process (AHP) is a structured technique for dealing with complex decisions that was developed by Thomas L. Saaty in the 1980 year. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. The base of this model is comparing variables by pair wise by Matrix relationship. In this way, pair wise of the effective variables on the concrete Pavement were considered and based on relative weights the output was extent. In the present research, combination of Indexing system Method with Analytical Hierarchy Process has been applied to assess the prioritize of concrete Pavement. By this process, classification and qualification of the numerous types of concrete Pavement would be accessible The findings of the research show that the Continuous Reinforced Concrete Pavement (CRCP) with (0/051) point promotes in first rank among 4 studied Pavements and thus it is the most appropriate Pavement, in

contrast Jointed Plain Concrete Pavement (JPCP) with (0/15) point goes down to the last rank. Prestressed Concrete Pavement (PCP) and Jointed Reinforced Concrete Pavement (JRCP) with (0/015,0/017) points are located in next ranks.

3. For road pavement maintenance and repairs prioritization, a multiattribute approach that compares fuzzy Analytical Hierarchy Process (AHP) and fuzzy Technique for Order Preference by Ideal Situation (TOPSIS) is evaluated. The pavement distress data was collected through empirical condition surveys and rating by pavement experts. In comparison to the crisp AHP, the fuzzy AHP and fuzzy TOPSIS pair wise comparison techniques are considered to be more suitable for the subjective analysis of the pavement conditions for automated maintenance prioritization. From the case study results, four pavement maintenance objectives were determined as road safety, pavement surface preservation, road operational status and standards and road aesthetics, with corresponding depreciating significance weights of [W = 0.37, 0.31, 0.22, 0.10]T. The top three maintenance functions were identified as Thin Hot Mix Asphalt (HMA) overlays, resurfacing and slurry seals, which were as a result of pavement cracking, potholes, raveling and patching, while the bottom three cape seal, micro surfacing and fog seal. The two methods gave nearly the same prioritization ranking. In general, the fuzzy AHP approach tended to overestimate the maintenance prioritization ranking as compared to the fuzzy TOPSIS.

From this paper it was concluded that Fog seal, Micro surfacing, Slurry seal, Cape seal, Chip seal, Thin HMA overlay and resurfacing. Fuzzy TOPSIS perform slightly better than fuzzy AHP. Also fuzzy AHP tend to overestimate prioritization ranking process.

4. One of the innovative approach for maintaining and rehabilitating the highways is to develop and implement simple pavement maintenance management system (PMMS). A simple priority ranking module that provides a systematic procedure to prioritize road pavement sections for improvement and selection of suitable maintenance strategies depending upon the budget is developed. The priority ranking methodology is based on priority index concept, which makes use of overall distress index model and traffic adjustment factors. It involves a process of acquisition of expert opinion through a series of questionnaires and the derivation of weighted average condition measures. Important aspects of the methodology are discussed and the index calculation technique is demonstrated. In the priority ranking module, pavements in a given jurisdiction are prioritized based on an overall pavement performance index derived from a combination of pavement surface distresses, traffic information and expert opinion. The proposed approach has demonstrated its reliability and ease of use in the example application.

5. Pavement deterioration is a complex process. It involves not only structural fatigue but also many functional distresses of pavement. It results from the interaction between traffic, climate, material and time. Deterioration is the term used to represent the change in pavement performance overtime. The ability of the road to satisfy the demands of traffic and environment over its design life is referred to as performance. Due to the great complexity of the road deterioration process, performance models are the best approximate predictors of expected conditions. In this study main distresses were identified from the selected road stretches. Regression models are then developed using SPSS (Statistical packages for social sciences) package. T test is used to check the reliability of the model.

The study involves Data collection, structural and functional evaluation, condition and roughness surveys, Analysis like modified structural number evaluation, Riding Comfort Index evaluation, Regression models, deflection, Pothole progression, roughness progression and validation of these models. Also it was concluded that SPSS values were nearer to observed values.

6. Prioritizing competing transport infrastructure investment schemes is an essential pre-requisite at all levels of transport decision making. All countries face the basic economic problem of allocating scarce resources among competing uses in a way that maximizes the social welfare. Therefore it is very essential to prioritise the projects to ensure that resources are focused appropriately. This paper introduce a Multi Criteria prioritization model based on novel set of factors like Growth Centers, Road Utilization, Connectivity, Accessibility, Backwardness and the amount of Commercial Vehicles using the road, to identify the roads to be improved which will result in socio-economic growth of the entire region. The weight of each factors in Composite Index calculation have been formulated using Analytical Hierarchy Process (AHP). Further this prioritization model has been used for prioritizing 20 Major District Roads (MDRs) in the state of Kerala, India. In this paper composite index were found out.

7. A primary purpose of a pavement management system (PMS) is to provide information so that roadway improvements can be priority ranked. Ideally, prioritization is a consistent and justifiable process. It should involve minimizing life cycle costs subject to minimum levels of serviceability and budget constraints. Prioritization is a complicated process that requires sound engineering judgment and a good understanding of local conditions. Current fiscal crises and rising roadway improvement costs have made prioritization decisions more important than ever. Priority analysis is a systematic process that determines the best ranking list of candidate sections for maintenance based on specific criteria such as pavement condition, traffic level, pavement functions, etc. Various methods are used for priority analysis ranging from simple listing based on engineering judgment to true optimization based on mathematical formulations. This paper examines theoretical and pragmatic problems surrounding the prioritization process. This study report a detailed review of various prioritization techniques and models developed for flexible pavements at global level. This will help in evaluating the usefulness of the various models in some particular condition having the similar prioritization parameters. A discussion on the limitations of the different models is also given in this study.

AHP is the best method from the above discussions to prioritize the pavement maintenance. Priority index for the parameters is essential for the assessment of the distresses and conditions of the sections undertaken. Also functional and structural condition surveys are necessary and for the assessment of the reliability of surveys, expert choice software for AHP is necessary.

STUDY AREA

THE INVENTORY DETAILS OF SELECTED STUDY AREA

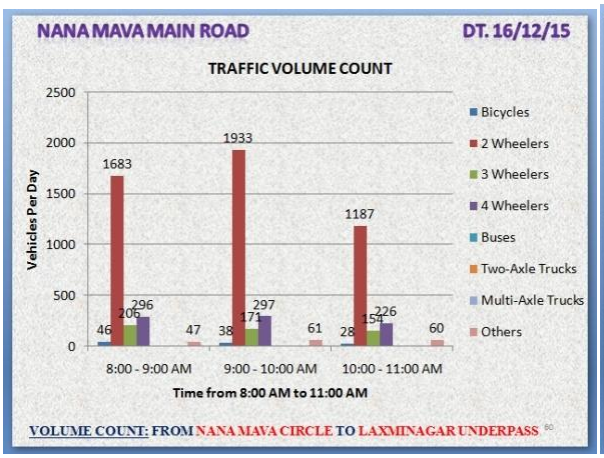
Sr. No.	Name of Section	Starting Point	Ending Point	Length	Carriageway Width	Median Width	Shoulder Width	Footpath Width
1	Nana Mava Main Road	Nana Mava Circle	Laxminagar Underpass	1 Km	7	0.7	2	2
2	Nana Mava Main Road	Laxminagar Underpass	Nana Mava Circle	1 Km	7	0.7	2.8	2
3	Raiya Road	Raiya Circle	Kishanpara Circle	1 Km	10.7	0.9	N/a	1.3
4	Raiya Road	Kishanpara Circle	Raiya Circle	1 Km	11	0.9	N/a	3.3
5	Dr. Yagnik Road	Jilla Panchayat Circle	Ramakrishna Ashram	1 Km	6.2	0.4	N/a	1.3
6	Dr. Yagnik Road	Jilla Panchayat Circle	Ramakrishna Ashram	1 Km	6.2	0.4	N/a	1.3
N/a – Not Applicable								

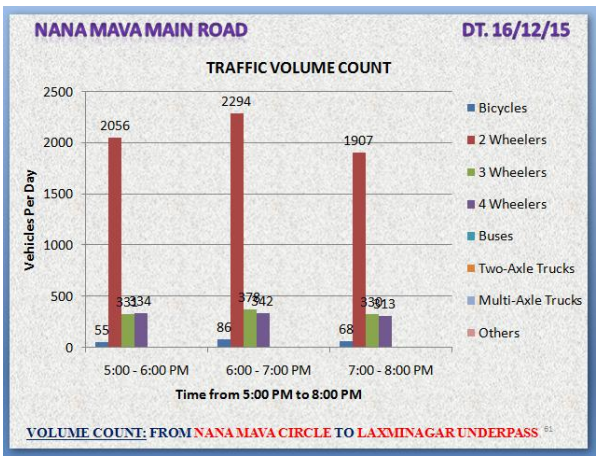
All roads are arterial with flexible road surface and paved shoulder each carrying 4-lanes and pedestrian footpaths. There is no availability of side drains.

The details of study area includes the name of the section, starting and ending points of selected stretch, number of lanes, distance, road category, width of carriageway of road and median, surface of road, availability of shoulder and their types, shoulder width, footpath width if footpaths are available and other cross section details.

TRAFFIC VOLUME COUNT

To count the traffic volume for the selected stretches traffic volume count surveys were carried out on each stretches for each direction of traffic from starting point towards the ending point and vice versa. The traffic volume count is represented as vehicles per day. Traffic composition of the roads undertaken for surveys considers all types of traffic vehicles including motorized and non-motorized traffic. Motorized traffic consists of two wheelers, four wheelers, Buses, Two-axle and multi-axle trucks while a non-motorized vehicle consist of Bicycles and three wheelers. Surveys were carried out for peak hours from 8:00 AM to 11:00 AM and from 5:00 PM to 8:00 PM. The volume was noted by counting the number of vehicles passing through the road section at every 15 minutes intervals by manual counting as well as mechanical counters.





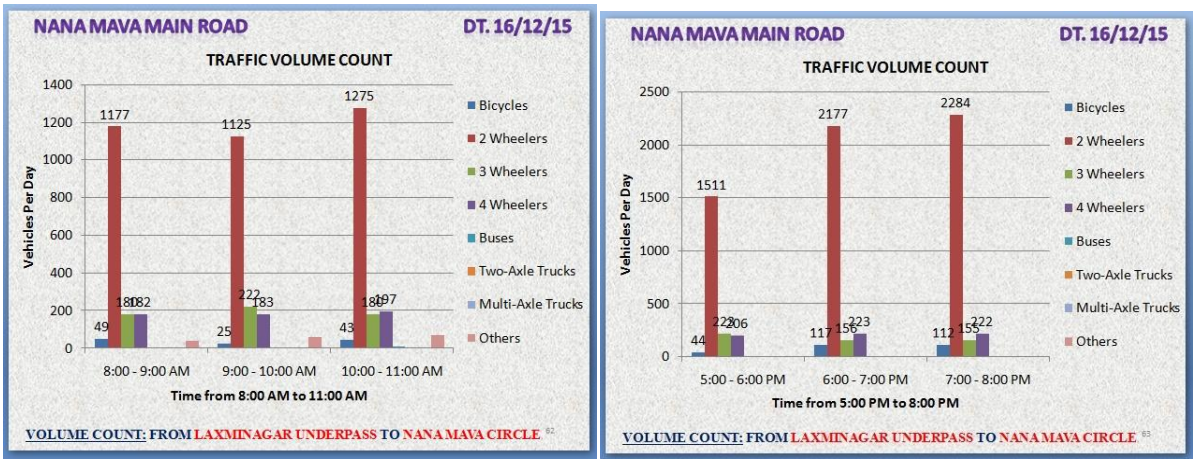


Fig. 4.2.1 Nana Mava Main Road traffic volume

Fig. 4.2.2 Raiya Road traffic volume

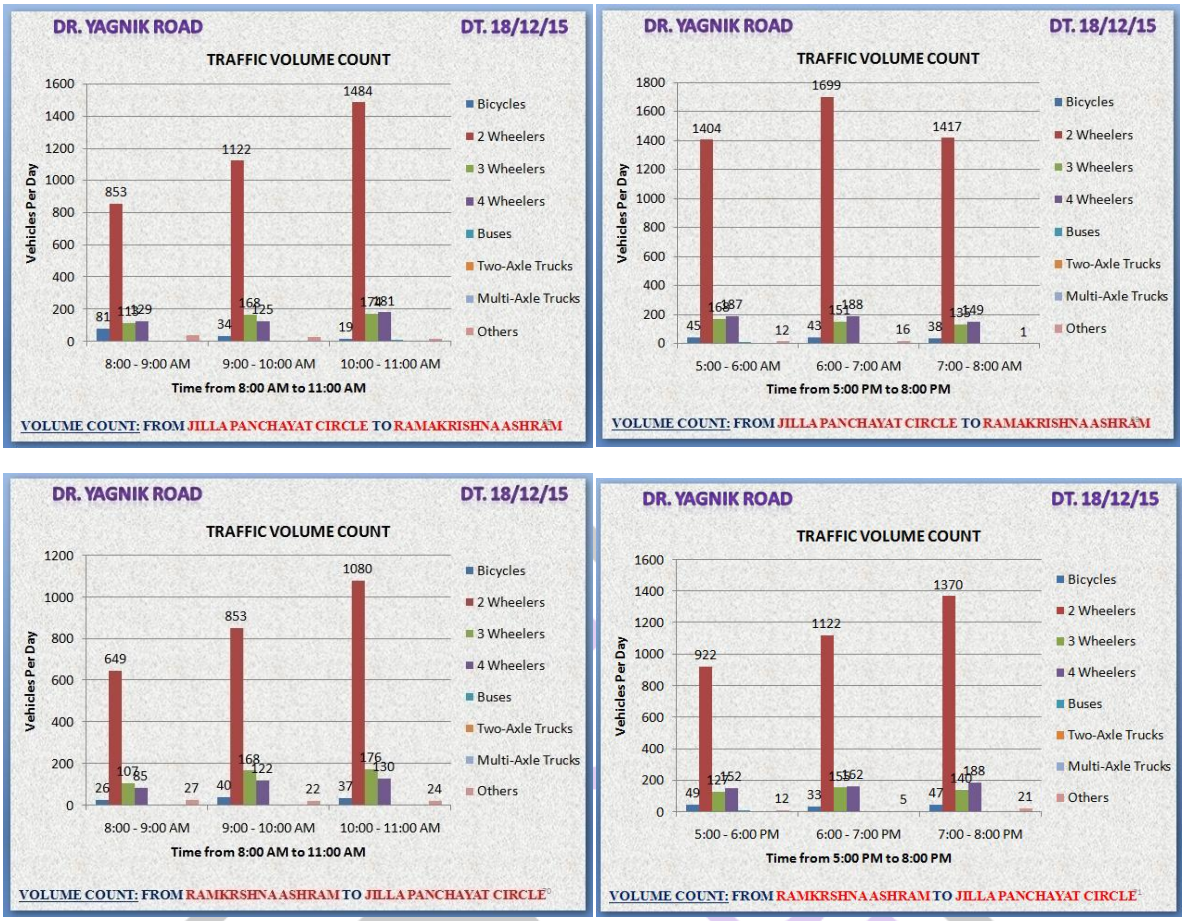


Fig. 4.2.3 Yagnik Road traffic volume

CONDITION SURVEY

Functional Condition Data would be collected by walk survey associated with actual measurements. The length and width of each section of roads are measured with tape. Also Pavement Serviceability Rating was considered in which experts associated for survey were selected. Three experts gave the ratings for the section based on the visual inspection of the road sections considering the distress conditions. The rating was done on scale of 0-5, 0 indicating very poor and 5 indicating very good condition of pavement section as below:

Sections	Direction	Rater 1	Rater 2	Rater 3	Avg. Rating	Road Condition
Nana Mava Main Road	Upside	4	3	4	3.67	Good
	Downside	4	4	4	4.00	Very Good
Raiya Road	Upside	3	4	3	3.33	Good
	Downside	4	4	3	3.67	Good
Yagnik Road	Upside	2	2	3	2.33	Fair
	Downside	3	2	3	2.67	Fair

ROUGHNESS SURVEY

For the riding quality of pavement, roughness or unevenness is considered and it is measured by bump integrator which is most commonly used road roughness measurement device. The readings by bump integrator shown at Nana Mava Main Road were 760mm/km at up side and 970mm/km at down side. The readings at Raiya Road were 840mm/km at upside and 1180mm/km at downside. And the readings at Yagnik Road were 630mm/km at upside and 650mm/km at downside. The above readings taken on urban roads have shown that all the roads are below 2000mm/km so they have good riding

quality as per the Guidelines for maintenance management of primary, secondary and urban roads, 2004

STRUCTURAL CONDITION

For measuring the structural condition of road, Benkelman Beam Deflection Method which is used to measure rebound deflection of pavement would be used. It is most commonly used instrument which is simple and cheap.

Rebound Deflections were evaluated as per the guidelines given in the IRC 81 – 1997 for measuring the results and carrying the survey for measuring deflections. Characteristic Deflection based on the statistical analysis of actual deflections are calculated as per the IRC 81 -1997 guidelines.

The result obtained from the Benkelman Beam survey had been shown in the table below. It shows the characteristic deflection of the pavement on given sections in both directions.

Deflection values of road sections

Characteristic Deflection Values (Dc)	
Section	Deflection
Nana Mava Circle to Nana Mava Underpass	0.273mm
Nana Mava Underpass to Nana Mava Circle	0.262mm
Jilla Panchayat Circle to Ramkrishna Mission	0.281mm
Ramkrishna Mission to Jilla Panchayat Circle	0.259mm
Raiya Circle to Kishanpara Circle	0.231mm
Kishanpara Circle to Raiya Circle	0.241mm

CONCLUSION

The results for traffic volume count are 2495 vehicles per hour for section from Nana Mava Circle to Laxminagar Underpass and 2081 vehicles per hour from Laxminagar underpass to Nana Mava Circle. There are 2604 vph from Kishanpara Circle to Raiya Circle and 2890 vph from Raiya Circle to Kishanpara Circle. There are 1710 vph from Jilla Panchayat Circle to Ramkrishna Ashram and 1347 vph from Ramkrishna Ashram to Jilla Panchayat Circle. As the traffic volume ranges between 450 – 4500 so the traffic volume can be termed as medium traffic

The result from Benkelman beam shows the different characteristic deflection of the given sections. The value ranges between 0.1 to 0.2 mm which is considered good. Hence there is no requirement of overlay.

The results from the Bump Integrator Survey for roughness evaluation showed that all the values obtained from survey were less than 2000 mm/km as per the MORTH: Guidelines for maintenance of primary, secondary and urban roads, 2004 so the riding quality can be considered as good for the selected sections of roads.

The results from PSR rating by experts had shown that rating for Nana Mava Main Road were 3.67 for upside direction and it is considered good and 4 for downside direction which shows its very good. The rating for Raiya Road were 3.33 for upside direction and 3.67 for downside direction which were good and also for Yagnik Road ratings were 2.33 on upside direction and 2.67 on downside direction which were considered as Fair.

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