Assessment of Asphalt Road Pavement Rehabilitation and Maintenance Practices: The Case of West Showa Zone in Oromia, Ethiopia

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Abstract. This study mainly aimed at assessing asphalt road pavement rehabilitation and maintenance practices in West Showa Zone with particular reference to the roads from Ambo to Gedo which covers over 64kms. The study aimed at identifying pavement distresses and causes of pavement distresses. According to data collection and analysis, it was found that the material properties and composition (28.1%), construction quality (18.8%), and road maintenance standards (15.6%) were perceived to be the major causes of pavement distresses on the roadway under study. On the other hand, the result of survey condition data obtained from ERA was analyzed and major distresses were identified including longitudinal joint crack, bleeding and tripping, potholes, generalized marked fretting, deformation, subsidence, rutting, patch, wide block crack, isolated scabbing, low shoulder and wheel path rutting. Besides, limited skilled manpower (\(\bar{x}=3.78\)), lack of appropriate pavement management system (\(\bar{x}=3.93\)), budget constraint (\(\bar{x}=4.43\)), absence of appropriate machineries (\(\bar{x}=3.53\)), and lack of monitory and quality control (\(\bar{x}=3.75\)) were among the major challenges related to effective pavement work, road maintenance and rehabilitation practices on the roadway under study.

Keywords: Pavement, Distresses, Rehabilitation, Maintenance, Evaluation.

1. INTRODUCTION
1.1 Background
The road network is a largest infrastructure, the rehabilitation and maintenance of which needs special necessity (Fakhri and Dezfoouli, 2017). As the nationwide highway connection demands keep on to grow, hence ensures the necessity for maintenance and construction practices that will support cover the lifespan of pavements at all levels. Apparently, no pavement is constructed that does not need rehabilitation and maintenance. To understand the which maintenance activity is taken for proper rehabilitation and maintenance of bitumen pavements, it is essential to use details evaluation of pavement to identifying and understanding the causes of failures of pavement.

In a number of developing countries road degrade due to lack of care has turn out to be a growing issue. Due to lack of maintenance the problem was discussed and the outcomes have been well-defined and
calculated. Nevertheless, the solutions are still not regularly understood and the expanse of the problem is not fully appreciated. Similarly, the actions required to correct the deficiencies are under-estimated. These contain the scale of care and capacity growth required, and the time-scale essential for formation an effective road managing system. Such a system would pause road network weakening and safeguard that economic, resources investments are made in a way which preserves the quality and value of the assets and, in calculation, expands the network in relation to the demands and importance of the users (Addis Ababa Project Administration Service, 1984).

Rapid data collection based on subjective decision has been used, because the collection of detailed pavement condition data is enormously costly and time-consuming, furthermore, preservative seal, restorative seal, crack seal, patching, surface milling, base repair, seal coat, full depth reclamation, resurfacing, widening, reconstruction, curb removal and replacement, pavement marking, and replacement, sidewalk removal and grading, mulched seeding, tree trimming (removal), striping and shrill overlay have been considered as activities for rehabilitation and maintenance (Fakhri and Dezfoulian, 2017). After the assessment of pavement surface physical characteristics, GIS software, as a practical tool, was used to display pavement section distress and the result of arrangement. According to Ebeling (2007), for better tracking and choice making when it comes to the users’ needs GIS helps answer questions and solve problems by looking at data in a way that is quickly understood and easily shared the collected data can be presented on a map. In the case of road data, GIS would have extensive pavement data. Additional information may include traffic volume, weather data, political districts, as-built information, population, sign retro reflectivity, and any other data that may have an effect on the road functioning at a high level. The present asphalt road surface condition needed some sophisticated tool to systematically identify pavement distresses which enable stakeholders take remedial action. As a result, the application of Arc GIS software was used, severe pavement distresses were identified and the results were diagrammatically supported.

The following could be mentioned among the local studies conducted which were partially related to asphalt road rehabilitation and maintenance practices. To this end, Temesgen Girmay (2016) studied asphalt road rehabilitation and maintenance management, (Kalid Ali, 2016) undertaken a study on assessing Ethiopia Roads Authority’s (ERA) pavement management system, and finally (Fikir Alebachew, 2005) studied at capital city Addis Ababa arterial roads pavement distresses, maintenance options and causes. All of the studies did not address the application of Arc GIS software in studying asphalt road pavement maintenance and rehabilitation practices. On the other hand, among the international studies on asphalt road pavement maintenance using GIS include researches conducted by Robert J.(2011), Acquah and Fosu (2017) and Fakhri and Dezfoulian (2017). These studies addressed the application of GIS on road maintenance both as a system of prioritization and management approach. Therefore, in this study, effort was made to fill this gap by using Arc GIS as a tool to study asphalt road pavement rehabilitation and maintenance practices in West Showa Zone in Oromia National Regional State.

2. RESEARCH METHODOLOGY
The research methodology section of the study highlights on research design employed to guide the study, description of the study area, study period, sample size, and sampling technique, tools for data collection, data collection procedures, data processing and analysis, data quality assurance and ethical issues.
2.1. Study area
West Showa Zone is situated in the west portion of Addis Ababa, the Ethiopia capital city. It is one of the twenty zones in Oromia National Regional state and runs from Holeta to Bako which covers a distance of about 254 kms including the distance between Holeta and Mugher asphalt road. The study area can be depicted in Fig. 1. The map is adapted and taken from ECDSWC: Transport Design and Supervision Works Sector (2016).

![Fig. 1. Study area](image)

2.2. Research design
This research employed descriptive survey design. So, this study was guided by mixed methods research which involves both quantitative and qualitative data to attain the specific aims of this study. Quantitative data was collected by using questionnaire (close-ended and open-ended), whereas qualitative data was collected through field observation.

2.3. Study period
This study took almost one year starting from the inception up to the completion of the final research report. Accordingly, it was begun in the late October, 2019 and completed in the early of November, 2020.

2.4. Sampling technique and sample size
Since the total study population was small in number, the researcher took all the available participants (i.e., the total population) as a sample. The participants were composed of professionals who were working as clients, in contracting companies and consultant offices to fill the questionnaires. Hence, 6 clients (Regional and Federal Roads Authorities), 18 contractors, and 8 consultants were taken as participants in the study.

3. DATA COLLECTION AND ANALYSIS

In this research Primary data has been collected from clients, contracting companies and consultant offices by using questionnaire. Similarly, field observation was used to collect visual condition data on the construction area which would help to make proper evaluation of the pavement surface. Finally, secondary data source (i.e., ERA document) was used to obtain information archived during the maintenance processes in the roadway under study. In order to collect pertinent data for the study, three key instruments were used.
3.1. Questionnaire
In current study Questionnaire was the primary data collecting instrument employed. With the help of questionnaire collection for survey data, providing organized, often mathematical data, being able to be managed without the presence of the investigator, and frequently being moderately straightforward to investigate (Wilson and McLean 1994, cited in Cohen, Manion and Morrison, 2007:317). The first section was supposed to collect demographic information about respondents. The second section was meant to obtain data about the causes of distresses on the roadway, the third was questions related to pavement rehabilitation and maintenance practices and associated challenges. The final section was supposed to gather data about pavement evaluation and challenges affecting pavement activities. The questionnaire was completed by respondents whose designations were office engineers, project managers, site engineers and surveyors who worked in five different organizations. In connection to this, primarily 36 respondents were planned to complete the questionnaire, but later it was confirmed that 4 members resigned from their respective organizations. So, the final questionnaire (both the close-ended and open-ended questionnaire) data was collected from 32 respondents.

3.2. Field observation
Field observation was used to collect visual condition data on the respective roadway which would help to make proper evaluation of the surface of the pavement. Thus, checklist was prepared (PASER rating scale, University of Wisconsin, 2002) to effectively conduct pavement evaluation. The checklist contained surface rating, visible distresses, general condition and treatment measures taken on the road surface. The ratings ranged from excellent (10) to failed (1). Twenty locations were randomly taken and observation was conducted by the researcher. In doing this, station numbers for each location were recorded, then visible distresses were evaluated and backed by sample photos which were taken on the actual road to illustrate the pavement surface condition.

3.3. ERA document
Since the road connecting Ambo to Gedo was under maintenance by ERA (Ethiopian Roads Authority), the researcher officially consulted ERA authorities to obtain pertinent data. This secondary data consisted of documents such as condition survey data, environment condition and cross section (i.e., both vertical and horizontal alignment) data. More specifically, the document related to condition survey data helped to properly identify and show the pavement distresses/failures and major causes of distresses/failures by using Arc GIS software.

3.4. Data processing and analysis
Quantitative data collected from contactors, consultants and clients through questionnaire was analyzed by using descriptive statistics such as frequency distribution, mean, mode, range, variance and standard deviation. On the other hand, the data collected through field observation was qualitatively analyzed and discussed along with the result obtained from questionnaire analysis as shown in Table 1.
Table 1. Data Evaluation by PASER rating scale (University of Wisconsin, 2002)

| Surface rating | Visible Distress                                                                 | General Condition/Treatment Measures                                      |
|----------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 10-Excellent   | Not Found                                                                        | Newly constructed                                                         |
| 9-Excellent    | Not Found                                                                        | Newly overlay. Like new                                                   |
| 8-very good    | No longitudinal cracks except reflection of paving joints.                        | Newly sealcoat or new cold mix. Slight maintenance required.              |
|                | Rare transverse cracks, frequently spaced (40' or greater)                        |                                                                           |
| 7-Good         | Surface shows nearly traffic wear, very slight or no raveling.                    | First symbols of aging. Maintain with routine crack filling. Structural   |
|                | Due to reflection or paving intersections Longitudinal cracks (open ¼”).          |                                                                           |
|                | Transverse cracks (open ¼”) spaced 10’ or more apart, little or slight crack     |                                                                           |
|                | raveling. No repairing or very few repairs in excellent condition.               |                                                                           |
| 6-Good         | Longitudinal cracks (open ¼”-1/2”) due to reflective cracking Slight raveling     | Shows signs of aging. Sound structural condition. Could extend life with   |
|                | (loss of fines) and traffic wear. Transverse cracks (open ¼”) spaced 10’ or more  | sealcoat.                                                                 |
|                | apart, little or slight crack raveling. Minor to moderate polishing.             |                                                                           |
|                | Extensive to severe flushing or repairing.                                      |                                                                           |
|                | Occasional repairing in good condition.                                          |                                                                           |
| 5-Fair         | Moderate to severe raveling (loss of fine and coarse aggregate).                | External aging. Sound structural condition. Needs sealcoat or thin non-   |
|                | Longitudinal and transverse cracks (open ½”)                                     | structural overlay (less than 2”)                                        |
|                | Shows first signs of slight raveling and secondary cracks.                       |                                                                           |
|                | First signs of longitudinal cracks near pavement edge.                          |                                                                           |
|                | Transverse cracking and first signs of block cracking. Slight                     |                                                                           |
|                | crack raveling (open ½”).                                                        |                                                                           |
|                | Extensive to severe flushing or repairing.                                      |                                                                           |
|                | Some patching or edge wedging in good condition.                                 |                                                                           |
| 4-Fair         | Severe surface raveling.                                                         | Significant aging and first signs of need for strengthening. Would benefit |
|                | Multiple longitudinal and transverse cracking with slight raveling.             | from a structured overlay (2” or more).                                  |
|                | Block cracking (over 25-50% of surface). repairing in fair condition.           |                                                                           |
|                | Slight rutting or distortions (1” deep or less).                                 |                                                                           |
| 3-Poor         | Closely spaced longitudinal and transverse cracks often showing raveling and     | Needs patching and repair to major overlay. Milling and removal of        |
|                | crack erosion. Block cracking over 50% of surface.                               | deterioration extends the life of overlay.                                |
|                | Some alligator cracking (less than 25% of surface). Patches in fair to poor     |                                                                           |
|                | condition. Moderate rutting or distortion (1” or 2” deep).                      |                                                                           |
|                | Occasional potholes.                                                            |                                                                           |
| 2-Very poor    | Alligator cracking (over 25% of surface).                                        | Severe distortion. Needs reconstruction.                                  |
|                | Severe distortions (over 2” deep).                                              | Needs reconstruction with extensive base repair. Pulverization of old      |
|                | Extensive repairing in poor condition.                                           | pavement is effective.                                                   |
|                | Potholes.                                                                        |                                                                           |
| 1-Failed       | Severe distress with extensive loss of surface integrity.                       | Failed. Needs total reconstruction.                                       |
Similarly, the data obtained from ERA document was used both to consolidate the data gathered through questionnaire and field observation. The survey condition data that was obtained from ERA document was fed to Arc GIS application to help show road pavement distresses/failures and indicate the major causes of pavement distresses/failures.

3.5. Data quality assurance
The questionnaire was pre-tested on (accounts 10% from the total sample size) before conducting the definite data collection. In the study pre-test results were not included, but used for reliability of the questionnaire items. The researcher checked the completeness of each questionnaire at the end of every response by the respondents. Finally, with the help of colleague’s completeness of the questionnaire was rechecked.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions
The main aim of this study was to assess asphalt road pavement rehabilitation and maintenance practices in West Showa Zone particularly on the roadway connecting Ambo to Gedo. It further investigated the maintenance activities and made use of Arc GIS software to clearly elucidate the visible pavement distresses. Following are the conclusions:

1. Some of the major distresses identified by Arc GIS application include, longitudinal joint crack, bleeding and tripping, potholes, generalized marked fretting, deformation, subsidence, rutting, patch, wide block crack, isolated scabbing, low shoulder and wheel path rutting.
2. Material properties and composition, construction quality, and road maintenance standards were perceived to be the major causes of pavement distress on the roadway under study.
3. ERA applied quality maintenance and rehabilitation work, used alternative treatment, and good overlay and patching strategy which are adequate to preserve pavement in a better condition and reduce expensive maintenance work.
4. Limited skilled human resource, lack of suitable pavement managing system, budget restriction, non-availability of suitable machines, and lack of quality control and supervision were found to be the most serious challenges related to pavement work, road maintenance and rehabilitation work on the roadway from Ambo to Gedo.
5. The present pavement work and practice by ERA on the roadway between Ambo and Gedo was found to be at a better condition.
6. The pavement surfaces were evaluated with longitudinal and transverse cracks moderate to severe raveling, extensive to severe flushing and polishing with slight rutting or distortions.

4.2. Recommendations
From the conclusions of this study so far, the recommendations have been forwarded for the improvement of the current road maintenance and rehabilitation practice by ERA particularly on the roadways in the West Showa Zone are as follows.

a) In the system of pavement management surveys of pavement condition are very important. Condition surveys inform the management about the actions to be taken to ensure the effective and efficient use of resources. Moreover, it enables the Federal Roads Authorities and other stakeholders to make early intervention which would help to prolong the life and service duration of the asphalt roads.

b) ERA has to give suitable attention to road maintenance works and seek for several fund options to fill the rehabilitation and maintenance practices. The authority has to emphasis on leading
preventive maintenance for pavements before they weaken into poor conditions; this can save a significant amount of pavement maintenance budget.

c) ERA should assess and adopt alternative maintenance strategies and treatment selection techniques to resist scarcity of resources required machine, labor, fund and has to develop its own organizational maintenance approaches for efficient use of available resources.

d) ERA and other stakeholders should hire adequate and skilled man power to carry out the rehabilitation and maintenance work periodically. Moreover, based on the findings, appropriate machineries should be fulfilled to completely carry out the rehabilitation and maintenance activities. On the other hand, the pavement management should take in to account the nature and type of the soil, environmental condition and traffic volume and construct quality pavement that suits the standard of the roadway under study. This reduces early deterioration.

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