

Assessment of Potholes and Accuracy of Selected Method

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Abstract— Road distress like cracks, potholes and settlement of sub-grade is rising due to climatic variations such as heavy rains, cyclic changes in temperature because of global warming and use of conventional method for road construction. India is having a significant concern in this segment. The conventional road surface management systems are becoming impaired in front of traffic density and condition of roads, which is weakening day by day. Compared to previous years in India, the year 2017 has 50% hike in number of road accidents occurring due pothole related issues. Lot of research is been done for repair of potholes but is lacking in its application. It is prominent and essential to develop techniques with rapid pothole detection having significant accuracy and in minimum expense. India is a vast country with more than 55 lacks kilometres of road networks and it is not at all feasible to access pothole damaged roads without a relevant technology. In this study efforts are been taken to implement remote sensing and GIS techniques in rapid pothole detection and their volume calculation. Data collection for case study is done using ODK Collect and analysed in QGIS software for pothole detection; while for cost optimization, volume is been calculated measured depth and calculated area in Auto CAD software. The information extracted by application of remote sensing and GIS will not only ensure the time-saving pothole detection but also can achieve cost optimization through optimum budget estimation of repair materials.

Key words: Potholes, Road Distress

I. INTRODUCTION

Construction of roads have been started from long years ago with use of various methods and materials. We have addressed a remarkable transformation and improvement in techniques of construction of roads accordingly as the time has been passed by. Many researches strive to improve the quality and strength of roads so that it could last longer and stronger without any distress like cracks, settlement of sub-grade and potholes. However, practically it is not possible as type of traffic, its density, climates and many other factors are changing day by day, gradually leading to damages in pavements. Not to mention the importance of maintenance of roads as we have witnessed a number of road accidents due to road surface distress and furthermore the damage faced by vehicles directly affecting the pockets of vehicle owners. According to information reported by police department of all States and Union Territories, total number of road accidents due to potholes for the years 2013, 2014 and 2015 are tabulated below in Table No. 1:

Sr No	Year	Road Accidents due to Potholes
1	2013	9966
2	2014	11,106
3	2015	10,876

Table 1: Total Number of Road Accidents in India

As one type of pavement damage, pothole is defined as a bowl-shaped depression in the pavement surface. A pothole is a structural failure in a road surface, usually asphalt pavement, due to water in the underlying soil structure and traffic passing over the affected area. Water first weakens the underlying soil; traffic then fatigues and breaks the poorly supported asphalt surface in the affected area. Continued traffic action ejects both asphalt and the underlying soil material to create a hole in the pavement.

Potholes form because asphalt surfaces eventually crack under the heat of the day and the constant stresses of traffic also when the pavement or the material beneath the pavement can no longer support the weight of the traffic it carries. there are two common causes of potholes: water and traffic.

The potholes are formed with the following 4 steps:

- 1) Potholes begin after snow or rain seeps into the soil below the road surface.
- 2) The moisture freezes when temperatures cool to freezing at night. The water becomes ice, causing the ground to expand and push the pavement up.
- 3) As temperatures rise, the ground returns to normal level but the pavement often remains raised. This creates a gap between the pavement and the ground below it.
- 4) When vehicles drive over this cavity, the weight of the traffic causes the pavement surface to crack and fall into the hollow space, leading to the birth of another pothole. The first prominent reason for formation of pothole is formation of crack.

II. LITERATURE REVIEW

A. K. Kamal, S. Mathavan, T. Zafar, I. Moazzam, A. Ali, S. Usman Ahmad and M. Rahman (2017)

proposed results of Kinect sensor performance assessment in which 2.8 % and 5.47 % of mean percentage error was found for depth calculation and volumetric calculations respectively, with the help of MATLAB software. Also compared the depth and volume of potholes for various conditions such as potholes with water, mud, etc. and plotted contour of potholes and RGB, depth and mesh plot of a natural pothole.

B. Muae, Z. Jiang, S. Jones, P. Sheinidashtegol, and M. Dzhumaliev (2018)

developed a road map for detected potholes and road damages, using social media (Twitter) and completed the hotspot analysis of potholes using heatmap layers of google maps API to determine hotspot location.

C. H. Yousaf, K. Azhar, F. Murtaza and F. Hussain (2018)

developed objective evaluation criteria for potholes localising action from the detected images of potholes. Moreover, categorised potholes using bag of words (BOW) approach

and classified potholes from images using scale-invariant feature transform (SIFT) feature point.

III. PROBLEM STATEMENT

Potholes are usually caused by the presence of heavy traffic and water on roads. Several studies conducted in cities such as Chandigarh and Mumbai point to the lack of a proper drainage system and weak proportioning of aggregates for road construction as major reasons for pothole formation. It is evident that potholes are such kind of dangerous parameter causing loss of lives that too on large extend.

Supreme court took a note of 3597 deaths due to pothole related road accidents in 2017. Around 50 people were injured when a bus overturned due to a pothole on Delhi- Haridwar national highway (New Indian Express). Moreover, it was observed that the number of road accidental deaths was more than the fatalities caused by terrorist attacks in India.

Therefore, it becomes necessary to ensure the use of standardized methodology and good quality material when constructing roads. There also needs to be regular maintenance and an effective system to ensure accountability. There is a need to incorporate the Safe System Approach in all aspects of road design, engineering and construction. Significantly potholes need to be repaired in less time as well as with long life solution and optimum cost.

IV. OBJECTIVES

The basic objective of this research is to study and analyse the assessment of potholes using techniques relied upon remote sensing and GIS, which gives maximum useful output in less time compared to traditional methods. Objectives of this study are broadly defined as,

- To study the use of ODK Collect mobile application for depth recording and other data collection.
- To study detection of potholes by geo-tagging them in QGIS Software.
- To calculate volume of pothole using Auto CAD software and measured depth.
- To test the accuracy of the selected method
- To suggest the filler material.

V. RESEARCH METHODOLOGY

Potholes are most annoying and frustrating form of road distress. As we know that potholes occur in irregular shapes and sizes hence, volume of filler material required to repair the pothole cannot be determine by visual inspection or any definite measuring equipment. This chapter gives brief information about the methodology opted for research work. The methodology for finding solution of above-mentioned problem is integrated in following points:

- Case Study
- Geo-Tagging of Potholes
- Volume calculations

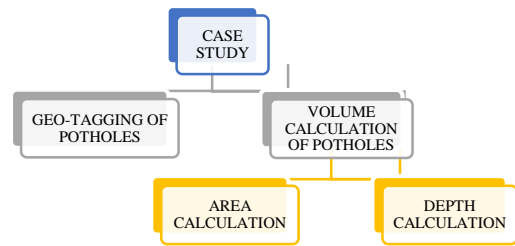


Fig. 1: Research Methodology

A. CASE STUDY

The road length of **5.6 km** is selected for case study, local street name: **Kharadi Bypass Road** which is present at periphery of air force station in Lohegaon, Pune.



Fig. 2: Case Study

During the onsite visit of 5.6km stretch road length study found out that 70 numbers of noticeable potholes were present. Pictures of each pothole were taken using Android Smartphone with GPS feature turned on for the global positioning coordinates capturing with photographs.

B. GEO-TAGGING OF POTHOLES

There are various methods for detection of potholes but majority of them are time consuming and tedious. For large data area survey, it is very difficult to access the whole area in limited time. QGIS software is used for detection of potholes which relies on the techniques of remote sensing and GIS.

Furthermore, the potholes identified in the case study were Geotagged by using QGIS software to obtain a location map of potholes. At first the photographs were taken in Smartphone (GPS feature is to be kept ON while taking photograph and the measuring scale should be kept aside the pothole for area calculations in AutoCAD software). These photographs were uploaded to QGIS software using “import photo” plugin, which were further analysed to get visual map of selected terrain showing the photographs of potholes with their Latitudes & Longitudes, which shows the present condition of road pavement under the study area.

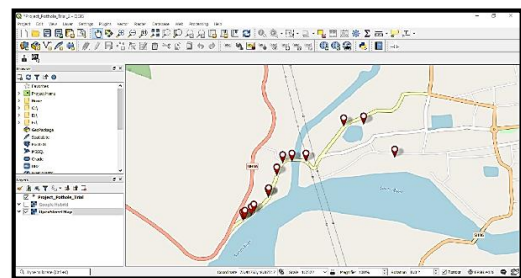


Fig. 3: Geo-Tagged Pothole in QGIS

C. VOLUME CALCULATION

After the Geotagging of all potholes in the study road stretch, the main issue to be tackled is volume calculations for filler material, which is done in two parts, Area Calculation & Depth Calculation

1) AREA CALCULATION

There are various methods for calculating the area of pothole like using MATLAB software and sensors like Kinect sensor which uses infrared waves to calculate area and depth of pothole instantly but these methods are very expensive and require expert level handling so we have selected area calculation using AutoCAD which is relatively easy and inexpensive method but is time consuming.

The area calculation for the pothole was performed using AUTOCAD software. Those pictures of potholes taken with measuring scale kept aside during the Geotagging of potholes were then imported in the AUTOCAD software using "IM" command, then the area for the captured pothole was calculated by plotting edge using "polyline" command and by scale referencing feature in AUTOCAD scale is adjusted and area is calculated using "area" command. This area is the recorded for further processing.

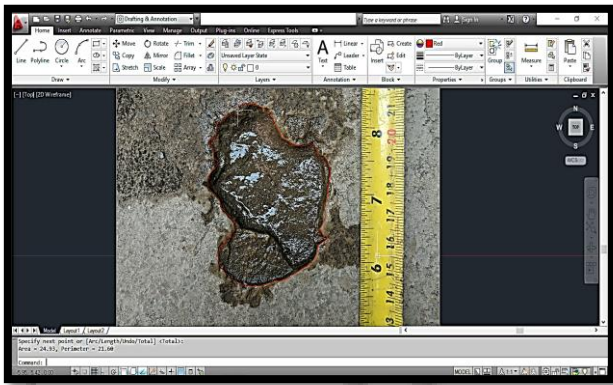


Fig. 4: Area Calculated in AutoCAD

2) Depth calculation

Data collection by using surveying instrument is too complicated. By using ODK Unskilled person can also handle easily and accurate results are obtained. Climatic condition doesn't affect the survey work when ODK is been used. It also reduces the total cost of the project and requires less time for completion of the survey. Data collection i.e. recording of depths and images of potholes occurring on 5.6 km route is done for this research work

Average depth of each pothole was found for volume calculation of filler material. Depth calculations were done manually at each pothole by taking average of 5 reading of depth at various points in pothole and recorded the same in the ODK application which further gives the summarized data of all pothole depths collected in the study in required formats.

VI. DISCUSSION

On combining all the calculated data of potholes, collected from respective methods i.e.

- Depth readings of pothole (in cm) from ODK mobile application.
- Calculated area of pothole (in cm²) from AutoCAD software.

We can calculate the volume of pothole i.e. volume of material required to fill pothole by following calculations:
 $Volume = Average\ depth\ of\ pothole \times Area\ of\ pothole$

Thus, by calculating volume of all detected potholes from the case study we get,

- Estimate of the total amount of filler material required for the repair of potholes.
- This estimate can optimize the filler material cost necessary for fixing the pothole.
- It saves the wastage material cost.

It achieves economy in maintenance and repair of potholes. Now after collecting all the information about the potholes in the study area, the exact quantity required for filler material and geographical position of each pothole is known. The repair process can be planned and put in the action effectively with minimum wastage of filling material & labour time.

A. Accuracy of Test

A random pothole was selected. Volume calculation was done by above methodologies. To measure the actual volume, sheet of gelatine was laid on the pothole then filled with water up to level surface. The volume of water was measured and compared with calculated volume. Volume of water was measured as 6960 cm³

Depth 1	2.6
Depth 2	2.9
Depth 3	2.5
Depth 4	3.0
Depth 5	3.9
Average Depth	2.98
Area	2069.1
Volume Calculated	6565.98
Volume Measured	6960.29

Table no. 2 Volume Comparison

$$Accuracy\ \% = (Volume\ Calculated / Volume\ Measured) * 100$$

$$= (6565.98 / 6960.29) * 100$$

$$= 94.33\%$$



Fig. 5: Volume Measurement by Using Water

VII. CONCLUSION

Due to heavy traffic and presence of water on road potholes are formed. Various studies show that improper drainage system and poor mixing of aggregates for construction of road are major reasons for formation of potholes causing loss of life on large extent. Many deaths occurred in road accident were due to presence of pothole on road.

This study tried to come up with a method to detect pothole and to determine how much material is required to fill those potholes. There are various advance methods of pothole detection using high cost sensors and heavy machines so there is a need to find a method which does not require any of those costly sensors so this study tried a approach which is not only relatively easy but also cost effective as no need of costly sensors or software is needed.

Due to this approach pothole detection and road repairs and their maintenance becomes easy and thus many lives are saved from accidents due to pothole, and overall road quality is increased.

REFERENCES

- [1] S. Mane, S. N. Gujarathi, S. S. Arkatkar, A. K. Sarkar, A. P. Singh, "Methodology For Pavement Condition Assessment And Maintenance Of Rural Roads," in Proc.IIT Roorkee National Conf. FYPMGSY., 2016, pp. 1-14
- [2] Mohd Sohel Deshmukh, Swapnil R.Rajput, "Smartphone Based Citizen Complaint System For Urban Maintenance Using GIS," IJSER, vol.7, no.5, pp. 1591-1599, 2016.
- [3] K. Kamal, S. Mathavan, T. Zafar, I. Moazzam, A. Ali, S. Usman Ahmad & M. Rahman, "Performance assessment of Kinect as a sensor for pothole imaging and metrology," Taylor & Francis International Journal of Pavement engineering., pp. 1-12, 2016.
- [4] Musaeov, Z. Jiang, S. Jones, P. Sheinidashtegol & M. Dzhumaliev, "Detection of Damage and Failure Events of Road Infrastructure Using Social Media," Springer International Publishing AG, part of Springer Nature., pp 134-148. 2018.
- [5] P Wang, Y Hu, Y. Dai & M. Tian, "Asphalt Pavement Pothole Detection and Segmentation Based on Wavelet Energy Field," Hindawi Mathematical Problems in Engineering., vol. 2017, pp 1-13, 2017.
- [6] K. De Zoysa, C. Keppitiyagama, G. P. Seneviratne, and W.W.A.T. Shihan, "A public transport system based sensor network for road surface condition monitoring," In Proc. Workshop, Networked Systems for Developing Regions, 2007, pp. 1-6.
- [7] Mednis, G. Strazdins, R. Zviedris, G. Kanonirs, and L. Selavo, "Real time pothole detection using Android smartphones with accelerometers," in Proc. Int. Conf., Distributed Computing in Sensor Systems and Workshops., 2001, pp. 1-6.
- [8] Buza, E., S. Omanovic, and A. Huseinnovic, "Stereo vision techniques in the road pavement evaluation," in Proc. 2nd Int. Conf., Information Technology and Computer Networks., 2013, pp. 48-53.
- [9] Yadav, H. Shinde, S. Sude, P. Shinde, "Assessment of Pothole Using QGIS & AutoCAD Software," International Research Journal of Engineering and Technology, vol 6, issue 4, no. 575, pp 2701-2704.