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TOMOGRAPHIC IMAGE BASED PAVEMENT CONDITION ASSESSMENT USING MACHINE LEARNING APPROACH.

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Abstract:

Tomography is a new nondestructive concrete pavement diagnostic tool that may be utilized for better quality assurance and control during construction as well as to aid in rehabilitation decision-making. Pavement condition evaluation gives data that may be used to economical judgments about its maintenance. Surveys are carried out with the help of high-end vehicles or on-the-ground processes to calculate distress on pavement. As this system is man-dependent, it tends to be dangerous, less efficient and costly. Photos of road to be used for determining distress is yet a challenge to be solved. Researchers have been able to construct strong techniques for evaluating pavement tomographic pictures with remarkable accuracies because to recent advances in machine learning. Machine learning algorithms, on the other hand, require a large ground truth dataset, which is typically unavailable in the pavement field. Pictures from the Mumbai-Pune highway and Dehu road were manually removed and tagged for categorization, resulting in a large number of Google street-view images. The model was then trained using the labelled dataset of Indian roads using the YOLO (you only look once) machine learning framework. The model is used in this study to

categorize the distresses and estimate their intensity at the same time. Indicators for determining pavement conditions are created for distress categorization segmentation and distress densification utilizing the YOLO machine learning framework using machine learning techniques. These outcomes are used to create a complete tool for pavement monitoring that assigns a score to each pavement Tomographic picture based on the kind and intensity of the distressed part. Thus, human intervention is restricted. This study might be useful in evaluating pavement conditions over time and assisting in making informed judgments for road restoration or rebuilding at the appropriate time.

Keywork: Tomographic images, Pavement condition, Machine learning, YOLO, accuracy index.

1. Introduction

In the construction sector, quality may endeavor to meet different consumer expectations despite shifting dynamics [1]. As the consumers become conscious regarding the quality, the construction firms are aggressively seeking to adopt high quality to ensure long-term viability [2]. Quality assurance (QA) is used along with total quality management (TQM) in construction business for quality management systems (QMS) according to Lau and Tang [3]. TQM is a culture that prioritizes customer satisfaction above constant improvement and innovation across the whole company process [4]. TQM make it possible to improve the satisfaction levels of the customer, enhances productivity and quality and healthy environment for competition according to Jaeger and Adair [5].

The building sector has long struggled to achieve acceptable quality standards. Each year, lot of resources are wasted due to lack of good quality management methods. TQM ideas, originally employed in Japan and more recently in the USA, have improved productivity, reduced the cost, and improved dependability in the manufacturing business. These ideas may be used to the building business as well. During the 1970s, for example,

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Japanese construction businesses began applying TQM, based on the experiences of Japanese manufacturers. Despite the fact that building is a creative, once-in-a-lifetime activity, the Japanese construction sector adopted TQM ideals that some believed were only applicable to mass manufacturing.

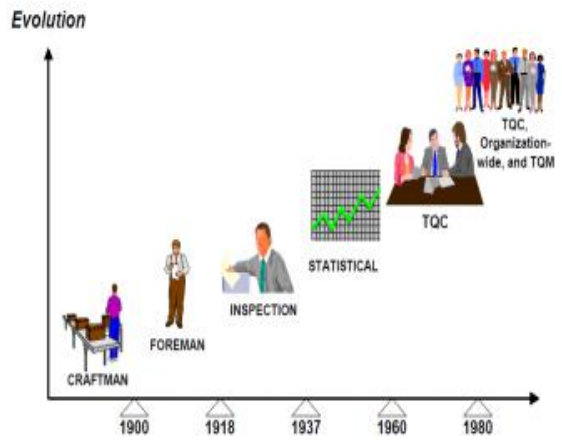

Fig. 1: Quality Control Evolution

Definition of quality

The quality of a project is described as meetings its functions and legal standards along with its aesthetics. The project requirements are expressed based on expectations from it. Quality is said to be good if the work carried out meets these expectations.

An efficient pavement management system (PMS) can be developed by identifying the distress on the pavement which gives in-depth analysis of its condition. Thus, economical and constructive decisions may be taken for its management. As the system for distress identification is man-dependent, it tends to be dangerous, less efficient and costly.

1.3 Benefits of TQM using Pavements model in the construction industry: Benefits of TQM in construction business are:

Achievement of consistency throughout project.

Enhanced control over all processes.

Reduced cycle time for construction.

Less losses.

The time it takes to get to the location has been cut in half.

Chemical spillage is reduced.

Increased performance measurement and improved consumer views of the business.

Gives the predication of unnecessary incident.

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2. LITERARURE REVIEW

Following section discuss the overall review of related work related to TQM,

Arash Hosseini, et al, 2019, This paper deals with different Quality control indicators for long-term performance of pavements. Geo-relational data base of in-service pavement is created and then linked with quality indicators and long-term performance. Methodology adopted is 1. Data collection, 2. Production quality data, 3. A dataset of 30 projects for about two hundred miles is used for performance analysis. The segments used are: alligator, transverse and rutting types of cracks along with longitudinal cracking. And to quantify this DI (Deterioration index) is calculated (DI=416.1X^0.02875-383.7).

The goal of this study is to link pavement performance at a specific area to individual data points collected during the mix manufacture and building stages. A total of 30 pavements were used to create 101 test sections. The resistance of HMA mixtures containing 12.5mm NMAS to rutting and alligator cracking is investigated.

Abhay Tawalare, et al 2016, This paper deals with PPI for rural roads which is useful for further development of rural areas. Because funding resources for rural road maintenance are limited, there is always a decision-making tool. Many parameters are considered in this paper which will be useful for PMGSY field engineers. In totality, twenty-two PD parameters were identified and out of which only necessary parameters were selected through expert opinions and these experts were having more than 25years of experience in rural road construction. A questionnaire was created to determine the severity of each characteristic contributing to rural road deterioration on a scale of 10 to 100 percent, and it was delivered to all district officials. 117 responses were received. And this data was analyzed and weightage of each was used to find PPI i.e Pavement Performance Index and validation was done.

The model is built on a priority ranking model, and it is the result of multiplying each degrading parameter's rating and weightage. A distress survey may be used to establish a rating for each. Validation revealed a PPI of 3.746, indicating that pavement performance in April 2015 was satisfactory. PMGSY field engineers will benefit greatly from this concept. PPI may also be used to generate a priority list of rural roads in need of repair and upkeep.

Aman A et al, 2016, A Hidden Markov Model (HMM) based framework for dealing with expectations of customers is formed in this paper. It utilizes house of quality for generating future requirements. The QFD make the decisions for pavement maintenance based on HMM. Data was collected and was in the form of pie charts and this data was marked in three categories namely High with 5, Medium with 3, and Low with 1 weightage. Socio-economic, safety, maintenance efficiency and environment are considered the main parameters. Further non-stationary hidden Markov model can be used for improvement, along with this uncertainties model can also be prepared. Also, advanced modelling techniques will be required for vast amount of computer programming and simulation.

Umesh Sahoo et al; 2014, This report is on rural roads, specifically 19 rural road test-sections are considered for performance study. Roughness and rutting are considered as main factors in varying traffic conditions. Here conditions used were tenth was kept shorter for better results considering minimum length limit up to 200m suggested by Cundil (1996) for roughness measurement. Here a NDT method of FWD (falling head deflectometer) is commonly used. The defection data is used to back calculate the layer moduli. Other parameters considered are as suggested in the previous study like rutting, raveling and cracking which form potholes and depressions. Pavement layer composition were also studied.

2.1 Research Problem:

• The conventional method of evaluating project bids, which places the most focus on price and gives less weight to prior expertise, present workload, and reputation for quality.

• Determining the state of a pavement is critical in determining the type and scope of repairs that should be made to the road in order to provide the necessary level of service to vehicle traffic.

• Efficient design and preservation of drains is necessary for main road especially in the mountains and heavy rain areas.

• TQM implementation for long term, particularly in the construction sector, causes a big issue.

• A lack of understanding and information on TQM.

• Heavy traffic, axle load, and a water-logged location are the main causes of distress.

• The occurrence of the pavement condition under evaluation in the Critical PCI Range does not require its immediate restoration.

• There is no way to measure the quality of building procedures.

Objective I: To Analyze existing method control statements used in pavement construction processes

Method Statement for Chandani Chowk Flyover project:

Granular sub base (GSB):

The scope of this job is to lay and compress well-graded GSB material on a prepared and authorized subgrade in line with MORT&H standard Article 401.

Quality Control:

• At the job site, the gradation of the material must be managed by making required modifications.

• At a rate of one test per 1000 sq.m., the compacted surface will be examined for field density. When evaluated according to IS: 2720, the degree of compaction should not be less than 98 percent (Part-28).

• The surface must be examined for levels at MORTH intervals longitudinally and transversely, and

the difference must be less than 10mm.

Subgrade:

Scope:

Construction of sub grade with approved borrow material as per MoRTH.

Construction of sub grade with approved suitable material available from the roadway excavation or any other excavation

Quality Control:

Compaction control: The compaction control shall be done by comparing the field dry density with the laboratory Maximum Dry Density for achieving 97% of compaction at the OMC +1% to -2%. Control shall be exercised on each layer to meet the required degree of compaction before going to the subsequent layer.

Dense Bitumen Macadam:

Scope:

- The work will consist of a double course of 135mm in two stages of construction. On a previously prepared non-bituminous / existing bituminous surface, the thickness of pavement the required as per specification. The purpose of this methodology is to outline the guideline for laying of Dense Bituminous Macadam At site
- Asphalt Batch mix plant (120 TPH) : 1 No
- Sensor Paver: 1 No
- Smooth Wheel tandem vibratory roller : 1 No
- Truck Mounted Bitumen Sprayer : 1 No
- Tippers : As per site requirement
- Thermometer for Measuring Temperature : 1 N of Mix.

Wet mix macadam Construction:

Material Specifications :

Los Angeles Abrasion Value	Max 40%
Aggregate Impact Value	Max 30%

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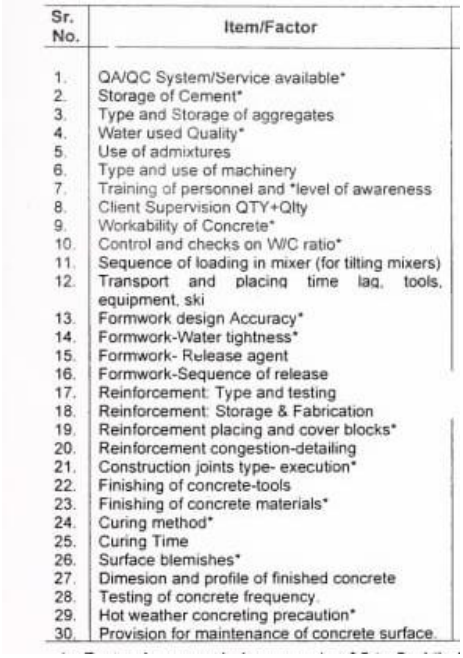
Combined Flakiness and Elongation Index	Max 35%
Plasticity index	Max 6
Gradation	Confirming to 400-13
Compaction	1 set for 1000Sq.m

Questionnaire :

- From IRC 57 2000, Table (E-2)-1 for Quality Grading for Concrete construction the following Questions were considered to know the acceptable quality of concrete.
- This Questions were asked to the Expert from NCC (Nagarjuna Construction Company) by physical visiting on site (Chandni Chowk Flyover Project).



Sr. No.	Item/Factor
1.	QA/QC System/Service available*
2.	Storage of Cement*
3.	Type and Storage of aggregates
4.	Water used Quality*
5.	Use of admixtures
6.	Type and use of machinery
7.	Training of personnel and *level of awareness
8.	Client Supervision QTY+Qlty
9.	Workability of Concrete*
10.	Control and checks on W/C ratio*
11.	Sequence of loading in mixer (for tilting mixers)
12.	Transport and placing time lag, tools, equipment, ski
13.	Formwork design Accuracy*
14.	Formwork-Water tightness*
15.	Formwork- Release agent
16.	Formwork-Sequence of release
17.	Reinforcement: Type and testing
18.	Reinforcement: Storage & Fabrication
19.	Reinforcement placing and cover blocks*
20.	Reinforcement congestion-detailing
21.	Construction joints type- execution*
22.	Finishing of concrete-tools
23.	Finishing of concrete materials*
24.	Curing method*
25.	Curing Time
26.	Surface blemishes*
27.	Dimesion and profile of finished concrete
28.	Testing of concrete frequency.
29.	Hot weather concreting precaution*
30.	Provision for maintenance of concrete surface.

Outcome of Questionnaire Survey for

Chandani chowk project :

- W.c ratio, Workability, Testing, Target Strength are used as per the MORTH Specifications and IS 456.
- Various Factors/ Items from the table are properly followed and maintained as per the given information so we can conclude that acceptable Quality work is done.

MCS by Ajwani Infrastructure Pvt. Ltd for Development of road (concrete road) at sector No. 16 Rajeshivaji nagar in prabhag No. 2"

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METHOD STATEMENT FOR EXCAVATION OF ROAD IN SOIL / ROCK.

- Compaction at OMC to achieve min. of 95% / 97% of MDD for the given case
- The cut formation, which serves as sub grade if found suitable, then the same shall be checked for its relative compaction as per table 300.2, and if fails then the same shall be loosened and compacted in layers in the specified manner.

Stemming:

- Stemming may be used if required, of free dry running material, which passes through a 2.8mm sieve and retained on 1.2mm sieve by 90%.

METHOD STATEMENT FOR EARTHWORK IN EMBANKMENT (FILLING)

- The following types of materials are not appropriate for embankment.

  a. Plants found in swamps, marshes, and bogs.

  b. Peat, log stumps, and perishable materials any soil classified as OL, OI, OH, or Pt. by IS: 1498.

  c. Materials that can spontaneously combust.

  d. Materials that have been frozen.

  e. Clay with a liquid limit more than 50 and a plasticity index greater than 25.

  f. Materials containing salts cause leaching in the embankment.

Acceptance Criteria :

- Field Dry Density Shall be greater than 95% of MDD.
- Optimum moisture content shall be +1% to -2% during the time of compaction

METHOD STATEMENT FOR EARTHWORK IN SUBGRADE (FILLING)

- The material that have LL less than 50%, PI less than 25%, Free swell Index Less than 50% shall be used for Sub grade construction. The material which is having Lab MDD of min.
- For sub grade, clods and hard lumps of soil will be broken down to a maximum size of 50mm.

Acceptance Criteria:

- Field Dry Density Shall be equal to or greater than 97% of MDD.
- Layer thickness tolerance shall be $\pm$ 20 mm.
- Optimum moisture content

shall be +1%to -2% during the time of compaction.

METHODOLOGY FOR GRANULAR SUB BASE

- Rolling shall be continued for giving sufficient number of pass to achieve field density in excess of 98 % of M.D.D. as per Lab.

METHODOLOGY OF CONSTRUCTION PAVEMENT QUALITY CONCRETE

- MORT&H specification clause No. 602 IRC 15 – 2011 and technical specification of contract.

MCS By Ajwani Infrastructure Pvt. Ltd. For "Widening and construction of road and Nalla on the land Transferred by Agriculture Department from Wadhmukhwadi Fata To Chavisawadi Fata on Pune

METHODOLOGY FOR BITUMINOUS MACADAM / DENSE BITUMINOUS MACADAM / BITUMINOUS CONCRETE.

- Bituminous concrete of 5.4% (V_g30) provides hot-laid and mixed bitumen of bituminous concrete by the total mixed weight per MORTH Clause 509.
- Bituminous' Macadam concrete of 4.5% (V_g30) provides hot-laid and mixed bitumen of bituminous concrete by the total mixed weight per MORTH Clause 507.
- Bituminous' Macadam concrete of 4.5% (V_g30) provides hot-laid and mixed bitumen of bituminous concrete by the total mixed weight per MORTH Clause 507.

Quality control:-

- All materials and workmanship must meet the requirements of section 900 of the MORTH, IRC, I.S., or the Tender QAP.

Objective II: To perform Tomographic image analysis on constructed and operated pavements, determine pavement condition index (PCI)

Proposed Methodology:

In this project, we are attempting to use a python code written to extract photos from Google street-view utilizing the Google Application Programming Interface (API). Pavement specialists analyzed the images by hand, considering nine various levels of discomfort. After then, the data set's performance was evaluated using You Look Only

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Once, a well-known deep learning framework (YOLO v2). YOLO's proposed model, on the other hand, did not quantify the fracture density. Hence, we studied the U-net type of model and developed it to evaluate the signals of distress density. Decisively, the conditional indices of the proposed developed models of YOLO and U-Net based ML predictive models were used to propose the distress conditional detection of the pavements of concrete or asphalt using the deep learning based predictive models. The key to verify the variety, quantity and quality of the utilization of the data is promptly noted. Because of the labeled datasets developed for the conditional rigid pavement author Majidifard et. al. represented the tomo-graphical image of pavement datasets. The extracted images consists of 7237 types of images which are considered as the datasets amongst 22 different sectionized pavements including the ones with interstate-wise routes and highways. Illustrated fig 2 summaries the major contributory part of the study.

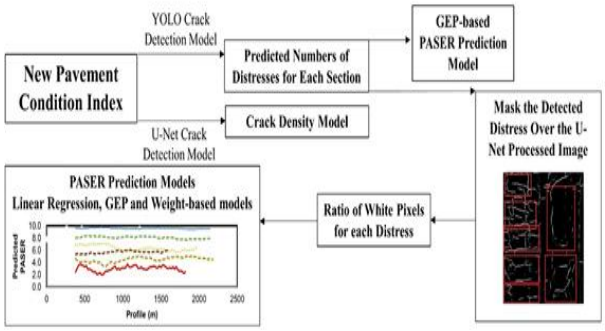

Figure 2. Proposed Work flowchart

3.1 Automated detection, segmentation and classification methods for cracks

First, we presented a one-of-a-kind dataset annotated for PD categorization and densification at the same time. The data comes from Google Street View, as well as manually collected photographs of the Mumbai Pune highway and Dehu Road, which provide us a diversity of camera perspectives to help the recognize severity of distinct types of fracturs and cracks.

Secondly, implementation of the delineating boundries of various abnormal conditions like critical shadow and non-cracked objects like trees, cars, etc. is segmented model to model as

per the distress signals. Overcoming intelligent models with high-end architectural designing are envisaged by accepting the challenge.

Contemporary conditional pavements based on cracked YOLO classifier, hybrid-ML and U-Net density model is used to detect the distress signals.

The tomographic process of segmenting one picture into many parts is known as image segmentation. Classification of lines and curves in the images under conceptual image segmentation is performed. Considering the background areas of the objects in the image, its segmentation is nothing but the extraction of edge-detection. Semantic objects like humans, cars or buildings in the tomographic and videos associates computer vision and image-processing copes for detecting object-based classification. In the ML and AI based development, the object-based classification and segmentation under both the image processing techniques carryout precisely. The segmentation of the classifier related to the objects in a single image is possibly used for grouping and categorizing into a single class. During segmentation, each object in an image belonging to a single class is highlighted with distinct hues in order for computer vision to recognise them. The degree of the distresses can be detected in crack segmentation, but there is no way to divide them into different categories. On the other hand, the distresses can be grouped into distinct categories in the classification techniques, but the severity cannot be quantified.

Thresholding and edge detection are the two most used segmentation methods. In automatic PD systems, threshold-based segmentation is often used. Edge detection is another common image processing approach. The quick reduction of picture data to useful information is a key advantage of edge detection. Various edge detectors like Roberts,

LOG, Prewitt and Sobel detectors are used to carry-out the process. Nevertheless, problems under edge-detection corresponds to characterization under spatial scale is tiresome to be detected. Because of the many features at various scales, it is recognized that working with Pavement Tomographic pictures in the process of PD is difficult. Wavelet-based edge identification at many scales has been prominent in pavement image processing during the last decade. Various hindrances of sudden lighting and shadows in the pavement images are introduced automatically with new technical challenges in the distressed signaling schemes. Here, we're attempting to create a new PCI using data from a crack categorization model and machine learning models.

Research carried by Majidifard et. al. on comprehensive development of the deep learning algorithms from the pavement-based data-set's distress signals have inspired this work. This section focuses on their work and how it relates to the present research. After evaluating several studies, the researchers classified and documented nine categories of the most essential distresses that impact pavement condition. Huge, distress database of pavement from 22 various US based areas are distributed section ally using python code in which communication between the API is carried-out with the google view street. In addition to this, the images acquired from the google view street is predefined as per the distress classifier signals, which is illustrated in the Figure-3. It offers an instant annotation of the 9 distinct types of categorical paving types. Therefore, from the figure illustrated, the blocking of cracks, selective reflection, sealed and lane based longitudinal cracks are amongst the highest boundaries in the boxes that are founded in the paving datasets.

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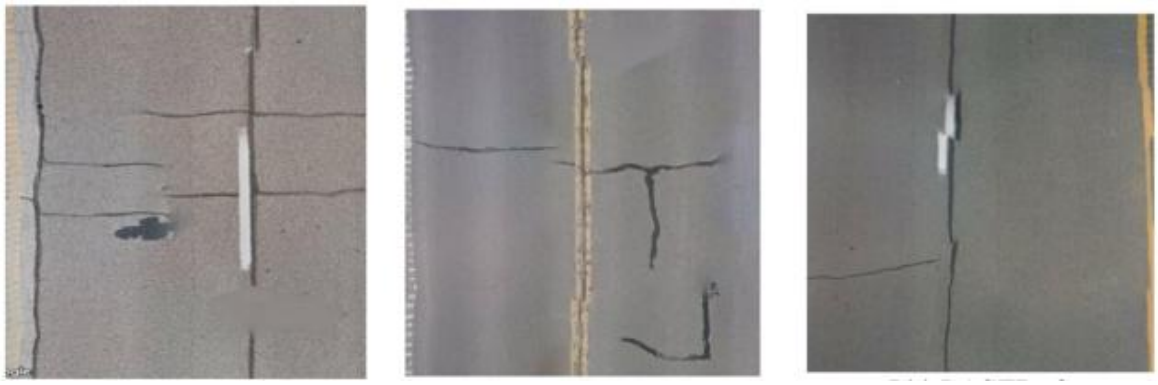

Figure 03: Sample Tomographic images for proposed model

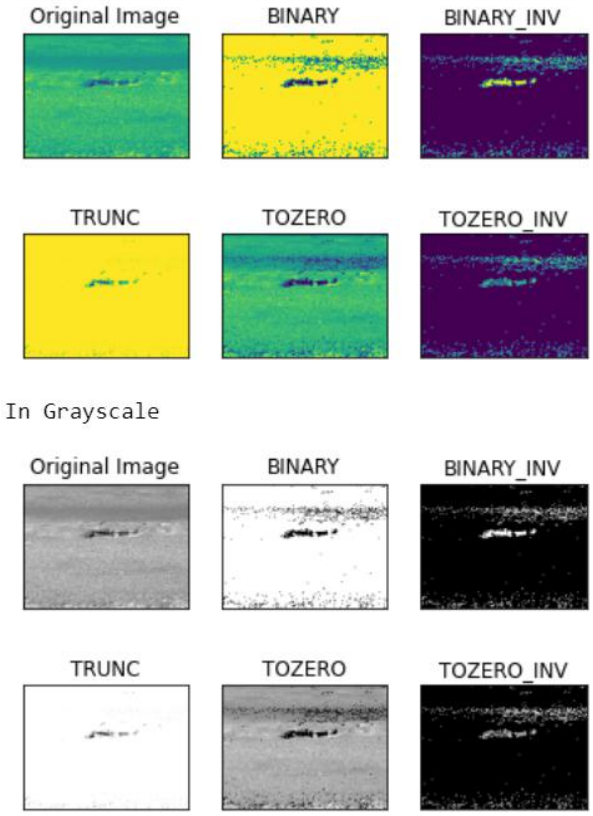

Figure 04: Conversation of tomographic images

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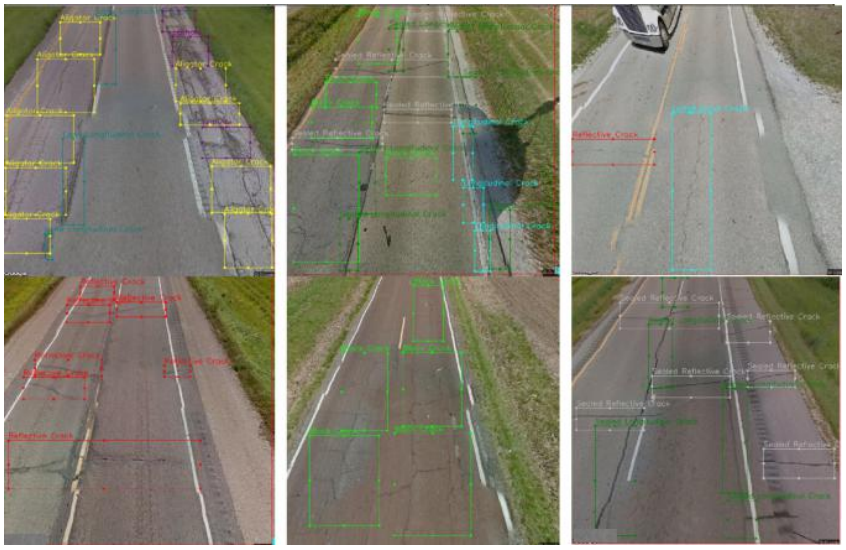

Figure 05: Obtain Result using proposed model

4. Conclusion:

A deep machine learning technique was used in this work to forecast road-way pavement quality. The models were trained using a large dataset of road conditions derived from Google Street View. Bounding boxes with nine distinct PD were added to the photographs. A cutting-edge deep learning system was used to automatically identify and categorize the PD. Moreover, 9 segments were formed for PDI. The density of the distresses was calculated using a pre-trained model approach. A U-Net based algorithm was used for this purpose. Road photos obtained manually in a range of atmospheric circumstances were used to fine-tune the pre-trained model. The proposed algorithm can distinguish characteristics such as automobiles, shadows and PD with accuracy.

The suggested algorithm has certain benefits over other deep-learning based algorithms. First, this technology reduced PASER's reliance on human judgement and improved its accuracy. Furthermore, this research is a

trailblazer in terms of producing a PCI prediction after PDI. Second, the algorithms were trained with freely available Google street-view pictures of roads. In future we will try to work on comparative analysis of different models with number of input images for more accurate analysis

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