

# BRIDGE INFORMATION MODELING AND AR USING TERRESTRIAL LASER SCANNER

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## Abstract

*There are many incidents where bridges collapse before its life span is over or just after it is built or even during construction, so all this calls for its routine inspection and methods to do it as efficiently as possible. One of the methods to do an inspection is using a terrestrial laser scanner. This paper mainly focuses on studying the methodology for inspecting the bridges using a terrestrial laser scanner and Augmented Reality technology. In this paper, Laser scanning data was used to prepare Bridge Information Model and that model was further processed in Unity to create an Augmented Reality model. All this requires various data processing and post-processing. With the help of this model, one can do bridge inspection at the comfort of the office and reaching those inaccessible areas which are not possible to reach with traditional methods. This paper focuses on finding a different method or approach to do Bridge Information Modeling and get data of bridges for maintenance purposes. Visual inspection was carried out from the model without going to the site.*

**Keywords:** Terrestrial laser scanner, AR Technology, Bridge Information Modeling, Visual Inspection, Unity, Point Cloud, Trimble Business Center

## I. Introduction

### 1. Background

In India, there are a lot of bridges getting constructed and there are a lot of bridges that are already constructed but no one has data about those bridges for maintenance purposes. A bridge's performance life is subjected to deterioration due to excessive usage, overloading, material, aging, and environmental impacts. There are various incidents of bridge failures and all this is due to lack of maintenance of bridges. So, inspection is required which requires knowing the details like plan, elevation, and design of the bridge. Visual inspection may also require rather significant logistics and bridge closure. Thus, the method is complex and time-consuming when obtaining the relevant information for bridge assessment, so all this calls for its routine inspection and methods to do it as efficiently as possible. One of the methods to do an inspection is using Terrestrial Laser Scanner. Bridge Inspection is required to ensure public safety. In this study, a Terrestrial laser scanner was used to scan the bridge site, and then the 3-D model was prepared from the point cloud. Then the 3-D model was further processed in Unity and AR model was prepared and all this output was further used to create as-built drawings and do a visual inspection of the bridge.

### 1.1 Terrestrial Laser Scanning:

TLS technique requires 3-D position information of object surfaces by contactless measurement and produces three-dimensional coordinate information in terms of points that define the whole building and object. We can do rapid and easy surveying with the help of TLS. Also, TLS is used for building information modeling (BIM) as well as for the measurement of shape deformation by 3D data. [12]

### 1.2 AR technology:

The motivation for this study is to know whether Augmented Reality could be used to eliminate the limitations and problems faced by engineers during visual inspection. TLS data in the form of point cloud and images were used as a base for AR. This is processed for display in a custom application written by authors. This is written using the computer games authoring platform Unity and is displayed on any android smartphone.

Augmented Reality gives a better technical understanding of projects and it provides solution creation while working on remote places But hardware unavailability makes it difficult to create XR content. We can use the phone, HMD Devices & Hololens Remote working is going to be new normal in upcoming years and for this XR is life-changing. [13]

## 2. Need for Study

Various incidents are happening of bridge failure due to structural weakness. Many bridges need to be assessed and monitored and to monitor them there should be a reliable method. Also, old bridges that are to be maintained do not have any details or drawings to be studied so, with the TLS technique, Bridge Information Model was created that gave details about the bridge and then the model was used to extract information for various purposes like an inspection. Visual inspection has been the primary technique for assessing the serviceability and performance of structures. As the traditional method is time-consuming and requires certain tools to access certain areas of the bridge which might require obstructing or stopping traffic and going to certain areas might be a risk to the person inspecting. Therefore to reduce the risk and save time we need to establish some non-contact technique that will be efficient and accurate. So to ease-out inspection and bring the whole bridge virtually at the office to inspect is the aim of the research.

## II. Methods

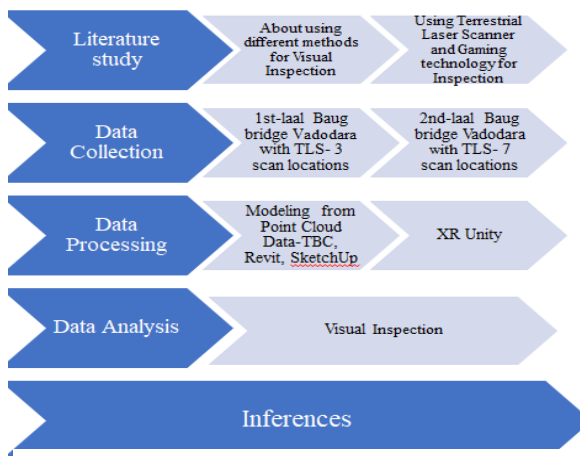


Figure 1: Methodology Adopted

The methodology followed during the study for this paper was

In this study first, a site of Vadodara was selected that is laal baug bridge and then it was scanned with TLS with proper care and minimizing errors and disturbances. TLS helped to capture data in the form of point cloud and that data can be used in many software for post-processing to create a 3-D model. This model helped to get information about the bridge and its condition. After 3-D modeling, the next step was to make an AR model and use it to do an inspection. We can use it for many purposes but in this study, we used a model to extract information, know the condition of the bridge, and do a visual inspection. Also, it aims to determine a detailed methodology for doing modeling and inspection.

### 3. Field Data Collection and Processing

#### *Data Collection*

With the help of TLS laal baug bridge was inspected and (fig 2) shows scan locations and table 1 shows the coordinates of the scan location.: After the instrument is fixed and all the adjustments and settings are done, we can start scanning process. The scanner scans within the fixed frame. It continuously rotates up and down on Y-axis scanning from top to bottom and also rotates clockwise on the X-axis. For scanning the full dome it took around 11 minutes. The scanner scans the objects first as image data through its camera

#### *Data Processing*

In Trimble Business Center data was imported and Processed. Removing the noise by removing unwanted regions was done in TBC. Model was not completed in TBC due to technical issues.so we then exported the file to various other formats to model further in Revit and other similar softwares After TBC, revit can help us create BrIM so edited point cloud was exported to Revit.. In revit piers were modeled.

Certain dimensions need to be assumed A heavy sketch-Up model of bridge was prepared and also surroundings were added to the model as it was to be used in Unity for AR model. Also we used this model to identify the defects and prepare plan, elevation and sections of bridge and also of the elements (refer fig 6). It helped us to know the dimensions also. Assumed dimension are the one which was hidden behind the noise

Model and Video with audio was prepared in Unity. A unity application was created and that includes a model, about inspection, table of remedies for defects. All this required two target images.

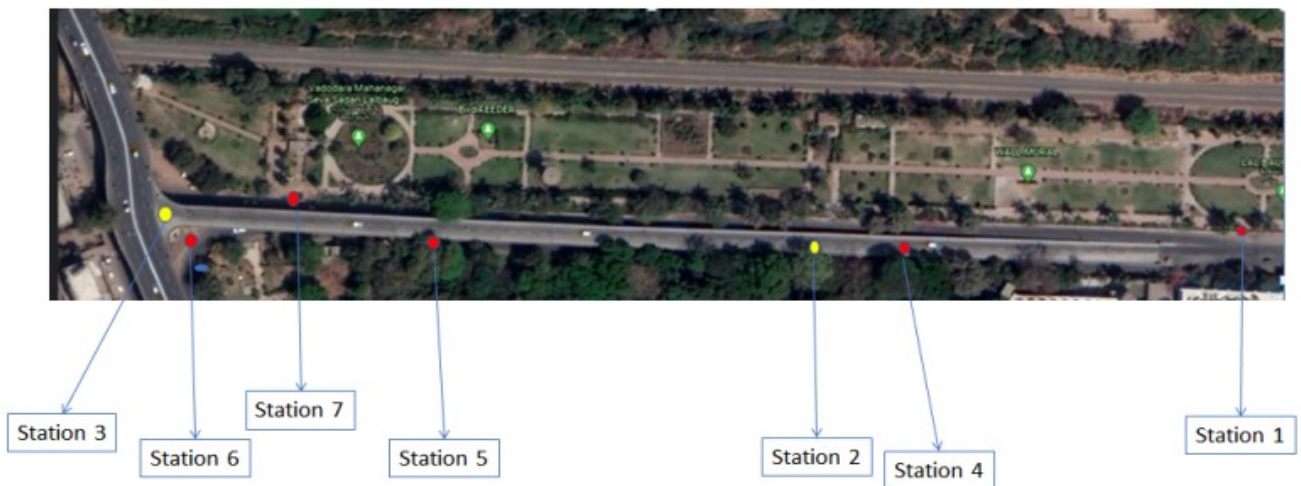


Figure 2 Location of station points



Figure 3: Final 3-D Model

Table 1: Coordinates of Scan Location

STN	X	Y	Z	CODE
1	1000	1000	100	stn1
2	1032.953	1000	100.549	bs
100	1234.069	1078.176	107.158	stn2
101	1383.856	1137.359	110.873	stn3
102	1049.498	1001.592	101.78	stn4
103	1298.252	1102.227	101.189	stn5
104	1376.654	1135.819	101.786	stn6
105	1370.584	1130.801	101.522	res stn 6
106	1356.484	1138.863	101.559	stn 7

#### 4. AR model development

For the processing in Unity, the first unity hub was downloaded and then in that unity version, 2019.3.11f1 version of unity was downloaded.

After that other packages were downloaded like an android studio and Vuforia developer was synced with Unity

First, the target images were decided (*refer fig 12*) in Vuforia which was an image of a model that was prepared. Then the ratings of images were checked. Rating should be above 3-star to process in unity and it was more than 3-star. After that 3-D model was imported in Unity and then align it on the image as per scale and orientation.

After this project was saved and build the project command was given in Unity and it converted and saved as .apk file. After doing the process in Unity target images were downloaded.

So to view model and another video output unity application was downloaded in the phone and then the camera was brought in front of target images. Target images showed the model and played the video as it was made in unity.

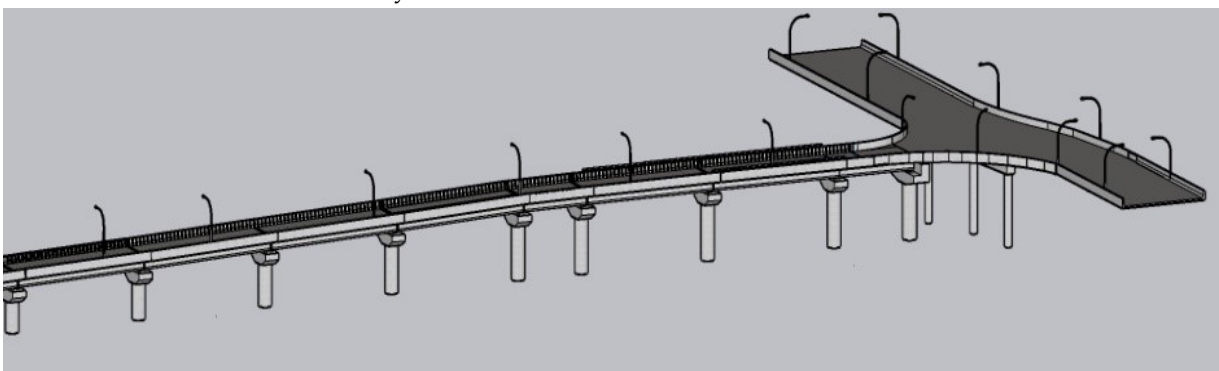
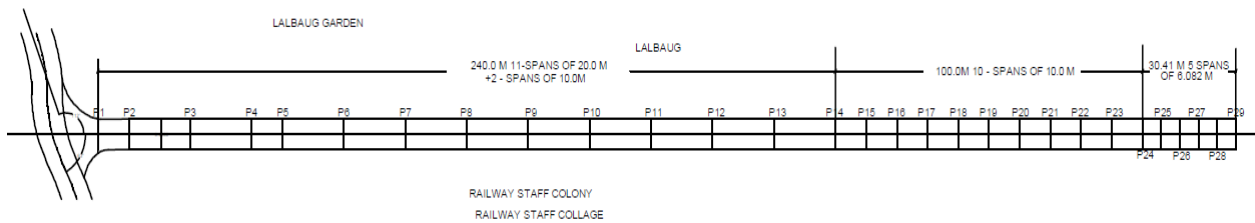


Figure 4: Final bridge model from point cloud

### III. Results

#### 5. Extracting Output from the 3-D model

After doing all the process of making a 3-D model and an AR model, data was used to create a plan, section of the bridge with all the dimensions as shown in *fig8,9,10* from the model. So bridge information modeling was done and then we used that 3D model to create an AR model which helped us to do visual inspection simply with the smartphone. Defects were visible in the 3-D bridge model but not in the AR model. To view AR model base images also known as target images are required. In smartphone, Unity application .apk need to be installed which will read the target images on any screen or paper to show us the model or video or audio that is worked out while preparing the application in Unity. The representation of cracks was also done in plans as seen in the model *fig 12*.



(*fig12*) Left side images show target images and right side images show their output. The first image is a part of the video. The other image shows the model. The second image will bring a model and it was analyzed and then from that cracks were examined and remedies were found out. These remedies were put up in the presentation form to be shown. The first image shows the location of cracks and how they can be repaired. All this was the output of the target images.

### IV. Discussion

This research here took up the case study of Laal Baug bridge Vadodara as per availability of the machine and point cloud was worked upon in various software and post-processing brought the following:

1. The data collected in the form of point cloud helped in making the 3-D model. This model helped us to create as-built drawings (*refer fig 5,6,8,9*) which were not available. So this model and as-built drawings helped us to know about the bridge and its condition and its whole structure can be identified which can further help us to do maintenance. For this research visual inspection was done and all the data was used to carry it out. This method for inspection is consistent and repeatable as compared to traditional method The 3-D model was used to process in Unity and produce AR model as seen in *fig 7*. This model can be viewed conveniently and details can be seen by adjusting the phone camera. We can zoom and see model with different angle by changing camera position This model is secure in terms of that it cannot be changed or edited so we can be assured that no changes are possible from outside as output is in terms of an application.
2. Bridge Information modeling was helpful for reaching this stage but it can further be used to present it in front of authority people to get permissions or approvals for maintenance or further restoration by actually showing them the unity model and the key problem areas just from an application of Unity in our smartphone and no need to carry heavy data or systems to show the details. Also with 3-D model data there is risk of data getting edited

and used but model in Unity application is safe. Also we can prepare presentation in Unity itself which can be used to present data and this file can also not be edited.

3. Frequency of inspection depends on damage detected. This bridge is not much damaged and can be inspected after 1 year as there is no damage to structural element of the bridge.

## 6. Process Setup for bridge inspection

1. Collecting data with tls-It should be noted that the data collection and images both taken by TLS
2. Processing data (part 1) – there are many software for this data to process. Here we used TBC and Revit
3. We exported the point cloud to sketchup and tried to make the model in SketchUp as Revit was crashing (only scan locations got exported) so we used hard copy from VMC and Revit model to extract the data. 3-D Model was prepared
4. We can now view the model in our phone through Unity app with the help of Target Images
5. By looking at this we can fill the Visual Inspection Sheet (*refer table 9*). But we could identify it only from the model.

## Acknowledgement

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