PIER CONSTRUCTION CIM BY UTILIZING 3D MODELING FROM PHOTOGRAMMETRY, 3D CAD, AND VR FOR REMOTE REBAR INSPECTION

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1. ABSTRACT

3D Modeling from photogrammetry has been widely used in various industries such as entertainment, manufacturing, and construction industry. Recently, 3D modeling has been adopted by many construction companies for different purposes such as quality assurance, mapping, progress tracking, and visualization. 3D CAD modeling allows a great opportunity to manage the project more reliably, as 3D CAD gives the chance to perform many operations and clarifications which were not possible with only the 2D drawings. Site inspection of rebar work in a remote construction site is a time and cost-consuming task. This paper aims to investigate a rebars inspection and quality assurance method by 3D modeling from photogrammetry. The results show that 3D models from photogrammetry can be used as an accurate rebars inspection method, and in comparison with 3D CAD design data against as-built 3D modeling data accurately and effectively.

2. INTRODUCTION

This study was conducted as part of the PRISM project from the Ministry of Land, Infrastructure, Transport (MLIT) for utilizing technology to improve construction management in civil engineering works. The construction site where the study is conducted is a bridge pier construction which is located at the General National Highway No. 5 Niki-cho, Niki-cho, Yoichi-gun, Hokkaido.

3. METHODOLOGY

Two cameras (an action camera and a mirrorless camera) were used for this study. Four software were used: 3D CAD software, videos processing and frames extraction software, 3D photogrammetry modeling software, and post-processing/superimposing software.

The cameras used in this study are: a 4K Ultra HD action camera with a Sensor of 1 / 1.7 inch CMOS and Effective pixels of 64 MP and a video resolution of 4K Ultra HD of 3840 x 2160 @ 24/25/30/48/50 / 60fps. The second is a mirrorless camera with a sensor resolution of 24 megapixels APS-C CMOS and a Maximum image resolution of 6000 x 4000 @ 11.0fps.

Fig. 1 action camera (Left), Mirrorless camera (right)

The software used for video processing and frames extraction is FFmpeg software. FFmpeg is a free and open-source software project consisting of a suite of libraries for handling video, audio, and other multimedia files. For 3D CAD we used Autocad software 2022 from Autodesk. for 3D modeling from photogrammetry, we used Metashape Professional which is used for the dense point cloud generation, editing, 3D modeling, and digital elevation model generation. For 3D modeling post-processing and superimposing the 3D Cad model and 3D model from photogrammetry, we used Cloud Compare software, which is an open-source point cloud (and triangular mesh) processing software.

The specifications of the computer used for processing are CPU Intel Core i9-9th generation, ram 64GB, GPU NVIDIA GeForce RTX 2070 Super 8 GB.

4. PROCEDURES

The photo/video shooting was done every 2-3 weeks depending on the construction progress. An engineer would carry the camera and start shooting video/photos horizontally back and forth and up and down. The shooting time is generally 3-5 minutes for videos and around 10-15 minutes for photo shooting depending on the target area. The shooting position should not be too close or too far from the target rebar area as shown in figure .2, the camera should always be focusing on the front rebars, and shooting should be done in good lighting conditions.

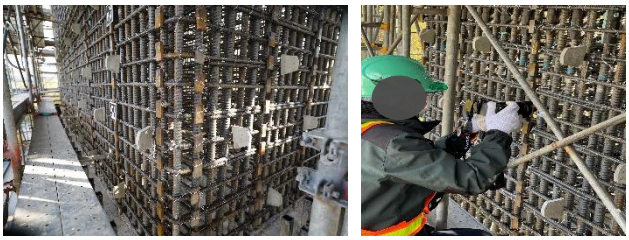

Fig. 2 views of the rebars on-site (left), rebars photo shooting (left)

After capturing the target rebar area, the photos/videos are then uploaded to the PC. Videos are then uploaded to FFmpeg software for frames extraction. Frames are usually extracted as 1-2 frames per second. Then video frames and pictures from the mirrorless camera are uploaded to Metashape Agisoft software for quality estimation. Then we can eliminate the blurry, out-of-focus, and over/underexposed photos.

The remaining photos are then processed in Metashape Software and aligned to produce the SFM model tie points

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(3-4 minutes), then MVS dense point cloud (4-6 minutes) as shown in the workflow below in figure 3.

The model used for postprocessing is usually a Dense point cloud model and we are using Cloud compare software. Figure number .3 shows the dense point cloud model of rebars.

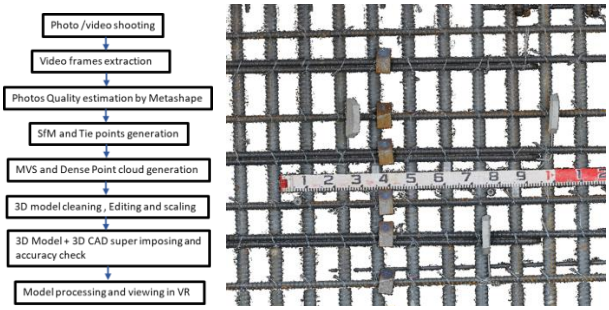

Fig. 3 Photogrammetry workflow (Left), 3D point cloud model of rebars (right)

The 3D Cad model was created from the 2D AutoCAD drawings by using Autocad 3D software from Autodesk, Some of the used commands For 3D Cad are extrude, Array, Loft, Press pull, etc. figure .4 shows the 3D cad model for the bridge pier.

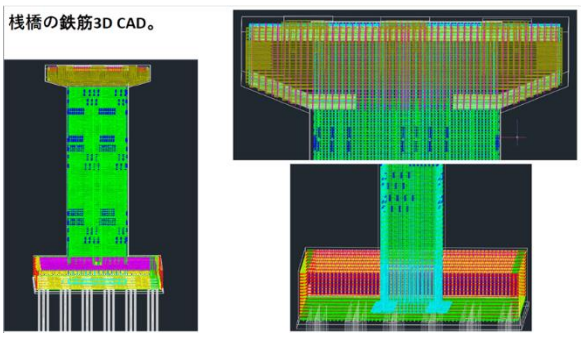

Fig. 4 3D CAD model of rebars

5. RESULTS & DISCUSSIONS

3D point cloud models showed a high level of details of the rebars (front layer only), and high accuracy level of 0.5 cm when compared with the scale bar and actual measurements.

Superimposing both the 3D CAD model and the 3D photogrammetry (as shown in Figure .5) model allowed checking the as-built rebar with the design rebar, and it provided an accuracy of less than 0.5 cm.

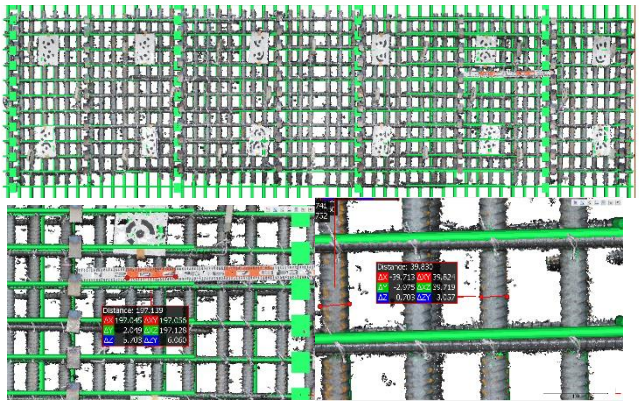

Fig. 5 photogrammetry model superimposed on 3D CAD model (top), 3D Models measurement, and accuracy check (bottom)

The 3D models can also be viewed interactively in a VR environment anywhere as the model can be uploaded to the cloud and it can be used for inspection, measurements, and writing comments to other members as shown in figure.6.

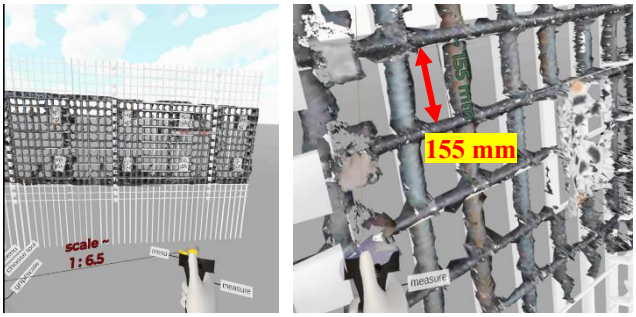

Fig. 6 3D models viewed in VR environment (left is model scaling and right is measurements)

6. CONCLUSION

It can be concluded that 3D modeling from photogrammetry showed an efficient, fast, and accurate method for replacing the traditional way of rebars inspection on construction sites. As-built of rebars against design data can be done successfully by superimposing both the 3D Photogrammetry model and 3D CAD design model with a high value of accuracy of around 0.5 cm.

Visualizing the 3D models in VR has great potential as the models are very interactive and realistic, it provided an easy tool for inspection and measurements of the rebars. Also, VR models can be shared on the cloud and viewed anywhere remotely and easily which is helpful in the case of remote sites.

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