THE AERIAL PHOTOGRAPHIC MEASUREMENT ON THE CONDITIONS OF PORT FACILITIES DAMAGED BY THE 1995 HYOGOKEN-NANBU EARTHQUAKE

Toshiyuki OYAMA
Head of Group
Group of Digital Mapping, Division of Urban Information
Amagasaki Technical Center
Kokusai Kogyo Co., LTD.
1-1-15, Nishinagasu-Chou, Amagasaki, Hyogo 660-0805
E-mail: oyama@kkc.co.jp
JAPAN

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ABSTRACT

The densely populated area between Osaka and Kobe that centered on Kobe City was greatly damaged by the 1995 Hyogoken-Nanbu Earthquake (M7.2) occurred in the early morning of January 17, 1995. The most part of facilities in the Port of Kobe was so heavily damaged that the facilities had not functioned for a long time.

This report showed the investigation results using the photographs taken by a helicopter in a low flight altitude and the results of the shift and subsidence of the structural objects in the Port of Kobe. It also showed the measurement results using a remote-controlled helicopter for getting the more detailed information in the damaged areas.

The measurement with photographs taken in a low flight altitude has advantages compared with the field survey. This method can keep the same measurement accuracy within the areas photographed, preserve the status of the damaged area in the form of image information, shorten the measurement period, and get the digital 3D data of the structural objects and the topographical conditions directly. In addition, it is an available method for understanding the damaged status in the damaged areas where need to be restored and reconstructed after the disaster.

The topographic maps and the surveyed data existed were also used to skip the steps of setting the control points which is indispensable for the photographic measurement. Although it slightly reduced the measurement accuracy, it can still meet the needs of grasping the changing conditions of the damaged area just after the disaster as soon as possible.

1. INTRODUCTION

The densely populated area between Osaka and Kobe that centered on Kobe city was widely and greatly damaged by the 1995 Hyogoken-Nanbu earthquake (M7.2) occurred in the early morning of January 17, 1995. The most parts of facilities in the Port of Kobe were so heavily damaged that the

facilities had not functioned for a long time. The quays, seawalls and breakwaters constructed by Caisson and blocks were heavily damaged. The sideways shifts (5 meters at largest), inclination, subsidence of the constructed objects were caused by the earthquake.

This report showed the investigation results using the photographs taken by a helicopter in low flight altitude and the results of the shift and subsidence of the structured objects in the Port of Kobe. It also showed the measurement results using a remote-controlled helicopter for getting the more detailed information in the damaged areas.

2. THE CHARACTERISTICS OF AERIAL PHOTOGRAMMETRY

The aerial photogrammetry has the following characteristics compared with the field measurement.

(1) Keeping the same measurement accuracy within the areas measured.
(2) Mapping and measuring the wide areas in a high speed.
(3) Providing the valuable information for the time series analysis on the areas or objects at that time in a format of image information.

The same measurement accuracy within the photographing area is said to be 1/10000 to 1/5000 of the flight altitude. Theoretically, the accuracy of the height and the plane position is different, in this case, it is discussed in the accuracy of altitude which has the worse accuracy. For example, the error for the aerial photographs taken in the altitude of 1000 meters will be 10 to 20 centimeters. It can be said that the measurement can be implemented within an error of several centimeters for the case of flight altitude of being about 300 meters.

3. THE OUTLINE OF WORKING PROCEDURES

There were more than 200 staffs of our company who lived in the Osaka-Kobe area, and most of them were suffered some kinds of damages on some extent from the Hyogoken-Nanbu earthquake. In order to provide the damage information for the purpose of restoration and reconstruction as soon as possible, many attempts including aerial photogrammetry had been conducted. Since the damage on the port facilities in the Osaka-Kobe area was so wide and so great, as one of the attempts, the aerial photogrammetry was selected because it can provide data for a wide area. It was planned to measure the variation and obtain the damage status. The investigation was mainly focused on the damage status of the public facilities, the measurement area was selected carefully and the man-operated helicopter was used to take the aerial photographs in order to obtain the detailed damage information. In addition, for the case of Meriken breakwater in the Port of Kobe, since there was a suggestion to keep the parts of damaged breakwaters as a memorial park, the remote-controlled helicopter was decided to be used for obtaining the detailed information on this breakwater.

3.1 Aerial Photogrammetry

3.1.1 **Photogrammetry by the Man-Operated Helicopter:** It is forbidden to take the aerial photographs by the man-operated helicopter under the altitude lower than 300 meters according to the air navigation law, the 21cm long focus lens (generally 15cm) was used to improve the measurement accuracy as possible as it can be done by keeping the flying altitude just above the 300 meters.

3.1.2 **Photogrammetry by a remote-controlled helicopter:** For obtaining the detailed information, the remote-controlled helicopter which is out of the control of the air navigation law was used to take the photographs in the altitude of about 10 meters by a 38mm lens.

3.2 Digital Mapping and Editing

The capture and editing of the 3D coordinate data were conducted by the analytical plotter and the digital editor.

3.3 Outputs

The plane, profile and bird's-eye view of the photographed area by image processing technology was output according to the different application purposes.

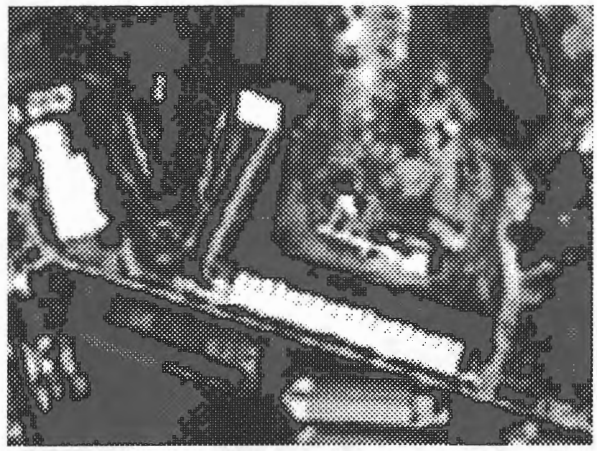

Figure 1 The Aerial Photograph of Quays in the Port of Kobe Before the Earthquake Taken in 1991

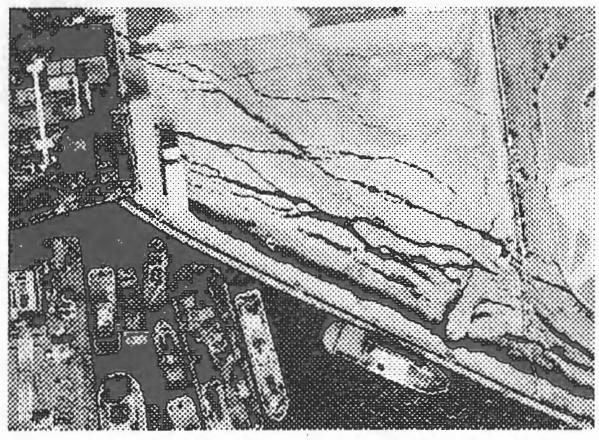

Figure 2 The Aerial Photograph of Quays in the Port of Kobe After the Earthquake Taken in 1995

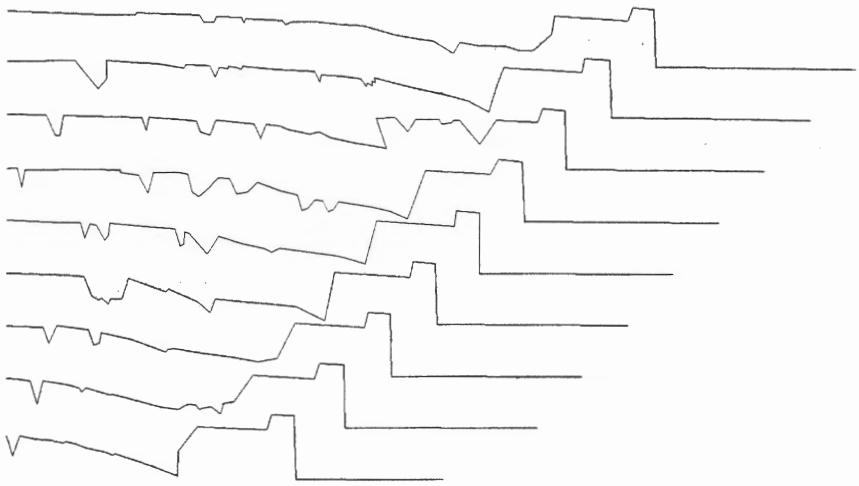

Figure 3 The Profile of Quay in the Port of Kobe.

This figure showed the measurement results for the profiles of every 5 meters in the depth direction. The measuring points were set to the changing points of height for every profile.

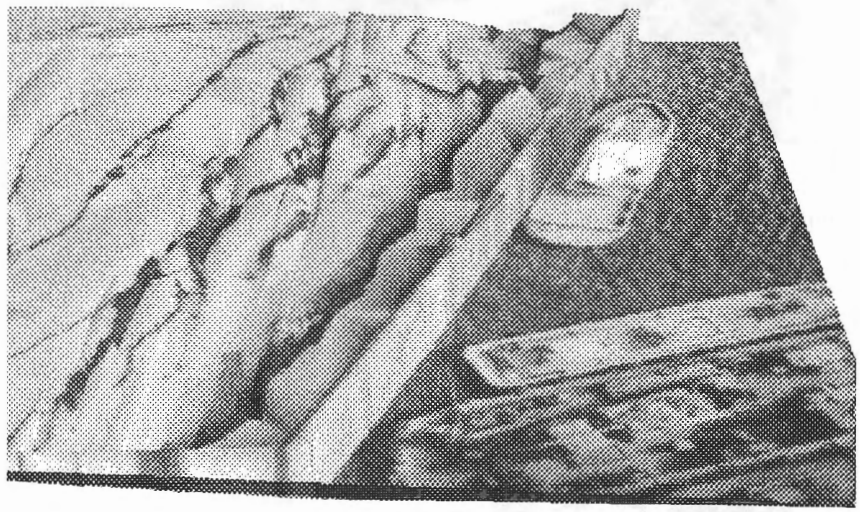

Figure 4 The Bird's-eye View of a Quay in the Port of Kobe.

It was created by the profile data shown in Figure 3. Since the profile data had only terrain data in it, the ships and sea surface are presented as the level 0 without any height value.

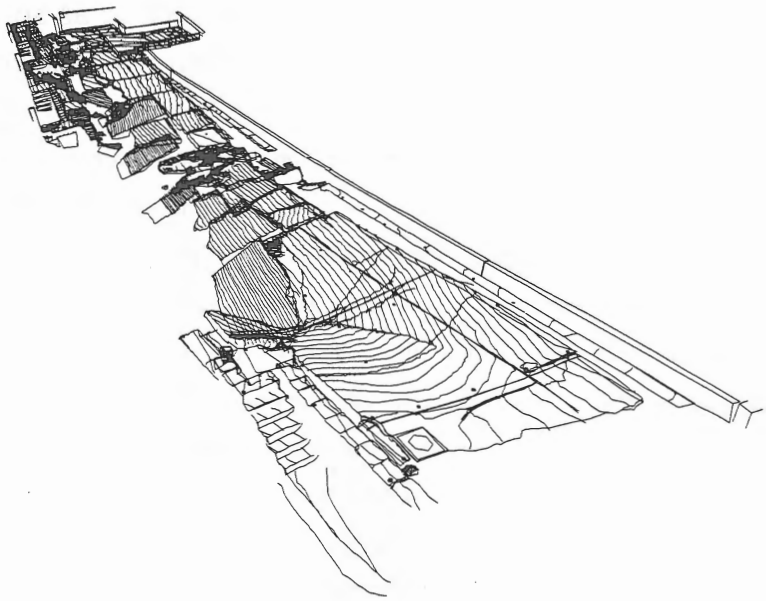

Figure 5 The Topographical Map for the Meriken Breakwater in the Port of Kobe. The 3D data for topography is presented as line.

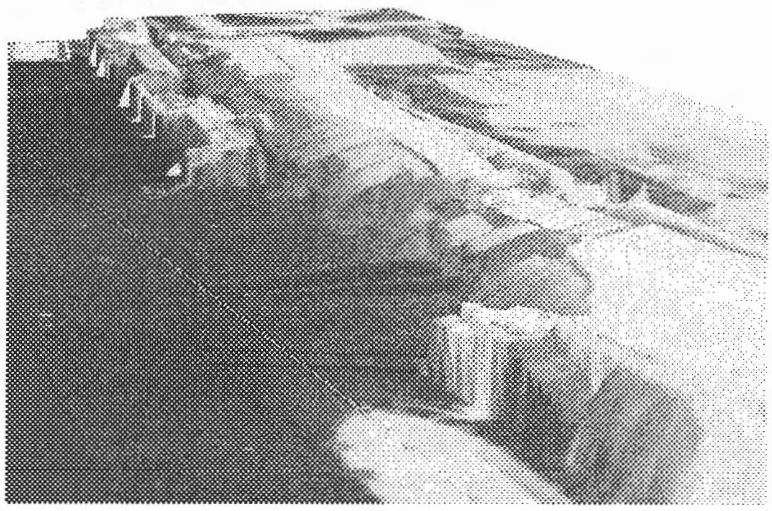

Figure 6 The bird's-eye view of the Meriken breakwater in the Port of Kobe. This figure was created by the 3D data shown in Figure 5.

4. DISCUSSION

The aerial photogrammetry for this reporting case was conducted in the field of close-range photogrammetry so called using the general technology of aerial photogrammetry. Although the plotting and measurement based on the side-view photogrammetry was not conducted in this case, this method can also be used and has been accepted in the other survey areas.

In order to understand the changing status of the constructed objects in a wide area and in an emergency case, it is confirmed that the aerial photogrammetry is quite effective in a low flight altitude. The aerial photographs were taken about one week after the earthquake, the maps and data can be provided successively just after the disaster without time delay.

The most important issue we faced was the determination of the control points for orientating the aerial photographs. It is necessary to determine the coordinates of the control points in order to register the photographs in the real world for the aerial triangulation or single-model photographs.

It is indispensable to set the photogrammetric targets and to pre-prepare the accurate control points, but for this case, there was no time to do it, the coordinates were read from the existed maps, as a results, the measurement accuracy was reduced in some extent. For this reason, there are no points that can be used to know the shifts between the data measured this time and existed, and it could not calculate the error range that was included in the measurement.

5. THE ISSUES NEEDED TO BE SOLVED IN THE AERIAL PHOTOGRAMMETRY

The determination of measurement method is the most important issue for conducting the measurement with high speed and high resolution in an emergency case. The study on the application of satellite data, ultra high-resolution satellite image and synthetic aparture radar data besides the aerial photogrammetry in the measurement has been promoted recently. The new scientific field called the space archaeology has been developed recently to obtain the information of remains under the ground by different kinds of satellite data, and many new discoveries have been made.

It is also necessary to put the focus on the recording characteristics of film due to the progress of its application to the photogrammetry. That is to say, it costs a lot to keep and maintain the films in a good condition, with the accumulation of films, the air condition equipment and the storage space can reach their limits that is available. If the image could be converted to the digital format, the color fading and storage space of films would be no problem. Howerver, if the digital data be maintained with the same quality as the analogous image data, the data could become a huge amount that is very difficult to be managed practically at present time. The quality of photograph at present is based on the size of silver particles on the film that is only several microns in size. It will be 4 GB in size (in case of color) to keep one piece of aerial photographs in a digital format with the same quality. It will take time to convert the aerial photographs completely to the digital format.