Easy tool for cost estimation of restoration of damaged sites

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ABSTRACT: Infrastructures in Japan are always exposed to threats of natural hazards. When structures are damaged, it is necessary to estimate cost of restoration and request budget to take necessary measure. To assist this procedure, JACIC Foundation developed a software tool for cost estimation of restoration of damaged sites. The tool is a combination of close range photogrammetry and CAD. For photogrammetry, compact digital cameras are available. The tool runs on a personal computer and is easy to use and cost effective. This paper shows basic idea, configuration and usage of the tool.

KEY WORDS: Close range photogrammetry, CAD, natural hazard

1. INTRODUCTION

Japanese territory lies in hazardous area. It is on a course of Typhoon. West coast and northern part of Japan suffers heavy snow fall in winter season, and 10% of significant earthquakes occur in the world actually occur in Japan. As a result, infrastructures in Japan are always exposed to threats of natural hazards. When structures got damage, to prevent farther effect, it is necessary to restore quickly. In the procedure, the first step is cost estimation. As is frequently observed in natural phenomena, there occur relatively small number of large damage and large number of small damages. It is desirable to introduce both administrative procedure and tools to ease load of handling large number of small damages for quick recovery from the damages.

2. TOOL FOR SMALL DAMAGES

To ease load of paper works for small damages, Ministry of Land, Infrastructure, Transportation and Tourism allows applying simplified cost estimation procedure. The procedure uses typical work items and standard price list. Survey can be reduced to width of damaged area and a typical cross section. To check adequacy of selection of parameters, applicants must take several photographs showing the damage with size. If applicants have to take pictures, it is a natural idea to use those photographs for photogrammetry so that we can ease the load of surveying. Recently, technology of close-range photogrammetry is advancing rapidly (Fraser et. al, 2000, Kunii et. al. 2002, Chikatsu et. al. 2003). The digital photograph taken for documentation can be used for photogrammetric survey if it is taken carefully so that they fulfill the request for close range photogrammetry. The quality of home use digital cameras are quite high nowadays. They use optical glass lenses, resolving power is usually more than 8M pixels and camera parameters such as focal distance, size of photo-sensor and so on are available through internet. It is precise enough to use for photogrammetry. When combine the technology with CAD software runs on PC and spreadsheet, we can realize easy tool to ease work to take care of small damages. Thus, JACIC Foundation decided to develop a tool for further ease the cost estimation and procedure for budget requesting procedure in case of small damages.

3. DESIGN OF THE TOOL

To design a tool, we must understand standard procedure of negotiation of government's allotted charge of restoration.
The procedure is divided into 3 phases. The first phase is to investigate a damaged site and decide if procedure should be started. If the damage is large enough to negotiate allotted charge with government for restoration, we take pictures as evidence, carry out survey to estimate shape and volume of damage and then decide what kind of restoring work should be done.
Then, as a second phase, using the result of survey, we design the restoring work and estimate cost using standard price list. When cost is small, we can apply simplified procedure. That requires typical cross section and length of the structure to be restored and categorized simple price list. The last phase is to bring in documents to . In case of small damages, assessment basically will be in the office. From time to time, investigators visit fields for on site assessment.
As is stated previously, the development of close range photogrammetry is rapidly advancing and quality of home use digital camera is quite acceptable. We can use digital photographs which any way should be taken at the site for surveying. Once 3D model of damaged site is constructed in a

computer, we can easily re-calculate necessary parameter from the model. When assessor reduce the size of restoration, re-estimation of cost and re-production of document is rather easy. What is more, as significant natural disaster seldom hit a small municipality, it is difficult for officials of such municipalities to become skilled in necessary procedure. In addition, recent economical situation do not allow municipal government to spend much money in tools. Thus, the tool must be priced sufficiently low and easy to handle as far as the precision of model is acceptable.

The necessary functions of the tool are

- Construct 3D model from digital photograph
- Draw necessary cross section and store it in a file
- Hand over the data to CAD module
- Put necessary comments on photographs
- Easy selection of primary data for specified restoration work
- Easy graphical design
- Direct reflection of design to spreadsheet for cost estimation
- Secure downloadable price list
- Automated cost estimation and creation of necessary documents
- Accept change in size of damaged area.

4. DEVELOPMENT OF MODULES

To meet above requirement, we decided to use existing software as both photogrammetry and CAD module. For photogrammetry module, we chose 3Diview by Tokyo Denki University (Chikatsu et.al. 2008) as the software was published as free software from the web-site of Chikatsu Lab., TDU and has a good reputation. For CAD module, we selected "Jin" of CIVIL SOFTWARE INTEGRATION. The tool is configured with control module, communication module to download price table, photogrammetry module, CAD module and spread sheet. The control module calls other modules sequentially and hand over necessary parameters. 3D model and orthoimage is stored in a storage, and finally document is pronted out through spread sheet. Simplicity is also important as this tool is used under 'upset' situation.

Accuracy of Photogrammetry module is checked in the test field. When photographs are taken symmetrically at 40-70m from targets, estimated coordinates and coordinates surveyed with total station coincides within 10cm in horizontal and vertical direction and about 25cm in depth direction. When photographs are taken from skewed position, accuracy of coordinates in depth direction get worse remarkably. To recover precision, we introduced 3rd scale and control scale in depth direction. When skew is about 15 degree and 3rd scale is set in depth direction, this technique works well. This does not require major modification and ease field work. Figure 2 shows test site. Figure 3 is distribution of targets and camera position.

Figure 2. Test site.

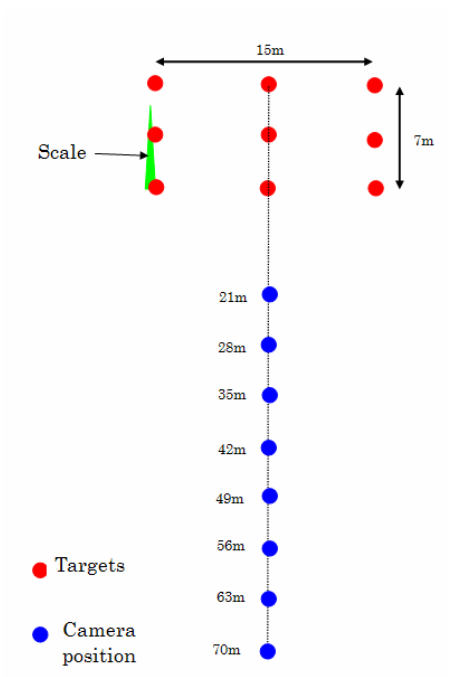

Figure 3. Distribution of targets and camera position. Camera position of right and left are 1/3 of the distance off from center. According to our experience, this proportion and using long focus lens gives best result.

Table 1 shows the result. In this test, Nikon D40x (10M pixels) with a long focus lens is used.

Distance (m)	Scale of photo-graph	Horizontal accuracy (cm)	Accuracy of depth direction (cm)
42	760	5	25
49	900	5.6	25
56	1000	6.3	25
63	1150	7.2	25
70	1300	8.1	25

Table 1. Test result. Symmetric measurement with a long focus lens.

At the same test site, skewed measurements are also tested. Figure 4 shows distribution of targets and camera position in case of skewed position.

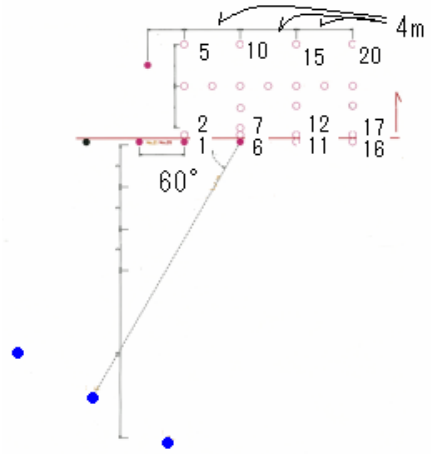

Figure 4. distribution of targets and camera positions. Numerals are number of targets.
Blue dots shows camera positions.

Table 2 shows the effect of 3rd scale. Here, we measured distance between targets and used that as scale. In real field work, just put a survey rod will do.

3rd scale	No.5-No.1 (7.414)	No.5-No.4 (3.238)	No.4-No.2 (2.523)	No.2-No.1 (1.664)
no scale	10.443	10.269	0.864	0.584
No.5-No.1	7.416	3.489	2.440	1.494
No.10-No.6	7.188	3.386	2.363	1.446
No.15-No.11	6.904	3.265	2.268	1.388
No.20-No.16	6.564	3.107	2.144	1.320

Table 2. Effect of 3rd scale. Numbers in parenthesis are distances measured by EDM.

We also modified the CAD module from original. Functions of CAD module is limited to necessary components so that un-skilled staff can easily get used to the operation.
In 2007 and 2008, we carried out demonstration and collect opinion of officials of local governments. Among question and comments in demonstration, request of accepting local rules and make visible correction with red ink were common and strong requests. In response to these requests, CAD and spreadsheet module was modified.

5. OUTPUT

Using this tool, users can produce damage restoring plan, cost estimation table and explanation leaflet for on site assessment. If correction is requested by an assessor, correction can be added visibly on the original plan and table with red ink (figure 5).

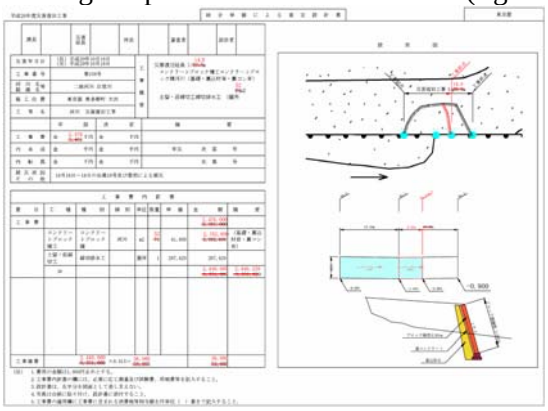

Figure 5: An example of restoration plan

6. EFFECT OF INTRODUCTION OF THE TOOL

From preliminary survey on prefectural governments and some municipalities, we could estimate cost reduction in terms of person-hours as is shown in table 3.

	Present work required (1 site)	Estimated work using the tool (1 site)	Reduced work (1 year)
Prefecture (mean)	4.2	2.0	748
City (mean)	4.7	2.0	190
Village and Town (mean)	4.7	2.0	112

Table 3. Estimated reduction of manpower

Besides reduction of necessary man power, an organization in charge of preparation of restoration of damaged infrastructure introduced this tool as skilled staffs retired.
Application of this tool also will accelerate standardization of documents. That will help assessors to quickly process the negotiation of government's allotted charge for restoration. When there occurs disaster, other prefectures send personnel for assistance. In such case, if they use

same system, it will be much easy to collaborate. Otherwise they must adjust local rules each other. That will lower efficiency.

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