Present Status in the Field of Engineering Survey in Japan

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Present Status in the Field of Engineering Survey in Japan

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SUMMARY

There are many applications to engineering survey in Japan especially to civil engineering, architectural engineering, machine engineering, ship engineeing, human and medical engineering, traffic engineering and so forth.

Among these developments in engineering survey are the surveying instruments, techniques, and integrated systems in the field, especially the application to civil engineering has remarkably advanced. The paper deals with the techniques, procedures, results of engineering survey in Japan which has been done recently and also includes the practical examples.

CONTENTS

1. Introduction

There are many applications to engineering survey in Japan, especially application to civil engineering architectural engineering, machine engineering, ship engineering, human engineering, medical engineering, traffic engineering and so forth. Many large scale works have been done in civil engineering since 1960 in Japan. In response to these projects, many kinds of civil engineering survey are necessary to do planning, controlling and checking from the beginning to the end. Development of the surveying instuments and computers has stimulated and changed the methods and techniques of surveying, especially in the function of mini-computer which has connected the works of surveying in civil engineering with the works of controlling and evaluating of civil engineering works directly in the field.

This paper deals with the some recent achievements in the engineering survey in Japan.

2. Engineering survey in civil engineering field

There are many engineering surveys in civil engineering field such as tunnel surveying,

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road surveying, city planning surveying, bridge and pier surveying, structure surveying, subsiding surveying, dam Surveying and so forth.

Japan is surrounded by sea and consists mainly of four islands. There are several big civil engineering projects which are now under construction.

The precise control surveys in parallel to this construction, are now being carried out, especially the surveying of the Seikan Tunnel which connects Hokkaido with Honshu island by high speed railway and the bridging surveying connecting Honshu and Shikoku island. These projects are the largest civil engineering works in the world and well known for its difficulties crossing the sea especially, the Seikan-Tunnel works include building a very long tunnel under the sea bed.

Structure surveying is the important works in civil engineering, sometimes the model behaviors are measured in the indoor experiments and checked in the field. There is a big social problem of subsiding in ground every year in Tokyo, Oosaka and other big cities in Japan. The precise control survey of subsiding quantity has been done for researching the cause of this phenomena and protecting future disaster.

2-1. Presise control Survey for the Seikan Tunnel

The building of a very long tunnel under the sea-bed of the Tsugaru Strait is now under construction in Japan. The tunnel has been planned to connect Hokkaido with Honshu island, the mainland of Japan, by high speed railways. The plan was orignated in the time before the second world war, but has become concrete after the war. The tunnel has a total length of 53.9 km and the part under the sea-bed of the Tsugaru Strait reaches as far as 23.3 km. The excavation of the pilot tunnel was commenced in 1964 after the investigation of geological condition and completed in 1984.

The Seikan Tunnel consists of a main tunnel, a sub-tunnel and a pilot tunnel. The main tunnel will be completed within a few years.

(1) Triangulation and Trilateration

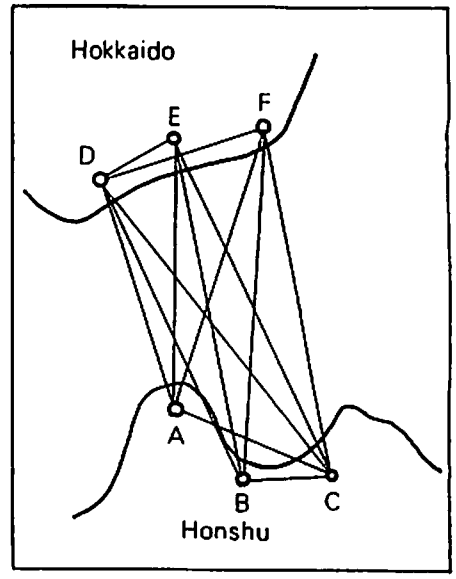
The first survey of the triangulation was made in 1965 by the Geographical Survey Institute. The standard deviation of the observation errors in the survey was estimated to be 0.6" from the closure of triangle. The base line was measured with a electro-optical distance measuring equipment (EDM). The astronomical azimuth was also observed at both sides. In 1970, resurvey of the triangulation was made by the Asahi-Koyo, Survey Co. Ltd. under the technical guidance of the geographical Survey Institute. The entire side length of the net was measured with the electro-optical distance measuring equipment (EDM). Special care was taken in the distance measurement about the errors due to atmospheric correction of the light velocity. From that year, all sides were measured by EDM every year. The following table shows the results of side-length measurement by EDM.

Point		Side length			
from	to	1970(mean)	1971(mean)	1972(mean)	1973(mean)
C	F	34,838,425m	.387m	.417m	.405m
C	A	15,915,000	.014	.009	.023
C	D	35,413,260	.311	.272	.275
A	D	22,698,739	.781	.743	.736
A	F	29,484,525	.507	.530	.516
D	F	17,629,103	.133	.132	.129

(2) Cross sea leveling

To determine the height difference of the base points in both sides, the precise trigonometric leveling crossing over the strait was carried out in 1965. In the survey of such long distance, the atmospheric refraction is the most serious error source, though it is eliminated approximately by means of simultanos reciprocal observations of vertical angle. Therefore, the variation of the refraction coefficient with height was taken into account at that levelling.

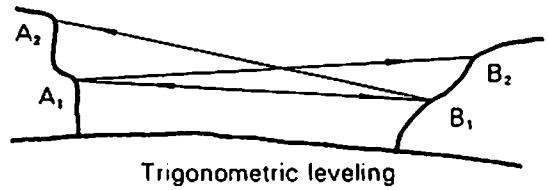
Two targets whose height difference is over 50m are observed alternatively from the opposite side, The maximum discrepancy of the four routes was 10 cm.



Triangulation net

(3) Related problems to the tunnel survey

The tunneling work under the sea-bed has abvanced to the distance of about 3 km in each side. The precise traverse survey, therefore, has been repeated in the tunnel so as to control the direction of the excavation. The traverse points, settled at every 300 m in the sub-tunnel, were measured with wild T3 and Geodemeter Model 6.



Trigonometric leveling

2-2. Precise structure surveying

In civil engineering, precise measurement is sometimes important for design construction with severe criteria. This has been done by combination of both the photogrammetric method and the geodetic surveying. The photogrammetric method is combined with the stereo-camera, comparator and computer,

and the problems, in this case, are the distribution and number of control points. Size and masking of control points, geodetic measurement of control points, position and direction of the stereo-camera and its selection, transformation and adjustment of the control points and the check of physical condition of camera and plates and especially the mathematical formulas for checking the control points are the key factors for this measurement. The inner orientation factors have an important effect upon the result. They must be considered in synthetic ways. In the actual measurement, the mean square error of measurements were about ± 0.2 mm in plane coordinate and ± 1.5 mm in height. The distance between cameras and object was about eight meters.

The deformation measurement of the dam was done by the geodetic precise measurement using EDM instrument of MECOMETER ME 3000 and Theodolite of DKM 3 or T3. This survey maintains the accuracy ±5.0″~1.5″ in closure error of triangle and within ± 1.0~1.5 mm in the error of side length.

These surveying systems can be applied widly for subsidence surveying of the bridge pier, the control surveying of overhead bridges and the crystal precise survey of earthquakes.

2-3. Measurement of ground subsidence

There is a big social problem of ground subsidence in Tokyo, Oosaka and other cities. In the Kansai district, Osaka and its surrounding cities have been doing precise leveling survey. The total leveling route length is now 1494 km and 10 administrative organizations are performing these works under the guidance of the Geographical Survey Institute.
The following table are the results of precise surveying in some leveling net.

Leveling net number	Total route length of each net	Permissible limit of error	Closure error of leveling net		
			1970	1971	1972
I	76km	±17.4mm	+12.2mm	+2.4mm	+3.3mm
II	79	±17.8	− 0.8	−8.3	−8.5
III	62	±15.7	− 4.4	−3.0	−2.5
IV	62	±15.7	− 3.2	+6.9	−8.4
V	69	±16.6	− 1.8	+1.0	+8.6
VI	60	±15.5	−15.4	+1.2	+1.2

3. Engineering survey in ship building

3-1. Volumetric measurement of spherical tank

The purpose was to prepare the tank table of a spherical tank for an LNG carriership. The surveying method combined photogrammetric method with the geodetic survey was introduced for checking of LNG tank Volume. The cameras which were lifted up to platform, were used for taking photos at ten different points and they positioned at

approximately 9 m from the wall faces to enable photographing by rotating the platforms. The aerial triangulation was assemblied by the photographic models by a single course adjusted by the points.

The measurement of tank was taken at 1296 points and resulted within the accuracy of ± 1 mm～1.5 mm compared with the precise geodetic survey of control points.

3-2. Measurement of subsidence of the lunching ways at Dock

In order to measure the subsidence in the case of launching a heavy weight tanker, the design of the launching ways for ships is very important. We used the instruments of photo-theodolite, laser transit, 35 mm movie camera, and soil pressure, (including the measurement of strain gauges at several points)

As control points, two special pegs were sunk near the center line of the ship. The P-30 photocheodolites of 5 set cameras were used for taking photos of ship behaviors at one second time intervals. The shooting time of the five cameras was synchronized by an oscillograph with the lunch lime of the ship. The 35 mm movie camera took a series of stereo-photos from the start of lunch to the time which the ship slid into sea in order to analyze the behavior of the ship.

3-3. Measurement of marine model propeller cavitation in Hull pressue.

Full scale investigations of propeller cavitation are very important in order to check the efficiency of the propeller and to find the cause of vibration and cavitation of the propeller. The thickness of bubbles in the case of cavitation was measured by comparing the propeller without tank water. The SKB-25 stereocamera was used for taking photos in combination with a strobe light. The propeller at high speed was photographed in coincidence with the high speed strobe light.

The coordinates on the plate could be transformed by comparing the propeller coordinates without tank water. The mean square error of measurement was ± 0.1 mm.

4. Engineering survey in traffic analysis

4-1. Photogrammetry for the analysis of traffic surveys in Tokyo Metropolitan area.

The projects were done at the request of the Tokyo Metropolitan Government. One covered the whole area of Tokyo district (about 580 km^2) by four RC-8 cameras and the other covered about 1.2 km^2 for the central part of Tokyo for a special detailed traffic survey using the camera RMK 15/23, 35 mm motor-drive camera and 70 mm motor-drive camera.

4-2. Mapping of traffic accident site

All police station headquarters in Japan which consist of 47 administrative units have done the mapping of traffic accidents systematically by using short-range photogrammetry.

There are about 3,000 policemen who are engaged in the mapping of traffic accident

sites. Nowadays they are using this technique for measurement of the creminal works.

4-3. Surveying and recording the degree of roughness on flatness of the road surface.

The Pacific Aero survey co. has developed the continuous photographic recorder of road surface and the Rut depth photos and has designed systems for their use. They have developed a high speed profilmeter which can measure the profile roughness of pavement at a high speed.

5. Engineering survey in human and medical engineering

The new microscope was used to take the stereomicrophotos for the precise quantitative morphological details of neuronal elements, especially the size of neurons including its dentrites.

Röntgen photogrammetry has been done for the precise measurement of the kidney and a specially designed plotter for röntgen photegrammetry was developed by the Tokyo Metropolitan Inst. of Gerontology, Dr. Otsu and prof Oshima in cooperation of Sokkisha Co. Ltd.

6. Conclusion and future tendency

Engineering survey has played an important role in the process of engineering works for planning and checking and the results have been most satisfactory. Since a few examples have been given here, we must perform more research in order to find the integrated techniques in considering econmical and easily applicable conditions, especially on-line jobs in the field.

We are now developing the surveying system using robots for future new techniques. Further, there will also be a need to develop more advanced software.

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