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Bogdan Szczechowski, M.Sc. Eng.
Andrzej Mucha, M.Sc. Eng.
District Geodetic and Cartographic Enterprise,
Gdańsk, Poland

THE PHOTOGRAMMETRIC MEASUREMENTS OF WATER RIPPLES ON HYDROTECHNIC MODELS

Abstract

In the report a new technique of measuring an instantaneous state of dynamically fluctuating water surface surrounded with models of naval hydrotechnical plants is presented.

To obtain a correct stereoscopic model of the targeted water surface the exposure is performed by the synchronous release of several photo-flash lamps.

The stereograms were elaborated by the analytical or analogous method. Finally a graphical map or numerical model is produced.

1. Introduction

The photogrammetric techniques are broadly known and utilised in various industrial branches for the long time, still they have been given further applications nowadays. In this report an exemplary application of photogrammetry for the model testing of hydrotechnic structures is described.

The important problem in the testing is to determine geometrical characteristics of a water surface surrounded by hydrotechnic model structures while various water undulations are induced by artificial means. To measure the characteristics special probes uniformly distributed on tested models are used in a research practice in Poland. However, only the punctual characteristics of undulation can be obtained by these means and this did not secure, among others, the proper interpretation of findings. The interpretational uncertainty combined with a great labouriousness involved in this part of testing made it necessary to look for a new research method. To solve the problems, a photogrammetric measuring method was developed several years ago. In general, either individual hydrotechnic objects /e.g. a breakwater and a pier, see figs 1 and 2 accordingly/ or some complex structures /e.g. harbour objects/ are subject to the model testing. The models are built, either of some earlier erected structures which are to be tested due to various reasons, or, more often, of certain objects to be erected. The models are built on the basis of a water reservoir and scaled down /generally at 1:100/, every location factors and research conditions being maintained. The latter conditions include, among others, a water undulation which is artifically induced on the models by means of a special facility, so-called undulation maker /see fig. 3/. By the various positioning of the maker in relation to the axis of an object, it is possible to simulate a natural multidirectional wavy motion. Through the regulation of wave propagation speed, waves of different known periods can be induced. A suitably positioned and operated undulation maker produces a specific ripple surface surrounding the object tested /see fig. 1 and 2/. The problem consists in the measuring of a physical state of the surface. As mentioned above a photogrammetric method can be used to carry out the measurements. The stereograms of the tested surface are made, just as in the case of mapping, and they are handled in analogue or analytical way. The way depends on specific needs or on a disposable equipment.

In contrary to map plotting, however, a proper undulation surveing is possible only when two following requirements are complied with:

1. Due to fact that a dynamical surface is subject to testing, photographs must be taken synchronously to the rate of surface variations. Complying with this requirement is necessary to produce a geometrically and physically correct stereoscopic model.

2. Because of water transparency, the measured surface must be suitably signalled before taking the photographs, otherwise only the bed of the reservoir instead of the water surface will be shown on photograms.

It was found by way of analysis, that approx 0.001 sec. synchronization of camera shutters is necessary when the surface variation is 1-2 m/sec. So far, no camera is known to have such a synchronization capacity. This made us to develop a new method of exposure with the use of stroboscopic effect. The method involves taking the photographs in the night by means of cameras with open shutters. The exposure results from the simultaneous flashlight of some photoflash lamps interconnected directly by means of photocells.

It is well to add that this way of exposure, due to the additional electric connection between the flash lamps and the undulation maker enables to take photographs at a moment which is exactly determined in relation to the waving action. Consequently, it is possible to properly choose the moments of carrying out consecutive stereograms enabling the geometric observation of the surface variation relating to the time, which is very important from the technical point of view.

The other necessary requirement is the signalling a water surface. Satisfactory results were achieved by way of numerous toilsome tests in which aluminium powder was sprayed over the water surface directly before taking the photographs

2. The description of the measurements.

First of all, a net of uniformly distributed fixed points constituting a photogrammetric network, was set out on tested models being the size of 10 x 10 m. Then, a suitably positioned and adjusted undulation maker was operated. As a result, a characteristic water surface was formed round the structure Next, the above described technique of exposure and signalling was utilized to make stereograms from elevated stands, about 10-12 m in height, situated at the top of a truck jack. Two scaled down stereograms are shown on fig. 1 and 2.

The photographs were made with the use of a high speed

Aviphot pan 33 photographic film or plates. Carl Zeiss UMK FF 10/1318 photogrammetric cameras were used.

Thus about 30 useful stereograms were obtained for each of the five tested models. The stereograms were proved to be an optimum descriptive material for the object and its conditions.

According to the up-to-date technology, the further, solely office work can be carried out by two following ways.

The first way comprises working out the stereograms on an autograph /in the case described a F stereometrograph was used/. As a result of the autogrammetric plotting a water surface contour map is directly produced in a scale of 1:10 with the contour interval of 1 cm. The map is completed in characteristic points by the heights obtained from the autograph counter. So far, in this method, a laborious machine setting of photographs must be executed due to stereogram area and in respect of plotting accuracy. The well-known advantage of this method, however, consists in the fact that a final result, that is a water-surface map can be directly produced. Such a map is plotted on a photographic plan and is shown on fig. 4.

When the numerical model of a surface is needed or when the autograph capacity is not sufficient, the other way of thestereogram plotting is used. This consists in the observation of stereograms on a precision stereocomparator e.g. Carl Zeiss stecometr stereocomparator, whereby, due to the characteristics of a tested surface, up to 1000 points are observed on a single stereogram /8-10 points per 1m^2 model surface as an average/. Then the observational results are processed on a digital computer /Polish Odra 1305 computer was used/. This produces three-dimensional field coordinates of observed points. The resulted numerical model of the water surface is subject to further analytical processing based on specialized programs. Furthermore, the model is transformed, either by the way of plotting on a plotter /e.g. Benson, Kongsberg, Caragraph, etc./, or by the ordinary or automatical contour interpolation, into a graphical map of the water surface.

It can be seen, that a water surface graphical map is the final result of the plotting operation irrespective of a way of plotting.

For each models tested untill now by the first or the second method, anywhere from ten to twenty such maps were elaborated. The maps give functional description of the direction and the period of the induced undulation.

The maps give a characteristic image of an entire model tested. When completed with the corresponding photographs rectifed to the same scale, the maps constitute a qualitatively new investigative material for hydraulic engineers.

To end with, it is well to emphasize, that the actual accuracy of the photogrammetric plotting was determined by some tests and found to be:

$$m_x = m_y = \pm 2mm$$

and

$$m_z = \pm 3 \div 4mm$$

Considering that the undulation heights were coming up to dozen or so centimetres, these accuracy figures are quite satisfactory.

References.

1. Zeller M. Photogrammetry manual, PWT Warsaw, 1950,
2. Linsenbarth A. Terestrial and special photogrammetry, PPWK Warsaw, 1974,
3. Joint publication, Analytical photogrammetry, PPWK Warsaw, 1972.

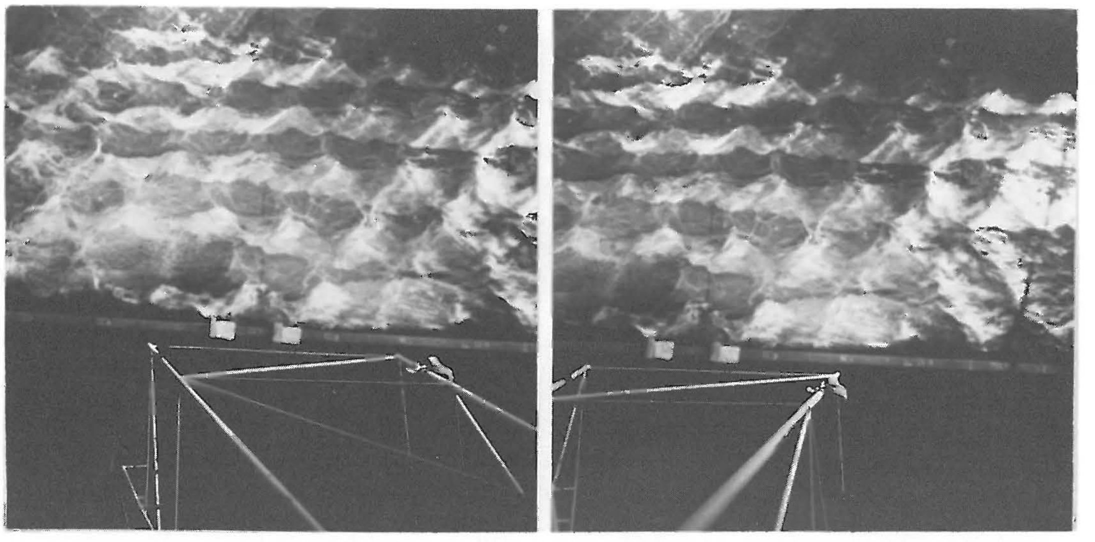

Fig. 1 A fragment of the scaled-down stereogram of a breakwater model.

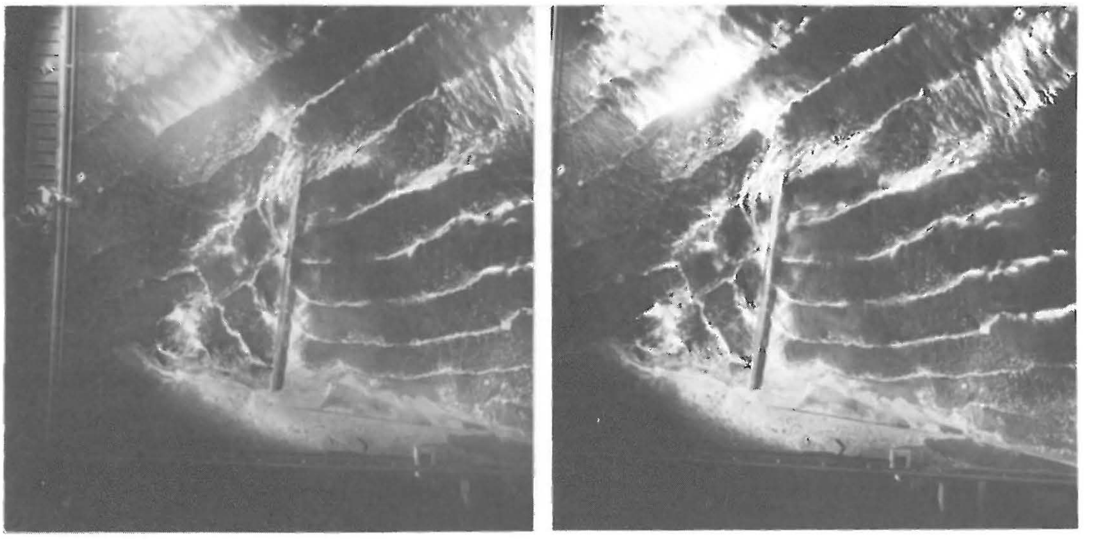

Fig. 2 A fragment of the scaled-down stereogram of a pier model.

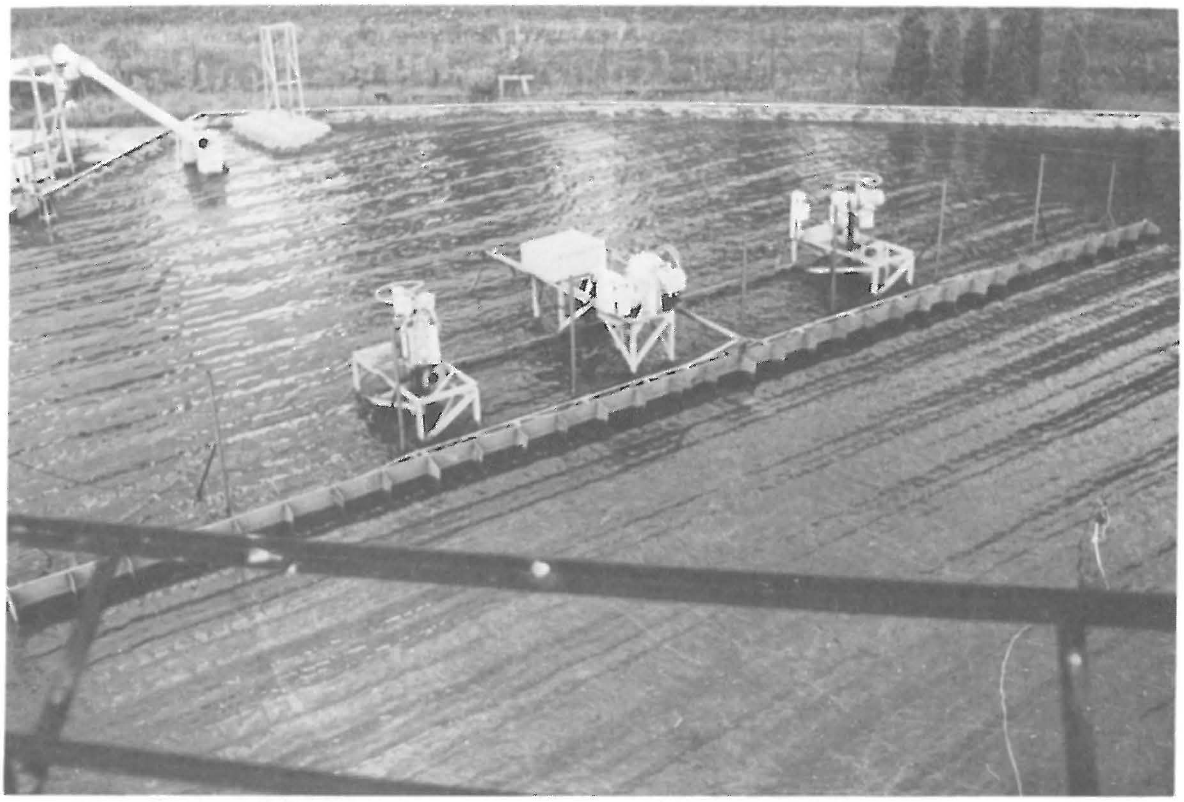

Fig. 3 The undulation water /a device inducing wavy motion on hydrotechnic models/.

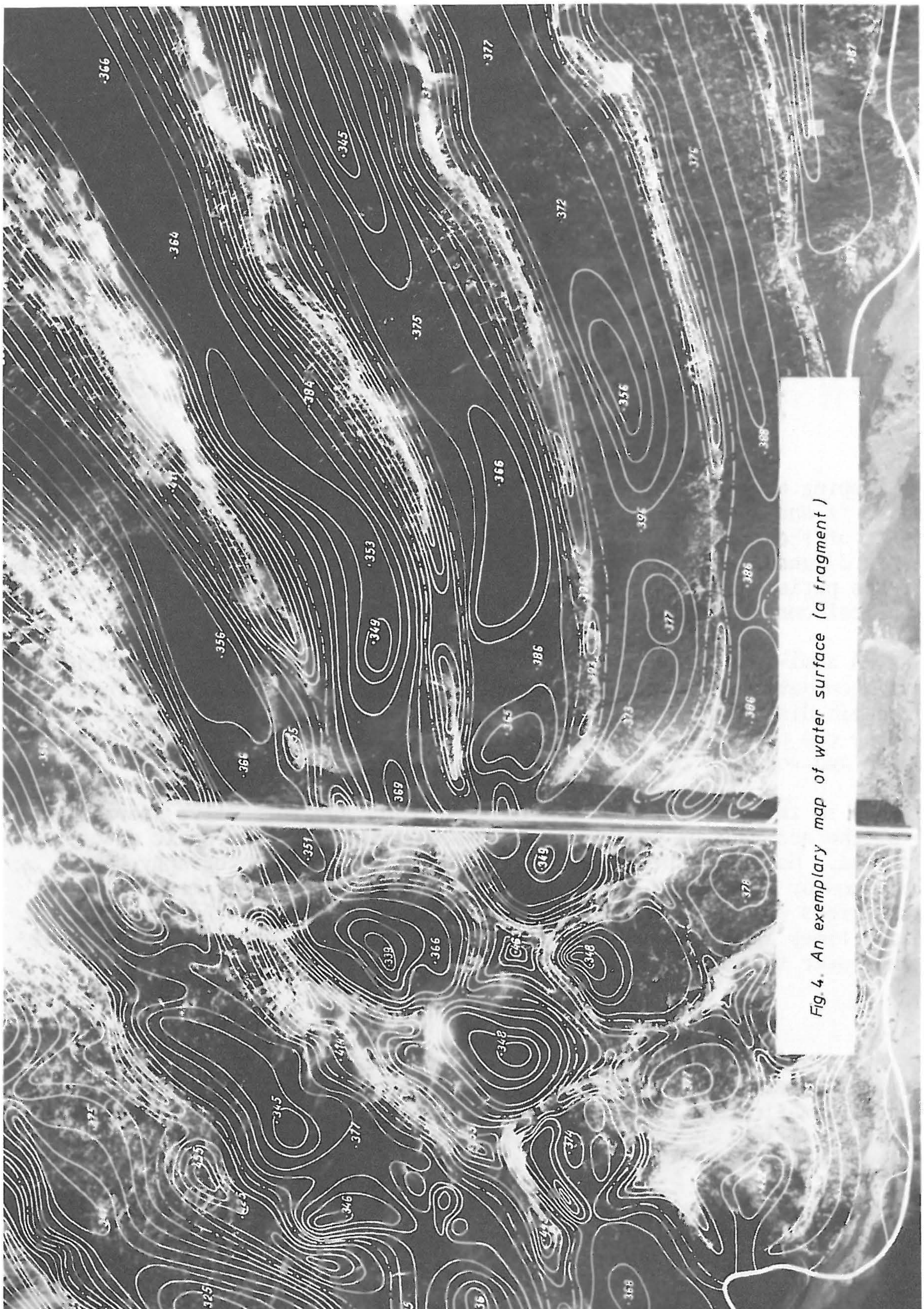

Fig. 4. An exemplary map of water surface (a fragment)