ANDRZEJ BANACHOWICZ
Gdynia Maritime University
RYSZARD BOBER, ADAM WOLSKI
Szczecin Maritime University
ANDRZEJ DOŁGOPOŁOW, ZENON KOZŁOWSKI
Szczecin Maritime Office

APPLICATION OF A DGPS SYSTEM FOR RUBBLE MOUND MOVEMENT ASSESSMENT IN KANAŁ PIASTOWSKI

ABSTRACT

This article presents the results of the examination of the bottom rubble mounds movements at the entrance to the Kanał Piastowski after its reconstruction in the years 2001 – 2005.

INTRODUCTION

Constant monitoring of the fairway bottom and shore parameters after the performance of considerable hydro-technical works together with new hydro-technical engineering solutions makes it a significant part of navigational safety. Modern satellite navigation systems can be used to inspect them, of course after checking the accuracy of their work in a given area.

DGPS, a radio navigational system commonly used at sea constitutes one of the ways to determine a position accurately. In the area of the Świnoujście – Szczecin fairway there are many possibilities to operate a DPGS system by making use of corrections transmitted by the reference stations in Dziwnów, Hammerodde and Wüstrow as well the EGNOS system.

This article presents the results of the examination of the bottom rubble mounds movements at the entrance to the Kanał Piastowski after its reconstruction in the years 2001 – 2005.

EXAMINED AREA

Bathymetric survey was carried out in the years 2002 – 2005 along the stretch in which the Świnoujście – Szczecin fairway passes through the Kanał Piastowski into the wide water area of Zalew Szczeciński (fig. 1). The accuracy of satellite systems was checked at the geodetic station P5002N at Brama Torowa 1. The results were compared with previous research [2].

Fig. 1. Świnoujście –Szczecin fairway; examined area

Before the reconstruction the passage of the canal called Kanał Piastowski leading to Zalew Szczeciński was guarded by two breakwater heads. Bad condition of the eastern head as well as the removal of remainders of the western head had accelerated the decision to build new longer breakwater heads at the entrance and broadening of the exit for Zalew Szczeciński. Reconstruction works on the breakwater heads started at the end of 2001. Parallel to building new breakwaters, work on the reconstruction of the part of Kanał Piastowski was under way. The construction of the exit heads was completed in the second half of 2004. The new shape of the exit made it possible to modernize the Świnoujście – Szczecin fairway so that it could be widened and deepened.

RESEARCH METHODS

In order to evaluate the accuracy of determining the position obtained by the DGPS system, surveys were made at the geodetic station P5002N located at these coordinates:

X = 6 027 507.840, Y = 3 325 383.730, close to the place of survey (Brama Torowa 1).

The following was determined for the surveying site:

- mean position of the place of surveying;
- accuracy of determining its position (p = 95%).

Signals transmitted by the reference stations in Dziwnów, Hammerodde and Wüstrow are logged by using the MINIMAX receiver made by the CSI Company. Additionally, a survey was made using corrections transmitted by a satellite of the EGNOS system.

Bathymetric survey was carried out by means of the Integrated Hydrographic System – SIMRAD which was installed on the vessel 'Lilka' operated by the Szczecin Maritime Office. It consists of, among others, a double head multibeam echo sounder EM-3000D working on the frequencies of about 300 kHz, a DGPS DSM Pro receiver, a SIS and Neptune software to acquire data from position and depth surveys as well as Cfloor data processing software.

RESULTS OF DGPS ACCURACY EVALUATION

Table 1 and diagrams 2 present the statistics of position distributions of the geodetic station measured in relation to the reference which was a geodetic position.

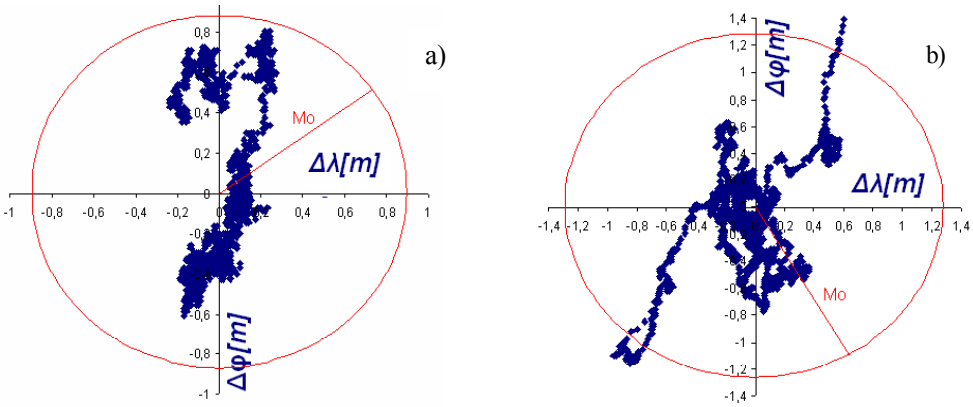
Table 1. Accuracy of position determination by means of the DGPS system at the geodetic station P5002N

Reference station	M_o (p = 0,95)	Mean position
Dziwnów	0,87 m	ϕ = 53°48,57385'N λ = 14°20,37027´E
Hammerodde	1,27 m	ϕ = 53°48,57211´N λ = 14°20,37355´E
Wüstrow	1,48 m	ϕ = 53°48,57292´N λ = 14°20,37203´E
EGNOS	2,38 m	ϕ = 53°48,57373´N λ = 14°20,37204´E

In case of obtaining a position when the corrections were used from the radiobeacons in Dziwnów, Hammerodde and Wüstrow, the signal strength (SS) was, respectively: Dziwnów 37, Hammerodde 28 – 29 and Wüstrow 43 dBμ, whereas the signal/noise ratio (S/N) was Dziwnów 23, Hammerodde 22 – 25, and Wüstrow 33 – 34 dB. The signals received provided for a continuous and proper survey to be carried out. The duration time of the respective survey sessions was sixty minutes. The accuracy of position determination depended on a given reference station and did not exceed 1.48 m for Wüstrow and 0.87 m for Dziwnów (p = 0.95).

Position accuracy when using the EGNOS system was 2.38 m, however an additional difficulty consisted in a lack of continuity for position determining due to frequent breaks in receiving EGNOS/SBAS signals.

In depth surveys the corrections from the Dziwnów station were used. However, in future, the use of RTK technique is recommended as it ensures the accuracy in determining a position which is an order of magnitude better than in case of reference stations. Figure 2 presents the scatter of instant positions relative to the mean position at a control point.



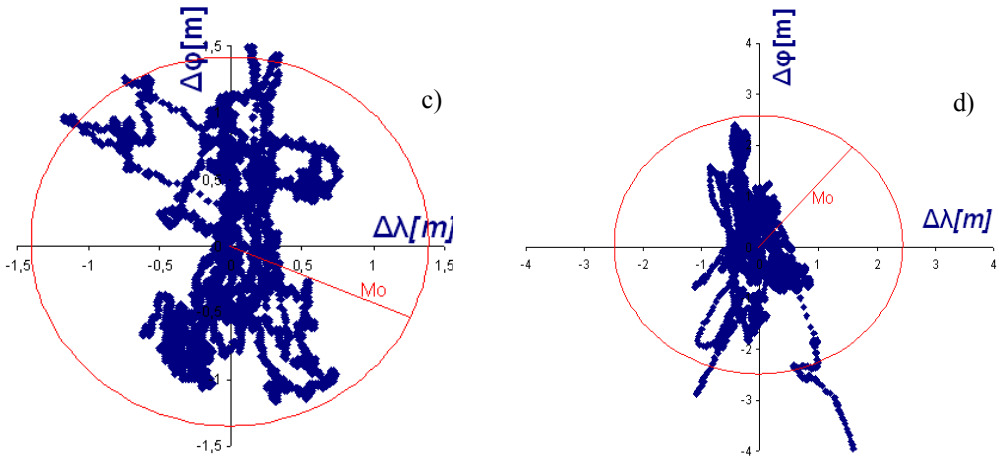


Fig. 2. Scatter of positions from the DGPS system:
a) Dziwnów station, b) Hammerodde station,
c) Wüstrow station, d) the DGPS system – EGNOS

RESULTS OF BATHYMETRIC RESEARCH

At the turn of the years 2003 and 2004 an analysis of bathymetric research in the area showed some minor deepening of the bottom in the vicinity of the eastern entrance head. Later bathymetric measurements showed that even a greater 'crater' formed in the bottom at the distance of 65 m westwards (fig. 3).

The results of the consecutive bathymetric measurements were shown as cross-sections, here called N – S and W – E sections. The cross- section of the bottom N – S (fig. 4) is parallel to the axis of the Świnoujście – Szczecin fairway. The cross-section of the bottom W – E (fig. 5) is perpendicular to the axis of the fairway at the kilometer 16.70 of the Świnoujście – Szczecin fairway. Changes in the shape of the bottom in the discussed area were depicted in the above mentioned diagrams.

The bathymetric measurement from April 2002, which is shown in the cross-sections, depicts the shape of the bottom before the dredging works connected with the reconstruction of the heads began. The W – E section shows the shape of the dredged bottom in Zalew Szczeciński that constitutes part of the Szczecin – Świnoujście fairway.

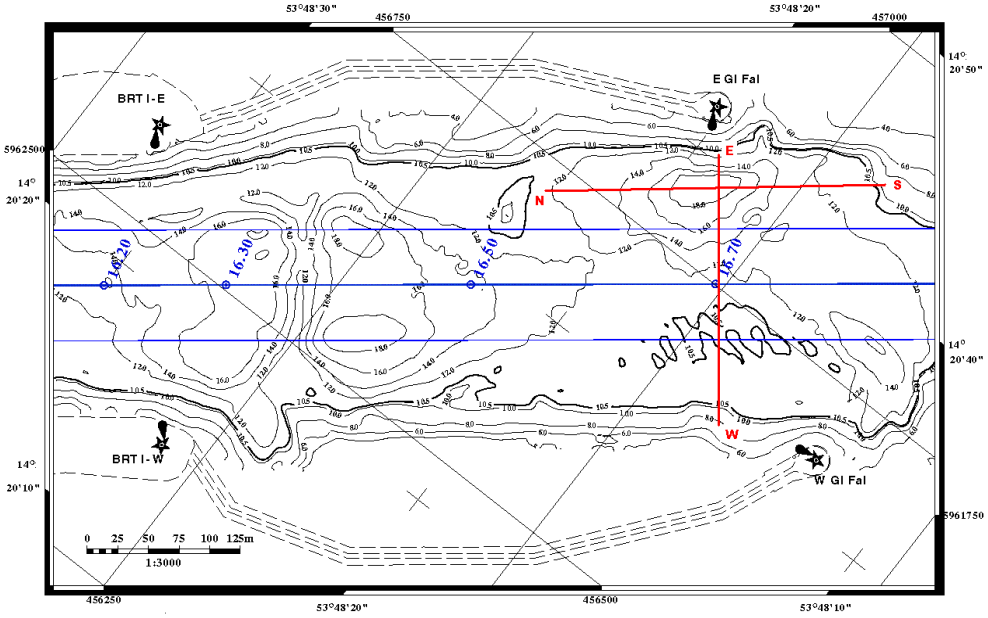


Fig. 3. Layout of bathymetric sections in the examined area

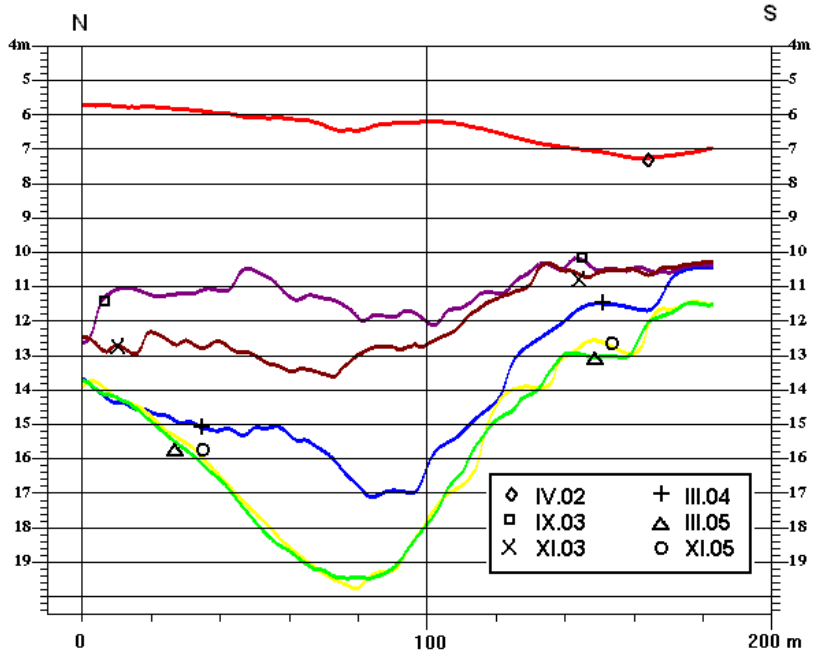


Fig. 4. Sections parallel to the axis of the fairway

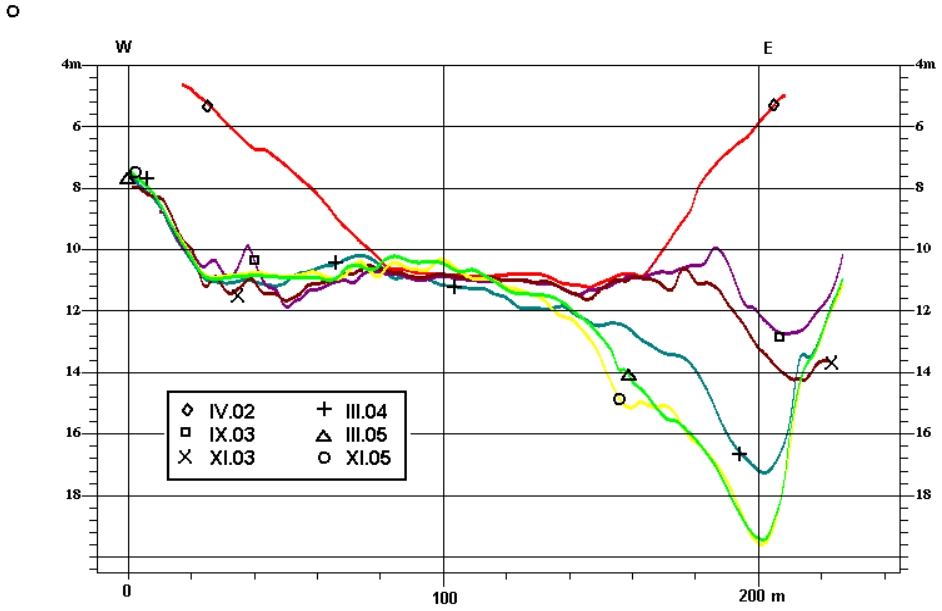


Fig. 5. Sections vertical to the axis of the fairway

The results of the measurements in September 2003 shown in the W – E cross-sections reveal a cavity in the bottom at the eastern head. It is an enforced and pre-designed shape of the bottom.

The measurement taken two months later in November 2003 was the first sign of an unpredicted hydraulic phenomenon. Probably the bottom material started to get washed out by western currents of Zalew Szczeciński. The bottom in that area was lowered by about 1.3 m and the depth increased to 14.2 m.

The next bathymetric measurements were carried out in March 2004 when the winter season 2003/2004 was over. The W – E perpendicular section of the bottom displayed rapid deepening of the bottom. The bottom lowering increased by two meters to the depth of about 17.4 m. Analysing the N – S cross-section, the above findings can be supplemented with the washing out phenomenon in the enlarged bottom area of this part of the fairway. Bathymetric measurements carried out in March and November 2005 revealed further considerable lowering of the bottom up to 19.4 – 19.7 m, that is about 2 meters in a year. It should be noted however, that at the same time the phenomenon of bottom fast deepening was found to stop.

The most recent bathymetric works (June 2006) show that the occurrence of cavity widening in the direction of Kanał Piastowski as well as the landslide from the slope in the cavity took place near the eastern head.

CONCLUSIONS

The examinations done proved that the DGPS system enables to carry out sounding in the Świnoujście – Szczecin fairway. The accuracy of position determination, depending on a given reference station, ranged from 1.48 m for Wüstrow to 0.87 m for Dziwnów (p = 0.95).

The dislocations of the bottom measured in the years 2002 – 2006 revealed its rapid deepening in the vicinity of the eastern breakwater, from 11.5 m to 19.4 – 19.7 m, that is 2 meters each year. Once that occurrence has been identified it is necessary to monitor continuously for any changes in the configuration of the canal bottom. Further increasing of the depth and widening of the deep water area will threaten the structure of the eastern breakwater and may consequently lead to a construction disaster.

At the same time it should be noted that the DGPS system and EGNOS in parti-cular do not provide for satisfactory accuracy in position determination. In future, moni-toring depth changes in the area in question should be continued with the use of more precise navigational systems e.g., an RTK system or systems based on laser measurements.

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