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Analysis of the ships' UKC by probabilistic model based on chosen real data in period 2005 till 2009

Keywords

under-keel clearance (UKC), probabilistic model, real data

Abstract

The paper is concerned with the analysis of under-keel clearance of ships based on real data from Szczecin Maritime Office. Using probabilistic method for UKC assessment give it possibility to create the distribution of under-keel clearance in several ship's passages and in further step to determine the probability of ship's grounding accident during the port approach. The results of using this type of model could be used in risk assessment of ships entering to the ports, therefore it is possible to used probabilistic model in Maritime Office employees' everyday decision making practice. Research results present verification of probabilistic model, based on data from Vessel Traffic Service database and probability of touching the bottom during ships' passages on Swinoujscie - Szczecin waterway. Moreover there are presented examples of these situations when entering to the port for analysed ships is not allowed according to the model.

1. Introduction

Due to developments in shipping, ports are under continuous pressure to accommodate wider and deeper-draught ships. Good solution is dredging of the entrance to the port but it is an expensive option. Therefore very important task is to find maximum safe draught of a particular type of ship for an existing port entrance channel as a function of the tide, wave condition and ship speed [3].
Since Under-keel clearance is the required minimum distance between the ship's keel and the bottom of the channel, local regulations sometimes stipulate it that a ship must maintain in their areas where pilotage may not be compulsory. The determination of minimal under-keel clearance is especially important for the port as it allows, basing the existing meteorological conditions and the type of vessels, to load the vessel maximally [6].
Marine staff at the ports needs an adequate decision support system to allow them to take ship allowance decisions based on proper and reliable data [3].
Because Swinoujscie, Szczecin and Police have special VTS procedures for entering and leaving these ports, and precise requirements are determined by Port Regulations and Marine Authorities have problem with decision according to entrance big-draught vessels, probabilistic model for under-keel clearance determination was created.
The paper presents verification of this model based on data from Szczecin Maritime Office. There are ships with length more than 180m, entering Swinoujscie, Szczecin or Police Port in years 2005-2009 analysed. Influence wave height and ship speed for the model was determined. Because probabilistic model of under-keel clearance determination could support the decision of Port Captain, it is possibility that using online program for under-keel clearance evaluation will be recommended by local Maritime Authorities.

2. Probabilistic model for UKC assessment

The stochastic model of under-keel clearance evaluation was presented in [1] and description and practical implementation process of developed probabilistic model of ship's under-keel clearance was explain in [5].
The main assumption of probabilistic method for UKC determination is based on Monte Carlo methodology. The model takes into account depth measurement uncertainty, uncertainty of draught determination in port, error of squat determination, bottom irregularity, tides and waves influence (*Figure 1*). Program is capable to consider above

mentioned uncertainties using distributions and their parameters.

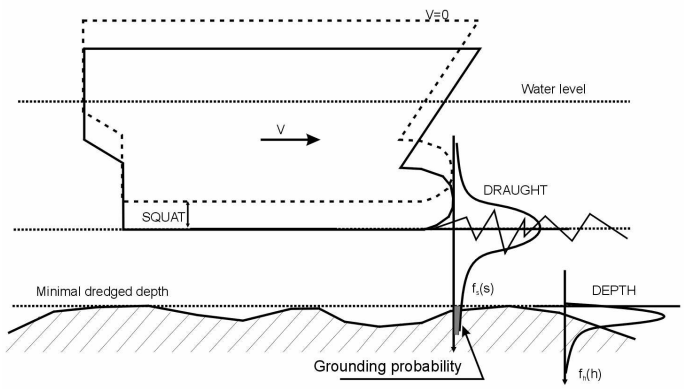

Figure 1. Concept of probabilistic under-keel clearance of ships determination [2]

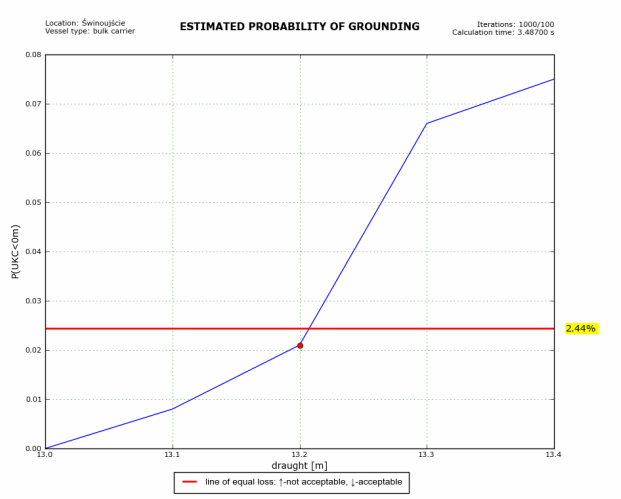

Figure 3. Example of decision support application result in Swinoujscie

Actually model UKC evaluation is available "on-line" on Maritime Traffic Engineering Institute web site and it is used for research tool. User can enter the basic ship and water region data. The remaining necessary data are taken from XML file located from the server. Model under-keel clearance is evaluated after running the application. The results of using this application are histogram of under-keel clearance for analysed ship (*Figure 2.)* and diagram P(UKC<0) in function of ship's draught (*Figure 3*). In this way program can be helpful to assess whether large vessel are allowed or not to enter to the port.

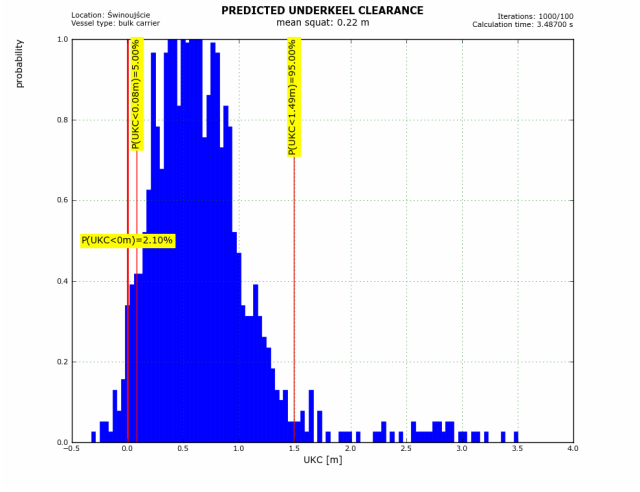

Figure 2. Example of results probabilistic model of UKC for one of ships which entered Swinoujscie Port in 2009

What is important this type of application allows determination of probability of ship's hull contact with the bottom what may be allow for better particular ship's view. Additionally information for user is the result of method of constant clearances (according to "The Guidelines for Designing of Maritime Engineering Structures") and mean squat value, calculated on the basis of empirical methods (Huuska, Millward'a 1, Turnera, Hooft'a, Barrass'a I and II) [2].

3. Local regulations for Swinoujscie, Szczecin and Police Port with regard to maximal vessels [4]

Swinoujscie, Szczecin and Police are ports where special local regulations are in force. The basic rule says, that no vessel which are 20 m or more in length may enter or leave the port or navigate in its area without the permission of the Harbour Master or VTS. In ports where the system is mandatory, in order to obtain permission, a vessel shall contact the Harbour Master's Office or VTS. The Master of each vessel, before entering or leaving a port, shall report to the Harbour Master's Office or VTS if that system is mandatory in that place, informing them of the voyage plan as determined in accordance with the reporting system being stated, as appropriate, the pre-notification should contain i.e. LOA, beam, GT capacity, vessel type, and maximum draught in fresh water.

Following regulations concerning length and draught of ship: vessels entering and leaving the port of Swinoujscie may not exceed 270 m in length overall, 42m breadth and 13.2m draught in fresh water. The overall length of vessels entering and leaving the ports of Szczecin and Police may not exceed 215m and the overall breadth may not exceed 31m. The

draught of vessels entering and leaving the port of Szczecin may not exceed 9.15m and the overall length may not exceed 160m. The draught of vessels entering and leaving the port of Police may not exceed 9.15m and the overall length may not exceed 170m. Moreover regulations say that, it is prohibited for vessels that are overloaded so that they exceed the draught permitted in the appropriate certificate to enter or leave the port (§18). A vessel may not enter the port, navigate in or leave the port without the Harbour Master's permission, if that vessel endangers safe navigation and operational order in the port area, and in particular when it is excessively trimmed or has a dangerous list.

On the Swinoujscie –Szczecin waterway are special restrictions according to ship's speed. Regulations say that vessels, sailing at maximum permitted speed, which generate waves that wash sea defences or that are capable of damaging port facilities or ships at berth, shall reduce speed to such extent that waves will not be generated. Maximum permitted speeds in the different Szczecin-Swinoujscie seaway stretches are given in the *Table 1*:

Table 1. Maximum speeds in the different Szczecin-Swinoujscie seaway stretches [4]

Lp.	Seaway stretch	Maximum speed [knots]
1.	From sea anchorage to buoys no 7-8	12
2.	From buoys no 7-8 to Gate no 1	8
3.	From Gate no1 to abeam of northern head of Chelminek island	12
4.	From abeam of northern head of Chelminek island to buoys no 13-14	8
5.	From buoys no 13-14 to abeam of beacon Krepa Dolna	12
6.	From abeam of beacon Krepa Dolna to abeam of beacon Radun Gorna	8
7.	From abeam of beacon Radun Gorna to Inski Nurt	12
8.	From Inski Nurt to the port in Szczecin and in port areas	8

4. Research results

Research was carry out for ships which entered to ports: Swinoujscie, Szczecin and Police in a period from 2005 till 2009. Parameters of each vessel were entered together with appropriate hydro-meteorological conditions as water level and wave height, which were checked in Vessel Traffic System database. Probabilistic model was used for all ships equal or longer than 180 m, and with draught equal or more than 7.5m. Because there was no information concerning ship's speed for each particular vessel, in analysis assumed ship's speed equals 6kt.

In connection with it, in the analysis were used 293 ships which entered Swinoujscie, Szczecin or Police Port. Maximum ship's draught which used in research was equal 13.2 m for Swinoujscie Port. Mean probability of ship's grounding in Swinoujscie – Szczecin waterway is insignificant and equal P(UKC<0)= 1.5% and mean under-keel clearance of ships which entered ports is 3.25m.

The *Table 2* presents number of ships and mean parameters from probabilistic model results in Szczecin, Swinoujscie and Police Ports in years 2005-2009.

Table 2. Research results in particular ports

	Szczecin	Swinoujscie	Police
Number of ships	59	167	67
Mean probability UKC<0	0	0,04	0
Mean UKC	2,31 m	2,17 m	1,52 m
Mean UKC on 95% level of confidence	4,59 m	4,67m	3,88 m

Figure 4 presents histogram mean under-keel clearance of ships in years 2005-2009 according to the probabilistic model.

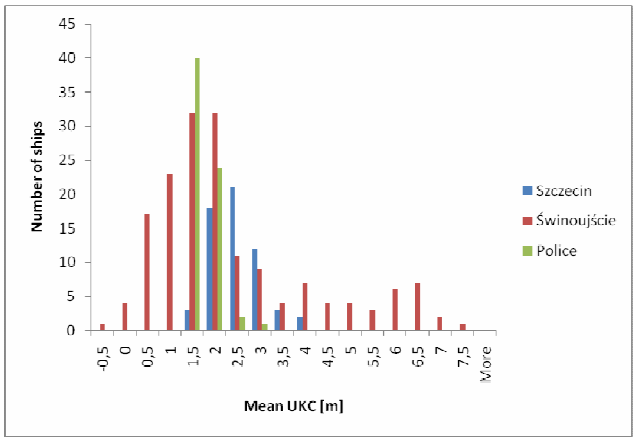

Figure 4. Histogram of mean UKC in analysed ports in years 2005-2009

In Swinoujscie probability that under-keel clearance will be less than zero is equal 0.04 and the most ships have entered to the port with under-keel clearance 1.5-2m. These results were obtained for

167 ships. In case of 59 ships which entered Szczecin Port mean probability of touching the bottom is equal 0 and the similar situation is in Police Port where the probability UKC<0 level for 67 ships. In relation to mean value of under-keel clearance during passage Swinoujście –Szczecin waterway was amount:

- for ships going to Szczecin: 2.3 m
- for ships which entered Police : 1.5m.

As a result from analysis it was found that the biggest number of ships entered Swinoujscie Port. The probabilistic model confirms decisions of Port Captain in Szczecin and Police but there are several situations in Swinoujscie, where the level of safety is not acceptable according to probabilistic model, so mean probability than UKC will be less than zero is equal 4%. These cases took place in very bad hydro-meteorological conditions, so it was possible to enter for ship with smaller speed (less than 6kt-which was used in verification). From 167 situations when large ships entered Swinoujscie port, 18 cases were not accepted by probabilistic model. In *Figure 5* mean under-keel clearance (UKCi) for these cases is presented together with value UKC on 5% and 95% level of probability.

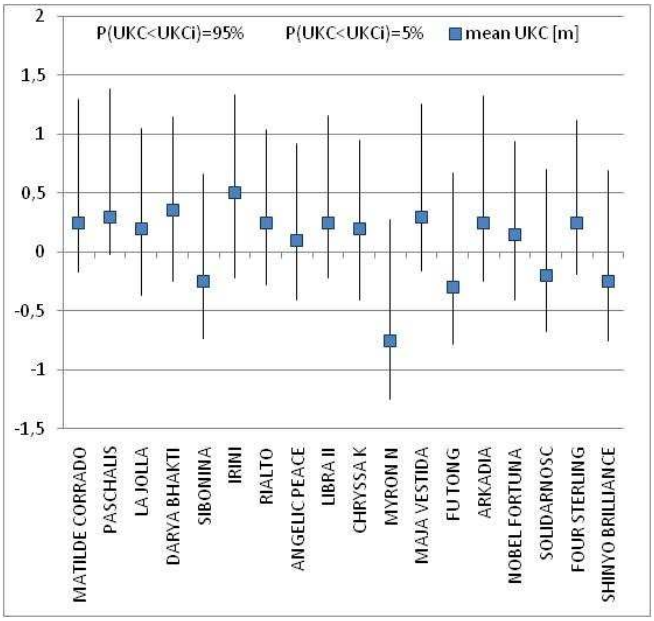

Figure 5. Under-keel clearance of ships without permission (according to the probabilistic model) for entrance to the port.

The model assess that probability of touching the bottom for presented ships is too large for safety entrance to the port but only 5 vessels had mean UKC less than zero. It is important that there are no information about real speed which had vessels during entering the port (analysis was used for speed equals 6kt). Because all of these cases took place in very bad hydro-meteorological conditions (strong breeze), it is possible that VTS operator suggested to reduce speed. *Figure 6* shows probability that UKC will be less than zero depending on ship's speed.

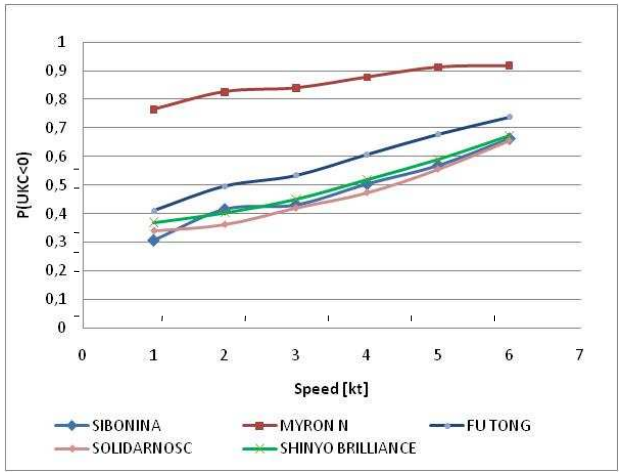

Figure 6. P(UKC<0) in function of ship's speed.

On the basis of research results presented in figure 6 it was found that entrance permitted for ship Myron N with length equals 229.84 m and draught 12.98m in 2005 was very dangerous. According to Maritime Office database this ship's entrance was at water level 498 cm and east wind with 7 in Beaufort scale. On the basis [7] wave height equals 2m was assumed for simulation and using probabilistic model (for this case). In this connection wave height influence on probability of grounding of analysed ship was investigated. The *Figure 7* presents probability then under-keel clearance for bulk carrier will be less than zero depending on wave height for different values of speed (3 and 6 knots).

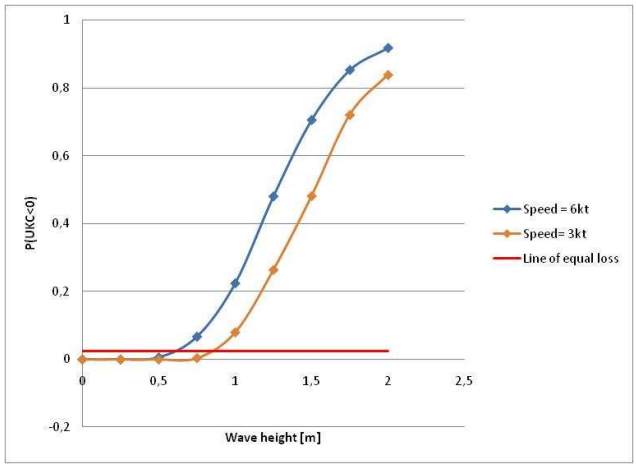

Figure 7. P(UKC<0) for bulk carrier "Myron N" in function wave height.

Additionally in *Figure 7* line of equal loss for analysed ship was marked. In this case model has not allowed for safety entrance to Swinoujscie Port for probability less than 2.44%. Therefore at initial conditions for all simulations carried out using by probabilistic model ship Myron N cannot enter Swinoujscie Port. In accordance with proposed model entrance for this ship is possible at wave height less than 0.85m. In this case wave height has more influence on probabilistic model than ship's speed change.

5. Conclusions

The probabilistic model confirms decisions which were made by Port Captains or VTS operators in Szczecin and Police Port in years 2005-2009 in accordance to vessels with big draught. In Swinoujscie Port there were some situations where model has not allowed for safety ship's approach. Mean probability level of touching the bottom during ships' passages with length over 180m in Swinoujscie - Szczecin waterway equals 0.015. Wave height change has more influence on calculated probability UKC<0 than ship's speed change.

After carried out the sensitivity analysis is intended to use the probabilistic model for UKC evaluation by Maritime Office employees' in everyday practice.

References

[1] Gucma, L. (2005). *Risk Modelling of Ship Collisions Factors with Fixed Port and Offshore Structures*. Maritime University of Szczecin, Szczecin.

[2] Gucma, L., Schoeneich, M.(2007). *Probabilistic Model of Under-keel Clearance in Decision Making Process of Port Captain*. Monograph- Advances in Marine Navigation and Safety of Sea Transportation TransNav'2007, Gdynia.

[3] Moes, J., Rossouw, M., Brophy, M. & Van Loon, F. (2002). *Minimum Safe Under-keel Clearance in Port Entrance Channels*. PIANC, Sydney.

[4] Port Regulations (2002). STANDING ORDER No 4 Director of the Maritime Office in Szczecin of 17th September 2002.

[5] Schoeneich, M. (2008). Probabilistic method and decision support system of ship's under-keel clearance evaluation in entrance to the ports. *International Symposium on Electronics in Transport*, Ljubljana.

[6] Website: www.transportweekly.com/pages/en/news/articles/56060/ 2008

[7] Wiśniewski, B. (1998). *Falowanie wiatrowe*. Wyd. Naukowe US, Szczecin.