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SOFTWARE PACKAGE FOR LOADING CALCULATIONS WITH USE OF IBM PC MICROCOMPUTER

SUMMARY

In this paper a version of the software package for carrying out on board loading calculations with use of the IBM-PC-AT microcomputer is presented. The package makes it possible to perform calculations with high accuracy of weight, stability, and strength of a ship and in a user-friendly way. As the input load conditions may be saved on disk and also printed, the programs may be helpful in everyday duties of ship's officer responsible for loading operations. Intended development of the software package is shortly discussed.

Introduction

Distribution of loads within a ship is vital for ship safety and effectiveness of ship operation. A task of disposition of loads in a ship should be solved in a harbour before starting cargo handling operations. High rate of these operations and fast changing information on amount and type of cargoes, as well as on ports of their destination, make problems connected with determination of an optimal variant of load distribution more and more important.

The main element in estimation of each variant of load distribution is the calculation of ship weight, stability, and strength, and then validation of its results and selection of the best variant with respect to criteria assumed. At the present time, a large variety of instruments are offered on the world market for helping ship's crew in carrying out loading calculations. In this respect, an officer responsible for cargo operations may have recently a choice of the following: a specialized calculator (offered, e.g. by such firms as Raytheon, Plath, ASEA, Kockums, F.S. Taxcal Ltd, Hatachi, Mitsubishi) or a universal computer provided, among others, with software for execution of algorithms of the loading calculations aboard (such software is offered, e.g. by Engineering Company, M.G. Honkanen Ltd, Techno-log GmbH, Anchor Marine, Navidyne).

In the years 1984-89, the specialized loading calculator DELFIN was also elaborated by The Ship's Automation Institute of The Merchant Maritime Academy in Gdynia in cooperation with the Radmor Works in Gdynia. It seems however, that a trend for installing one central computer on board, which enables to perform different tasks (e.g. running material records, controlling ship's navigation, executing loading calculations etc), has much higher chance for development. This is at present an optimal solution in respect of both economical and technical aspects of the problem.

A software package described below in this paper is a continuation of the research carried out earlier in The Ship's Automation Institute of The Merchant Maritime Academy in Gdynia.

Programs of the package (written in Turbo Pascal 6.0 programming language) make it possible to perform calculations of weight, stability, and strength of a ship with use of the IBM-PC-AT microcomputer provided with a graphic adapter of Hercules, EGA or VGA type.

Categories of compartments, description of loads

The programs described here enable to simulate distribution of loads within a ship. Simultaneously, the calculations of weight, stability, and longitudinal strength of an intact ship in still water are carried out. Owing to these programs, quick, simple, and secure estimation of basic operational parameters of a ship is possible dependent upon an assumed distribution of loads on board. A ship is idealized as a two-dimensional object whose basic parameters of stability and strength are calculated, knowing the weight of a load component Q_i and the coordinates Z_i , X_i , which determine location of a given load component in the basic reference system, i.e. a distance from the baseline (plane) (PP) and a distance from the reference frame plane

containing aft perpendicular (PR), respectively.

Load components are assumed as the weights Q_i , that are concentrated in points of coordinates Z_i , X_i corresponding with their centres of gravity. The programs enable also selection of an optimal variant of the load distribution to be done. A ship considered is intended for the carriage of loads in holds, tanks and containers as well as for the carriage of the nonstandard loads. A load in holds and tanks is characterized by its weight Q_i and the ordinate of its centre of gravity Z_i . It is also

possible to insert a default value of Z_i from tables describing the ship (this is the maximum value permissible for a given type of compartments or later - an actual value).

For a compartment of the hold or tank type, the abscissa X_i is derived from the tables describing the ship. For this type of load, its weight Q_i is only input. Nonstandard loads may be disposed in an arbitrary point of a ship and they are taken as concentrated loads having the weight Q_i and the coordinates Z_i , X_i .

Each compartment is described by means of a code. A compartment code is selected by the code command Number (code selection from the numerical keyboard) or by the commands: Next, Continue, Previous, Nonstandard. After the selection of a standard compartment code the input and acceptance of weight data are performed, and finally an actual value of the ordinate Z_i for loads in holds and tanks is displayed, which may be changed after confirmation of intention to change it. The abscissa X_i is not changed (as being inserted from tables). For a nonstandard load, however, values of its weight Q_i and coordinates Z_i , X_i should be put in. Values of the weight Q_i and of the coordinates Z_i , X_i constitute a weight record. After accepting a weight record and performing Load or Unload commands, ship's load condition will be updated and the calculations of stability and strength performed. The basic data describing a ship, indispensable for the calculation of ship's load, stability, and strength, are prepared in a form of tables containing:

- data characterizing the empty ship (ship's displacement, weight moments, coordinates of the control frame sections, the maximum values of bending moments and shear forces at the control frame sections etc);
- data describing filled compartments (maximum weight in a compartment, the height of centre of gravity of a filled compartment over PP, the distance of centre of gravity of the compartment from PR);
- coefficients of polynomials approximating moments and buoyancy forces of the ship's forebody in respect to the control frame sections;

All the changes in ship construction, which might influence a lightship weight distribution and location of its centre of gravity or ship load compartments, require the data contained in the tables describing a ship to be updated accordingly.

Menu structure

The software package contains eight options: Cargo, Read, Display, TotLoad, TotUnl, Info, Print, Help. The menu structure of the package together with the available

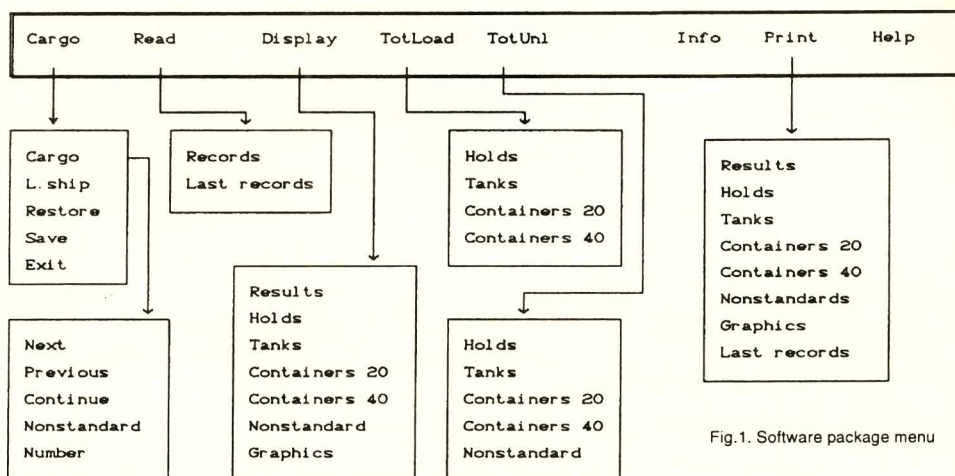


Fig.1. Software package menu

commands is presented in Fig. 1.

The programs make possible:

- determination of the "lightship" load condition (L.ship);
- visualization -on a graphic monitor screen- of a load condition of every compartment, results of the calculations of ship's weight, stability, and strength as well as displaying curves of bending moments and shear forces (in a form of bar diagrams);
- printing of results of the weight, stability, and strength calculations, filling state of each compartment, diagrams of bending moments and shear forces; the printouts may serve as the documents required in compliance with the amendments to the International Convention on Safety of Life at Sea 1990, p.7.4;
- checking of results of the calculations and of input data. The basic Cargo option, which contains 5 commands (Cargo, L.ship, Restore, Save, Exit), enables to simulate loading or unloading of a ship with arbitrary portions of load defined in accordance with the following format (see Fig. 2):
- code of compartment;
- weight of a load (in a direct form, i.e. using the Number command, which means typing a value Q on the keyboard, or with use of the Full command, which is equivalent: in the case of loading - filling a compartment with the maximum weight for that compartment, but for unloading - emptying completely a given compartment of load);
- distance of centre of gravity of a load from PP;
- distance of centre of gravity of a load from PR.

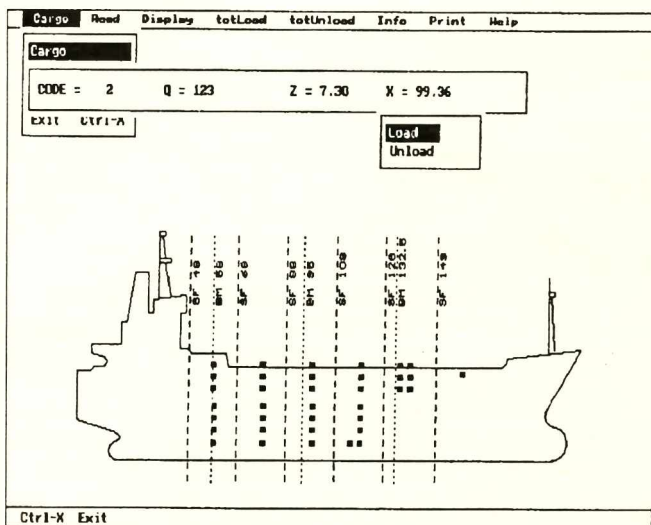


Fig. 2. A screen display when inserting a weight record

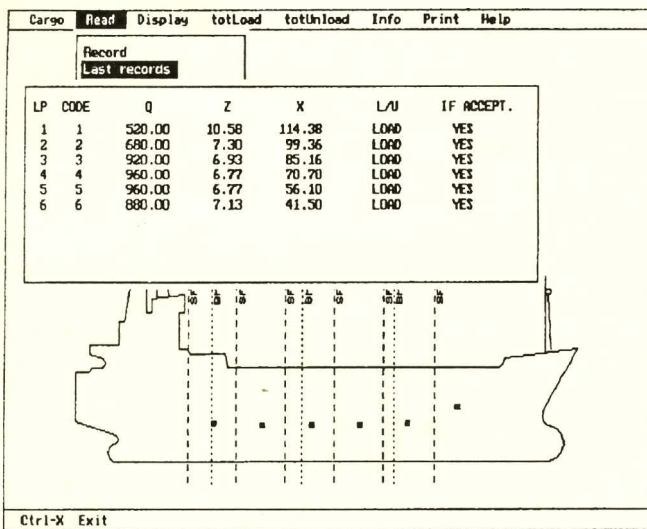


Fig. 3. A screen display after entering the Hold command from the TotLoad option and the Last records command from the Read option

When a weight record is being inserted, the following is checked:

- code of compartment;
- weight of load, whether it would exceed the maximum value of ship displacement;
- weight of load, whether it would exceed the maximum value allowable for a given compartment;
- weight of a load of the zero value;
- coordinates, whether they would exceed allowable dimensions for a given compartment or for a given ship in the case of nonstandard loads.

For each properly put in weight record a ship load condition is actualized and then the calculations of stability and strength are performed. Moreover, the L.ship command from the Cargo option makes possible the determination of the "lightship" load condition. Results of calculations for the lightship are also displayed. In the Cargo option commands are contained for storing (the Save command) an actual load condition on disk or retrieving from the disk (the Restore command) an arbitrary, but previously saved, load condition. The above described commands help to simulate different load conditions and to choose an optimal one.

In the Cargo option, the Exit command is also included, which enables to exit the program. Using the Tot. Load option, it is possible to put in the maximum value of weight to compartments of each type, i.e.: HOLD, TANK, CONTAINER 20, CONTAINER 40, under the condition that the maximum ship displacement would not be exceeded (see Fig. 3). Similarly, using the Tot.Unl option, it is possible to empty a particular type compartment, the nonstandard type inclusive. Using the Result command from the Display option, it is possible to display on a graphic monitor screen actual results of the calculations of weight, stability, and strength. The user may also display filling state of selected compartments when using the same option but entering a command, which determines a given type of compartment (HOLD, TANK, CONTAINER 20, CONTAINER 40).

The Graphics command from the Display option enables presentation of the bending moments and shear forces diagrams in the control frame sections for an actual ship load condition. Filling state of an arbitrary compartment, defined by its code, may be retrieved with use of the Record command from the Read option.

Selecting of a compartment code in this command is executed in the same way as in the Cargo option. It is also possible to display the last ten weight records inserted (the Last Records command) - even those not accepted. The Print option enables printing - depending on a command chosen - results of the weight, stability and strength

Friday 1992-Apr-24
Time: 05:25:51
Name of ship: m/s JAGAT

RESULT OF STABILITY
AND STRENGTH RANGE CALCULATION

TOTAL DISPLACEMENT	10702.00 T
ZG0	8.12 m
ZG1	8.32 m
ZG2	8.38 m
TRIM	-3.55 m
DRAFT AT MIDSHIP	5.96 m
DRAFT AT F.P	4.19 m
DRAFT AT A.P	7.74 m

BENDING MOMENTS

BM 58	114184.44 Tm	(170.47%)	EXCEEDED RANGE
BM 95	90179.20 Tm	(134.63%)	EXCEEDED RANGE
BM 132.5	49792.80 Tm	(74.34%)	

SHEARING FORCES

SF 48	238.38 T	(5.97%)
SF 68	654.27 T	(16.37%)
SF 88	1092.29 T	(27.33%)
SF 108	1403.83 T	(35.13%)
SF 128	1320.50 T	(33.05%)
SF 149	1466.78 T	(36.71%)

Total holds weight	4920.00 T
Total tanks weight	0.00 T
Total containers 20 weight	0.00 T
Total containers 40 weight	0.00 T
Total nonstandard weight	0.00 T

TOTAL CARGO WEIGHT 4920.00 T

Friday 1992-Apr-24
Time: 17:07:50
Name of ship: m/s JAGAT

WHAT IN HOLD					
LP	Code	Q(T)	X(T)	Z(T)	%
1	1	520.00	114.38	10.58	100.00
2	2	680.00	99.36	7.30	100.00
3	3	920.00	85.16	6.93	100.00
4	4	960.00	70.70	6.77	100.00
5	5	960.00	56.10	6.77	100.00
6	6	880.00	41.50	7.13	100.00

Fig. 5. Example of a filling state of holds

calculation (see Fig. 4), filling states of compartments of a given type (see Fig. 5), and the diagrams of bending moments and shear forces at the control frame sections. The remaining options: Help and Info are of an informative character only, i.e. they contain information about the program itself and its execution.

Conclusions

The programs described have been started with the use of the data characterizing the B-599.1 ship; the data are general enough to allow for their ease implementation also for ships of a similar range of load calculations. The program for the load calculations allows for automation of the operations connected with complementing and putting in weight records, i.e. putting in a compartment code, a weight, and coordinates of its centroid, which is the most time-consuming and requiring high attention to be paid by the operator. The software package is provided with an adequate set of options and with commands helping in carrying out loading and unloading operations, and it ensures the accuracy of calculations up to 10^{-6} , as well as

a tolerance for semantic-syntactic errors of a user. Input data are currently checked and messages are displayed in case of exceeding the maximum values of parameters connected with a ship, load or load compartment. The fact that the calculations are executed as soon as a weight record is properly put in gives the user a possibility to currently control basic parameters of ship's weight, stability, and strength. Results of the calculations in the alpha-numerical format are clearly visualized, but bending moments and shear forces are also graphically presented. Filling states of load compartments are shown in tables. As load conditions may be saved on the disk and also printed, the programs presented may be helpful in everyday duties of ship's officer. The described software package for loading calculations is not a closed one. It is possible to extend the package with new modules. In the future, some programs will be added which would enable inserting weather criterion and arms of the curve of statical stability.

It is moreover intended to add an option which would make possible to optimize ballast conditions of a ship (with the objective function: minimum amount of water ballast, and constraints: permissible ship displacement, initial metacentric height, trim, bending moments and shear forces at the control frame sections).

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