Development and analysis of normative teqchnique for designing the small sea port facilities

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Abstract: *At present, with rapid growth in maritime transport, the issue of improving the quality and reducing the time of design of marine terminals, ports and related facilities comes to the forefront. To this end, it is necessary to perform design works which are of integrated nature and are distinguished by high level of automation. The problem can be solved by creating a highly efficient automated system of design based on modern methods of engineering analysis and modeling.*
KEY WORDS: *SMALL MARITIME PORT, LANDING-STAGE, YACHT CLUB, PORT HANDLING.*

1.Introduction

Along with rapid growth in maritime transport, the issue of improving the quality and reducing the time of design of marine terminals, ports and related facilities comes to the forefront.

The process of creating port or terminal, as well as of any transport infrastructure facility proceeds through several stages, from business idea to the analysis of commercial results of operation. This process involves creation of the design and working documentation, as well as the construction, putting into operation and operation of a facility. Besides, the process of creation of a facility involves several parties, including: customer, investor, designer, operator, supervisory authorities, consumers and so on.

The main element of the port technological structure is a shipping complex, which is a complex of engineering means (buildings, installations, equipment, transport and engineering communication) required for port activities. implies cargo receipt, loading, unloading and comprehensive maintenance of maritime transport ships. Port operation also envisages receipt and delivery of cargo by rail, road, river, pipeline and other types of transport.

That is, the main task of the technological processes of port is to make the optimal decision, which includes safe handling of ships, rapid loading and unloading and comprehensive maintenance. At the same time, it is necessary to enhance the capacity of cargo turnover, development, environmental safety and economic feasibility of the decisions taken.

2. Preconditions and means for resolving the problem

The design process with regulated norms can be divided into several stages. At the initial stage, two or more competitive versions of the technological process and the shipping complex master plan are discussed. At the same time, the technical data of production should not be below the standard level.

In the next stage, the effective investments are calculated on the basis of quantitative and qualitative indicators obtained in the development of the relevant part of the project. As aseparate section of the project there is considered such organization of major and auxiliary works when occupational health and fire safety requirements are completely observed.

At the initial stage of the calculation of the construction of port, there is considered the intensity of the loading and unloading operations, which is determined by the duration of works, production breakdown time and is calculated by the formula:

$$P_{\text{dail y}} = \frac{1}{\sum_{i=1}^{n} \frac{A_i(t_{cti} - t_{sti})}{24D_i}} \qquad \frac{T}{\text{day} - \text{and} - \text{night}}, \quad (1)$$

where

n – number of ships under study;

D_i – estimated cargo turnover of i-type ship, T;

A_i – estimated share of i-type ship in the estimated cargo turnover;

t_{cti} – time spent on loading (unloading) operations, hr;

t_{sti} – standing time of ship at a port, hr.

The weighted share of i-type ship in total cargo turnover (Q) is a value $(A_i \cdot Q)$, from which the total maintenance time of a given type of ships is calculated by the formula:

$$T_i = \frac{A_i \cdot Q}{P_i},$$

where the value P_i is a daily intensity f ship operation and is calculated by the formula:

$$P_i = 24D_i/(t + t)$$

If you divide total cargo turnover (Q) by the time of its handling *T=ΣTi*, we get the formula T = ΣTi in the reduced form, or what is the same with the composition of ships having the given initial values, their share in the estimated cargo turnover and by processing technological parameters, we can get the average value - daily cargo production.

The annual capacity in tonnes can be calculated by the formula:

$$P_{an} = \frac{30P_{daily} \cdot K_{met} \cdot K_{del} \cdot N_m}{K_m}, \qquad (2)$$

where

N_m – number of months of navigation;

K_{met} – meteorological conditions factor;

K_{del} – ship delay factor;

K_m – irregularity monthly coefficient.

By analyzing the formula 2, we get the following sequence of the used estimated values:

1. If the daily productivity calculated by the formula 1 we multiply by 30, we get the maximum (monthly) intensity of cargo turnover - $30P_{daily}$.
2. If the obtained value $(30P_{daily})$ we multiply by the irregularity monthly coefficient (K_m), we get the average monthly cargo turnover $30P_{daily}$ ./ K_m.
3. The value $30P_{daily} \cdot K_{met} / K_m$ is the average monthly cargo turnover with account for metrological conditions.
4. The value $30P_{daily} \cdot K_{met} \cdot K_{del} / K_m$ is the average monthly cargo turnover with account for metrological conditions and delay (without breakdown).
5. The value $30P_{daily} \cdot K_{met} \cdot K_{del} \cdot K_m / K_m$ is the annual with account for metrological conditions and delay.

That is, the annual capacity of port is the volume of cargo turnover that it can provide for a given use factor. Obviously, this volume is lower than the capacity of ports.

Let us consider the essential and critical explanation, such as the irregularity of cargo traffic and explain how it interrelated with the major calculated parameters. In general, the ratio of the maximum value of cargo traffic to the average value is called the irregularity ratio of cargo traffic. For example, for monthly cargo traffic $K_m = Q_m / Q_{m.av.}$, from which the maximum monthly turnover is

$$Q_m = K_m \cdot Q_{m.av.} = K_m \cdot Q_{an}/12 \qquad (3)$$

In the technological design, it is important to determine the loading (occupancy) ratio of port. It is recommended to specify the number of harbors according to the formula

$$N = \frac{Q_m}{30P_{daily} \cdot K_m \cdot K_{met}}$$

where Q_m – the estimated monthly cargo turnover in a port, t/per month ;

P_{daily} – the intensity of loading and unloading operations, t/daily;

K_{met} - the utilization ratio of working hours of port with account for breakdowns caused by meteorological conditions;

K_m – monthly irregularity ratio.

If we provide the simplest transformations of the formula, we'll get:

$$N = \frac{Q_m}{30P_{daily} \cdot K_m \cdot K_{an}} = \frac{Q_m \cdot N_m}{P_{an}} = \frac{Q_{an}}{P_{an}} \qquad (4)$$

That is, the essence of the obtained formula is that we must divide the total required annual cargo turnover of port or terminal by the estimated theoretical cargo turnover of a single harbor that gives us the required number of harbors. In addition, the value obtained should be rounded up to the nearest whole number. At this time, the effect of this rounding up is on the initial value of the harbor use ratio is not considered. If in calculating the given value of use factor K_{use}=0,5÷0,6, the number of harbors is 1.3, then rounding up to the nearest calculation number will give us 2, although this will reduce the use factor K_{use} to 0.35. That is, there will be ship demurrage. The rounding up to 1 results in an increase in the use factor K_{use} up to 0.9, which is higher than the recommended value.

For the sake of clarification, let us consider the following example: assume that, the basic navigation period is 300 days, for the sake of simplicity, there is no monthly irregularity. At the same time, cargo turnover is carried out by two types of ships - the estimated capacity of one is 100,000 tons and 10,000 tons is the estimated capacity of the other. At the same time, their quantitative ratio is 3:1 and the maintenance time is 6 days and 1 day, respectively. In this case we can calculate the rate of working on a ship:

$$P_{\text{daily}} = \frac{1}{0{,}75 \cdot \frac{6}{100000} + 0{,}25 \cdot \frac{1}{10000}} = 14290\ t$$

It is widely accepted that the use factor for ships carrying general cargo is K_{use} = 0.6, the navigation capacity is:

P_{zn} = 300 · 0,6 · 14290 = 2571430 t

If the volume of ships is 30 and 100 ships respectively, then the cargo turnover is:

30 · 100 000 = 3 000 000 t/annually, and

100 · 10 000 = 1 000 000 t/annually, and

That is, the total cargo turnover is 4 000 000 t/annually, and the calculated number of harbors is:

N_{harb} = 400 000/2571430 = 1,55

If in this case we round the number of harbors up to 2, then the time budget will be 600 days. It should be noted that the maintenance time of ships with a capacity of 100,000 tons is 180 days, while for ships with a capacity of 10000 tons, the maintenance time is 100 days. That is, for a total of 280 days, from which K_{use} = 280/600 = 0.47, while the initial value was 0.6.

That is, it is clear that the construction of two full-scale harbors that will enable us to handle large ships is not feasible. Therefore, it is feasible to construct one harbor to berth ships, which will provide its loading capacity with a use factor K_{use} = 180/300 = 0.6. Another harbor will be used simultaneously for other ships with a load factor of K_{use} = 100/300 = 0.33.

Practically, during the 300-day navigation period, in the case of 30 large ships, for each one there are 10 days, and the maintenance time is 6 days. In the case of 100 small ships, for each one there are 3 days on average, including 1 day for maintenance. This distribution pattern is shown in Figure 1.

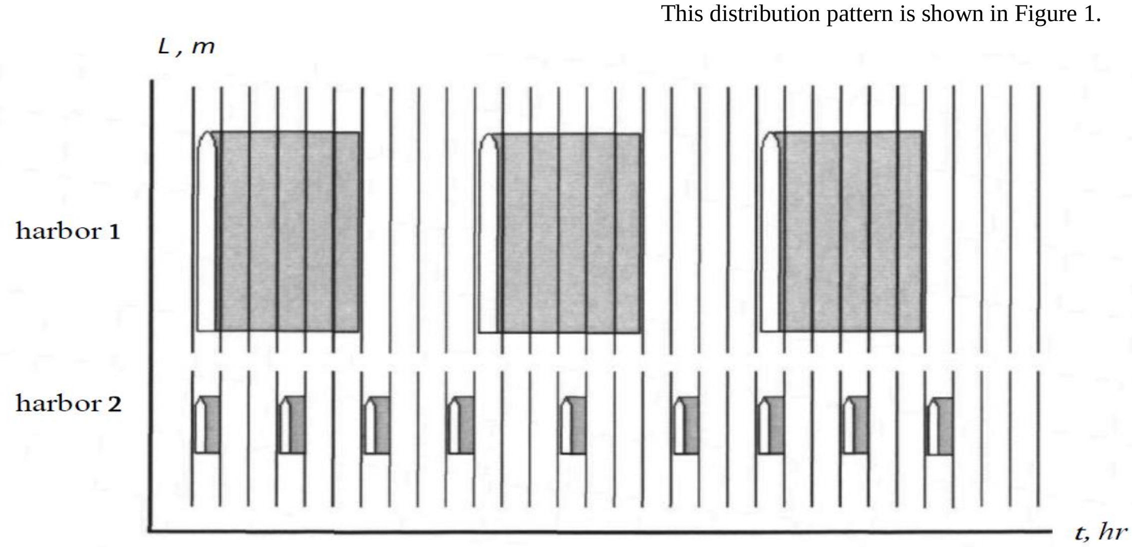

Fig. 1. *Handling of ships by two harbors*

It should also be noted that if all ships are handled by one harbor, then the use factor is K_{use} = 290/300 = 0.96, and this maintenance pattern is shown in Figure 2.

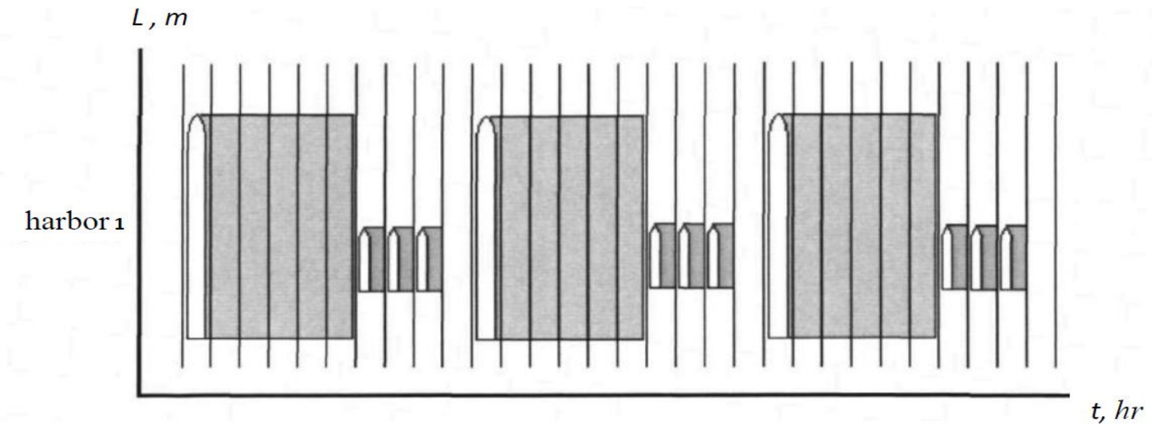

Fig. 2. *Handling of ships by one harbor*

If the small ships are handled during a large period of time, they will not affect the maintenance time of the large ships (that is, when the large ships enter, the small ones are in standby mode). In addition, with a high productivity of harbor, which is rated to the large ships, the maintenance time for the small ships can be reduced, or several small ships can be handled simultaneously.

3. Conclusion

In the technological design, it is important to determine the utilization ratio of working hours in ports, with account for meteorological conditions. The numerical value of this ratio (K_{met}) is important for determining the values, such as the annual required capacity of port and the number of harbors. The ratio essentially takes account for the effect of of precipitation, wind and ambient temperature the operating conditions. By multiplying this ratio by the annual navigation time budget, the designer reduces the port's operating time budget. In fact, due to the impact of unfavorable meteorological conditions, there occur delayed entries of ships to a port in the fleet. In this period, additional equipment shutdowns, and in some cases the ship is moved from the shore to the inshore mooring.

The purpose of future work is to design the construction of small harbors for the small-capacity ships on the Black Sea coast, particularly on the Batumi-Poti section, based on the technique, with a view to delivering transport and logistics services.

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