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Marine transportation-technological systems safety and development

Iegupov Konstantin[1]*, Rudenko Sergey[2], Nemchuk Oleksiy[3]

[1] Odessa National Maritime University https://orcid.org/0000-0002-8342-820X
[2] Odessa National Maritime University https://orcid.org/0000-0002-1671-605X
[3] Odessa National Maritime University https://orcid.org/0000-0001-5633-8930
*Corresponding author: *yegupov.k@gmail.com*

The article deals with marine hydraulic structures design and operation, considering the influence of various superstructures and reloading equipment. The analysis of seismic resistance of the hydraulic structures erected in the seismic regions of Ukraine has shown that the actual seismic loads on the structures significantly exceed the design loads being determined by regulatory documents prior to 2006. In the era of globalization, transformation of cargo flows, changes in their structure, the issue of ports planning development, implying port capacities balanced development, namely: sea zone port zone, and land zone development, becomes particularly important. The design of hydrotechnical structures should be carried considering the transshipment complexes at the quay with proper scientific support.

Keywords: hydrotechnical structures, reloading equipment, seismic, ice and wave loads

Безпека і розвиток морських транспортно-технологічних систем

Єгупов К.В.[1*], Руденко С.В.[2], Немчук О.О.[3]

[1] Одеський національний морський університет
[2] Одеський національний морський університет
[3] Одеський національний морський університет
*Адреса для листування: *yegupov.k@gmail.com*

У статті розглянуті питання проектування і експлуатації морських гідротехнічних споруд з урахуванням впливу різних надбудов і перевантажувального обладнання. Аналіз сейсмостійкості гідротехнічних споруд зведених в сейсмічних районах України показав, що фактичні сейсмічні навантаження на споруди значно перевищують розрахункові навантаження, які були визначені нормативними документами до 2006року. Проектування гідротехнічних споруд повинно здійснюватися з урахуванням знаходяться на причалі перевантажувальних комплексів, при належному науковому супроводі. Світовий досвід дозволяє визначити розвиток портів як одну з найважливіших складових розвитку економіки держави. В епоху глобалізації, трансформації вантажних потоків, зміни їх структури особливо важливим стає питання про планування розвитку портів, що припускає збалансований розвиток портових потужностей, а саме: розвиток морської зони, портової зони, сухопутної зони. Так, за статистичними даними, загальна тенденція зростання перевалки вантажів у всіх портах Чорноморського регіону до 2016 року, для портів України в 2016 році показала різке скорочення перевалки транзитних вантажів з Росії і Білорусі - нафти і нафтопродуктів, вугілля, руд, металів при нарощуванні переробки імпортно -експортних вантажів - контейнерів і зерна. Інфраструктура морських портів являє собою складний симбіоз будинків, будівель, споруд, механізмів, конструкцій, розташованих на території і (або) акваторії морського порту і забезпечують роботу транспортної інфраструктури країни в цілому. Сам по собі морський порт залежний елемент транспортної інфраструктури. Вирішення питання стратегічного планування комплексного розвитку складної інфраструктури можливо тільки на підставі аналізу та прогнозу довгострокового розвитку вантажної бази. В українських портах працює більше 500 портальних кранів, середній вік яких становить понад 37 років, деякі портальні крани працюють по 50 років. Зазначений вік перевищує європейські стандарти практично в два рази. Виробничі потужності портів представлені в основному парком портальних кранів імпортованих за програмою Мінморфлот СРСР, балансова вартість яких через багатократні індексації значно перевищує ринкову

Ключові слова: гідротехнічні споруди, перевантажувальне устаткування, сейсмічні, льодові та хвильові навантаження

Introduction. World experience enables to define ports development as one of the most important constituents of governmental economic development. In the era of globalization, transformation of cargo flows, their structural changes, the issue of ports development planning becomes especially important that intends balanced development of port capacities, namely marine zone, port area and ground zone development. Thus, by static data, general growth trend of goods transhipment in all the ports of Black Sea region till 2016 year, showed drastic transhipment reduction for Ukrainian ports in 2016 for goods from Russia and Belarus, such as mineral oil and petrochemicals, coal, metals, when increasing processing of import-export cargo as in containers and grain.

Materials and methods. For Ukrainian marine industry, there are two mutually exclusive approaches to issue solution about its future development. The official position is ports privatization and concession, which is apparently "an only possible way of Ukrainian marine industry development". According to this position, marine industry reform is one of current government activity priorities and among first steps there is a formation of special marine administration and administration reforming of Ukrainian ports.

According to representatives of sea trading ports enterprises, in case of privatization, private investments would be used in building port facilities which are currently involved by no more than 65%. In this case, the port infrastructure owned by the government would decline. It means that it is possible to develop strategical infrastructure objects only by the government sector income of the port industry economy that generates up to 8 billion UAH per year. Although, the government should reject the privatization and increase the share of capital investments in the infrastructure of ports, which in 2015 amounted to no more than 5% of their income.

The maritime ports infrastructure represents a complex symbiosis of buildings, structures, edifices, mechanisms, constructions, located on the territory and (or) the water area of the maritime port and provides the work of the government transport infrastructure system in general. The maritime port itself is a depended element of the transport infrastructure. The solution for the strategical planning issue for complex development of a complicated infrastructure is possible only if based on analysis and forecast of long-term cargo base development.

Figure 1 – Combination of buildings, structures, edifices, mechanisms constructions located on the territory of maritime port

In accordance with the law of «maritime ports of Ukraine» from 17.05.2012, reloading equipment refers to the objects of ports infrastructure. In order of «The development strategy of maritime Ukrainian ports until 2015» approved by the Ministers Cabinet of Ukraine on July 16, 2008. №1051 (Expired after signing the order of July 11, 2013 №548-p) the port infrastructure was defined as a specialized property complex, as well as storage facilities and grounds, loading and unloading mechanisms and other property. According to the strategy of 2008, the attraction of investments in the development maritime ports were planned through public-private partnership (PPP). However, during the eight years work of different ministries and administrations the procedure for the PPP has remained at the same level. For the specified period of time it was possible to modernize the infrastructure of the main Ukrainian ports and become competitive subjects of the international transport system.

After 2013-year reform assets of every seaport were divided into two groups:
– Strategic objects (water area, docks, other hydrotechnical constructions, communications) are assigned to administration of sea ports (ASP) with main office in Kiev and branches in every port;
– Nonstrategic objects (including storage areas and other main facilities in the rear of the berths) are left on balance of governmental stevedore companies (GSC).

It should be noted that strategic objects are usually objects that require "long" investments, payback period of which is measured with decades.

Overload capacity of ports are usually attributed to nonstrategic objects, i.e. subject to privatization.

Nowadays Ukraine has 13 seaports, excluding five Crimean ports. According to state property fund, infrastructure of ports is worn out on 70÷80%, which means that it is necessary to refresh or modernize handling equipment of Ukrainian ports.

There are above 500 gantry cranes working in Ukrainian ports, average age of which is above 37 years, some gantry cranes are working for 50 years. Said age exceed European standards almost twice. Ports production capacity are usually presented as park of gantry cranes imported under the program of the ministry of the navy of the USSR, book value of which far exceeds market price due to multiple indexing.

The institute Chernomor NII Project analysis of berthing facility operating time showed that by now the operating time of most berthing facilities is 30-40 years and it is getting close to standard or exceeds standard. Based on the same source, the amount of constructions, that are being exploited for 30 years and more, is about 70%. [5].

These numbers testify that most of the handling equipment and berthing of ports and former Ukrainian shipyard do not meet the modern requirements. Besides, as seen on practice, the technical exploitation of the port hydrotechnical structures is often carried out with significant deviation from regulatory requirements for different reasons. There are facts of reduced security level of port hydrotechnical equipment exploitation, among which there should be noted:
– Unsatisfactory work of tally services and department of technical exploitation on compliance with modes of berths cargo operation, including assessment of overloads impact on structures technical state Permissible loads on piers are almost not revised;
– Maintenance work and overhaul are held out of time;
– Carrying out repair work not in full, often with an involvement of organizations without any experience of working with marine hydrotechnics;
– Untimely carriage of engineering inspection and a hydrotechnical structures survey;
– Absence (or presence not in full) of technical documentation;
– Design operation mode is being changed arbitrarily on active docks (re-profiling, increase in design depths and others);
– Projecting, survey, diagnosing, certification are being carried out without reconciliation with the state territorial organization that is responsible for direction «sea transport».

Cases of scientific and technical products output (prospecting, projects, surveys with the assessment of technical condition, certification and recommendations for change of exploitation mode) by different unspecialized structures have become frequent, often with the violation of current standards and legal system of Ukraine at low technical and engineering level, excluding the perspective of development of enterprises.

Research results and analysis of them. A significant change of technical normative base, for the period of existence of Ukraine as an independent country, led to a situation when the majority of port infrastructure objects, that were commissioned in times of former USSR and are exploited nowadays, do not meet the requirements presented by these standards. For example, with implementation of the building code V.1-1-12:2006 and the reduction V.1-1-12:2014 «Building in seismic districts of Ukraine», formally none of the hydrotechnical constructions of ports in Odessa and Illichevsk, built until year 2006, does not provide the required class of responsibility, since their calculation and designing were conducted without inclusion of a possible seismic event happening.

Wherein strategic objects of the port infrastructure, specifically docks, protective and bank-reinforcing structures, the water area, underwater channels that provide port activity and so on, are less vulnerable, from a strategic planning perspective, in long-term planning for the macroeconomic risk factor connected with a sudden change of the world market conjuncture, structure of the freight traffic, decrease in investment activity and others.

Figure 2 – Deformation of the berth due to overloading

In the process of marine hydrotechnical constructions projecting, it is necessary to consider a lot of natural factors. These include hydrological, hydrographic, engineering geological, geomorphologic and meteorological conditions of the building district. Hydrological conditions include the sea wind, ice conditions, level fluctuations, sea currents, tsunami waves. Hydrographic conditions include the depth of water, the seabed and adjoining coast topography. Engineering geological and geomorphologic data about the seabed structure, physical and mathematical properties of bottom soils and sediment migration has a special significance. The main meteorological factor is the wind regime (speed, direction, duration). Also in the process of marine constructions, it is necessary to perform seismic calculations. Herewith constructive features of a structure and existing engineering geological conditions of the building area should be considered. [6].

The present technical condition of hydrotechnical constructions that were built in soviet times, is unsatisfactory and in some cases emergency for many reasons.

First of all, the main ones are insufficient considering of the factors above; violation of building technology in hydraulic structures; using substandart building materials and products.

Ukraine nowadays is one of the most dangerous countries in the world in terms of man-made disasters. It is extremely densely saturated with industrial infrastructure of various purposes, in most of the cases extremely worn out. For many years, any attention was not paid to ensuring the safe operation of enterprises. It led to the fact that the number of potentially dangerous objects reached several thousands and continues to grow. And some of them, such as the Odessa Port Plant, in case of seismic catastrophe, can harm a millionaire city with its poisonous emissions.

Odessa is a part three most seismically dangerous regions of Ukraine (Crimea – 6-9 points, Odessa – 6-9 points, Transcarpathian region – 6-8 points).

For many years, major repairs of structures were not carried out, as a result of which the life of structural strength is almost exhausted, which threatens to lose it even with weak earthquakes. Vulnerability grows every day. Currently, intensive development of territories for the constructions is under way. Not only of residential buildings, but also large, unique structures, which destruction can lead to significant economic and social losses from seismic influences (Figure 3-5).

The development of the Black Sea shelf, creation of environmentally hazardous industries - oil terminals and oil pipelines, occurs because of seismicity increasing on the coast. And today, with the scientific substantiation of the strategy for port infrastructure development, special attention should be paid to issues of ensuring the reliability and safe operation of both newly constructed and exploited and reconstructed facilities.

Figure 3 – Significant deformations of the berth territory from the earthquakes action

Figure 4 -- Tilting the crane due to the action of seismic forces

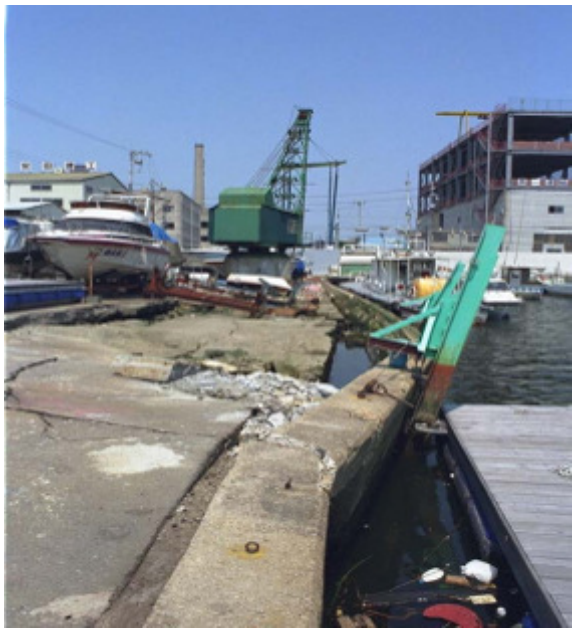

Figure 5 – Deformations of the berthing facility cordon line

Earlier, before 2007, structures calculations and their bases located on landslide slopes were made in accordance with SNIP 2.01.07-85* «Loads and impacts» and SNIP II-7-81* «Construction in seismic regions», and in accordance with these SNIPS, the seismic hazard in the south of Ukraine was equal to 6 points, so calculations for seismic impacts were not required.

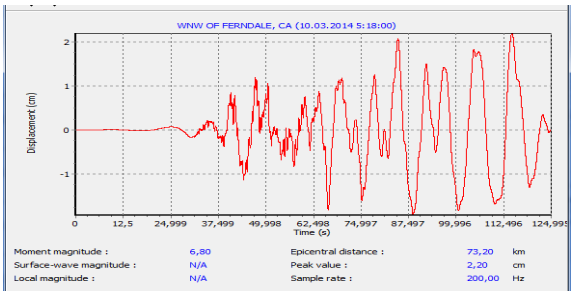

Figure 6 – Calculated accelerogram

But since 2007 DBN B.1.1-12:2006 «Building in seismic regions of Ukraine» has been put into operation. According to the OCP-2004-A map, the Odessa region is in the zone with a seismicity of 7 on the EMSH-98 scale.

Strength calculations of hydraulic structures, landslide slopes stability, structures located on them and coast protection structures in the Odessa region should be carried in accordance to seismic loads. These effects can be specified either by the linear-spectral method or by a direct dynamic method, according to the calculated accelerograms of the earthquake which represent a three-component function of oscillations acceleration in time.

The necessity of calculation joint work of the «foundation-construction» complex and various loads and impacts, leads to the complication of the structures basis design. Calculation of emergency (seismic) impact using calculating accelerograms, accounting nonlinear physical properties, accounting construction stages, complicates the task of calculating and designing marine hydraulic structures, at the same time makes possible to obtain rational solutions that provide specified operational properties with regulated reliability and safety parameters.

Conclusions. Calculating, design, technical operation, repair, inspection and reconstruction of port hydraulic structures issues have traditionally been regulated by the requirements of departmental (former Ministry of the Navy of the USSR) regulatory documents. There are no actualized versions of these documents that correlate with state building regulatory documents.

Regardless of port industry current strategy development, a systemic state approach is required to create a modern technical regulatory framework and effective methods for monitoring compliance, especially for strategic port infrastructure facilities.

While designing hydraulic structures, it is necessary to account several numbers of factors and requirements that would ensure an effective structures operation, reliability and durability.

According to the analysis basis of surveys and the requirements existing regulatory documents results, it is necessary to designate the design parameters of natural and seismic impacts on the designed structures, considering their life service.

The hydraulic structures design should be carried out considering the transshipment complexes at the wharf with proper scientific support.

The usage of new constructive solutions requires appropriate experimental studies, including in-situ and laboratory conditions.

During the project implementation, it is necessary to comply the requirements of regulatory documents that ensure the proper quality of installation and building works.

At the present, it is necessary to improve the calculating methods of the stress-strain state of the soil foundation under hydraulic engineering structures, considering alternating effects.

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