

SOME CONSIDERATIONS ON HARBOUR EQUIPMENT FOR CARGO HANDLING. FIXED AND MOBILE TOWER CRANES

CÂTEVA CONSIDERAȚII PRIVIND ECHIPAMENTELE PORTUARE PENTRU MANIPULAREA MĂRFURILOR. MACARARE TURN FIXE ȘI MOBILE

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Rezumat: Acest material se concentrează pe principalele mașini și echipamente portuare utilizate pentru transportul și manipularea materialelor în zonele portuare, și anume macaralele portuare. Puteți obține o perspectivă holistică asupra logisticii maritime de manipulare a mărfurilor în zilele noastre folosind acest tip de echipament.

Cuvinte cheie: macara, port, industrie maritimă

Abstract: This material focuses on the main harbour machines and equipment used in transportation and material handling in port sides, namely the harbour cranes. You can gain some holistic viewpoint about maritime cargo handling logistics nowadays using this type of equipment.

Keywords: crane, harbor, maritime industry

1. INTRODUCTION

A rapidly growing world population imposes different and diverse ways of transporting the products worldwide. UNCTAD - United Nations Conference on Trade and Development (2020, 14-th April, online) stated that almost 85% of international trade in products is carried at sea by shipping industry. Until the early 2000s, seaborne trade was dominated by liquid bulk, mainly oil. But nowadays it shifted toward dry cargo – including coal, iron ore, grain and manufactured goods (see fig. 1, a).

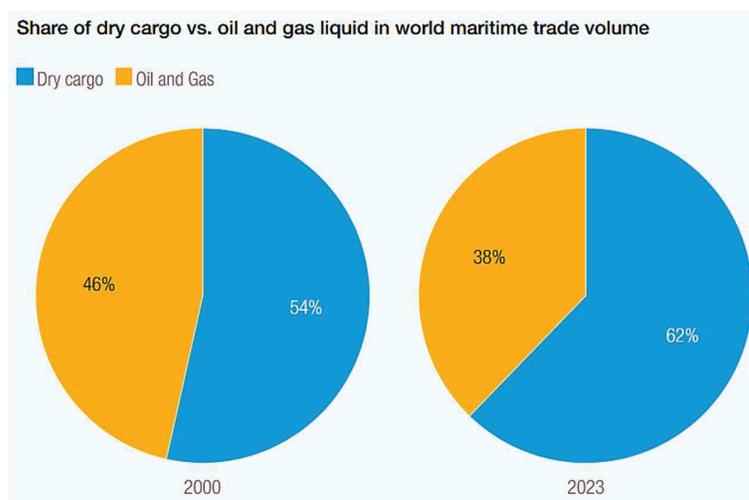


Fig. 1, a. Share of dry cargo vs oil and gas liquid in world trade maritime volume
<https://unctad.org/news/>

So, the shape and progress of the world economy is directly depending on maritime industry, especially on ports development. Ports measure the volume of containers they handle in twenty-foot equivalent units (TEU - the standard size of a container). In 2014, approximately 650 million TEUs were handled by all ports world-wide (UNCTAD, 2014) [8]. In 2019, 811 million TEUs of containers were handled in ports worldwide. World container port throughput (fig. 1, b) grew by 2 percent between 2018 and 2019 (UNCTAD Handbook of Statistics) [9].

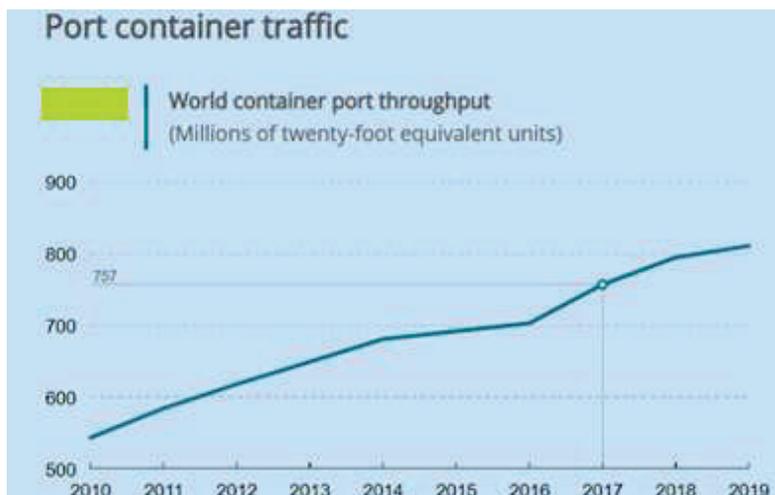


Fig.1, b. Worldwide container port throughput, in TEUs/year
<https://unctad.org/publication/handbook-statistics>

The reality is that the deep meaning of maritime activities can be defined by logistics activities. Logistics is a highly broad concept which involves many businesses and management related functions and also it is divided into many activities/functions which can be listed as follow: transportation, inventory management, order processing, warehousing, customer services, handling, packaging, labelling, information management, returned product management, salvage scrap disposal, and site/location selection (Lambert, Stock, & Ellram, 1998; Ballou, 1999; Wood, Barone, Murphy, & Wardlow, 2002; Bowersox, Closs, & Cooper, 2010).

Maritime logistics versus maritime transportation (Lee, et al., 2012, p.12)

Table 1.

	Maritime Transportation	Maritime Logistics
Concept	The process of carrying and handling cargoes across the ocean	The process of planning, implementing and managing the movement of goods and information involved in ocean carriage
Focusing point	Maritime transportation emphasizes individual functions relating to sea transportation. Each function pursues its own aims or competitiveness.	Maritime logistics is concerned with not only individual functions relating to sea transportation, but also an effective logistics flow as a systematic entity of the logistics integration system.
Managerial function	Sea transportation activities: contracting, shipping, sea voyage, moving cargo, and loading/unloading.	Sea transportation activities: contracting, shipping, sea voyage, moving cargo, and loading/unloading. Additional logistics services: Stripping/stuffing, storage, warehousing, offering a distribution center, quality control, testing, assembly, packaging, repacking, repairing, inland connection, and re-use

Some considerations on harbour equipment for cargo handling. Fixed and mobile tower cranes

According to Panayides (2006), “the integrated demand for maritime transport brings on a maritime logistics concept”. Lee (table 1) and his friends (2012, p.11) define maritime logistics as follow: “**Maritime logistics is referred to as the process of planning, implementing and managing the movement of goods and information involved in the ocean carriage.**”

In the following lines, a brief harbour equipment classification is presented.

2. HARBOUR EQUIPMENT - CLASSIFICATION

The following scheme is presenting a brief classification of the main harbour equipment.

1. **Cranes**
 - fixed– tower type (tubular or lattice)
 - hammerhead type
 - DERRICK type- high capacity (can be mounted on vessels)
 - mobile – tower → on tires
 - on rail
 - crawler
 - portal – caisson construction
 - lattice construction
 - driving mode
 - electric
 - thermal engine (ICE – Internal Combustion Engine)
 - attachable equipment (WT) (working tool)
 - grabs → scrap - metallic waste
 - timber – for long materials
 - clamshell – materials’ dw - reduced (0,8 t)
 - medium (1,6 t)
 - high (1,4 t)
 - hook – simple
 - double
 - container handling devices
 - electromagnets
 - flexible lifting equipment (straps, chains, cables, nets)
2. **Straddle Carriers** – on tires → manual control
 - automatic control
3. **Harbor Stackers** – telescopic boom
 - vertical column
 - electric drive
 - thermal engine (ICE – Internal Combustion Engine)
4. **Mobile ship loader** – belt conveyor
 - helical conveyor
 - pneumatic conveyor; vacuum conveyor
 - hydraulic conveyor
5. **Telescopic ship gangway**– for pedestrian transport
6. **Front loaders** – for bulk materials

The main aspects regarding the fixed and mobile – tower harbour cranes that serve ports in the loading and unloading process cargo are discussed below.

2.1. Harbour Fixed Cranes

The component elements of an usual tower crane and the main movements are presented below.

- 1- chassis
- 2- wheel bogie
- 3- fixed tower
- 4- slewing section
- 5- special double action bearing
- 6- jib
- 7- pendants
- 8- counter jib
- 9- concrete counterweight
- 10- central concrete pads
- 11- lifting hoist
- 12- moving trolley
- 13- operators cab
- 14- hook

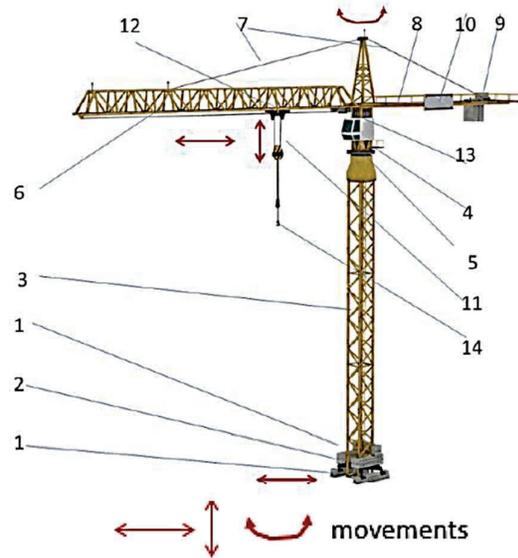


Fig. 2. Tower crane. Component elements and movements

A. Fixed Cranes

Fixed Cranes with tower



Fig. 3. Fixed crane with tower
<https://en.wikipedia.org/wiki/Panamax>

Fixed cranes are real working solutions for vessels, assuring machine's stability during the working cycle and saving space while handling cargoes.

This is a slewing type crane installed on fixed foundation pedestals comprising both cylinder luffing as well as wire luffing slewing.

They provide the optimum balance between restricted space and working efficiency.

Some considerations on harbour equipment for cargo handling. Fixed and mobile tower cranes

The design of the cylinder luffing of this crane enables a rapid, efficient loading and unloading of vessels up to the **Post-Panamax class** (Panamax and New Panamax or Neopanamax - terms for the size limits and capacities for ships travelling through the Panama Canal).

Fixed Crane with tower - Fixed Slewing – on pontoon bridge.

Fixed Slewing cranes is the optimum choice when stress levels on the ground must be kept low and space in that harbour is limited.

The upper carriage is fitted on a **fixed base column** reducing so the space required, but also ensuring the high productivity rates from the range of *mobile harbour cranes*.



Fig. 4. Fixed slewing crane on pontoon bridge

<https://www.liebherr.com/en/>

Fixed crane with tower - Barge Slewing - on barge



Fig. 5. Fixed crane on barge - Barge slewing

Barge Slewing is a floating type crane concept which combines the high performance of mobile harbour cranes and barge solutions.

This type of crane, fitted on barges and pontoons, are tailor-made to individual requirements and can be autonomously operated in sheltered waters.

For example, LBS (Liebherr barge slewing): Max. lifting capacity-45 t; Jib length-38 m; Slewing max.: 0,8 rot/min; Mobility: fixed; Field of use: Bulk handling / Container handling / General cargo operation

Configuration and Installation - Practical Application

Port cranes are designed especially to be the suitable for operation on narrow quaysides (figure 6) following the main features:

- economical and robust pedestal design
- point reinforcement of the quayside very solid, rising so the carrying capacity
- low forces and moments affect the crane's pedestal making dense positioning of the cranes on the quayside possible
- electric components are protected from the environment

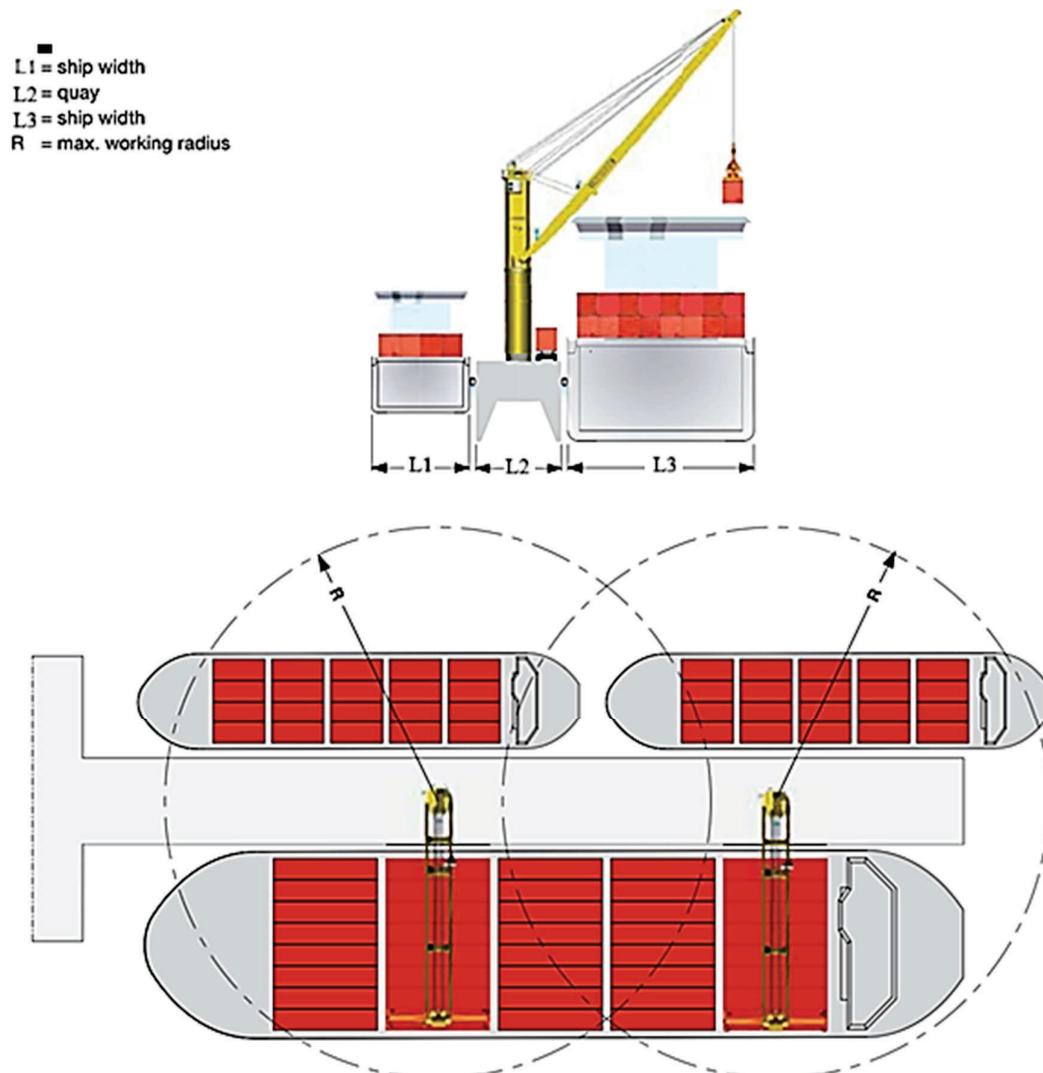


Fig. 6. Fixed crane with tower handling cargoes between vessels

<https://www.directindustry.com/>

Pedestal

The upper pedestal of the crane is welded to the lower pedestal, enabling straightforward and uncomplicated installation of the cranes.

B. Hammerhead Crane



Fig. 7. Hammerhead crane (*Hammerkran* - original name)

The "hammerhead" - or giant cantilever (figure 7) crane, is a **fixed-jib crane** consisting of a steel-braced tower on which revolves a large, horizontal, double cantilever.

The forward part of this cantilever or jib carries the lifting trolley, the jib is extended backwards to form a support for the machinery and counterbalancing weight.

In addition to the motions of lifting and revolving, there is provided a so-called "racking" motion/ plane-parallel movement or simply plane movement, by which the lifting trolley, with the load suspended, can be moved in and out along the jib without altering the level of the load. Such horizontal movement of the load is a marked feature of later crane design.

These cranes are generally constructed in large sizes and can weigh up to 350 tons.

The design of *Hammerkran* evolved first in Germany around the turn of the 19th century and was adopted and developed for use in British shipyards to support the battleship construction program from 1904 to 1914. The ability of the hammerhead crane to lift heavy weights was useful for installing large pieces of battleships such as armour plate and gun barrels.

Giant cantilever cranes were also installed in naval shipyards in Japan and in the United States.

These cranes provided repair support for the battle fleet operating far from Great Britain.

C. Derrick Crane

A derrick crane (fig. 9) is a lifting device usually composed of mast (frame or tower) and lifting arm. There are three or four lines (cables) connecting the mast to the lifting arm, controlling it in going up and down.

To lift a load, a separate and special equipment (hoist) runs under the lifting arm with a hook as the **hoisting mechanism**.

Derrick cranes are mounted on vessels or dockside.

Features:

1. There are 4 driving system for hoisting mechanism, 2 driving system for luffing mechanism.
2. The entire derrick crane chassis adopts basic support on concrete platform, which can effectively ease the crane horizontal and vertical deformation.
3. Multi-layer winding line reel drum. **Hoisting winding drum** - wrapped with 4 layers of wire rope, and **luffing drum** - wrapped with 5 layers of wire rope.
4. Complete frequency, lifting half load speed is 2 times of the full load speed.
5. Using inverter, encoder and a series of electronic control system to ensure the 4 lifting motors keep synchronous running.

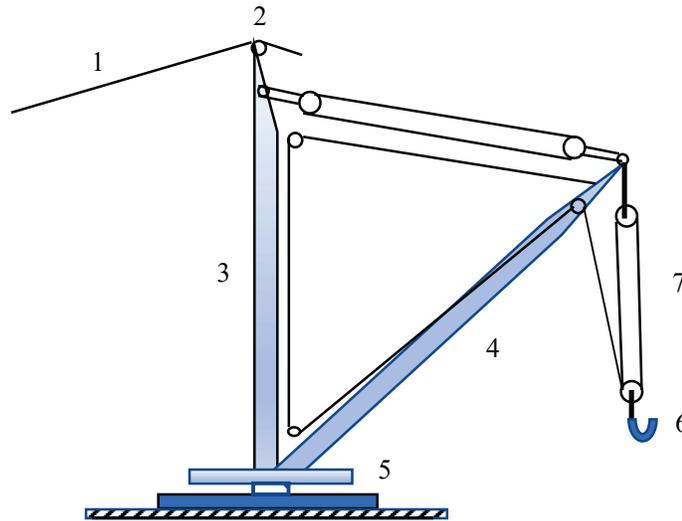


Fig. 9. Derrick crane – working equipment scheme
1-guy; 2- point; 3- mast; 4- boom; 5- bull wheel; 6- load hook; 7- hoist

Forms of derricks are commonly found aboard ships and at docking facilities. Some large derricks are mounted on dedicated vessels, and known as **floating derricks** and **sheerlegs**.

The derrick derives its name from a type of gallows named after Thomas Derrick, an English executioner during the Elizabethan era.



Fig. 10. Derrick Cranes <https://www.alamy.com/derrick-cranes-in-the-port>

2.2. Harbour Mobile Cranes – HMC

In addition to the fixed version of port cranes, there is also the mobile maritime crane – a versatile version successfully used in harbour spaces.

2.2.1 Mobile Cranes on Rubber Tires

Mobile harbour cranes are an extremely versatile type of crane being universal all-rounder.

It is a key asset for handling all types of cargo: from containers to bulk commodities, general cargo and even heavy lifts up to 308 tonnes at 18 metres outreach and up to 100 tonnes at 47 metres outreach. The product range covers all vessel sizes up to megamax and capsized.

Diverse applications and varying terminal designs call for different equipment configurations. The mobile harbour cranes enable full modularity, and so flexibility, across the entire product range.

The **travelling system**, whether *rubber-tyred*, *rail-mounted* or a *floating unit*, can be easily adapted to meet the port infrastructure.

The **drive concept** which can be chosen from a conventional *diesel engine*, a *hybrid drive* or an *electric drive* system.

The mobile harbour crane is characterised by an outstanding modularity designed to meet with all port requirements.

The upper part of the cranes (the slewing platform, tower and boom) remains basically the same. However, depending on the conditions and requirements at the harbour, the substructure can be chosen from a number of variants resulting in five different types of lifting solutions.



Fig. 11. Harbour Mobile Crane

<https://www.liebherr.com/en-us/maritime-cranes>



Fig. 12. Harbour Mobile Cranes (HMC)– component elements

1- chord boom ; 2- luffing cylinder; 3- hydrostatic drive; 4- X-shaped support base; 5- tubular tower design; 6- machinery housing; 7- individual wheel sets



a. Bulk handling

This type of mobile crane assures highly effective bulk handling using various types of grabs. With a maximum material handling rate of up to 2,300 tonnes per hour (productivity), mobile harbour cranes are suitable not only for inland ports, but also large sea ports.



b. Heavy lift

The flagship model in the mobile harbour crane sector has a maximum load capacity of 308 tonnes at 18 metres outreach, which can even be doubled in tandem operation.

Fig. 13. HMC - Fields of use

a – bulk handling; b- heavy lift; c - container handling; d - general cargo



a. Container handling

The cranes are able to serve vessels with widths of up to 22 rows of containers, which means from Feeder ships up to Ultra Large Container Vessels (ULCV). Using manual, semi or fully automatic telescopic spreaders, all regular container sizes can be handled.



b. General cargo

Lifting attachments can be quickly and easily exchanged to suit the actual handling requirements. The crane control system, automatically recognizes and pre-selects the lifting device, ensuring unique versatility and continuity in the technological process.

The main components for HMB are the following:

- Chord boom - the four struts (lattice design) of the boom provide maximum stability precise crane movement and a longer service life.
- Luffing cylinder - the tension cylinder is located above the boom, being so protected from damage through swinging loads. There is no risk of buckling and the piston rod is fully protected in parking position.
- Hydrostatic drive -closed hydraulic loops are used for all main functions such as hoisting, slewing and luffing. The crane driver benefits from extremely precise control
- X-shaped support base - the star-shaped supporting base reduces the torsion strain on the steel structure and ensures optimal vertical stability during operation.
- Tubular tower design - the round tower design minimises torsion and distributes forces evenly to the steel structure and the slewing ring. As a result, the service life of the crane is significantly increased.
- Machinery housing - the machine housing is made of Glass-Fibre Reinforced Polymer (GFRP) making it low weight and corrosion-free. Furthermore, all components are easily accessible for maintenance work. The swing radius lies within the support base of the crane and so eliminates the risk of collision.
- Individual wheel sets - all wheel sets are individually steerable and have load balancing, whereby the ground pressure for each wheel does not exceed six tonnes. Access from all sides provides for easy maintenance. Furthermore, the 360° mobility ensures highest manoeuvrability, so an advantage at narrow quays and terminals.

Areas of use

The multifunctionality of the mobile harbour cranes (HMC) makes them effective for all areas of application in the harbour.

Lifting attachments can be exchanged within a matter of minutes thanks to the simple modular structure.

After selecting the software, the respective lifting attachment is ready for immediate use.

3. CONCLUSIONS

The paper focuses the main features of fixed and mobile tower cranes used in port sides for loading and unloading cargo ships – the vessels designed to transport goods, raw materials, and commodities globally, forming the backbone of international trade .

Although maritime trade volumes have grown steadily, the official data gathered reveals periods of major disruption, such as the 2008–2009 financial crisis and also the COVID-19 pandemic.

More recently, the war in Ukraine, the tensions in the Red Sea and a drought in the Panama Canal have exposed vulnerabilities in key maritime corridors and checkpoints.

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