

The First Dry Docks

Introduction

This is the final paper in a short series looking at the civil engineering aspects of transport projects prior to the industrial revolution. Other papers include:

- **Early Canal Projects**
- **The First Railway Projects**, and
- **Myths and Legends: The Origins of Standard Gauge Railways¹.**

The need to clean, repair and maintain ships has been a challenge from the time merchant and military vessels became too heavy to simply drag up a beach, to a position above the water. One of the early solutions to this challenge involved using the change in water level caused by the tide to assist the maintenance process, another was to increase the pulling power by using animals and simple machines. Other solutions involved creating basins that could be closed to the sea and drained; initially these were temporary structures intended for one-off use, then in 1495 the first reusable dry dock was constructed at Portsmouth Dockyard in the UK².

These ancient solutions have evolved into the various types of dry dock used today:

1. The process of hauling ships out of the water continues with modern marine railways.
2. The concept of temporary enclosures also continues, mainly for civil engineering constructions, and
3. The concept of a floating dry dock has been developed.
4. The concept of the reusable dry dock invented in 1495 also continues to be important (but with improved gates and linings).

The primary focus of this paper is the reusable dry dock which forms an integral part of most major dockyards³.

Alternative options

Using the tides

The simplest way to clean and repair the bottom of a ship was to beach the ship shortly after high tide and use the time until the next high tide for the scraping, cleaning, painting, and/or tarring the underwater part of the ship⁴.

¹ These and other linked papers can be downloaded from **The evolution of construction management:**
<https://mosaicprojects.com.au/PMKI-ZSY-005.php#Process2>

² Source: *Dry Docks through Five Centuries*. CAPT. J. E. Rehler LT. G. C. Bottger. The Military Engineer Vol. 56, No. 369 (January-February 1964), pp. 43-45 (3 pages)

³ To see the events discussed in this paper in a comprehensive historical timeline download
Project Management - A Historical Timeline:
https://mosaicprojects.com.au/PDF_Papers/P212_Historical_Timeline.pdf

⁴ The obsolete nautical term for this is *graving*, which is why some dry docks are referred to as *graving docks* in older publications.



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The graving process could be helped by pulling the ship over to one side (a process called careening), this allowed one side of the ship to be cleaned and repaired during one tide, and the other during the next. The problem with this approach is the strictly limited period between tides. In most parts of the world high tides occur every 12 hours (approximately) limiting the effective working time to 10 hours or less.

But, in some parts of the world, tides are very small or non-existent, this includes the Mediterranean Sea and the Persian/Arabian Gulf. This required a different approach.



Using temporary enclosures

Tides in the Mediterranean Sea are virtually non-existent, this created a challenge for the Egyptians, and later the Greeks as the size of ship increased. The Egyptians conducted graving operations by making use of shallow natural inlets, after the ship had entered, a clay embankment was constructed across the entrance and the water was bailed out either by hand of simple water wheels. When the repairs were complete, the embankment was removed and the ship floated out. The Ancient Greeks used a similar approach, pulling a ship up the beach and then building a wall behind the vessel to keep the work area dry. The use of natural, or manmade, temporary enclosures has continued through to the modern era.



Treasure Shipyard, Basin 6 after excavation. (Courtesy of Nanjing Municipal Museum)



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Two Ming Dynasty shipyards have been located in Nanjing the *Treasure Shipyard* and the *Longjiang Shipyard*. The former was the site where the Treasure Ships used on Zheng He's maritime expeditions (1405–1433) were built. The latter was founded at the beginning of the Hongwu period (1368–1398) in the Ming dynasty to provide ships of a military nature to protect the capital (Nanjing, until 1421) and also to defend some of China's waters and shores against pirates. These dockyards were used for both construction and maintenance and a number of ships of significant size were built⁵.



⁵ Two Ming Dynasty shipyards in Nanjing and their infrastructure. Sally K. Church: <https://www.semanticscholar.org/paper/Two-Ming-Dynasty-shipyards-in-Nanjing-and-their-Church/e0ee64692cf705ea8616ec9c28e53394b1223028>

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The use of this type of facility is still common in major civil engineering projects with sections of a tunnel (or other structure) being built in an enclosed 'casting basin' which is subsequently flooded and the sections floated out and moved into their final position.

Using marine railways

In the modern context, a marine railway is a permanently fixed track system, equipped with a cradle and winding mechanism that allows the cradle to be lowered into the water, a boat floated onto the cradle and secured and then the boat and cradle pulled up to a point well above the waterline. With the process being reversed to launch the boat. The size of boat that can be handled is limited by the pulling power of the winch system.



The use of this type of system can be traced back to the Phoenicians who used crude windlasses and timbers fixed to the beach to act as slideways. A tradition that continues to this day:



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Floating drydocks

The idea of using a semi-submersible dock can be traced back to 1700. In modern times floating dry docks can be massive structures designed to partially submerge by the flooding ballast tanks to allow ships to float into the dock and then pumping out the ballast to float the dock floor and ship clear of the water.

For the first 100 or so years this type of dock was called a *camel dock*; the outer shell (normally a repurposed hull of a larger vessel) was sunk onto a river bed, the vessel to be dry docked was floated in then gates were shut and the water pumped out. This concept was first used in 1700 and remained in use until the first of the hollow floating docks (similar to the image below) was constructed in 1845.



Dry docks

Of greater interest from the civil engineering perspective was the shift from temporarily walling off an inlet from the sea to the construction and use of permanent dry docks. This trend started in the 15th century when Henry VII bought 8 acres of land to build the first dry dock in the world in what is now Portsmouth Harbour. The dockyard is much older, Richard I ordered construction of the first dock on the site in 1194, while his successor John added walls around the area in 1212.

The new dry dock was needed to facilitate the dismantling of an existing warship, and the construction of a new larger vessel recycling the usable parts from the older ship. It was designed and built by architect Sir

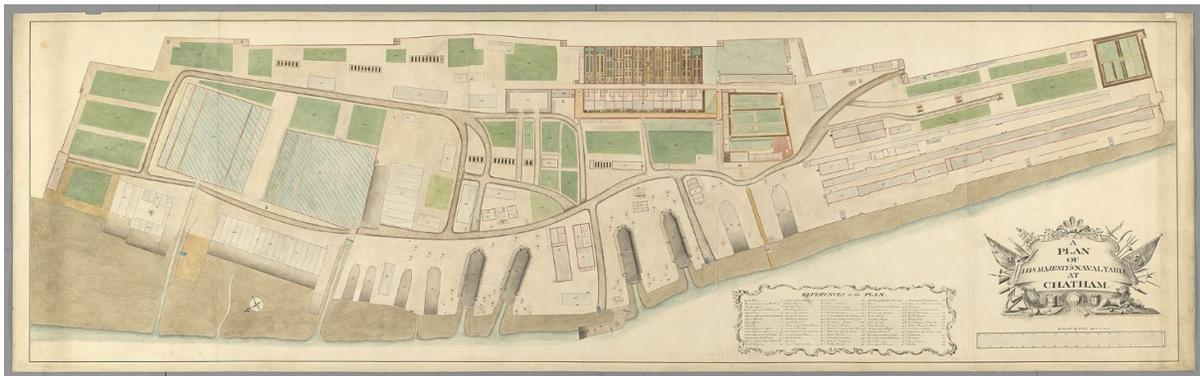


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Reginald Bray a trusted councillor of King Henry VII. Work began of 14th July 1495 and was completed by 17th April 1496, the cost of construction was said to be £193. 0s .6 pence and 3 farthings (some £170,000 in today's money)⁶.

The dock was kept dry by two great gates, these were staggered in their position at the entrance to the dock and both reached across the full width of the dock. The intervening space was filled with clay and shingle to form a watertight dam. Once the gates were closed and the space filled, the water was removed from the dock by an 'Ingyn' this was probably a bucket and chain pump worked by a horse-gin. Getting a ship out of the dock was a lengthy procedure as all of the compacted clay and shingle had to be removed from between the great gates before they could be opened; we are told this took 20 men, 24 days.

Similar dry docks were constructed in other naval dockyards including Chatham's first dry dock, which was opened in 1581. The detailed plan of Chatham Dockyard (below), published in 1774, shows the expansion of this facility with additional dry docks and slipways.



The major improvements in drydocks since the 15th century were the introduction of watertight gates either similar to those used in canal locks or floating caissons; the use of stone, brick and later concrete to line the docks instead of the tree trunks and timber used by Sir Reginald Bray, and improvements in pumping.



A floating caisson gate, the shape wedges tightly into the dock entrance when the gate is sunk in position.

⁶ See: <https://portsmouthdockyard.org.uk/timeline/details/1495-worlds-first-dry-dock>

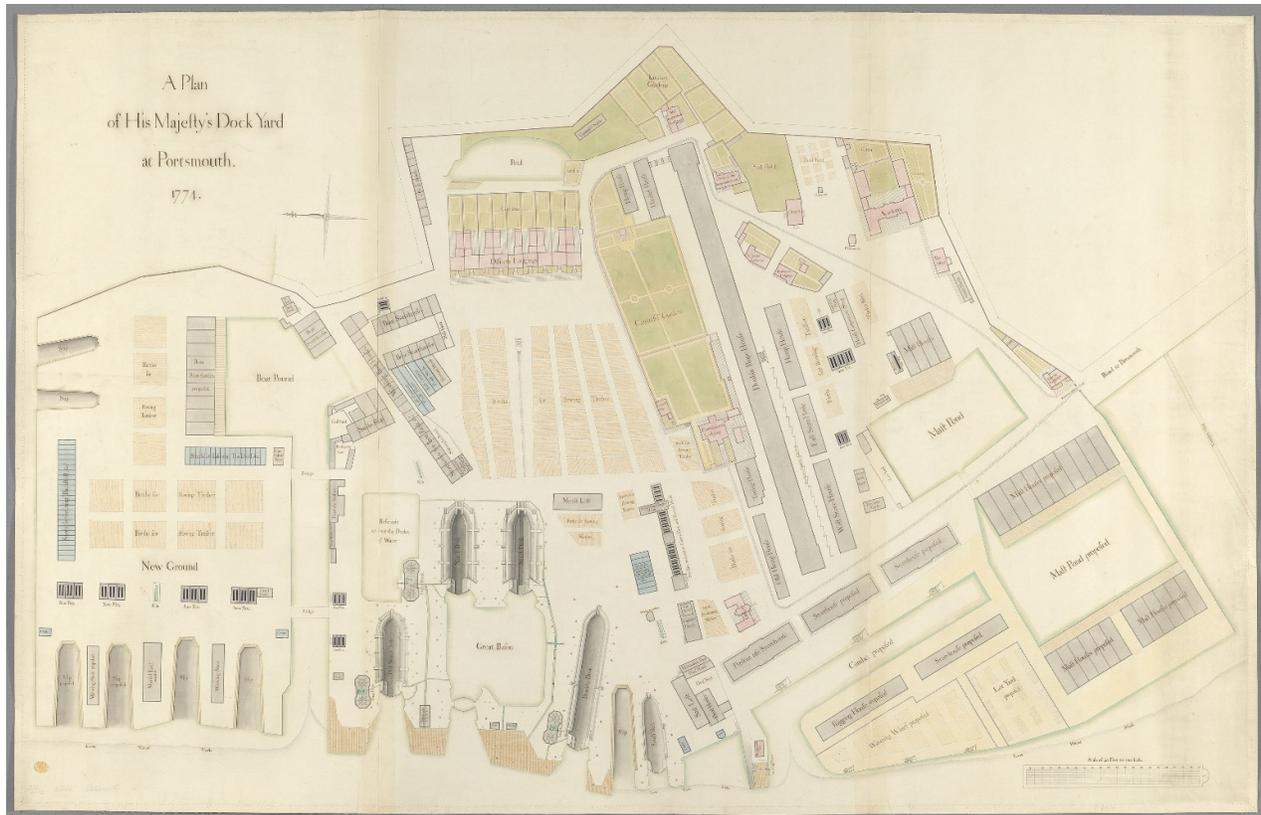
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A set of mitre gates with a stone lined dry dock behind.

Dock No. 2 Portsmouth Harbour

Some drydocks have a remarkably long life. No. 2 Dock at Portsmouth was completed in 1802 and is still in use. But why is the dock called No. 2? This plan from 1774 shows several drydocks.



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In 1796 Samuel Bentham was appointed Inspector General of Naval Works by the Admiralty with the brief of modernising the Royal Dockyards. For Portsmouth, he proposed expanding the Basin (building over the double dock in the process) and adding a further pair of single docks built entirely of stone. The proposal was accepted; the new docks (now known as Nos 2 and 3 docks) were completed in 1802-3.



What makes No. 2 Dock significant (apart from its age) is that on 12 January 1922, HMS Victory had to be moved into the dock because her condition was so poor that she would no longer stay afloat and she is still there – see photograph above taken during the move. This makes No. 2 Dock the oldest dry dock in the world still in use with national treasure, preserved in a listed monument that is over 220 years old.

HMS Victory is older. She is a 104-gun first-rate ship of the line of the Royal Navy and still in commission. She was ordered in 1758, laid down at Chatham Dockyard in 1759, launched in 1765, and commissioned in 1778. HMS Victory had been in active service with the Royal Navy for 40 years by the time the Battle of Trafalgar was fought in 1805.

Conclusion

The engineering projects discussed in this series of papers demonstrate significant design, management, and organizational abilities by the people charged with undertaking the works. In many cases these projects were completed 100s of years before the concept of project management emerged. The control systems used demonstrate a good understanding of cost control (or at least accounting). Whereas time management and workflow / resource management seem to have been more intuitive.



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The full series of papers are at: <https://mosaicprojects.com.au/PMKI-ZSY-005.php#Process2>

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