The construction and history of the Albert Dock

Anthony Clarke BSc CEng FIStructE MICE CARE

The construction of the historic south docks in the 1840s changed Liverpool forever and made it an international port recognised all over the world. At the northern end of the former World Heritage site is the Grade I listed Albert Dock.

Merseyside Development Corporation (MDC) was formed in 1980 just before the Toxteth riots and was tasked with regenerating the dockland areas including the Albert Dock. I was a member of WG Curtin's structural engineering team appraising the condition of the buildings for MDC.

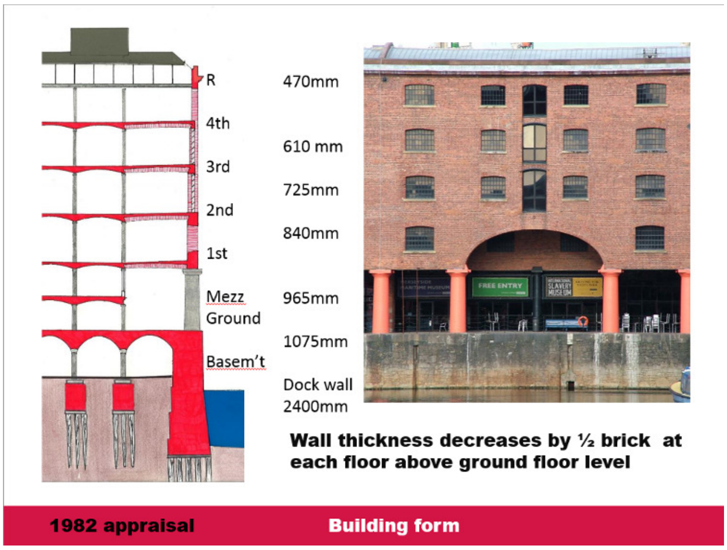

Figure 1

Elevation and section through the warehouse wall.

The superstructure of this bonded warehouse is constructed solely from cast iron, wrought iron and masonry.

The building's condition was poor with heavily staining and cracked brickwork from years of neglect. 2nd World War bomb damage had not been repaired. The walls reduce in thickness at each level (fig 1). On the dockside elevation, vertical slots allowed goods to be taken straight out of the ship's hull and into the upper floors of the bonded warehouses.

The cast iron columns are arranged on a rectangular grid. (Figs 2 & 3) The cast iron "inverted Y" beams span between the columns without any physical connection. The spine brickwork wall is load bearing. The floors are masonry arches with shallow rise that span between the beams. Wrought iron tie rods resist the arch thrust. "In-floor ties" are set above the floor arches to tie the building together. The ground floor sandstone arches are deeper and do not have under-arch ties. The floor finish is quarry tiles or York stone.

A rectangular "bond bar" sits in the middle of all walls and had caused severe cracking of the brickwork. The roof is made entirely of wrought iron with plates on slender trusses.

Prepared for the 2021 Annual Conference of the Association of Industrial Archaeology and Merseyside Industrial Heritage Society.

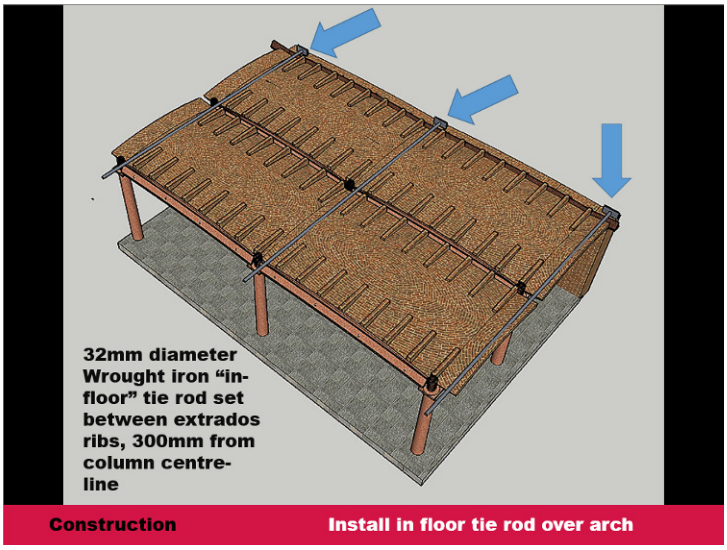

Figure 2

Isometric view on the top surface of the masonry floor arch showing the in-floor wrought iron ties.

When complete granular fill would be placed on the spandrel and then the quarry tiles laid to create the warehouse floor surface.

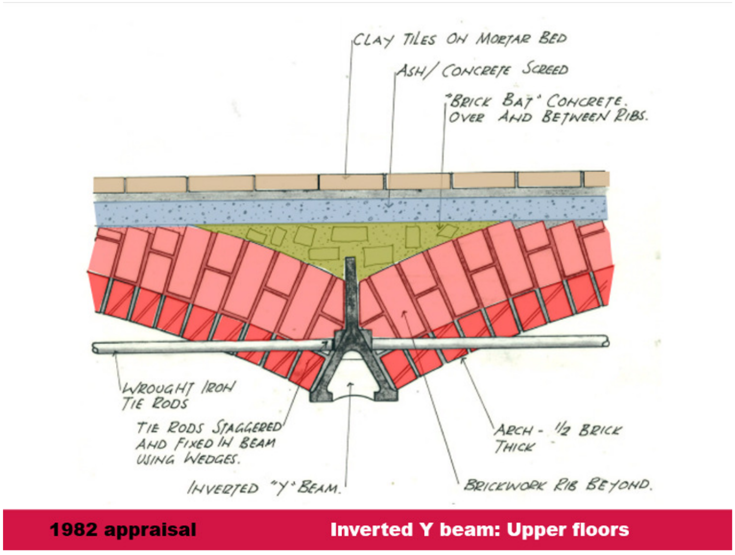

Figure 3:

Section through an upper floor showing the arrangement of the cast iron beam supporting the masonry arches and the under floor ties.

Appraisal findings

The appraisal concluded that significant repairs were required, particularly to the bond bar within the walls. The foundations were investigated with deep trial pits and showed that:

- Block A is supported by piers and walls built off the bedrock. Block E is supported similarly but on clay. (Fig 4) The remainder of the buildings are piled. Beech tree trunks would have their bark and branches stripped off then turned upside down and driven to refusal.
- The warehouse piles were in good condition because they were fully immersed in clay or placed entirely under water. In the dock traffic office the piles were decayed because the foundation is higher meaning that the fluctuating water table caused wetting and drying along the pile shaft. The whole building had to be underpinned.

Full scale load tests were undertaken on the piles, floor beams and roof structure to the warehouses. The tests proved that:

- Underpinning was not required.
- The roof trusses and floor structures could support the required load without strengthening.

The restoration was undertaken in two stages. Initial stabilisation contracts made the buildings water tight, safe and secure. The second stage converted the buildings to their final use.

Restoration contract details

The first phase had to be completed in time for the tall ships race in July 1984. Masonry cracks were repaired by resin injection then the walls were blast cleaned. The embedded bond bar was the biggest challenge. It was too costly to remove so various repair trials were undertaken. The chosen repair required resin to be applied under pressure down the crack and suction provided internally. In this way the resin was drawn through to fill and bond the crack together. This process allowed the bond bar to be retained without significant long term damage.

Several foundation had failed beyond repair due to overload. Heavy temporary works were required whilst removing and replacing the cracked granite stones.

Civil Engineering works were also underway. The docks were dredged; damaged dock walls rebuilt and new dock gates installed.

How the Albert Dock was built.

Jesse Hartley, the Dock Engineer took up his role in 1824 despite having no previous experience of dock engineering. He continued in this role until his death in 1860. He had worked in his father's business as a bridge builder which may explain why the buildings are based on masonry or iron arches. When he died he ordered all his papers were to be destroyed so there is virtually no detail to show how he built these docks.

From my private research I note that two activities were critical: The construction of the river wall and then the warehouses. Both required timber piling.

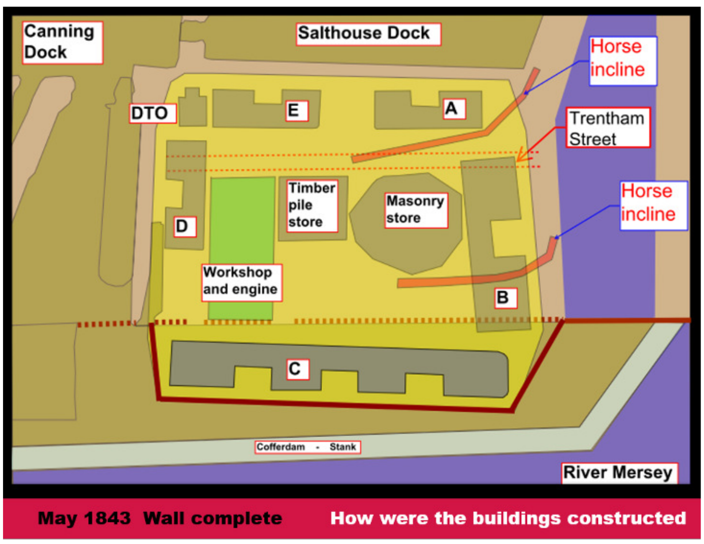

Figure 4:

Illustration based on a legal drawing from the Merseyside Maritime Museum archives.

A dock plan survives and shows that $^{2}/_{3}$ rds of the site is built on previously reclaimed land To construct the new river wall and warehouse C would have required protective temporary structure. The dock minutes show that Hartley started work on block A where the rock is at its shallowest level so no piling was required. Leaving a band of ground in place he could work safely without fear of flooding of this block's excavations. The river wall probably started at the same time, however before it could be constructed temporary works would be needed to prevent the River Mersey flooding the work area. Three commonly used methods of that time were as follows:

On short lengths of wall it is possible to use an earth dam. Hartley used this method at the Canning half tide Dock entrance. The old name is a “Stank”. Excavated material could be tipped to create a long mound. He could simply transfer it by horse and cart and tip it into the Mersey and work his way along the work area. I suspect that Hartley did not use this method since it would have taken used this method to build the new river wall. By placing excavated ground in the river he formed a cofferdam the length of the site. In the middle of the dam he would use either a clay core or by driving interlocking iron sheet piles.

The second method could have been a piled cofferdam. Two continuous lines of timber sections could be driven into the river bed down into the clay. The upper section would have to extend above the high water level (HWL) of the tide. The gap between the rows would be filled with clay. The combined wall creates a strong defence against the tide. This method was used on the river wall in front of the Houses of Parliament in London in 1836.

The third method requires the use of a caisson. This is a large timber box whose height would extend from the river bed level to a position above the HWL. It would be constructed on site and then floated out to the work area. When in position it would be flooded so that it rested on the river bed. The water could be pumped out and sealed at the base. The construction of the structure could then start. This method was often used to construct bridge piers in a fast moving river but would be difficult for a continuous wall.

Hartley completed the construction of the river wall in less than three years. It is unlikely that any of the above method could be used as they all require long duration works to install and then have to be removed upon completion. He would not have had the time to build both the temporary dam and the permanent works in such a short period. There are no records to show how he built the wall but I suspect that he used short length sheet piled caissons. Two or more would have been used. Working from the north towards the south, the river would be dredged, the walls timber piled driven in place from an anchored barge. The two activities would work ahead of the rest and then one of the caissons would be installed. The ground would be excavated around the piles which would have a cut-off below the LWL of the Mersey; The piles could be trimmed; cribwork installed and the lowest levels of masonry constructed to a level above the river bed. Whilst this wall continued to be built, a second caisson would be installed working along the river wall. When the wall reached the top of the sheet piling then the first caisson could be removed and the work completed under tidal conditions. The caisson would provide additional working time between tides but would frequently flood. I suspect that a steam driven chain pump would have been used on a falling tide to allow quick access to the work area. When the wall reached the HWL, backfill would be placed behind it. The coping / quayside surface would have been laid as a late activity to allow the ground to consolidate. The whole process would repeat working along the river creating a tiered level of masonry.

Records indicate that by May 1843 he had the river wall and Block A nearly complete with 2 ½ years still to run on the contract. Block C would take the longest. Blocks E, D and B were probably working in parallel. Piles were probably driven by the use of an A frame and a heavy weight. A combination of one or two steam engines, man and horse power would lift the weight which would drop onto the pile head.

The construction of these buildings must have been a very labour intensity activity. It is amazing to think that one man, Jesse Hartley designed, planned and supervised the building of all the work on the South docks. He completed the construction of Albert Dock and the river wall in the same time that it took to repair and refurbish the same buildings in the 1980s. Liverpool owes a great deal to Hartley for leaving us a fantastic legacy that today is a world class tourism destination.

This technical paper summarises a presentation given by Anthony Clarke on the 4th September at the 2021 Annual Conference of the Association of Industrial Archaeology.