Dunston Staiths, Gateshead: Repair of one of Europe's largest wooden structures

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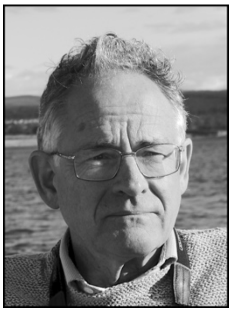

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1. Introduction

The River Tyne in the north-east of England has been a major discharge port for coal from the Northumberland and Durham coalfields for centuries. Wharfs, known locally as Staiths, were constructed near the mouths of navigable rivers as a means of discharging coal from railway wagons into ships, and the Dunston Staiths was the largest timber structure in Europe at the end of the nineteenth century. Its repair history has been reasonably well documented and so it provides a good case study of timber deterioration. The structure is now owned by the Tyne & Wear Building Preservation Trust (TWBPT), and they have carried out some repairs, which will also be described in this presentation.

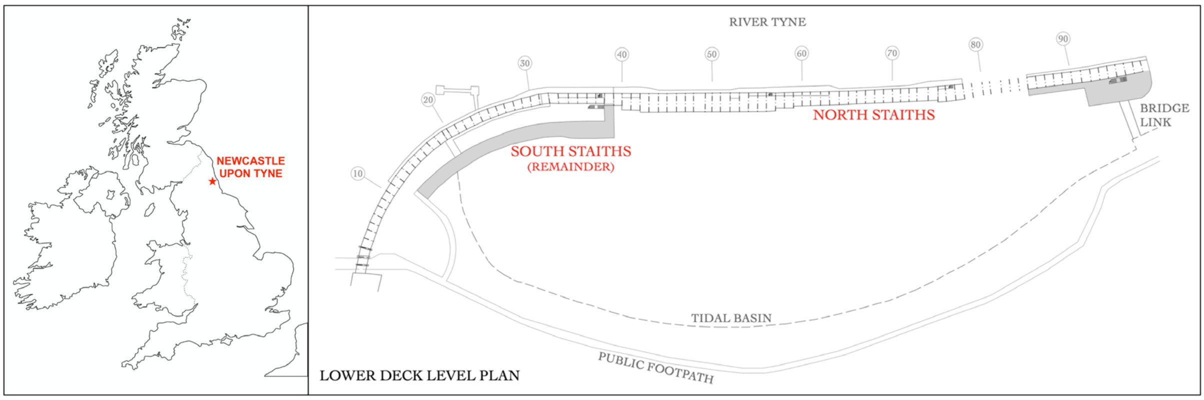

Figure 1: Site / Location Plan

By the early 17th century more than 200,000 tons of coal were being shipped from the River Tyne every year and it is estimated that by 1700 two thirds of the total output of British coal pits was produced at collieries close to the banks of the River Tyne. At that time it was usual to transport the coal downriver in open boats, called keels, into the holds of seagoing vessels. However, towards the end of the 18th century some mine owners wished to avoid the double handling that this entailed, and they began to construct timber staiths, which were linked to their pits at first by horse drawn wagonways and later by steam railways. These staiths allowed coal to be carried from pit to ship without any need to use boats. The massive increase in coal production in the 19th century led to the building of ever larger staiths.

Figure 2: Dunston Staiths – c1938 (Credit TWBPT)

Construction of the Dunston North Staiths by the North Eastern Railway was completed in 1893 on the south side of the River Tyne just upstream from Newcastle. There was berthing for three ships on the riverside. In 1903 increased demand required three more berths to be constructed, which involved building the South Staiths, duplicating the first Staiths, and excavating a large tidal basin between the Staiths and the riverbank, which allowed for several more ships to anchor while waiting to load. The structure was directly connected to the railway system so that coal could be delivered to sidings on top of the Staiths from where large discharge gantries were used to load the ships.

Figure 3: Dunston Staiths Today

Output from the Dunston Staiths continued to increase and the peak in 1938 was around four million tonnes each year. However as the mines were worked out this dropped to two million tonnes by 1943, and by the early 1970's to less than half a million tonnes.
The North Staiths were extensively repaired in the 1970's, and the South Staiths partially dismantled to reduce maintenance costs, but the National Coal Board who owned the Staiths decided to close the site altogether in 1980. And by 1984 the structure was totally derelict. In 1985 one of the conveyor gantries collapsed and the structure suffered badly from arson attacks and neglect. Feasibility studies and structural appraisals were under-taken throughout the 1980's with a view to dismantling parts of the structure and re-using the reclaimed timber to repair the remainder, and this culminated in a major repair scheme which was completed for the Gateshead National Garden Festival in 1990, but since then lack of maintenance and more arson attacks have allowed further decay to take hold. The Tyne and Wear Building Preservation Trust took over ownership and in 2012 a significant repair programme costing about 600 000 Euros was undertaken with funding from English Heritage and the Heritage Lottery Fund, and a further small programme of repairs (150 000 Euros) was planned for 2018, but failed to get the funding. In 2019 another fire caused damage to another section oft he deck so a temporary bridge built of scaffolding was erected across the gap.
In 2022 a Feasibility Study proposed a new use for the eastern part of the Staiths as a community hub, cafe and Garden Centre, re-imagining part of the National Garden Festival of 1990.

2. Description

Dunston Staiths has statutory protection as a Scheduled Monument and is Grade II Listed. The Gateshead Garden Festival left the structure in sound structural condition and safe for public access. The work at that time included the demolition of most of the South Staiths, including withdrawing all the associated piles, and providing a low level access deck on the part that was retained. Steel and timber access stairs were provided in two locations to give access to the top of the North Staiths from the low level deck of the remaining parts of the South Staiths. An access bridge was provided to a low level decked area of the east end, across the mouth of the basin. It is the North Staiths that have been the subject of the recent repair programme.

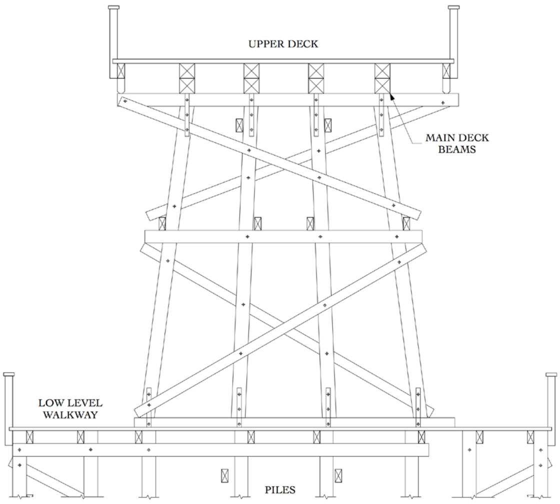

Figure 4: Typical Support Frame

The Staiths comprise a simple structural framework of 98 trestle frames on timber piles at 5.3 metre centres, supporting a timber deck spanning between the frames, with a width varying between 8 and 12 metres. There are additional intermediate frames to carry six steel discharge gantries and hoppers.
The deck is inclined upwards from the land end at a gradient of 1 in 90, to allow for the return of discharged railway trucks by gravity, and the height of the furthest end above the water is about 12 metres. There is cross bracing in both directions, the longitudinal bracing taking in three frames, which results in some lengths of timber up to 18 metres, although some are in two parts spliced together. The main frames are composed of four or more vertical or inclined posts 305mm x 305mm in section on 325mm x 325mm timber piles. The main cross heads at deck level and the main longitudinal sections are two layers of 305mm x 305mm timber, and the secondary edge beams, bracings etc. are 305mm x 150mm or 225mm x 150mm. The deck was originally 305mm x 75mm thick planks, nailed to the longitudinal beams. The piles are greenheart or pitch pine and the original superstructure Baltic pine and Pitch pine, but repairs were generally carried out in Douglas Fir, pressure creosoted.
Structurally the design is well thought out in that there is a cross beam on top of the piles, which is the base beam of the trestle, and the deck cross head sits on top of the trestle, so all the loads on the trestle are in compression only, apart from the cross bracing which is bolted on to the side of the frame. The frames were apparently fabricated in the horizontal position and lifted in to place to fit into slots on the pile cross head. All timbers are held together with wrought iron straps and bolts.

3. Repair History

The whole structure has continually suffered from arson attacks and rotting timber.

In 1983 the following options for the future of the Staiths were considered:

1. Do minimum to keep the structure safe.
2. Remove the entire upper structure to reduce the maintenance obligation using retrieved materials to offset the cost of demolition and execute repairs to the South Staiths.
3. Remove east half of the upper North Staiths.
4. Repair the whole structure using new materials.
5. Extract areas of piles from the derelict South Staiths and convert and utilise the timber to repair the remainder of the structure.

So in the 1980’s the last of these was carried out.

The central part of the South Staiths was removed, including the piles, leaving the two ends which were decked out at low level. Two flights of access stairs were provided up to the top deck and all the remaining structure was repaired. The percentage of single crossheads that had failed was 30%, and 60% of the outside cantilevered deck bearers had failed. The deck was renewed entirely, and the repairs were completed in 1988 at a cost of around £1.2m. (1.5m Euros). So we have these works as a datum for measuring subsequent decay.

Figure 5: Garden Festival Staircase

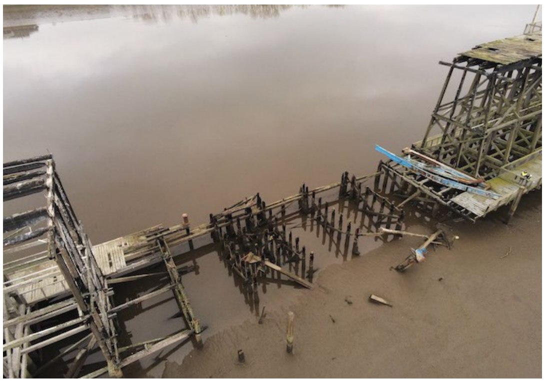

Figure 6: Fire Damage (2003)

After the Garden Festival the structure was closed off and maintenance stopped.
In 2003 a large section was damaged by fire, and ten frames were completely destroyed only leaving the exposed pile heads. This meant that there was no access along the structure from one end to the other.
In 2012 after the structure had been taken over by the Building Preservation Trust further surveys were undertaken and funding for a repair programme was made available.

4. 2012 – 2015 Repair Programme

It was accepted at an early stage that it would be impossible to fund repairs to the whole structure, so of the 98 frames only frames 1 – 8 which are land based, and frames 32 – 39 which are near to the stairway put in for the Garden Festival, would be repaired at this time. The areas selected for repair were those that had been damaged by fire and timber decay and included the lower parts of the frame posts at the land end, and the main deck beams and frame cross heads of frames 32 – 39.

Figure 7: Land Based Frames

Figure 8: Fence Post Decay

Both were regarded as a trial for more extensive repair at some future date.
What added to the cost was the need for dismantling parts of the deck and upper structure in order to get at the frames below. The cost of this was reduced by not fully replacing all the deck boards, while allowing enough decking for access along the structure. In the event the absence of decking has allowed visitors a better understanding of the construction, which can now be seen from above as well as below.
An additional item was the complete renewal of the fencing along the areas that were intended to allow public access.
A major cost was the scaffolding and crash deck required to be built over the river beneath the deck.

5. Timber Species Selection

Considerable thought was given to the timber species to be used in the repairs. The original timber was Greenheart (*Chlorocardium rodiei)* for the piles, which has survived well, and no repairs were considered necessary at this time. The superstructure originally used Baltic Pine **(***Pinus sylvestris)* or Pitch Pine **(***Pinus caribaea***)**. The repairs in the 1970's and 1980's used Douglas Fir (*Pseudotsuga menziesii).*

It was very noticeable in 2014 that the decking, for instance, was in excellent condition (apart from a few isolated planks that needed replacement) whereas the lower level walkways, which were evidently in sound condition after the Garden Festival, had decayed to the point of collapse. It was concluded that the difference was due to the presence or not of preservative treatment. Although Douglas Fir is not now generally considered to be receptive to preservative treatment, the deck planks had a CCA (Chromated Copper Arsenic) type preservative and the main beams a creosote preservative. This appears to have been effective in the deck planks, which are 75 to 100mm thick, but not in the thicker sections, from the fence posts (100mm x 150mm) upwards, where superficial treatment has allowed internal decay to take hold. Both of these treatments are now restricted by European Directives.

The Heritage Lottery Fund required new timber to be sourced from sustainable forests, which restricted the species available. English Heritage, the government conservation department, wanted the new material to be as near the original as possible, but also to be long lasting, considering the status of the monument and the need to preserve it for as long as possible. An additional constraint has been the Maritime Management Organisation which controls pollution in or near a tidal water, further restricting the options for chemical treatments.

Consideration was given to using Douglas Fir for the above-water structural repairs. It would have been structurally strong enough but its durability would be in question for the sort of time frames suitable for a Scheduled Monument. Greenheart is available from a sustainable source, but Pitch Pine is not. Greenheart is difficult to work and would have been awkward for the joint configuration and drilling that would be required. Second-hand Pitch Pine was sourced, but cutting it to size was thought to be problematical because of the likelihood of embedded metalwork, so it was not considered suitable.

The thirty years since the Garden Festival has allowed extensive timber decay to take hold and this equates with the quoted design life of exposed softwoods of around 20 years. For a monument such as this it was felt that a fifty-year life would be more appropriate. The timber finally selected with assistance from TRADA (The Timber Research and Development Association) was Ekki. (Lophira alata), which is a hardwood from what was a sustainable source in West Africa, imported through Holland, however it is now on the IUCN Red List. The handrail timber selected was Opepe, which has similar strength characteristics to Ekki but is easier to work to the profile required. The main downside of using Ekki is its relatively high movement values with change in moisture content. This would require connecting bolts to be checked regularly and tightened as necessary.

In 2014 the deck planks were surveyed and about 100 individual planks were identified as requiring replacement (about 7%). The main defect was wet rot starting from splits and shakes in the top of the plank. However since then regular inspections have shown continued deterioration of the remaining planks, and about 50 more require replacing each year. This represents a thirty year cycle of complete replacement. Ekki was used for the replacements in 2015, but the cost has dictated that subsequent replacements are likely to be Douglas Fir, in spite of its reduced design life.

6. Inspection/Survey of Deck

A micro-drill survey of the deck structure was carried out in 2015 by BM Trada. This was chiefly required so that the deck could be analysed for its capacity to carry construction loads now, and in the future for small fire appliances. A visual inspection and calculation check had confirmed that the deck could carry the anticipated pedestrian loads that would be required for public access, in part because in 1980's the deck planks were increased in thickness from 75 to 100mm thickness for this very reason. They were generally in good condition and could if necessary span over defective supporting beams. Also taken into account was the original design loading which was for fully laden coal waggons on two rail tracks, which was substantially more than any possible future loading.

It soon became apparent that timbers that looked sound externally could have very considerable internal decay. In some cases this resulted from the previous preservative treatment only penetrating a few millimetres, and rot setting in from exposed end grain. This was particularly evident in the balustrading fence posts and handrailing which were Douglas Fir, and which, away from end grain exposure, were perfectly sound. The rot in the main deck beams started from the top, where the 20mm gap between the deck planks allowed water to sit.

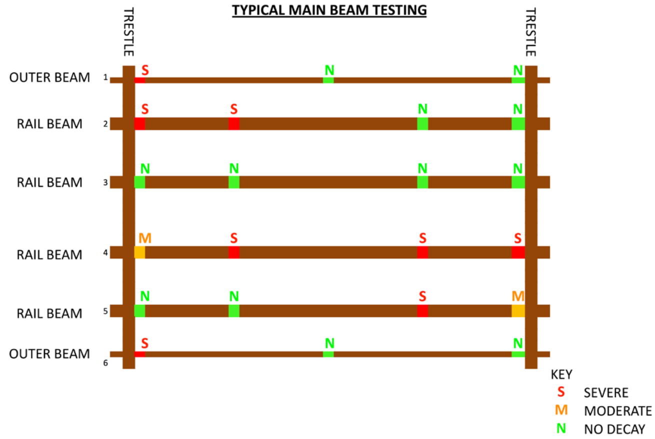

Figure 9: Main Beam Testing (Credit: BM Trada)

BM TRADA's condition survey with a micro-drill tested the main deck support beams by drilling down from deck level (there being no access below). The main deck beams comprised two 305 x 305 beams on top of each other, and an extended drill bit allowed the lower one to be tested also. They tested 206 upper deck beams in 752 locations (ends and centres), and severe decay was noted in 17% of these locations, and in 36% of the beams. The lower beams were tested in 100 locations and this revealed that there were 14 results where the upper and lower beams had severe decay in the same locations (in the centre or at the ends). In some locations there was severe decay on the lower beams where the upper beams were sound. As only one beam is required for current loading requirements a rotten lower beam was not of concern structurally as long as its ends were sound, where it provides bearing support to the upper beam.

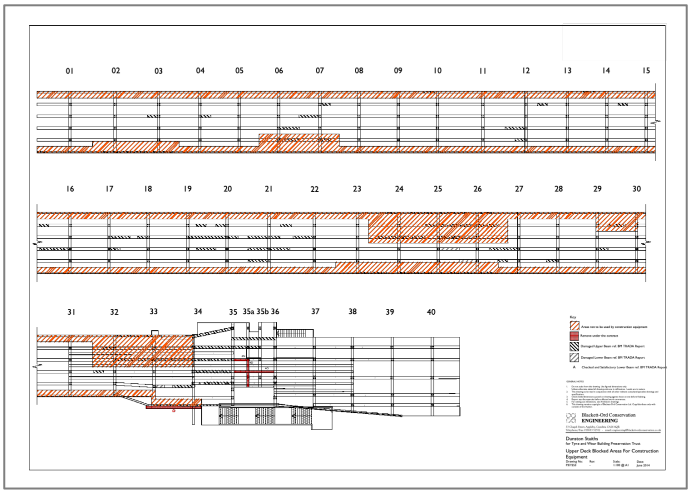

Figure 10: Upper Deck Safe Access

Following this testing it was found to be possible to fence off areas of doubtful strength so that construction traffic could be confined to the less severely decayed areas. Timber decay can be very localised, particularly at the bearing ends of beams where there may be exposed end grain, and the micro-drilling of necessity had to be selective. With timber of this size up to half a dozen drillings may be needed for complete satisfaction that there is sufficient sound timber remaining in any one location. In fact in spite of several visual inspections and the micro-drilling, one of the crosshead beam ends failed unexpectedly under its own weight during the course of the repair contract.

7. Repair Philosophy

Where timbers are being replaced thought has been given to the detailing so as not to leave exposed and end-grain or surfaces where water can sit. Where end grain has to be exposed – between the handrailing sections for instance, an air gap has been left, and where possible spaces allow water to drain rather than being trapped. All new fixings are stainless steel, which is now much more readily available than it was in the 1980's, although the galvanised fittings and bolts used for the Garden Festival works are still in good condition.

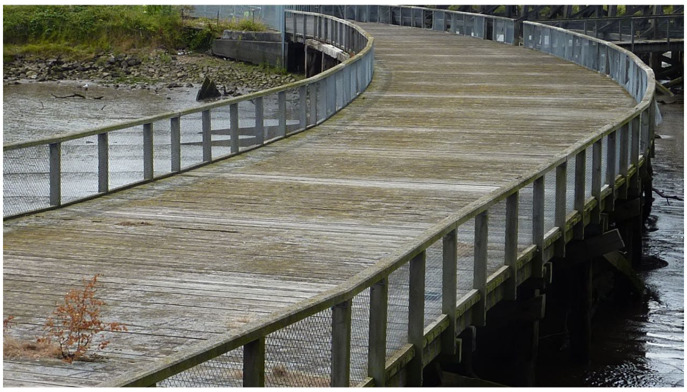

Figure 11: Lower Deck Lichen Growth

The principles of timber conservation and repair are in many ways more relevant in softwoods, as at the Staiths, than with hardwood as would be used in, for instance, medieval timber framed buildings. The latter is all to do with maintaining suitable environmental conditions so as to ensure that wet and dry rot or insect infestation will not occur. Such timber must be protected and detailed such that there are no water traps or contact surfaces where water cannot drain away. At the Staiths the most vulnerable area is where there are gaps between the deck boards, which allow water to sit on top of the support beams. Ideally these water traps should be kept clear, or alternatively filled with slips of timber.

With an exposed structure such as the Staiths, the environmental conditions cannot be controlled – it is a fully exposed structure in a marine environment – so careful detailed design and selection of the most durable species of timber is a more important consideration.

One curious observation is the variation of lichen growth on the deck planks. The colouring clearly shows the presence of the support structure beneath, showing that tiny changes in air movement can have an environmental effect on the timber.

Figure 12: Upper Deck Repairs (2015)

Where possible the deck beams were replaced as whole beams, spanning between the frames. This necessitated taking up the deck to gain access. The lower beams were not replaced as whole units, but only where needed in short lengths to support the upper beams over the trestles. The crosshead repairs did not usually need whole beam replacement and so halved joints were used between the old and the new, as was the case with the vertical posts, and these were bolted with stainless steel bolts. Diagonal bracings were repaired using scarf joints.
A significant number of repairs were required where the frame cross bracing was fixed to the frame posts, where corrosion of the bolts had split the timber. In most cases the old bolts could be removed and replaced with stainless steel, with a secondary cross bolt to close the split. Where it was not possible to remove the old bolt new ones were inserted close by. Where it was not possible to insert the secondary bolt, where access for drilling was impeded by other members, large toothed timber connectors were used under the plate washers to help hold the split together. Where corroded bolts were left in-situ there remained a risk of future corrosive expansion, and hence more splitting of the timber, but for the medium term this was prevented by the cross-bolting.

8. Handrailing

Handrailing was re-detailed so that the top rail joints are not over the posts, and the bottom rail did not sit on the deck planks as before. This not only prevented water retention, but it allowed individual planks to be replaced without removing the handrailing.

Figure 13: New Handrailing

9. Recent Developments

The Dunston Staiths are an important part of the cultural history of the area, representing an industry and way of life that has almost completely disappeared. However future use for a structure such as this is crucial as a way of maintaining public interest and generating some income. At present there are monthly open-air food markets. In 2014 Wolfgang Weileder, Professor of Contemporary Sculpture at Newcastle University, conceived a temporary sculpture comprising a large black cone standing on the eastern end of the Staiths. It was about 9 metres high and made as a hollow cone of recycled plastic planks. The public were admitted in small numbers to attend events within the cone. A short BBC Television film was made of the event.

Figure 14: The Cone

At the same time consideration was given to constructing a low level access bridge across the burnt out gap, a distance of some 40 metres - a substantial structure in itself, so that there could be public access along the full length of the structure and a landfall at both ends, but the funding has not been forthcoming.
In 2019 another fire damaged frames 31-32, luckily only the outer edge of these frames were affected. A security balustrade was installed to restrict access to unsafe areas and allow public use of the Staiths. In May 2020, a second fire in this location caused significant damage, preventing safe public access. This cut off the circular visitor route that had been established using the lower deck, the stairs from the Garden Festival and the upper decks, so we designed a temporary pedestrian bridge which was constructed from scaffolding to bridge the gap.

10. The Future

Regular inspections are essential, using micro drill and roped access, and a fifth of the structure should be inspected in this way every five years, to give a continuous record of the rate of decay.
In the United Kingdom there is virtually no public funding for this type of historic monument however much it is statutorily protected – and it is a criminal offence to damage such a structure. The problems are not only the on-going maintenance costs but the backlog to repairs. We have estimated that it would cost around 20 million euros to put the whole structure back into a sound condition, but the ongoing maintenance cost would still be substantial.

The options are for the future are:

1. **Managed decay;**
   The problem here is the management. The Port of Tyne would not be happy if pieces of the structure or, more importantly, a steel discharge gantry, fell into the river.
2. **Selective retention;**
   As with historic monuments generally we are interested in the significance of the structure, whether physical or historical, but with Staiths one of the most significant aspects of it is its size, which would be lost if only a small part was retained.
3. **Fence off the unsafe or dangerous sections;**
   This still presupposes maintenance of the safe bits and management of the rest.
   Meantime we can at least reduce the risk of fire damage, by careful observation. The river bank to the south of the site had been derelict since the Garden Festival, but recently new housing has been built overlooking the river and the Staiths, so the risks of unauthorised entry and arson are substantially reduced.
4. **An alternative use**
   A feasibility Study in 2022 by a team led by Nicholas Kirk Architects considered a partial re-use of the east end of the structure as a community hub, cafe and garden centre. This, combined with selective repairs to the main structure to allow public access along its full length, would cost around 6m Euros. This is a possible way forward, with a gradually expanding development attracting visitors to the structure, but still at a substantial cost.

11. Conclusion

The Dunston Staiths is an important historic industrial monument that is subject to continuing decay. It has been difficult to secure funding in order to repair this significant structure, and once repaired the maintenance costs will be considerable, for which an income stream will be hard to provide.

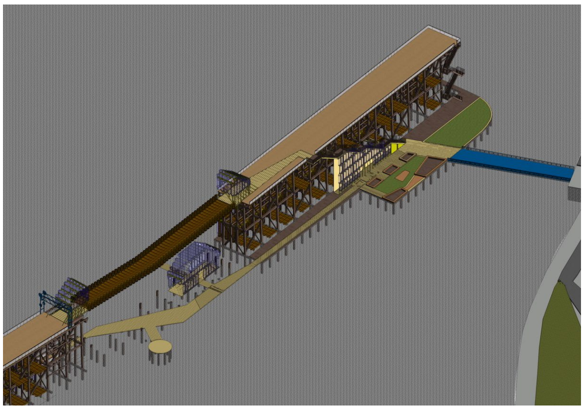

Figure 15: Concept Imagery
(Credit: Nicholas Kirk Architects)

Figure 16: Artist Interpretation
(Credit: Nicholas Kirk Architects)

It is a popular historic site, which is open to the public at week-ends, but almost regardless of any use to which the structure may be put there are a substantial costs involved in keeping it, and this is a problem that the «heritage industry» and the Government has failed to address.

12. References

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