CONSTRUCTION OF PILED QUAYS USING THE LAND INFILL METHOD

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ABSTRACT

The Land Infill construction method for open piled quays is outlined, which offers savings in time and cost during construction. The use of insitu concrete mattress slope protection, which can be installed below the deck enables the use of the Land Infill method. Where piled quays are constructed by traditional marine methods, concrete mattress installation below the deck can also be used to save time.

Key words: Land Infill Method, Insitu Concrete Mattress, Berth Scour Protection, Installation Below the Deck

1 INTRODUCTION

Land Infill construction methods for open piled structures have been developed to save time and cost. The piling and platform is constructed working in the dry from Land Infill as shown in Figure 1. Then cranes are installed on the deck whilst the slope is formed by dredging pumping and insitu concrete mattress scour protection installed in the wet underneath the platform.

Insitu concrete mattress protection is often more practical and cost effective than rock to piled slopes and it can be installed under piled platforms to enable use of the Land Infill method.

Case histories are presented showing the Land Infill method:-

- Quetzal Port, Guatemala
- Port Au Prince, Haiti

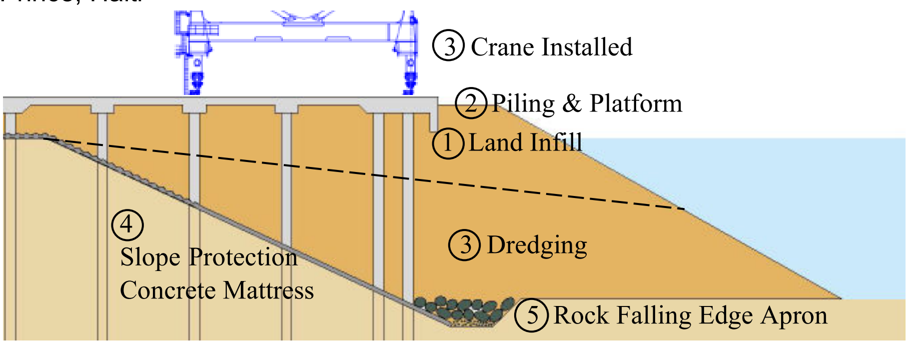

Figure 1. Land Infill Method

Insitu concrete mattress scour protection can also be installed under piled platforms where traditional marine construction methods are used for the piled platform (Figure 2). This can shorten the construction period by taking slope protection off the critical path. Case histories are presented showing examples of installation below the deck presently in progress and an historical example from 1984:-

- Al Faw Grand Port, Iraq
- Belawan Port, Indonesia, 1984

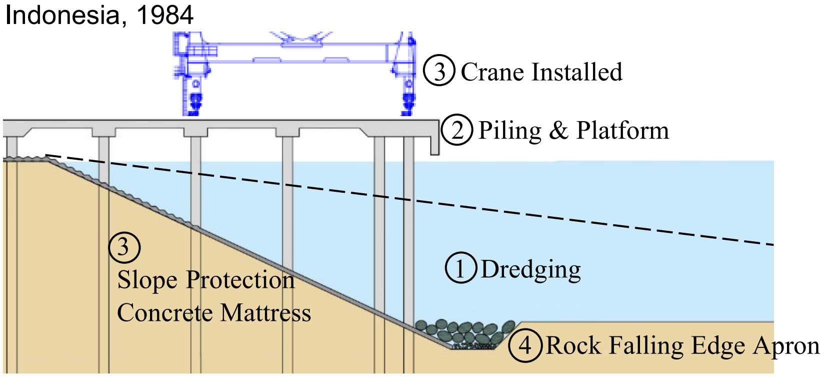

Figure 2. Traditional Marine Construction with Concrete Mattress Installed Below the Deck

2 CONCRETE MATTRESS

Insitu concrete mattress aprons are formed by divers rolling out mattress fabric underwater which is zipped and clipped around piles and pump filled with highly fluid small aggregate micro concrete typically of 35 N/mm² strength, Figure 3. Joints between mattress panels form 'ball and socket' shear joints as shown in Figure 4 to a Constant Thickness mattress type. This produces an apron of interlocked concrete slabs underwater, which gives high resilience against currents, propeller and jet flows where edges are suitably protected. Concrete mattress to pile seals are reliably created using proven mattress seal arrangements and engineering control (Figure 5).

Concrete mattress installation by divers is practical in working conditions of currents up to some 0.5 m/s and in wave action up to some 0.5 m with appropriate protection before the concrete sets.

The construction reliability needed for underwater work should follow a proven marine quality control process as outlined in Hawkswood et al. (2014) and (2013) which should be specified and supervised. Some examples of reliable construction are shown in the case histories.

Edge details are particularly important to prevent concrete mattress underscour and failure. Normally rock falling edge aprons or reactive hinged edge blocks are used to manage the risk of edge scour. The design of insitu concrete mattress aprons can follow PIANC 180 (2015) guidance and updated guidance specific to concrete mattress by Hawkswood *et al* (2018) & (2023).

Insitu concrete mattress has been installed under piled platforms for some 40 years as described in the Belawan case history.

Figure 3. Mattress Under Deck

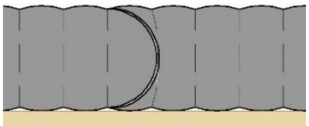

Figure 4. Ball and Socket Joint

Figure 5. Pile Seal

3 LAND INFILL CONSTRUCTION METHOD

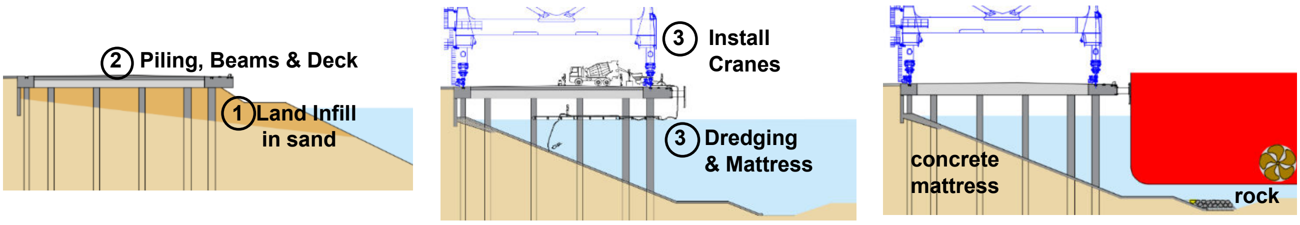

Figure 6. Land Infill Sequence

The Land Infill method is outlined in Figure 1 and shown in further detail in Figure 6. This method was used at Quetzal Port, Guatemala where the sand strata was removed by dredging pumps. The relative advantages and disadvantages of the method are shown in Table 1 below.

Table 1. Advantages and Disadvantages of Land Infill Construction Method

Advantages	Disadvantages
Quicker construction of the structure	Additional soil infill and removal
Piling from land not barges	Restricted working under the platform:
Piling through soil only	• dredging & slope preparation
Platform construction on land	• slope protection

For projects where the soils cannot be reliably removed by dredging pumps, excavation can be by long reach excavators or similar equipment, which operates between piling and transverse beams with platform slab construction omitted until later. This method has been used for the replacement container terminal at Port au Prince, Haiti where the soil types are more variable, comprising sandy gravels with occasional clay layers.

The various Land Infill methods of construction generally speed up construction of the platform and the overall project delivery period. It does however put much greater emphasis on reliably establishing the soil type and marine working conditions, methods for dredging, slope preparation and scour protection, as well as design for constructability. These aspects can be handled by experienced engineers often using risk management techniques.

For pile platforms constructed by the Land Infill method, use of insitu concrete mattress has proven to be an effective method of slope protection. Divers install and zip mattress fabric between piles upon slopes under the platform before pump filling with a sand: cement micro concrete from the bottom upwards.

3.1 Constructability

Once a construction method for a quay platform has been selected, the design should be developed to allow effective constructability. Insitu concrete mattress can be readily used where access is limited under the platform with a rock falling edge apron or similar to the perimeter. This approach provides an effective combination capitalizing on the materials' respective merits. The perimeter rock protection can be readily placed outside the plan area of the platform and be monitored and maintained if necessary. Alternatively, a scour reactive hinged edge can be used (Hawkswood *et al*, 2023).

Greater working tolerances to slopes are usually required for slope preparation compared to level beds. The determination of practical working tolerances often needs to take into account the accuracy of survey methods, construction plant capability, pile tolerances, protection type, local geotechnical stability, working conditions, soil behaviour, and the need to minimise diver working time.

3.2 Case Histories: Land Infill

3.2.1 Quetzal Port, Guatemala

Contractor: Copisa SA, Year: 2015

The Land Infill construction method (Figure 6) was chosen mainly to reduce the project delivery time to 1.5 years. The local sand was used for Land Infill allowing the reinforced concrete piling and platform construction to be undertaken working in the dry in a quicker and more cost-effective way. On completion of the deck and platform, erection of the cranes commenced immediately as shown in Figure 7.

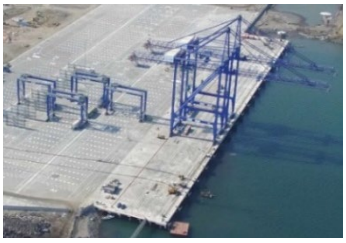

Figure 7. Crane Installation above deck

Figure 8. Dredging by Toyo Pump

The dredging pumping and scour protection took place whilst crane erection was taking place. The sand infill was removed to low water level by excavation plant working under the platform. The remaining submerged sand strata was removed by dredging pumps handled by purpose made barges, Figure 8. A slope construction tolerance of ±0.45 m was used. Figure 9 shows the resulting section to accommodate container vessels with a 15m draft.

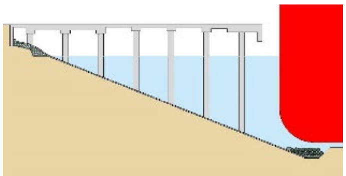

Figure 9. Quetzal Port

Figure 10. Open Hole Mattress

Constant thickness mattress was used on the underwater slope, with permeable Open Hole mattress to the wave zone (Figure 10) and a rock falling edge apron to the toe and sides.

The scour protection was undertaken under the deck off the critical path allowing significant saving in time and cost to be made. Significantly the local sand could be readily removed by dredge pumps allowing full construction of the deck before dredging pumping. The assessment of pumpability of the local sand material is important and was well assessed on this project.

3.2.2 Port Au Prince, Haiti

Contractor: GLF (USA) Engineer: Technital, Year: 2015

The new piled wharf replaced the container berths which collapsed due to liquefaction in the 2010 earthquake, Figure 11. The piles, vibro compaction and reinforced concrete beams were constructed from land using the Land Infill method. The local strata was sand with some gravels and occasional silty/clay layers and so dredge pumping could not be used. Slopes were excavated by long reach excavators working between beams as Figure 12 with crane mounted water jetting controlled by Diver used to remove material under beams and around piles. Slope tolerance were +0.3 m & -0.45 m. Panels of mattress fabric were premade to suit the width and length of bays between piles, which were fixed around piles and zipped to neighbouring panels. A highly fluid mix of 2:1 sand:cement was developed using local sands and cement for mattress filling. Purpose engineered pile seals were used to reliably seal around piles. Additional mattress fabric was allowed to cater for pile position tolerances and slope preparation tolerances.

Figure 11. Collapsed Container Berth

Figure 12. Excavator Working Between Beams

A porous filter point mattress was used in the wave zone. Rock armour was used as edge protection. The resulting section is shown in Figure 13 to accommodate container and cargo vessels with a 10m draft.

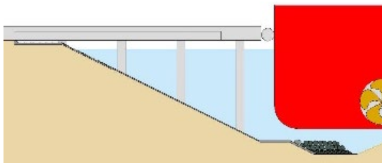

Figure 13. Port Au Prince

4 CONCRETE MATTRESS INSTALLATION BELOW THE DECK

Where piled platforms are constructed by traditional marine methods, insitu concrete mattress scour protection can also be placed after construction of the deck. This takes the installation of protection off the critical path and saves time.
Other common forms of scour protection require access from above and need to be placed before the deck is complete.

4.1 Case Histories: Concrete Mattress Installation Below the Deck

4.1.1 Al Faw Grand Port, Iraq

Contractor: Daewoo, Designer: Senest
Port Engineer: Technital, Year: 2023
This container port is presently under construction. The container port is being formed using an open piled platform with quays 1.75km long for phase 1.
Concrete mattress scour protection has been selected to be installed beneath the deck, taking the scour protection works off the critical path and saving programme time compared to the original rock protection design. Figure 14 shows the typical section to accommodate container vessels up to 400m long with a 16m draft.

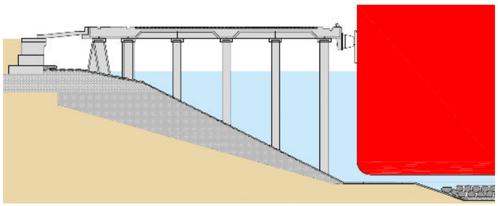

Figure 14. Al Faw Grand Port

4.1.2 Belawan Port, Indonesia

Engineer: Halcrow and Partners, Year: 1984
This jetty was constructed using the traditional marine method. Concrete mattress scour protection was used as it was more cost effective than the rock protection originally designed, Loewy et al. (1984). Concrete mattress protection was installed as scour protection to slopes both before and after construction of the deck allowing flexibility for construction.
The Port Authority reports that it continues to perform well. Figure 15 shows the typical section.

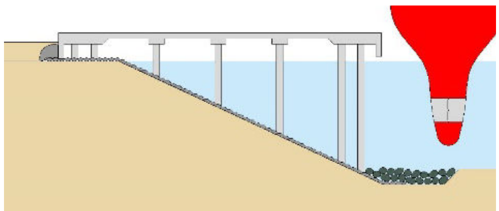

Figure 15. Belawan Port

5 CONCLUSIONS

The Land Infill method of construction of open piled quays has been developed & well used by contractors working upon projects at Port au Prince, Haiti & Puerto Quetzal, Guatemala. The contractors reported savings in both cost and time. The Land Infill method allows:-

- Piling and platform construction in the dry
- Earlier installation of cranes and project completion
- Concrete mattress protection installed under the platform off the critical path.

The ability to install insitu concrete mattress under the platform enables use of the Land Infill methods. Contractors need a good understanding of local soils and conditions to select and develop a suitable Land Infill method. This enables comparison with traditional marine construction methods and relative time and cost considerations.
Where open piled quays are constructed traditionally by marine construction methods, concrete mattress protection is often being installed under the platform in order to save time.

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