CONSTRUCTING MODERN PORTS WITHOUT STEPPING ON WATER

by

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ABSTRACT

When the decision for the construction of a new port is taken, investors and operators look for a modern and economic engineering solution and a tight schedule for construction and starting of operations.

Engineering solutions for mostly ports structures involves the installation of piles supporting concrete or steel superstructures. In the case of Piers and Jetties an approach trestle is required to reach adequate water depths, and in some cases, pass along shallow or mangrove areas inaccessible or avoided for floating equipment.

For these situations, the strong integration between the structural design and the construction methodology is a key factor for the execution of the works. The cantitravel method which is a system that allows the work to progress regardless of the environmental conditions without stepping in water also means less impact on the environment.

This paper approaches 20 modern port installations worldwide designed and constructed with innovative construction solutions for achieving low costs, low risk, reduced construction time and reduced downtime due to adverse environmental conditions.

1. INTRODUCTION

When the decision for the construction of a new port is taken, investors and operators look for a modern and economic engineering solution and a tight schedule for construction and starting of operations.

Engineering solutions for mostly ports structures involves the installation of piles supporting concrete or steel superstructures. In the case of Piers and Jetties an approach trestle is required to reach adequate water depths, and in some cases, pass along shallow or mangrove areas inaccessible or avoided for floating equipment.

For these situations, the strong integration between the structural design and the construction methodology is a key factor for the execution of the works. The cantitravel method which is a system that allows the work to progress regardless of the environmental conditions without stepping in water also means less impact on the environment.

This paper approaches 20 modern port installations worldwide designed and constructed with innovative construction solutions for achieving low costs, low risk, reduced construction time and reduced downtime due to adverse environmental conditions.

These 20 ports where successfully constructed in Brazil (8), Peru (6), Cuba (1), Dominican Republic (1), Equator (1), Algeria (1) and Republic of Djibouti (2).

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2. PORTS AND TERMINALS

2.1. 2001: Belmonte Terminal- Veracel Celulose S.A – Brazil

2.1.1. Brief Description of the Terminal

- Timber loading terminal
- Platform: 136 x 30m, 7 mooring / berthing dolphins and Trestle: 382m long / Breakwater: 320m long
- Barges up to 5.000 DWT

Figure 1: Belmonte terminal – Veracel, Brazil

2.1.2. Why the cantitravel construction method was selected

- Open sea exposed location subject to waves, current and wind action
- Environmental restrictions avoided the construction of temporary jetties in the coast to support the construction activities
- Very shallow water along the coastline

2.1.3. Structure Conception x construction methodology

A technical evaluation of three different spans (8,0 m 10,0 m and 12,0 m) has been performed to define the best regarding the structures and the construction methodology, resulting in the selection of a 10, 0 m typical span.

The structure comprises precast RF concrete elements with minor in situ concrete, supported on steel pipe plies with a RF concrete plug in the top.

Figure 2: Cantitravel - Belmonte terminal – Veracel, Brazil

2.1.4. Key Figures

- 25 m of structure and foundations / week, achieving a production of 1 span/14 h.

2.2. 2002: Pier III- Iron ore Export Terminal – Vale – Brazil

2.2.1. Brief Description of the Terminal

- Causeway: 250m and Trestle: 132 x 10.10m

- Platforms: 24 x 30.10m; 35.6 x 33m and Loading Pier: 364 x 18.75m
- Vessels: 364.767 DWT / 75.000 DWT
- Tide variation: 7.0 m
- Currents: 6 Knots

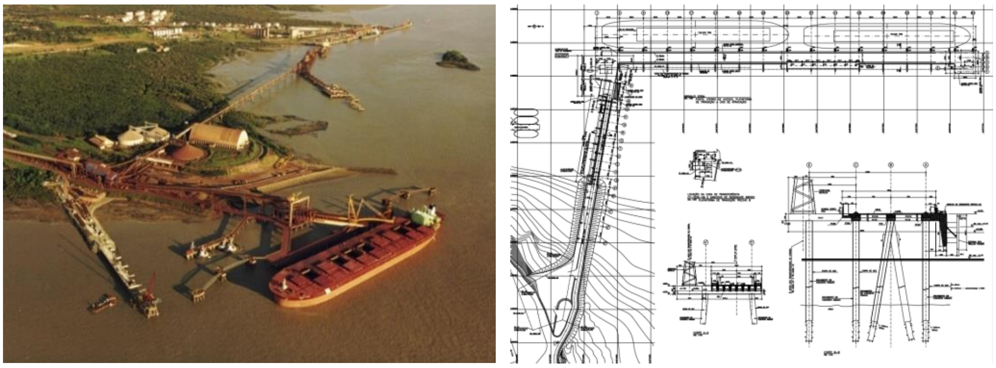

Figure 3: Píer III, VALE, Brazil

2.2.2. Why the cantitravel construction method was selected

- Extreme tidal conditions with tide variations up to 7.0 m originating currents up to 6 knots.
- Floating equipment and self-elevating platform not suitable for local conditions;
- Accident with a self-elevating platform at the site before the cantitravel method was adopted where applicable;

Figure 4: Pier III, Brazil

2.2.3. Structure Conception x construction methodology

The premise of using a single cantitravel starting from the shore line and proceeding along the trestle and the loading pier was a key factor to define the spans, pile arrangement, structure conception, and weight of the structure elements and equipment to be handled by the cantitravel crane.

Thus, the span of the access bridge and the loading pier were defined at 12 meters and 9 meters respectively.

In the layout there is a 100.95 degrees deflection between the trestle and the loading pier.

Along the trestle the cantitravel advanced in the position in which it would be used in the construction of the loading pier so that its displacement along the same was possible by means of jacking and relocation of its wheels.

The pile guides and templates as well as the cantitravel travelling girders used along the trestle have been reused along the pier after quick adaptations.

All piles were drilled in the rock.

2.2.4. Key Figures

- Trestle: 24 m (2spans) /week

- Loading Pier: 22,5 m (2,5 spans/ week

2.3. 2004: Liquid Bulk Terminal Doraleh – Djibouti

2.3.1. Brief Description of the Terminal

- Flammable Bulk Liquid Import Terminal
- Causeway: 1,060 m long;
- Foundations with steel pipe piles, steel decks and precast slabs;
- Trestle / pipe racks: 197.5 m long and loading platforms: 15 x 71.25 and 15 m x 56 m;
- Connection between the two Loading Platforms: 14 x 75 m;
- 4 Mooring dolphins.
- Vessels: Main berth 30.000 to 80.000 DWT and secondary berth 5.000 to 30.000 DWT
- Tide variation: 2.9m
- Current velocity: 1 knot

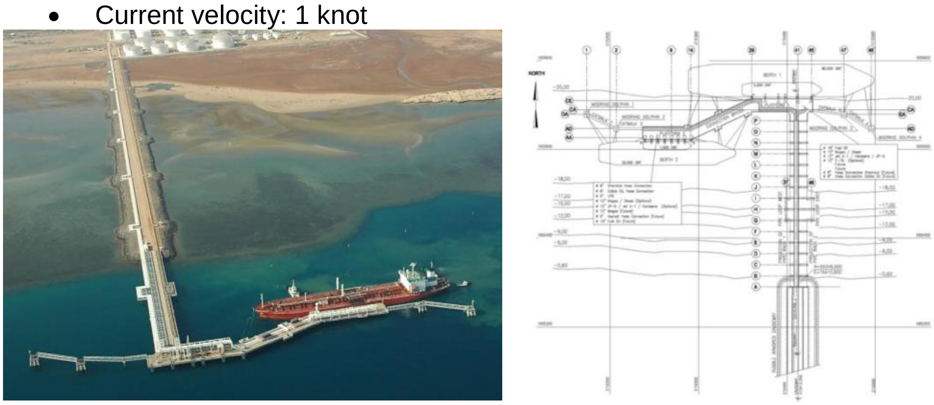

Figure 5: Liquid Bulk Terminal Doraleh – Djibouti

2.3.2. Why the cantitravel construction method was selected

- Substantial reduction of possible delays due to weather conditions, tidal variation, wind, currents and waves;
- Access for men and supplies from behind through the already finished permanent structure;
- Jetty and trestle structures designed mostly with steel structures, reducing cycle time for the cantitravel construction method.

2.3.3. Structure Conception x construction methodology

The 1060 meters long causeway at the beginning of the access to the pier was located at shallow waters close to the shoreline. The trestle is 197.50 meters long, consisting of fifteen 12.50 meters spans. Both platforms consists of 7.5 meters longitudinal spans.

The jetty and the trestle structures were designed mostly with steel structures for the traveler construction method.

The rubble armored causeway replaced part of the steel trestle and allowed the anticipation of the activities on site while the erection of the Cantitravel was underway.

The Cantitravel was used for the construction of the trestle and the berthing structures. For the execution of the mooring dolphins and catwalks, floating equipment was selected.

The Cantitravel was designed to have its wheels relocated due to direction changes along its path.

Figure 6: Liquid Bulk Terminal Doraleh – Djibouti- Cantritravel

2.3.4. Key Figures

- Steel structures fabricated and pre-assemble in Brazil and shipped to the side.
- Construction and installation in Djibouti in 6 months.

2.4. 2005: Areia Branca Offshore Export Salt Terminal Expansion– Brazil

2.4.1. Brief Description of the Terminal

The cantitravel has been used in the construction of the expansion of the storage area of the terminal. The original characteristics of the terminal are:

- Artificial island 10 miles offshore, built with steel circular sheet piles cells filled with dredged sand
- Storage area 100 x 200 m
- Conveyor trestle: 500 m
- 3 mooring / berthing dolphins plus 2 additional new ones and 3 mooring buoys
- Vessels: up to 75,000 DWT
- Barge unloading wharf 200 x 12 m

The cantitravel was used for the expansion of the storage area by 100 x 100 m and the expansion of the barge unloading wharf. The perimeter of the expansion area comprises a sheet pile double wall cofferdam filled with dredged sand. The storage area was also filled with dredged sand

Figure 7: Areia Branca Offshore Export Salt Terminal Expansion– Brazil

2.4.2. Why the cantitravel construction method was selected

- Very exposed location with rough sea conditions
- Use of floating equipment not feasible

2.4.3. Structure Conception x construction methodology

- Vertical steel pipe pile were intercalated along each cofferdam wall to allow the progress of the cantitravel.

Figure 8: Structure Conception x construction methodology

2.4.4. Key Figures

- The average progress of the cantitravel was 15m/week double wall cofferdam

2.5. 2006: Cais 4 – Container Berth Terminal- Suape – Brazil

2.5.1. Brief Description of the Terminal

- Wharf: 600m long x 24m wide;
- Container Carriers: up to 75.000 DWT;
- Tide variation: 2,50m

Figure 9: Cais 4- Suape- Brazil

2.5.2. Why the cantitravel construction method was selected

- Logistics Convenience;
- Local experience;
- Construction speed / Schedule Constraints

2.5.3. Structure Conception x construction methodology

The use of cantitravel makes construction easy due to the high downtime resulting from local currents, waves and winds.

The wharf consists of concrete piles spaced every 4m, supporting a superstructure of precast elements with cast in place concrete.

The wharf construction was divided into two spreads. The first was performed by the Cantitravel and a main crawler crane to execute the activities of pile driving. The secondary spread performed the activities of precast assembly, concreting and rock layer construction with a secondary crawler crane.

Figure 10: Cais 4- Suape- Brazil

2.5.4. Key Figures

- The average progress of the cantitravel was 25 m/week along the wharf

2.6. 2006: Container Terminal - Doraleh - Djibouti

2.6.1. Brief Description of the Terminal

- Vessels: up to 180,000DWT, 12,500 TEU´s;
- Yard: 480 x 1050m / Trestle: 2,080 x 36.50m / Wharf: 1050m long;
- Tidal variation: 2.7m

Figure 11: Container Terminal - Doraleh - Djibouti

2.6.2. Why the cantitravel construction method was selected

- Construction activities independent of weather conditions, tidal variation, wind, currents and waves.

2.6.3. Structure Conception x construction methodology

The wharf spans were defined in order to obtain the most effective arrangement to withstand the construction and operational loads. The longitudinal axes were spaced each 6m along the wharf.

The foundation was composed by steel pipe piles with concrete filling at the top. The superstructure consisted of reinforced concrete with 4 longitudinal beams, part in precast concrete and part in cast-in-place concrete connected by T precast elements.

The progress of the wharf construction was based in two main spreads:

- Spread 1: Is the advanced spread performed by the Cantitravel and the main crawler crane, regarding the activities of pile driving;
- Spread 2: Is the secondary construction front following the Cantitravel performed by a secondary crawler crane, regarding the activities of precast assembly and concreting.

The method using two spreads advancing independently permitted to speed up the cycle of activities and the total time of construction works.

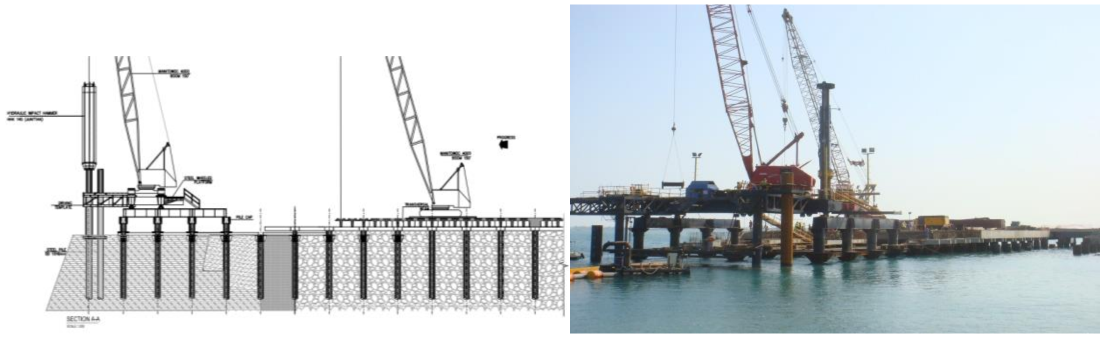

Figure 12: Container Terminal - Doraleh - Djibouti

2.6.4. Key Figures

- The average progress of the cantitravel was 18 m/week along the wharf

2.7. 2007: LNG Melchorita – Peru

2.7.1. Brief Description of the Terminal

- LNG Export Terminal;
- Breakwater: 760m pre-cast concrete blocks / Trestle: 1,350m long;
- 10 Mooring and Breasting Dolphins;
- 120m access bridge to the RLOF (Rock Load Out Facility)
- Utility Dock and Loading Platform: 31.95m wide and 54m long;
- Vessels: tankers up 165,000 m³ of capacity;
- Waves: Hs= 4.2m.

Figure 13: LNG Melchorita – Peru

2.7.2. Why the cantitravel construction method was selected for the construction of the Trestle and the RLOF

- Exposed location to rough seas and wave breaking zone turning unfeasible the use of floating equipment, barges and jack up barges.

2.7.3. Structure Conception x construction methodology

Driven steel pipe piles were used all along the trestle and loading platform. The roadway comprises pre-cast concrete slabs supported by steel decks

Additionally, to the trestle and the platform the use of the cantitravel allowed to build a temporary trestle used to transport and launch majority of rocks for the breakwater, resulting in significant savings.

Also, in this project, with a longitudinal span of 18m, a heavy crane was necessary. Due to the weight of piles and steel structure, all the structure was designed specially to accommodate such operational conditions. Seismic and wave attack have been considered during detail design of the cantitravel.

Figure 14: LNG Melchorita – Peru

2.7.4. Key Figures

- The average progress of the cantitravel was 30 m/week along the trestle;

2.8. 2007: Rock Load Out Facility - RLOF - Melchorita Peru

2.8.1. Brief Description of the Terminal

This work is part of the LNG Melchorita Project, previously described.

The rock load out facility (RLOF), constituted of a quay protected by a breakwater, allowed during construction the load of materials on the split barge used for the construction of the rubble mound breakwater (760m long). After completion of the Marine Works, the RLOF remained as a permanent berth facility to accommodate up to 4 tug boats, a pilot vessel and line boats.

A 250m structure was built to access the rock load out facility. This structure is connected to a rock loading platform 242m long.

- Breakwater: 242.35m long / Trestle: 104.55m long and pier: 141.7m long
- Split barges for the construction of the rubble mound breakwater
- Waves: Hs= 4.2m

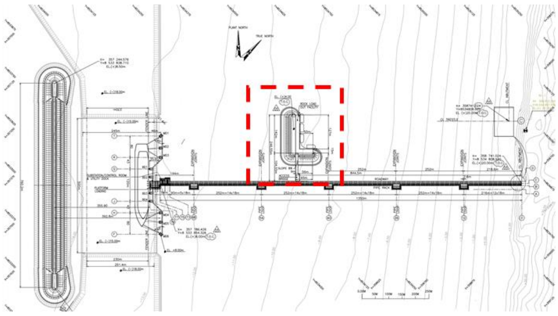

Figure 14: Rock Load Out Facility - RLOF - Melchorita Peru

2.8.2. Why the cantitravel construction method was selected

- Due to the same reasons mentioned for the main structure. As this structure is located 700m from shoreline, the swell is even a worse problem for floating equipment;
- Reducing downtime due to action of waves and breaking zone.

2.8.3. Structure Conception x construction methodology

The concept of the structure is very like the main trestle. Steel pipe piles, steel structure with a pre-cast concrete roadway.

The pier spans of 13m were defined in order to obtain the most effective arrangement to withstand the construction and operational loads.

Due to the inclination of the RLOF, a safety control system was installed in order to guarantee a regular and safe displacement of the RLOF Cantitravel, mainly seawards.

All piles were driven with the Cantitravel system.

Figure 15: Rock Load Out Facility - RLOF - Melchorita Peru

2.9. 2009: Container Terminal - Callao – Peru

2.9.1. Brief Description of the Terminal

- Entrance yard: 400 x 150m / Container yard: 650 x 225m / Wharf: 650 x 36m;
- Vessels: ULCS up to 130,000DWT;
- Embankment.

Figure 16: Container Terminal - Callao – Peru

2.9.2. Why the cantitravel construction method was selected

- Optimizing cycle of activities and reducing total construction time;
- The terminal was to be built in a very confined area with restricted room to barges maneuvering and anchoring. The anchors would interfere with the normal operation of the existing port;
- The cantitravel system has proven in Peru to be an efficient and reliable method for quay construction.

2.9.3. Structure Conception x construction methodology

The piles were steel pipe piles with concrete filling on the top.

The superstructure is pre-cast concrete elements domes shape. This superstructure is a very innovative design eliminating formwork on site.

The wharf spans of 6m were defined to withstand mainly the operational and seismic loads.

The wharf construction was divided into two spreads. The Spread 1 was performed by the Cantitravel and a main crawler crane to execute the activities of pile driving. The Spread 2 performed the activities of precast assembly, concreting and rock layer construction with a secondary crawler crane.

The method using two spreads advancing independently permitted to speed up the cycle of activities and the total time of construction works.

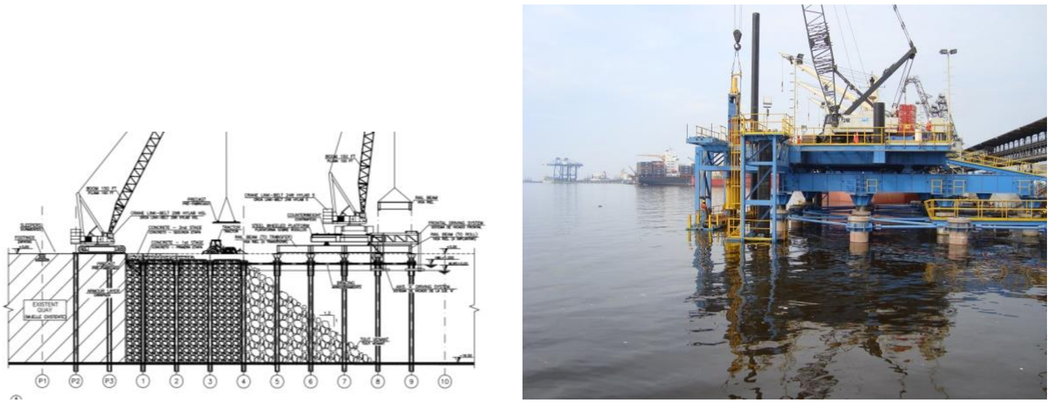

Figure 17: Container Terminal - Callao – Peru

2.9.4. Key Figures

- The average progress of the cantitravel was 18 m/week along the wharf

2.10. 2009: ARZEW Fertilizer Export terminal – Algeria

2.10.1. Brief Description of the Terminal

This work comprised the detailing of Cantitravel system, in order to attend the construction methods of the Access Trestle and Loading Platform as part of the marine structures of the Algeria/Oman Fertilizer Project.

- Bulk Urea and Liquid Ammonia Export Terminal;
- Trestle: 1,200m long and Loading Platform: 260 x 62m;
- Mooring dolphins;
- Vessels: up to 60.000 DWT;
- Steel wheeled platform: 22.10 x 36.60 m;
- Capacity (Crane of 300 tons and Spans up to 20m)
- Waves: Hs= 4.16 m for a return period of 1 year.

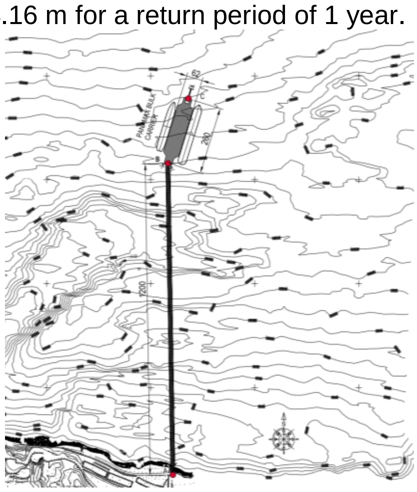

Figure 18: ARZEW Fertilizer Export terminal – Algeria

2.10.2. Why the cantitravel construction method was selected

- Local meteocean severe conditions and unprotected area did not allow the use of floating equipment;
- Heavy equipment for pile driving and assembly structure was required and not available in the region. The equipment to be used on barges would be significantly bigger.

2.10.3. Structure Conception x construction methodology

All structures designed for Trestle construction were adapted to perform also the construction of the Loading Platform.

The Trestle structure was composed of 60 spans 20m long and the platform of 27 axes with variable spans (11.5m and 9m long spans). Foundation is 60” diameter steel pipe piles. Superstructure is formed by steel beams and girders, welded and flanged.

The structure was designed to support a 300 tones crawler crane and all the equipment required for construction activities. The design allowed the crane tracks to be parallel to the trestle axis to increase the load chart capacity for lifting piles and precast slabs up on the trestle.

Figure 19: ARZEW Fertilizer Export terminal – Algeria

2.10.4. Key Figures

Not disclosed.

2.11. 2010: Phosphate Export Terminal - BAYOVAR – PERU

2.11.1. Brief Description of the Terminal

- Trestle: 250m long and Wharf: 250m long;
- Vessels: up to 75,000 DWT;
- Tide variation: 2.14m;
- Waves: Hs= 4m.

Figure 19: Phosphate Export Terminal - Bayovar – Peru

2.11.2. Why the cantitravel construction method was selected

- Unprotected construction area opened to the Pacific Ocean increases considerable the downtime using floating equipment. Rocky bottom profile also makes difficult to operate both barges and jack up barges.
- The height of the structure at the abutment also contributed for the cantitravel method option.

- The use of drilled shafts in the execution of the foundation required a fixed platform to guarantee safe operations.

2.11.3. Structure Conception x construction methodology

The structures of the trestle and platform were constructed in two spreads, Spread 1 and Spread 2. The Spread 1 consisted of a crawler crane on the steel wheeled platform to perform the activities of pile driving. The Spread 2 included a static platform with a secondary crawler crane to perform the activities of precast assembly and concreting.

The static platform was composed of two separated parts located in two spans for its movement. The displacement was performed by the crane to lift and transfer one part towards forward or backward.

The trestle was designed to withstand a 10m span and the wharf was designed with a longitudinal axis each 6.67m. For that, it was possible to develop a solution with a cantitravel that could advance and drive two axes of piles at a time on the wharf construction sequence, reducing the time of the cycle of activities.

The foundations were composed by steel casing allowing the drilling and concrete of the drilled shaft.

The superstructure was a mix of pre-cast and cast in place reinforced concrete.

Figure 20: Phosphate Export Terminal - BAYOVAR – PERU

2.11.4. Key Figures

- Trestle 15 m/week
- Pier 14 m/week

2.12. 2010: Embraport Container (3 Cantitravelers) – Brazil

2.12.1. Brief Description of the Terminal

- Wharf: 660 x 110m;
- Container yard on piles / Container yard on landfill;
- Vessels: up to 120,000 DWT.

Figure 21: Embraport Container– Brazil

2.12.2. Why the cantitravel construction method was selected

- Due to the width of the structure, the use of three cantitravelers speed up the total construction time.

2.12.3. Structure Conception x construction methodology

The wharf was divided into 4 longitudinal segments, with a total length of 660m, consisting of precast and in-situ concrete superstructure supported by concrete piles with 90cm of diameter. The 660m long corresponds to the 1ª Phase of the Terminal, already built. The second phase foresees an extension of 440m, totalizing 1,100m long.

The piles are spaced longitudinally every 3.75m in the axis “A” and every 7.5m for the other axes (“B”, “C” and “D”).

The construction methods included the use of three cranes on three cantitravelers, working simultaneously to lift and drive the concrete piles of their axes. The precast assembly was performed by a gantry crane, independently of the cantitravelers spread.

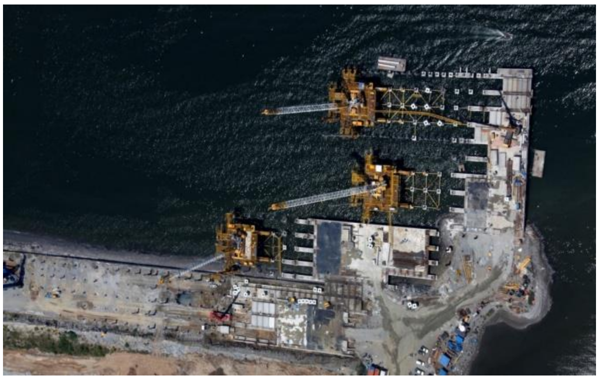

Figure 21: Embraport Container– Brazil

2.12.4. Key Figures

- Wharf 15 m/week/ cantitravel

2.13. 2012: Pier IV – Iron ore Export Terminal- São Luis – Brazil

2.13.1. Brief Description of the Terminal

- Vessels: up to 400.000 DWT;
- Tide variation: 7m;
- Current velocity: 6 knots

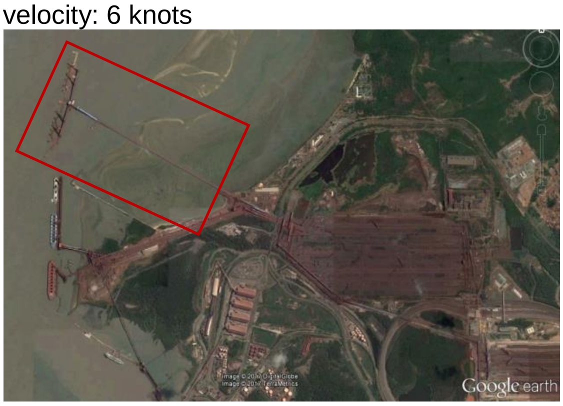

Figure 22: Pier IV – São Luis – Brazil

2.13.2. Why the cantitravel construction method was selected

- The structures at this project were initially being built using a jack up barge;
- The conditions at the site do not recommend the use of floating equipment. The currents are very high (up to 6 knots) and tide variation of 7m makes the maneuvering and handing of floating equipment extremely. Not without reason

the jack barge operating at the project has collapsed, turned down and was completely lost.

- At this time, a cantitravel system was quickly mobilized and finished the remaining structures.

2.13.3. Structure Conception x construction methodology

The foundations were composed by steel casing allowing the drilling and concrete of the drilled shaft.

The superstructure is a mix of pre-cast and cast in place reinforced concrete.

The Cantitravel was designed to execute the structures for the Accesses to Pivot 1 and 2 and the platforms of Pivot 1 and 2. The longitudinal spans were 11.30m/15.50m.

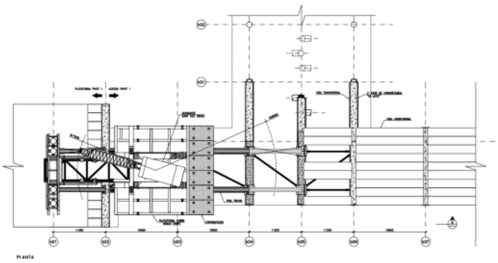

Figure 23: Pier IV – São Luis – Brazil

2.13.4. Key Figures

Not disclosed.

2.14. 2012: Matarani Export Bulk Terminal– Peru

2.14.1. Brief Description of the Terminal

- Trestle: 171m long / Pier: 261m x 21.4m;
- Vessels: up to 50.000 DWT;
- Waves: Hs= 2.84m.

Figure 24: Matarani Export Bulk Terminal– Peru

2.14.2. Why the cantitravel construction method was selected

- The wave conditions, the rock bottom profile and logistics aspects prevent the use of floating equipment;
- Severe wave climate would cause high operation construction downtime. There was no anchoring system allowing safe operation for barges;

- The use of drilled shafts in the execution of the foundation required a fixed platform to guarantee safe operations.

2.14.3. Structure Conception x construction methodology

The foundation is drilled shafts using steel casings. It consists of a system of concrete piles cased with steel pipes, distributed longitudinally every 7.5m and drilled in rock.

The superstructure is composed by pre-cast elements connected by cast in place concrete. The trestle had a slope of 3%, starting at the level +10,60m to the level +7,00m in accordance with the pier elevation.

The cantitravel system was used as support to all construction activities, including pre-cast element and concrete pouring. The crane used in the cantitravel had capacity of 250t, and performed all the activities in only one Spread, such as driving and drilling the piles, lifting and assembly the precast elements.

The cantitravel was designed to have its wheels relocated due to the direction change along its path.

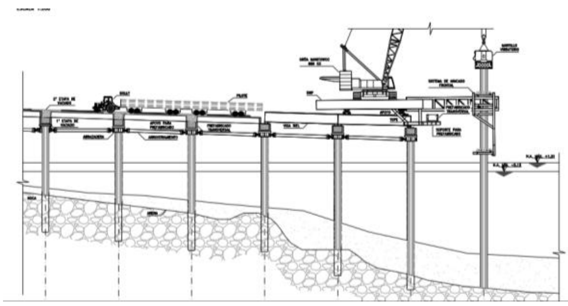

Figure 25: Matarani Export Bulk Terminal– Peru

2.14.4. Key Figures

Not disclosed.

2.15. 2012: Minerals Export Terminal - Callao, Peru

2.15.1. Brief Description of the Terminal

- Trestle: 315m long / Pier: 220m x 21.25m;
- Vessels: up to 60.000 DWT.

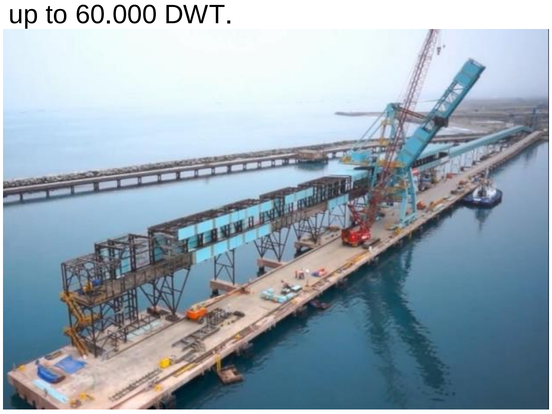

Figure 25: Minerals Export Terminal - Callao, Peru

2.15.2. Why the cantitravel construction method was selected

Similarly, to the Callao Container Terminal, this terminal was built in a very confined area with restricted room to barges maneuvering and anchoring.

2.15.3. Structure Conception x construction methodology

The piles were steel pipe piles with concrete filling on the top. The piles were spaced longitudinally each 10m at the trestle and every 9m at the pier.

The superstructure was pre-cast concrete elements as well as cast in place concrete for connecting the structures.

The pier and the trestle were located continuously, with no deflection between them, and not requiring cantitravel turning.

The construction activities were divided into two Spreads. The Spread 1 was performed by the Cantitravel and the main crawler crane, regarding the activities of pile driving. The Spread 2 was the secondary construction front following the Cantitravel and performed by a secondary crawler crane, regarding the activities of precast assembly and concreting. Both cranes had a capacity of 250t.

Figure 26: Minerals Export Terminal - Callao, Peru

2.15.4. Key Figures

- 25m/week

2.16. 2012: Mariel Container terminal - Cuba

2.16.1. Brief Description of the Terminal

- Wharf: 702m x 37m and Dike;
- Container storage area: 281.115 m²;
- Vessels: up to 200.000 DWT.

Figure 27: Mariel Container terminal - Cuba

2.16.2. Why the cantitravel construction method was selected

- Optimizing cycle of activities and reducing total construction time;
- This project was similar to the Callao Container Terminal, which used successfully the construction method with Cantitravel.

2.16.3. Structure Conception x construction methodology

The wharf consists of a reinforced concrete platform supported by steel pipe piles with concrete filling at the top. The piles are spaced in the longitudinal direction each 7.62m.

The superstructure is composed by a mix of precast type "Domus" and in-situ concrete.

The wharf construction was divided in two spreads. The Spread 1 was performed by the Cantitravel and a main crawler crane to execute the activities of pile driving. The Spread 2 performed the activities of precast assembly, concreting and rock layer construction with a secondary crawler crane.

The method using two spreads advancing independently permitted to speed up the cycle of activities and the total time of construction works.

Figure 28: Mariel Container terminal - Cuba

2.16.4. Key Figures

- 18m/week

2.17. 2016: Import Coal Terminal - Punta Catalina – Dominican Republic

2.17.1. Brief Description of the Terminal

- Trestle: 1300m long / Pier: 335m x 27m;
- Vessels: up to 80.000 DWT;
- Breakwaters;
- Outfall and Intake structures;
- Shore protection;
- Hurricane waves: H=11.5m.

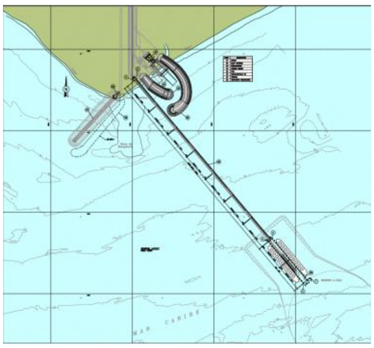

Figure 29: Import Coal Terminal - Punta Catalina – Dominican Republic

2.17.2. Why the cantitravel construction method was selected

- Exposed location to severe wave conditions turn into unfeasible the use of floating equipment, barges and jack up barges

2.17.3. Structure Conception x construction methodology

The trestle connects the structure of the pier to the continent and is divided into 7 segments. The deck of the trestle is at variable elevations, with an increasing slope towards the sea of 0,254%. In the longitudinal direction, the axes are spaced every 12 m.

The pier is divided into two segments. The mainly deck of pier is at elevation of +10.5 m. Fenders and bollards are located on both sides of the pier, connected by a concrete beam placed at the level +7.00 for berthing and mooring of vessels. The piles are spaced longitudinally every 8.7m.

All the piles are steel pipes with concrete filling at the top, and battered 1:10 in the transverse direction only at the trestle. The piles support the precast elements and in situ concrete.

The pier and the trestle were located continuously, with no deflection between them, and not requiring cantitravel turning.

The construction activities were divided into two Spreads. The Spread 1 was performed by the Cantitravel and the main crawler crane, regarding the activities of pile driving. The Spread 2 was the secondary construction front following the Cantitravel and performed by a secondary crawler crane, regarding the activities of precast assembly and concreting.

Figure 30: Import Coal Terminal - Punta Catalina – Dominican Republic

2.17.4. Key Figures

- Trestle: 30m/week
- Pier: 15m/week

2.18. 2018: Posorja Multi-Purpose Terminal – Equador

2.18.1. Brief Description of the Terminal(Under Construction)

- Wharf: 200m x 36.43m / Dike / Container yard;
- Vessels: up to 157.000 DWT;
- Tide variation: 3.6m

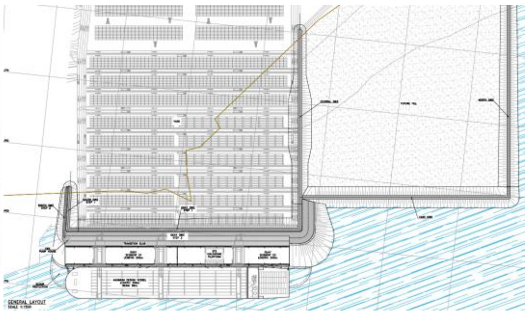

Figure 31: Posorja Multi-Purpose Terminal – Equador

2.18.2. Why the cantitravel construction method was selected

- The use of the cantitravel system for the client became very familiar and due to previous experiences the Client considered the construction preferential method.
- Also, the location of the berth related to the access channel to the inner port associated to unfavorable environmental conditions made the cantitravel system a more feasible method.

2.18.3. Structure Conception x construction methodology

The quay of the Posorja Multi-purpose terminal is divided into two segments of 200m each. Under the quay, the dike is sloped, creating different effective lengths for the piles of different axes. All piles are vertical, made of steel pipe piles filled with reinforced concrete, spaced longitudinally every 6.30m.

The piles are drilled shafts into the claystone and sandstone.

Superstructure are domes form pre-cast elements with a cast in place cover slab. This scheme has been proven an efficient and durable structure under hard seismic conditions.

The structure is being constructed using the cantitraveler method, through two construction spreads. The activities of pile driving and drilling are being performed by the main spread, composed by a crawler crane at a steel wheeled platform. The activities of precast assembly and in situ concreting are being performed by a secondary spread, with a crawler crane in the retroarea.

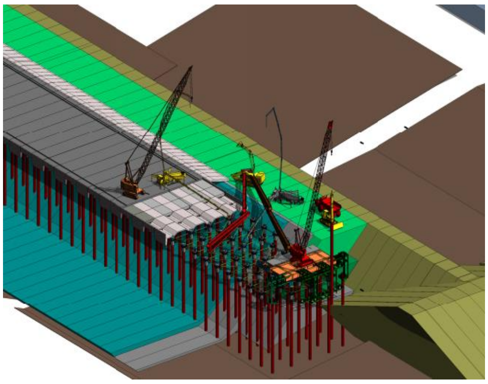

Figure 32: Posorja Multi-Purpose Terminal – Equador

2.18.4. Key Figures

- Expected: 15m/week

3. COPYRIGHT

References

Sabino, L.S., Tepedino M., Hueb M. & Filho R.C.S. (2006). Offshore Bulk Terminals in Developing Countries – Innovative Techniques For Construction, 31st PIANC Congress, Portugal.