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Monitoring and reliability study on structural elements at Onne Port Extension using non destructive method

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Abstract

A reliability and failure monitoring study was done to ascertain the durability of Onne port extension in order to achieve the expansion and rehabilitation intention of the Nigerian Government. A non destructive method of structural adequacy test method using the Schmitt hammer test was done to ascertain the structural integrity of the members using rebound value scheme. The upsurge in materials and human activities due to Onne port as an acclaimed oil and gas free zone area have necessitated the construction of additional berthing facilities, a massive reinforced concrete diaphragm walls at both the front and the back of shores measuring (1300mm x 2600mm) and (1000mm x 15250mm) widths and depths respectively and is tied at 1000mm intervals with 80mm diameter bars. The diaphragm walls numbering 6912 staggered 500mm, mortar vireo pile of differential lengths, Stabilization Island compacted at 95% of maximum dry density with a 250mm thick reinforced concrete slab as quay deck were tested. The need to standardize the facilities in the port is to meet international best practice.

Key word: Construction, Facilities, Integrity, Reliability and Test.

1. Introduction

The history of ports development in Nigeria dates back to the 19th century, long after the onset of sea borne trade and transactions which followed the adventures of early explorations of oil in the African coasts. Prior to this time, explorative and trade activities involving European missionaries and wide coastal stretch from Calabar to Lagos became imperative.

The concept of port as an integral part of social and economical development of a country had hither to not been addressed. Port operations and management had remained under the controls of different government departments. As of 1954, increasing agitations that were to lead the country to independence were steadily unfolding: time had therefore come to think of a well constituted body to control and manage the nation's ports. The port ACT was promulgated and in April 1955, the Nigeria Ports Authority commenced full operations and between 1955 and 1966 of its existence as a corporation body, the Authority addressed fundamental issues that were vital to the success of the ports industry and equally relevant to the overall national economy. In recognition of the importance of having trained hands on its payroll and in response to the policy of nigerianization in the years proceeding independence in 1960, the Nigeria Ports Authority embarked on elaborate manpower development through cadetships training awards in marine, accounts general management, Civil, Electrical and Mechanical engineering and by early sixties beneficiaries of the training award began to graduate and formed the core of Nigeria professionals that began to shape the future of the ports industry.

Since 1962 till date, port developmental approach became tailored along declared national objectives. The Authority development strategy became programmed to fall in line with improvement in port facilities, comprehensive and concrete efforts to rehabilitate existing infrastructure, modernize and develop port Authority. However the need to carry out these developments on port facilities was borne out of the post civil war period which had tremendous impact on the port in Nigeria. The security aspect of the port came into focus and Port Harcourt port was closed to foreign traffic; Lagos thus became the only available port serving the country's maritime transport needs and with its comparatively limited capacity, was made to bear the weight and burden of the tremendous flow of war time cargoes and other goods coming into the country ranging from reconstruction machinery, including heavy structure for some basic industries, construction materials consumer goods flooded the nation was battling to solve congestion, another and more problematic form of port congestion was lurking behind the corner: the rapid growth of Nigeria population: the vast agricultural resource of the country the sudden increase in the posted price of petroleum from her rich mineral resources had generated on impetus for revolutionary changes in the political, educational, socio- economical and industrial projects resulting in high demand for building materials. In consideration of the need for deep sea ocean vessels that would be involve in lifting liquefied natural gas, crude oil, oil related products and project cargoes for the National fertilizer company (NAFCON), the Nigeria Port Authority Strategically located the Federal Ocean Terminal at Onne and the construction of the first phase which consist of 750 meters berthing facilities with 30ha of stacking area was completed and commissioned in 1996. Also the second phase of 570 meters of berthing facility with a stacking area of 39ha is also completed.

The third phase of the construction of the Federal Ocean Terminal at Onne which was award for construction in 2007 comprises of construction of berths 4, 5, and 6 which fits in between the berths 1, 2, and 3 in the first phase and berths 7 and 8 in the second phase. Furthermore the expected upsurge in maritime operation at Onne Port as a transshipment centre, oil and gas free zone and especially to reaffirms the position of the position of the complex as the hub of central and West Africa Oil and Gas Industry required infrastructural upgrade/expansion of the port facilities and to standardize the port in line with international best practices. This has prompted the management to seek approval for the following under listed projects which have been approved by the Executive Council and are currently at different completion stages and are being monitored by the Nigeria Port Authority Project Monitoring Team and sometimes with an appointed Engineering consulting firm.

2. Literature review

Review on construction of road, JETTY:
A road is a convenient way over which vehicles and all sorts of traffic can lawfully move. A roadway includes the entire area consisting of the highway and all structures pertaining to the road within the limits of the defined boundary or "right-of-way" (Gurcharan singh 1973). Construction of road dated back to 3500BC. In Mesopotamia soon after the discovery of wheeled vehicle which was invented and this necessitated the construction of hard surfaces, although a stone road surface was found as early as 1500BC.On the Island of Crete in the Mediterranean. A reference has been made in the bible about a road construction between Babylon and Egypt after 539BC; but the first roads about which there is some authentic record arte those of the Assyrian Empire Constructed about 1900BC. Actually road construction work was taken in hand only during the period of Roman Empire. In that period, road were constructed in large scale and the earliest construction techniques by the Romans were an extensive system of roads radiating from Rome for military purposes. A jetty is marine structure which consist mainly of two (2) parts; the foundation which is mainly pile and is the most economical form of construction for cargo jetties as well as berthing structure and pipe trestle for oil tankers, have the function of transferring loads from the supper structure through weaker comprehensive starter or through water into stiffer or more compact and less compressive soils or unto rock and also piles used in marine structures are subject to lateral loads from impact of berthing ships and from waves. (M.J.Tomlinson 1994)**.**The material for pile can be precisely specified and their fabrication and installation can be controlled to conform to strict specifications codes of practice requirement, the calculations of their load carrying capacity is a complex matter which at present time is based partly on theoretical concepts derived from sciences of the soils and rock mechanics, but mainly on empirical methods based on experienced (Euro code no 7 geotechnical 1991).

3. Methodology

The strength of the structural elements is measured using the concrete rebound hammer usually referred to as the Schmidt hammer. According to BS1881: part 202; ASTM C805, The concrete hammer is a hand held instrument used for testing the quality of hardened concrete in the structure. This is done to obtain the gained increase strength on a structure. The guiding principle is that the rebound of a elastic mass impacting on the concrete surface is a function of the hardness of the surface. Therefore the harder the surface, the greater is the rebound distance.

The procedure adopted is:

1. The surface is abraded with carborundum stone to remove irregularities.
2. The hammer is pushed firmly against the concrete until the trigger button is automatically released.
3. The hand pressure is then reduced to allow the plunger to fully emerge from the instrument.
4. Extra hand pressure is then applied to push the plunger back into the instrument, compressing the internal spring to the point the trigger mechanism overrides and causes the impact force to be applied to the surface.
5. While applying the hand pressure, the push button is pressed to the plunger in place, retaining the reading on the graduated scale.
6. The corresponding strength to the reading on the scale is then noted.

The tests were carried out on the following cases:

CASE 1: Reinforced rigid pavement road: The road constructed and tested comprises three (3) phases.
Type “I” is a dual carriage way of width 8300mm each lane, a median of 2400mm, side drains and wall way of widths 1200mm and 1800mm respectively; both side and total width of 2500mm which is applicable to Road “A” only.
Type “II” is a single carriage of 900mm width, side drains and road shoulder of widths 840mm and 1300mm respectively. This is applicable to Road “B” and “D” only.
Type “III” is only a single carriage of 1000mm width, side walk and drains of various widths and it is applicable to Roads “C”, “E”,”I”, “I2”,”I3”, only.
The road is designed as a 250mm thick concrete pavement with a gradient of 2.5%, cast over a 0.3mm polythene sheet crushed stone layer: this formation overlies Geotextile material on a well compacted sub grade.

CASE 2: Jetty areas: The immense incursion of erosion on the unprotected shoreline between the active berths 1, 2, and 3 and the recently completed berth 7 and 8 gave rise to the construction which is located along the edge of ogu creek channel on bony river, the shore line that lies adjacent to the existing quays at the Federal Ocean Terminal.
The proposed construction, which is designed as a closed quays on piles to allow for a minimum draft at 12m must be in alignment with berth 1-3 berth line and also adjacent to berth 7 and 8 (WACT Project)

The Project involves the construction of a new “L” shape quay with overall dimension of 765m (Long side) and 95m (short side) by 35.59 as the width of the quay platform (divide into 13nos quay. Quay nos1 has been designated as the heavy lift platform 62.5 meter length, while the remaining 12 no quays are standard quays with provision of basic port infrastructure service and the dredging of the berths to a final draft of 12 m.

4. Test results and field study

A non-destructive test was carried out on the concrete elements using schdimt hammer and the table below represents the strength of two (2) cases in this work.

TABLE 1: Result of Heavy Lift Platform Schdimt Hammer Test. (N/mm^2)

1						
2		33.2 27.5 28.4		28.4 30.4 32.3		28.4 28.4 28.4
3						
4	28.4 30.4 32.3		28.4 32.3 32.3			32.3 26.0 28.4
5			5m			

6	28.4 32.3 32.3	5m	28.4 32.3 32.3	5m	28.4 32.3 28.4	
7			5m			
8			34.3 28.4 28.4			30.4 32.3 28.4
9						
10	32.4 28.4 28.4				28.4 27.5 28.4	
11						
12		33.4 28.4 32.3		28.4 27.5 28.4		28.4 28.4 28.4

TABLE 2: Result of standard Quay Schdimt Hammer Test. (N/mm2)

1	5m	5m	5m	5m	5m	5m
2	@ α= +90º @ α= 0º @ α= -90º	28.4 28.4 32.3		30.4 27.5 28.4		34.3 28.4 28.4
3						
4	26.0 28.4 28.4		28.4 28.4 28.4			
5						
6		28.4 26.0 30.4		27.5 34.3 32.3		28.4 28.4 32.3
7		5m				
8	5m	28.4 28.4 30.4	5m		27.5 32.3 32.3	
9		5m				
10			32.4 28.4 28.4			32.4 28.4 28.4
11						
12		30.4 27.5 27.5		26.0 28.4 28.4		32.3 28.4 28.4

5. Discussion

Construction cost planning for the projects:
Construction cost planning encompasses planning judgment, cost techniques and accounting disciplines for developing standard cost, financial forecast, project budget and cost control measures with ultimate goal of achieving project profit cost objectives. The onne ports works uses standard cost concepts for costing work packages, work items or activities.

The cost of a work unit which may be an activity, a work item or a work package is composed of one or more cost element. The process of cost estimation would be simple if it were possible to directly correlate various cost elements to the activity that incurs them. These costs can then provide a clear picture of the construction cost and thus simplify planning, forecasting, accounting and controlling costs. In order to identify the cost associated with an activity, construction cost general referred to as production cost or overheads

Product cost = Direct cost + Indirect cost

Direct cost: these are cost of materials, labour and other expenses which can be identified with the execution of on item of work or activity
Indirect cost: these include cost attribute to a given project but cannot be identified with the performance of a specific activity. In other words, all other cost other than direct cost are covered under indirect cost production overheads: these include indirect manpower, materials and other indirect expenses e.g. salary and wages for supervisors, tradesman's tools and consumable material, and general purpose plant thriving cost. The following below summaries the cost of Onne ports extension works

a. Summary of cost in Naira (#) for Rigid Pavement Road Construction.

Preliminaries	59,500,000.00
Site clearing and Earth works	133,544,854.10
Drains	402,778,963.29
Concrete pavement	796,925,362.18
Miscellaneous	64,000,000.00
GRAND TOTAL	₦1,456,749,179.57

b. Summary of cost for Jetty Construction.

Preliminaries and general items	9,832,000.00
Dredging and reclamation works	11,716,790.00
Jetty structure	56,317,605.60
Contingency	1,500,000.00
GRAND TOTAL	₦79,366,396.54

On the observed strength of the bay, since the Schmidt hammer was applied at angle of $\alpha = +90, 0, -90$ degrees (directly) on the surface, the observed strength ranges from a minimum value of 26.0 N/mm2 to a maximum of 34.3 N/mm2, and this is quite satisfactory when compared with the standard concrete strength of 24 N/mm2

6. Conclusion

The monitoring of structural adequacy of the elements at Onne Port extension works and non destructive investigation/experimental findings in the work provided an opportunity to advance the engineering knowledge in the field of rigid pavement construction especially in the Niger Delta area due to the swampy nature of the terrain/subgrade which have made roads to continually fail to withstand the test of time under pressure of traffic. Traffic in the port area is high due to conveyance of cargoes from the port area to different distribution on the country, so this gave rise to the sand filled of the swampy areas which was left to settle over a period of time: the road with dowel bars at be constructed are reinforce concrete road with attendant drainage networks which empties into the nearby creeks.

The jetties and wharfs existing in the country since pre-colonial days times are mainly the deck on piles open construction types except for some with anchored sheet piles incorporated into the design to prevent washing away of the sand filling behind the jetty which provides support for the stacking areas.

The closed construction which have recently been adopted in port Le Havre (France), port of Ravenna (Italy) and port Bandar – Abbas (Iran) and Onne Port (Nigeria) is the first to be built. It is a massive reinforced concrete diaphragm walls at the water front 26.55m and also at the back of the jetty (anchor diaphragm wall) 15.25m tied in intervals with 80mm diameter rods and between the diaphragm walls are 6912 staggered 500mm diameter mortar vibro piles of differential length and spacing's. Its suitability and adequacy has to be tested to ensure it adaptability and functionality in Nigeria especially the Niger delta region of Nigeria. The deck consist of 500mm thick sand-cement stabilization island compacted at 95% of maximum dry density (AASHTO) with 250mm thick deck reinforced concrete slab as quay deck. This would have an increased load capacity at 6-tonnes/msq and 12tonnes/msq on the standard. Quay and lift platform respectively unlike the existing deck on piles construction with 4 tons/msq for standard quay and heavy lift platform respectively.

Also the ship capacity of the berth is 30,000kg dead weight and the berth for 12.00m draft with reference to the chart datum (Lowest Astronomical Tide). The conventional constructions evolves to incorporate recent technological advances and as port facilities are enhanced to meet the anticipated challenges of the upsurge in maritime activities at the oil and Gas free Zone area in Onne and the global standard of port facilities in line with international best practices. This updated engineering information becomes important. This information should be used to provide consistent basis for developing port facilities with respect to historical practice and innovative design methodologies

Recommendation

The designs and methods of construction highly listed in this work should be taken as a standard for developing port infrastructure in the country especially areas with similar terrain and heavy cargo handling possibilities.

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