

FIELD ASSESSMENT OF OLD JETTY IN MALAYSIA

TAN JOO EE

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Specially dedicated to...

To all my teachers in life

Thank you.

ABSTRACT

Malaysia being a maritime country now faces the problem of lack of knowledge on how to assess the performance of old marine structure from available local practitioners. The existing guidelines adopted are still too complicated to be applied in engineering practice. There is an urgent need for a simple yet reliable method for assessing old structures. The project report presents detailed investigation findings on 68-year-old jetty facility which is still in service in northern part of Peninsular Malaysia to assess its structural condition. The objective of the report is to develop a practical assessment programme, to determine the long term relation between the rates of structure deterioration by measurements of material properties, and to determine the remaining service life of the jetty. A combination of direct tests and non-destructive tests such as concrete core compression test, rebound hammer test, carbonation tests, chloride ion ingress test and steel pile thickness measurement were performed. Direct testing on concrete cores has indicated the approximate remaining compressive strength of 33.5N/mm^2 . The result from the rebound hammer tests found that the Main Jetty's equivalent compressive strength was 32 N/mm^2 which is below present marine structural standard of minimum 50 N/mm^2 . The close approximation of the results shows that field tests using NDT can produce sufficiently adequate results for assessment of marine structures as long as the results of the NDT have been validated. Carbonation tests on the concrete cores shows that the 68-year-old jetty is not experiencing significant detrimental effects from carbonation. From observation of the core indicates that carbonation will remain within the concrete structure even after repair works unless concrete section affected by carbonation is completely removed. Chloride ion ingress is an observation of long term exposure effects to aggressive environment. The ingress of chloride is influenced by the location of the structure. It is found that the South Mooring Dolphin age 59 year old has shown high chloride content beyond the concrete cover and is therefore at higher risk of exposure to chloride induced corrosion. Steel thickness measurement is for assessing the critical steel pile member of the jetty facility where reduction of steel thickness is an indication of mass loss which is related to the capacity of the piles to carry load. As a conclusion, field assessment tests proposed in this report is simple yet produces reliable results for assessment of structures.

ABSTRAK

Malaysia sebuah negara maritim yang menghadapi masalah kekurangan pakar tempatan yang berpengetahuan bagi penilaian prestasi struktur marin tua. Garispanduan sediaada adalah terlalu rumit untuk dilaksanakan dalam amalan kejuruteraan praktikal. Suatu kaedah penilaian yang mudah dan boleh diterimapakai adalah sangat diperlukan. Laporan ini telah mengemukakan suatu kajian terperinci ke atas struktur jeti berusia 68 tahun yang masih beroperasi di utara Semenanjung Malaysia bagi tujuan mengenal pasti keadaan strukturnya. Objektif laporan ini adalah untuk membangunkan suatu rancangan penilaian praktikal, menentukan kesan jangka panjang kadar kemerosotan struktur melalui pengukuran sifat bahan, dan menentukan baki hayat perkhidmatan jeti. Suatu kombinasi ujian termasuk ujian terus and ujian tanpa musnah seperti ujian mampatan konkrit, “*rebound hammer test*”, ujian pengkarbonatan, ujian pengingresan klorida dan pengukuran ketebalan cerucuk keluli telah dilaksanakan. Ujian beban terus ke atas sampel konkrit menunjukkan bahawa kekuatan mampatan anggaran konkrit adalah 33.5N/mm^2 . Hasil ujian “*rebound hammer tests*” didapati kekuatan mampatan setara Jeti Utama adalah 32N/mm^2 dimana nilai ini adalah kurang daripada piawai terkini iaitu kekuatan mampatan minima 50N/mm^2 . Keputusan yang hampir setara di antara keduanya menunjukkan kaedah ujian tanpa musnah boleh memberi keputusan yang boleh diterimapakai bagi mengenal pasti keadaan struktur marin sekiranya kaedah tersebut telah disahkan terlebih dahulu. Ujian pengkarbonatan pada struktur berusia 68 tahun menunjukkan tiada kesan yang memudaratkan akibat pendedahan kepada karbon. Pemerhatian menunjukkan bahawa kesan pengkarbonatan akan kekal sekiranya kawasan yang terlibat tidak dibuang, walaupun kerja membaiki telah dibuat,. Ujian pengingresan klorida boleh menunjukkan kesan jangka panjang akibat terdedah kepada pesekiraan yang agresif. Kadar pengingresan klorida adalah dipengaruhi oleh lokasi struktur berkenaan. “*South Mooring Dolphin*” yang berusia 59 tahun menghadapi risiko pengarat disebabkan oleh pengaruh klorida yang tinggi. Pengukuran ketebalan keluli adalah bertujuan bagi mengkaji struktur kritikal seperti cerucuk keluli di mana pengurangan ketebalan keluli yang diukur menunjukkan pengurangan jisim pada cerucuk and seterusnya berkaitan dengan pengurangan kapasiti cerucuk untuk menanggung beban. Sebagai kesimpulan, ujian padang yang dikemukakan dalam laporan ini adalah mudah dan member keputusan yang boleh dipercayai bagi menilai keadaan struktur.

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LIST OF ABBREVIATION AND SYMBOLS

%	Percentage
ACI	American Concrete Institute
ASCE	American Society of Civil Engineers
BS	British Standards
CO ₂	Carbon dioxide
Cl ⁻	Chloride ion
Fe	iron
Fe ²⁺	Ferrous ion
FFP	Fit-For-Purpose
H ₂ O	Water
NDT	Non-destructive Tests
MSL	Mean Sea Level
O ₂	Oxygen
OH ⁻	Hydroxyl ion
pH	Potential of Hydrogen
ppm	Parts per million
UPV	Ultrasonic Pulse Velocity

CHAPTER 1

INTRODUCTION

1.0 Introduction

With advancement of technology and an ever-increasing demand for oil globally has created a situation where the planning and construction of new berthing accommodation for the oil companies to load and discharge cargoes are lacking behind the demand for new facilities. As one of the means of managing this situation, oil companies are looking into means of prolonging and upgrading their facilities to meet the current demand. In Malaysia for instance, the oil companies are paying more attention to ascertain that their facilities e.g. terminal jetties in operation are at Fit-For-Purpose (FFP) level. Concern for the safe operation of the terminal jetty is encouraging them to focus on conducting assessment, investigation and maintenance programmes on structures serving beyond their design life span. Some of the common properties of structure which we will look into include concrete compressive strength, concrete durability and mass loss in steel structures. Any indication of deterioration can be assessed by measurements of common structure properties.

Marine jetties have to adequately maintained its functionality at the same time be safe for use. They are exposed to hostile marine environment and also at times unusual loading conditions often associated with marine structures (ASCE, 2001). Deterioration of structures over a long term period will eventually cause the structure to degrade and lose its structure performance. It is reported by (Potty et al., 2013) that 80% of Malaysia's offshore platforms are beyond its design life of 25 years. It is recommended that these type of structures needs to be assessed for ultimate capacity to determine whether it can remain further in service. The possibility to conduct direct tests to determine ultimate capacity on in service existing structure does not come by easy. Therefore a combination of Non-destructive Tests (NDT) and concrete core compressive strength test are recommended for assessment of in service structures. The results from these tests can aid decision on whether to repair, restore, and strengthen or replacement of certain structural components to meet the Terminal's operational requirements.

1.1 Problem Background

In the most ideal case for assessment of old structures, documentation of design basis, historical structural integrity assessment data and latest qualitative and quantitative data on the structure is required for deterministic assessment of the current structure condition. However, it is common that the data available is either missing or incomplete. Therefore most assessment of old aged structures are based on past experience or superficial remedy to symptoms found on the structure at the time of the field investigation. The remedial actions taken under such circumstance may yield unsatisfactory outcomes and at times aggravate the condition of the old structure.

The aggressive environment which marine structure is subjected to is well recorded. The moist marine environment induces chloride and carbon to penetrate the concrete cover of reinforced concrete structure, and once the ingress of these chemical exceeds the cover of the concrete the reinforcement steel will be susceptible to corrosion once the passive layer of the reinforcement is disturbed. As for steel structures in marine environment is susceptible to extensive mass loss if its protective coatings are not well maintain. Excessive mass loss due to corrosion in steel structure would cause the structure to lose its functionality. Reliable information to assessed old structures is necessary for reliable deterministic assessment of current structure condition. The remaining service life of the structure can be estimated with greater certainty.

1.2 Research Problem

There are many assessment records of old marine structures around the world e.g. North America, Northern Europe and Persian Gulf to list a few. However, too few assessment records of marine structures in ASEAN countries such as Malaysia, a maritime country with bustling growth of seaport with average growth rate of +8.64% base from a 5-year data from 2007 to 2011 (Soon and Lam, 2013). Over time, marine facilities will gradually age and will need to be maintained and rehabilitated. It is clear that practitioner in Malaysia face the problem of a lack of knowledge in assessing performance of old marine facilities.

Since assessment of structures has to be specifically designed to take into account many parameters such as the climate, marine water composition, and material, locally developed guidelines should be used for the assessment of structure.

Currently, the existing local guidelines developed are too complicated to be applied in actual engineering practice. There is a need to develop a comprehensive guideline in assessment of structures locally. It is important because any recommendations based on foreign assessment records on remedial works may not work to mitigate the rate of deterioration for local structures.

There is a demand in the industry to have a simple to execute yet reliable assessment programme which is deterministic and able to assess old marine structure that is still in service. Through the assessment programme the Fit-For-Service Level of the structure can be ascertained and the remaining service life can be predicted. If the structure is found to be sound and good condition, then there will be no further action required other than continual monitoring of the structure. If the structure is found to be in distressed, remedial works may be recommended should the works be economically viable or to downgrade the use of the structure for lighter use. In extreme cases, a structure may have to be demolished and rebuilt. Due to the economical importance of maritime activity to the country there is a necessity to formulate a reliable method to assess existing locally for in service structure and to determine the remaining service life at Fit-For-Service Level.

1.3 Research Aim and Objectives

The main goal of this research is to come up with a practical assessment programme for old marine structure assessment taking into account local environment and availability of assessment methods locally. The following are the objectives to achieve in my research:-

- 1) To develop a practical assessment programme for the assessment of the old marine jetty subjected to aggressive marine environment using non-destructive tests (NDT) and historical data
- 2) To determine the long term relation between the rate of structure deterioration by measurements of strength, durability properties and mass loss.
- 3) To determine the remaining service life of the jetty facility using information from non-destructive tests (NDT) methods and direct tests method.

1.4 Research Scope

The scope of study will be focused on marine structure assessment of existing jetty member up to 68-year-old at the time of assessment in 2014 with the use of NDT testing and information from historical data. The members studied in detail are North Mooring Dolphin (Dolphin J), South Mooring Dolphin (Dolphin I), Reinforced Concrete Main Jetty with flare head and Disused Reinforced Concrete Dolphin (Dolphin A). All of the members are located by the seaside and exposed to the same environment.

Historical data on the jetty facility reveal that the reinforced concrete main jetty has been in service for 68 years since 1947 and the disused Dolphin A has been exposed to the marine environment since 1947. From past records on the jetty inspection, the date when Dolphin A ceased to be at FFP condition is not known. It is only certain that, it is recorded that at year 1992, Dolphin A has already ceased its service as part of the jetty main component. The Dolphin J and I have been in service for 57 years since 1958. These members will be assessed its structure condition using selected NDT methods and laboratory tests.

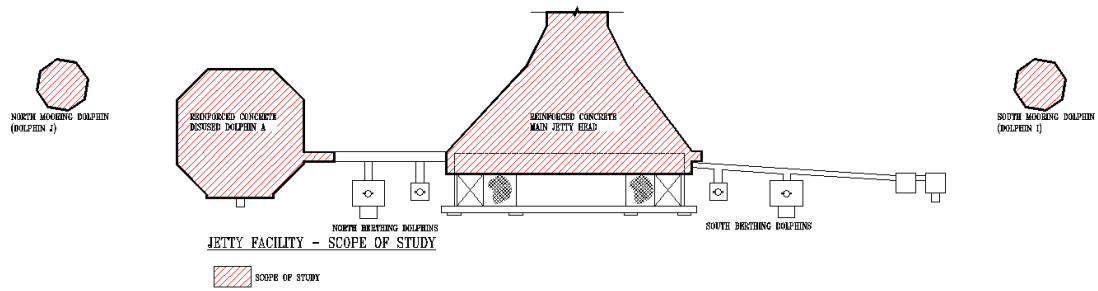


Figure 1.1 Jetty Facilities – Scope of Study

1.5 Significance of Research

There is an ever increasing demand on oil and gas companies to expand their loading and discharging capabilities with an increase in tanker size and frequency of tankers received. There is little allowance for existing facilities to be closed for inspections and maintenance. However, there scarcity of marine assessment programmes available in Malaysia. The benefits expected from this study are:

- 1) The proposed practical assessment programme can be applied for local marine structure in Malaysia.
- 2) Able to provide a long term relation data on existing structure in Malaysia between the rate of structure deterioration by measurements of strength, durability properties and mass loss.
- 3) Able to sufficiently estimate the remaining service life of the jetty facility using information obtained from the study.

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