Transformation of a 30 year old Oil Terminal into a modern double LNG Terminal – Part 1: Refurbishment of the Approach Trestle

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Summary

This paper describes the works that were undertaken to refurbish the existing approach trestle of the South Hook LNG Import Terminal to the standards of a modern LNG facility. Extensive surveys were initially undertaken to determine the condition of the trestle. From this, a refurbishment strategy was devised whereby the deck elements were to be replaced by new composite slabs and the bents were to be refurbished. The bents were repaired by hydro-demolition of the damaged concrete and replacement with a proprietary repair product. Corroded reinforcing bars were replaced and additional bars were added where required. An impressed current cathodic protection system was installed and over-sprayed to protect the structure against corrosion during the required additional design life of 30 years; a titanium mesh was applied above mid sea level and underwater anodes below. As the approach trestle is located in an ecologically sensitive area, special precautions were implemented to ensure that no spillage of contaminated products could occur during construction.

Keywords: Offshore Structures, Assessment/Repair, Durability, Inspection and Maintenance, LNG terminal, hydro-demolition, reinforcement repair, cathodic protection, ecologically sensitive environment

1. Introduction

The South Hook LNG terminal is located at the former Esso Refinery in Milford Haven, South Wales. The location was chosen partly due to the presence of an existing jetty in a natural deepwater harbour, which was used as an oil refinery until its closure in 1983. The jetty was subsequently decommissioned in 1990. To enable the importation of LNG at the jetty and to maximise the benefit of the existing deepwater mooring, the access trestle was refurbished and two new state of the art berths were constructed.

2. Environmental Constraints

The existing jetty structure is within a special area of conservation incorporating several sites of special scientific interest, which is a highly protected categorisation falling under European law. Directly under the jetty approach trestle is an area of red maerl coral, the only known bed in Wales. This is a form of calcified seaweed that takes thousands of years to grow. Concern for this and the general ecology of the area by both the client and the permitting authorities led to the decision to re-use as much of the old approach structure as possible. A major refurbishment scheme was thus required for this section of the works.

3. Survey and Proposed Rehabilitation Strategy

The existing trestle structure showed evidence of deterioration, primarily due to corrosion of reinforcement steel. This corrosion had resulted in areas of cracking, spalling and delamination of

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the concrete. At the FEED (pre-contract) stage, a condition survey was undertaken to identify the cause of the deterioration, determine the extent of the problem. The survey was based on a thorough visual inspection complemented with following tests: half-cell potential survey, resistivity survey, extraction of dust samples for chloride ion analysis, carbonation depth and cover meter survey. The visual inspection of the deck slabs of the access trestle showed that the concrete was in poor condition, particularly the soffit of the western longitudinal edge beam and the waffle slab beams, which were cracked or spalled over the majority of the length of the approach. It was therefore decided that the deck elements would be replaced. The crossbeams showed many instances of cracked, spalled and delaminated concrete. These were generally located at their soffits and at the bottom of the hexagonal columns. The proposed refurbishment strategy for these elements consisted of the removal of damaged concrete and replacement with a proprietary repair concrete, complemented with the installation of an impressed current cathodic protection system. The hollow prestressed concrete piles that support the approachway were found to be in very good condition. In order to guarantee the required 30 year service life, however, a water anode cathodic protection system was provided to protect the piles along their submerged length.

4. Refurbishment

The refurbishment of the bents was undertaken over two stages, the first of which focussed on the repair of the damaged concrete. The concrete elements were firstly inspected and areas of corroded reinforcement were identified. Hydro-demolition was used to remove areas of spalled concrete exposing corroded reinforcement, thus allowing the extent of reinforcement corrosion to be assessed. Necessary repair and strengthening strategies were developed by the site engineers with the assistance of the designers, with the selection of strategy being based on the extent of reinforcement corrosion and the type of reinforcing steel that was found in the concrete. Additional reinforcement was added to the concrete and was either welded to the existing reinforcement, was anchored with a chemical compound or was anchored using a conventional lap length, the choice of which was dependant on the working space available at the section under consideration. The designers devised typical details of where any additional longitudinal reinforcing bars and shear links were to be placed in the section and these were used to guide the site team in the appropriate placement of the reinforcement, with any necessary modifications adopted in order to ensure compatibility with the existing reinforcement that was found in each appropriate location. The first stage of the repair was completed by the application of shotcrete (sprayed concrete) to restore the crossheads to their original shape.

The second stage of the refurbishment consisted of the placement of a cathodic protection (CP) system. An atmospheric CP system was provided above mid-tide level, which consisted of a titanium mesh that was attached to the external face of the repaired concrete in the crosshead. This mesh was then overlaid with 25mm of sprayed concrete. A submerged CP system was provided below mid-tide level, which consisted of a water anode fixed to the pile.

The existing deck was replaced with new deck elements in the form of a composite slab with a steel truss sub-frame. This option was chosen as there would be no increase in weight when compared with the original roadway, but the new roadway would be capable of resisting the larger live loads that were required. The new deck was designed so that it had the same thickness as the existing deck and thus permitted use of existing bent crossheads without any modifications. The deck elements were prepared on land and placed on the crossheads upon completion of the refurbishment of the bents.

5. Conclusions

The refurbishment of the original approach trestle to the level of a modern “state of the art” approach way that it is capable of resisting the applied forces that are required from the use of the structure as part of an LNG terminal for an additional design life of 30 years was successfully completed with negligible impact on the environment. This was achieved by carefully selecting the best refurbishment strategy, based on an extensive survey campaign, and by developing appropriate construction strategies.