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# Welding assessment of a damaged crane pedestal of a container ship

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**Abstract**

A structural integrity assessment of a damaged crane pedestal/column of a container ship is presented. Crane cabins and pedestal/columns are subjected to fatigue coupled with sudden overloads during cargo operations and corrosion effects due to sea environment. Significant number of surface cracks was detected around the pedestal/column, at inner and outside of the crane foundation, close to the main weld seam and, in consequence, the ship-owner ordered a survey. The main weld seam and the sites where cracks were found are evaluated in the present study. For the purpose, the sample material (hot rolled steel plate and upper ring) of the pedestal was provided by the shipyard and macro and micrographics were observed. Results did not show any cracks, although they have been found by the NDT technical services of the shipyard which have decided to remove them by the grinding process. The weld seam did not also show relevant defects, whereby the replacing of the pedestal/column by a new one would not had been necessary. Regardless of some occasional overloads, the surface cracks found on the pedestal/column could be a consequence of the normal operation conditions of the crane during the last 5 years and also due to poor maintenance.


*Keywords*: structural failure survey, weld macrostructures, structural integrity, pedestal/column of container ship.

## 1. Introduction

Container ships have cranes to handle loads in ports. They include the supporting structure and their foundations. The pedestal/column are subjected to sudden loadings as result of the crane operating coupled with corrosion effects due to sea environment which can cause damages in the structural integrity. Ships are exposed to a range of corrosion environments and, as result, the patterns of corrosion can vary widely. Corrosion and corrosion-related problems have been considered to be the most important factors which lead to age-related structural degradation of ships and their equipment. Corrosion can lead to thickness decrease, fatigue cracks, brittle fracture and also unstable failure. Literature reviews [1-4] have identified the main corrosion mechanisms that can be found in ship structures as well as the main environmental factors that affect them. In the practice to monitor the growth of corrosion during the ships lifetime is to obtain thickness measurements at regular inspections for maintenance and classifications according to the requirements of International Association of Classification Societies (IACS) [5]. The design of steel ships typically incorporates a corrosion allowance, i.e. an amount of corrosion loss that can be tolerated before the structural system is considered compromised [6]. Repairing and replacement of structural details may be necessary, incurring very considerable cost penalties due to direct repair and delay costs.

Residual stresses play also an important role in the performance materials, parts and structural elements. The effect in the engineering properties of materials such as fatigue and fracture, corrosion resistance and dimensional stability can be considerable, whereby should be taken into account during design, fatigue assessment and manufacturing [7]. This study was carried out on a container ship (five years old), where the cabin crane No.1 (fore crane ship) presented some structural deformation combined with corrosion effects. Fig. 1 shows a general view of the container ship and the handling equipment (3 cranes, 45 ton each one).

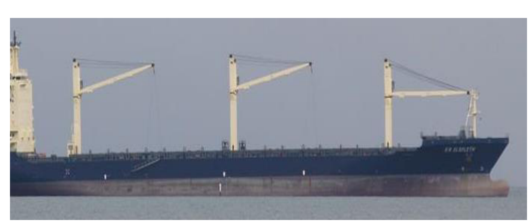

Fig. 1 Container ship with the 3 cranes and its pedestals.

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When the ship was at shipyard to replace the damaged crane cabin, NDT tests were performed in the crane foundation (pedestal/column) by ultrasonic and magnetic particles close to the main weld seam between the flange and the crane pedestal/column. Twenty surface cracks were detected by a dye check inspection around the pedestal, at inner and at outside the pedestal, being the extension and depths evaluated. However, the size of cracks found was considered acceptable by the shipyard and therefore was decided to remove them by grinding of the material on the affected areas. The NDT report delivered by shipyard to the ship-owner considered that the foundation could have been eventually affected by sudden overloads under cargo operation which could have caused some local deformation on the pedestal/column. In the following the Class Surveyor also recommended the replacing of crane pedestal. Taking into account the shipyard report, the Manufacturer Technical Services and ship-to-shore (STS) Competence Cranes have also concluded that the foundation was affected by the found cracks and therefore could have caused changes in the material structure. The grinding of the cracks could have not been successful and therefore strongly recommended the replacing of pedestal/column by a new one.

Then the manufacturer has sent a new pedestal/column, but this one came with a new design and a thicker steel plate. The costs of this replacing could be attributed to the Ship Insurance or Protection and Indemnity (P&I) if the damage was a consequence of a sudden overloading by negligence of the crane operators. Hence the ship-owner ordered a damage analysis report to a scientific laboratory for determining damage's cause.

The aim of this research work is to evaluate if the damage of pedestal/column was mandatory for the replacing by a new one, and also if the damage (cracks found) of the pedestal/column was a consequence of sudden overloads or not. In the following sections, the material characterization is presented firstly, and then both laboratory examination and results are presented and discussed.

## 2. Material and procedures

### *2.1 Chemical composition and mechanical properties*

The pedestal/column is a hot rolled steel plate, see Fig. 2 (a) and (b). The material of flange (upper ring, iii) is steel S355NL (27 joules/-40 ºC) (a), and the hot rolled steel plate is the S355N (27 joules/-20 ºC), as can be seen in the sketch, Fig. 2 (b). The flange cross-section is 112 mm x 84 mm, and the hot rolled steel plate is 25 mm thickness.

Table 1 shows the chemical compositions in weight percent [%] and Table 2 shows the mechanical properties of the flange and hot rolled plate steel presented by the manufacturer.

Anisotropic properties of rolled steel plates are related to pancake inclusions in the rolling direction, residual stress and mechanical fibering [8]. The S355N is a type of high strength and low-alloyed normalized steel, which is widely used at ship structures, being the weldability the more important parameter at the soundness of construction.

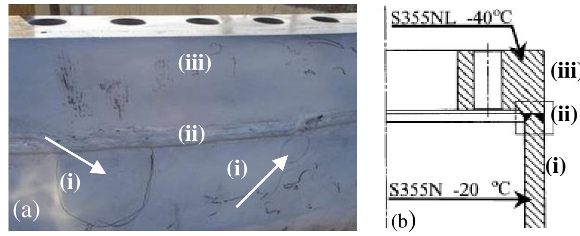


Fig. 2. (a) Crane base pedestal/column surface where cracks were localized (i); (b) column sketch with the upper ring (iii), shell plate (i) and the weld seam (ii).

Table 1. Chemical composition (W %).

| Grade | C | Si | Mn | P | S | N |
|---|---|---|---|---|---|---|
| S355N | 0.20 | 0.5 | 0.9-1.65 | 0.03 | 0.02 | 0.015 |
| S355NL | 0.18 | 0.5 | 0.9-1.65 | 0.02 | 0.02 | 0.015 |
| **Grade** | **Al** | **Cu** | **Ni** | **V** | **$C_E$** | |
| S355N | 0.02 | 0.55 | 0.50 | 0.12 | 0.43 | |
| S355NL | 0.02 | 0.55 | 0.50 | 0.12 | 0.43 | |

Table 2. Mechanical properties.

| Grade | min. yield strength MPa | tensile strength MPa | min. total elongation [%] $L_O = 5.65 \sqrt{S_O}$ |
|---|---|---|---|
| S355N | 355-345 | 345 | 470-630 |
| S355NL | 355-345 | 345 | 470-630 |

According to the shipyard report, surface cracks were found at inside and outside of the hot rolled steel plate (25 mm thickness), close to the main weld seam, as is shown in Fig. 2 (a) (i), and some ones also appeared on the welding seam. Most of cracks were found to starboard of the crane. The cracks size ranged between 50 mm and 100 mm long and between 1 mm and 5 mm deep. Cracks were detected by NDT, i.e. magnetic particles and ultra-sounds test. As the cracks size were considered acceptable by the shipyard, the technical services for ship repairs removed them by grinding of the material as it is shown in Fig. 3 (a) and (b) indicated with white arrows.

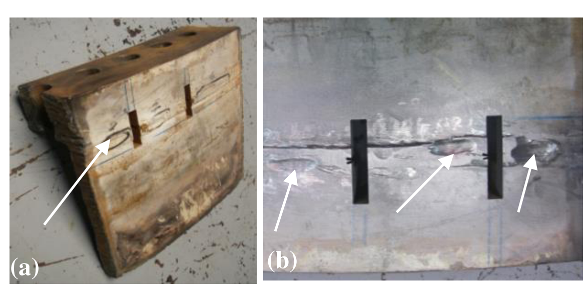


Fig. 3. (a) Flange and (b) hot rolled steel plate, with two holes from where the samples were cut.