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Design and Finite Element Analysis of Fabricated Panama chock with 225T capacity

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Abstract:- *Panama chocks are used specifically for the guidance of rope mooring/towing lines on board a large ship or vessel. Intended for heavy duty use, the chocks are generally manufactured from high quality cast steel in various grades dependent upon the particular application and loadings required. Panama Chocks can be either, or alternatively can come supplied with a base plate to be welded to a plinth.*

Chocks are used in heavy duty shipping applications and are essentially deck fittings which act as a guide to feed a line in a particular direction to boost efficiency and protect the rope from undue wear and tear due to a significant reduction in abrasion. This in turn will prolong the operational life of the rope in use.

They normally form part of a standard mooring/towing setup which set in between a mooring bollard and ship bitts on the deck. Hence the importance of Panama chocks plays a vital role in various rigs or vessels. Cast from high quality steel, the Panama chock is normally painted or galvanized to protect it from harsh weather conditions and the effects of salt corrosion. The supply condition of these particular units means that they can be installed on deck more or less immediately.

This design of panama chock proves that the chocks not only available as molded pieces but also can be fabricated in the workshops using large pipe bends and plates. The safe working load of the panama chock is 225 MT (496 kips). The size and shape of the panama chock are determined in such a way that the rope can be accessible through the chock to the tugger within the range of angles required by tugger and chock dimension match to a standard cast chock. Finite Element Analysis is carried out using Ansys 12.0.

Keywords—Bulwark mounted, cast steel, Mooring bollard, Panama chock, ship bits and Tugger.

1. INTRODUCTION

The Panama chocks are generally installed on the vessel to guide the chain/rope mooring lines when the vessel to be moved from the yard to field and vice versa. The rope is tied from the tugger to smit bracket which is welded on the deck with a base plate. To guide the rope and limit the range of direction, these panama chocks are introduced between the smit brackets and the tugger.

a) Towing Arrangement

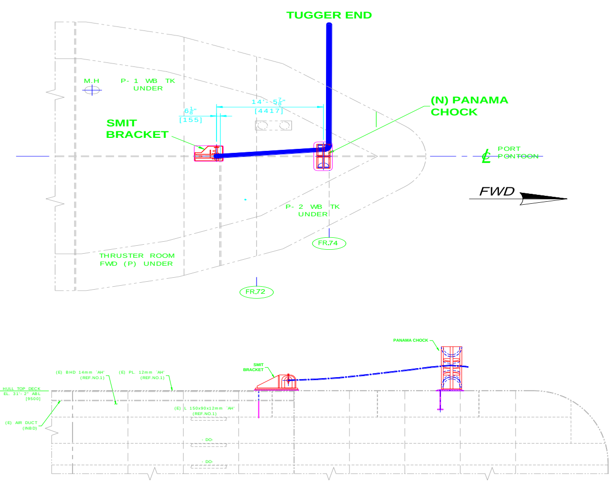


Figure 1: Towing arrangement of a typical Pontoon

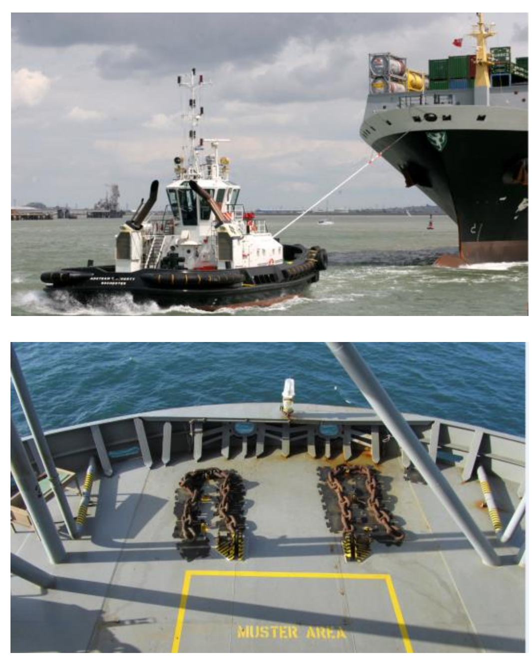


Figure-2: Typical arrangement of bulwark mounted chocks

Figure 3: Typical arrangement of deck mounted chock

2. METHODOLOGY

This paper presents the design of 225 MT (496 kips) Panama chock which can be fabricated in the workshops using large pipe bends and plates, rather than going for a cast chock and can be installed on the vessel with similar requirement. A 22" diameter Schedule 160 pipe is cut into two pieces to form a 'C' shape. These two 'C' shape half cut pipes are joined together to form a panama chock shape and the chain access requirements as

Figure 4: Typical Cast chock

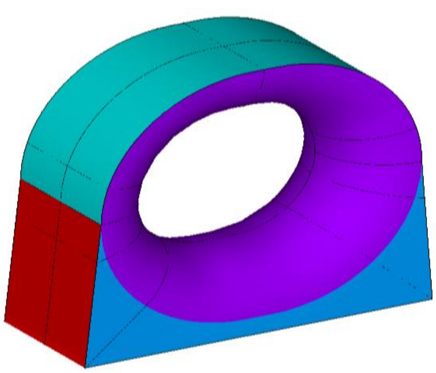


Figure 5: Designed fabricated chock

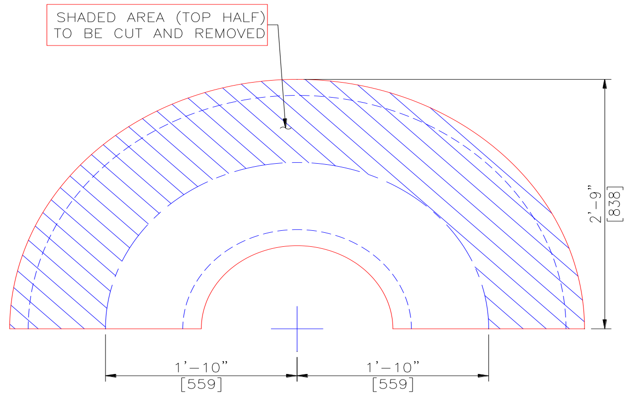


Figure 6: 22" DIA 180° Return SCH-160 pipe

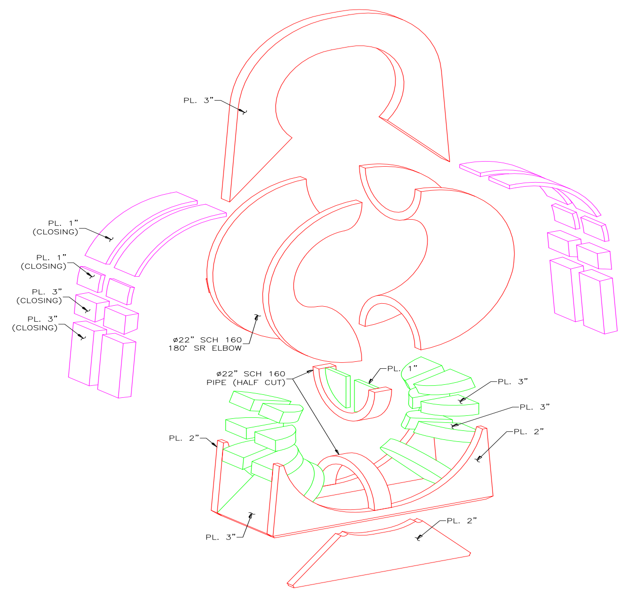


Figure 7: Parts of Fabricated panama chock

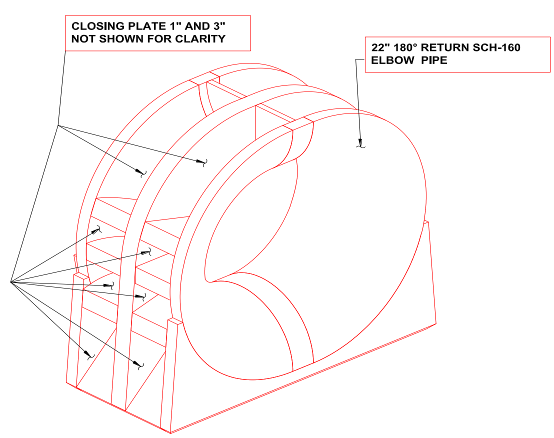


Figure 8: Overall view of fabricated panama chock

3. FINITE ELEMENT MODELING

3.1 FE model

The finite element model of the Panama chock is modeled in Ansys 12.0. Mid plane surface of the Panama chock is modeled using 4-noded quadrilateral shell elements (Element type: Shell 63). The finite element model plot of the panama chock is shown below.

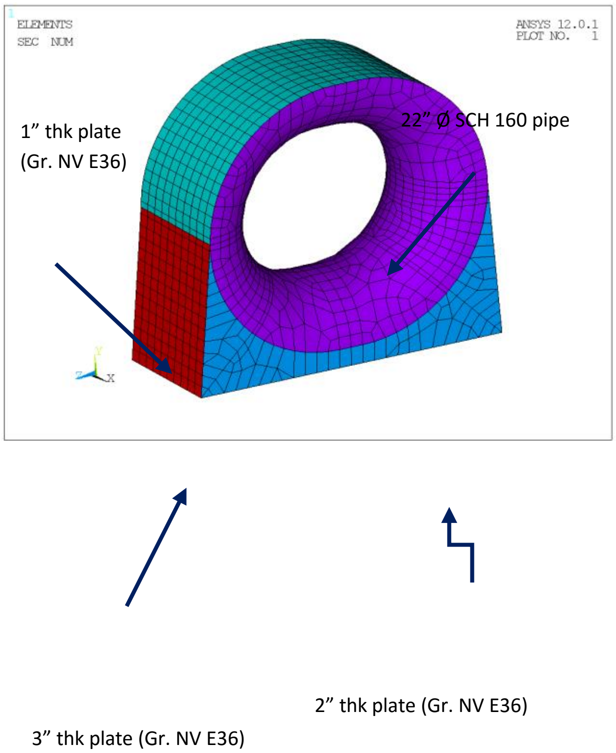
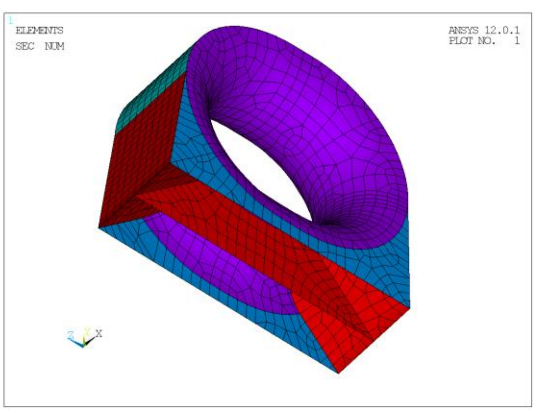


Figure 9: FE Model - Fabricated panama chock



View from bottom

Figure 9: FE Model - Fabricated panama chock

3.2 Material properties

The material used for the fabricated chock structure is as follows:

i. **For 22" dia SCH 160 pipe:**

Material – API 5L X52

Density – 490 lbs/ft^3

Yield strength, f_y – 52 ksi (358 MPa)

Ultimate tensile strength, fu – 66 ksi (455 MPa)

Young's Modulus – 30457.9 ksi (210 GPa)

Poison's ratio – 0.3

ii. **For other plates:**

Material – NV E36

Density – 490 lbs/ft^3

Yield strength, f_y – 51 ksi (355 MPa)

Ultimate tensile strength, fu – 67 ksi (460 MPa)

Young's Modulus – 30457.9 ksi (210 GPa)

Poison's ratio – 0.3

3.3 Boundary conditions

The Panama chock was constrained in all directions at the bottom part of the chock as shown in the figure below.

However, the center plate was not constrained as it will not be welded to the existing deck.

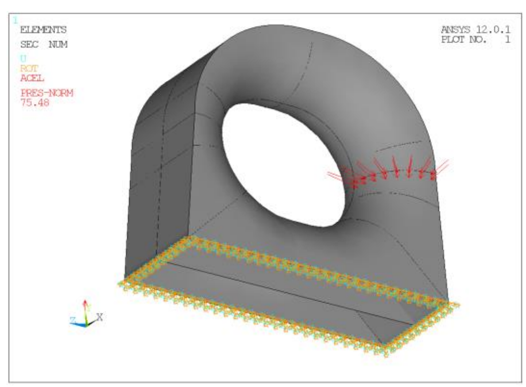


Figure 10: Boundary condition - Fabricated panama chock

4. LOADING CONDITIONS

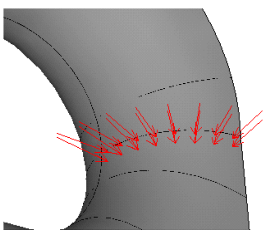
Safe working load (SWL) of the panama chock is 225 MT (496.04 kips).

As per DNV-OS-E301, chapter-2 and section-4, the towing fastening devices, including fairleads and their supporting structures shall be designed for a load equal to the minimum breaking strength of the weakest link in the unit's towing bridle and/or towing pennants. The breaking strength of the unit's towing bridle and/or towing pennant shall not be less than 3 times the towing load.

Therefore, design factor considered = 3.0

Design load of the Panama chock = 225×3 = 675 MT (1488.12 kips).

This load will be applied as pressure load on the contact area of the rope/sling/chain with the chock as shown in the figure below.



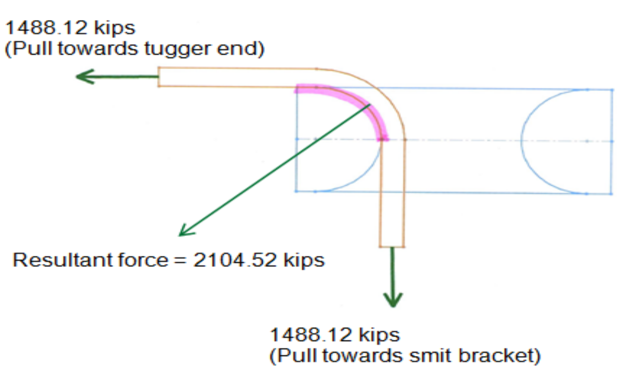
i. Calculation of contact pressure on the chock:

SWL of chock = 496.04 kips

Design factor = 3.0

Design load on the panama chock = 3.0×496.04 = 1488.12 kips

As the pull force will be in both the directions, the resultant force due to pull forces is considered.



Resultant force = 2104.52 kips

Arc length of the contact = 13.94 in

Assumed width of the contact area = 2 in

Contact area of the rope/sling = 13.94×2 = 27.88 in²

Pressure applied on the panama chock in resultant direction, P = 2104.52/27.88 = 75.48 ksi.

ii. Allowable criteria:

As per DNV-OS-E301 Chapter-2, Section-4, P306, the nominal equivalent stress, σ_e, in the towing devices and their supporting structures shall not exceed 0.9 σ_f and 0.8 σ_f respectively.

Where σ_e = von-Mises stress (Equivalent stress) and σ_f = Yield stress of the material.

5. FE RESULTS

The static finite element analysis is carried out for the Panama chock for the design along with the self-weight of the structure.

Maximum deflection observed in the Panama chock is 0.07" which is well below the allowable limit (L/120). Refer figure 11.

The maximum von0Mises stress on the panama chock is found to be 49.22 ksi (Localized stress on only one element due to boundary condition and can be ignored) whereas allowable stress is 46.8 ksi. Refer figure 12 & 13.

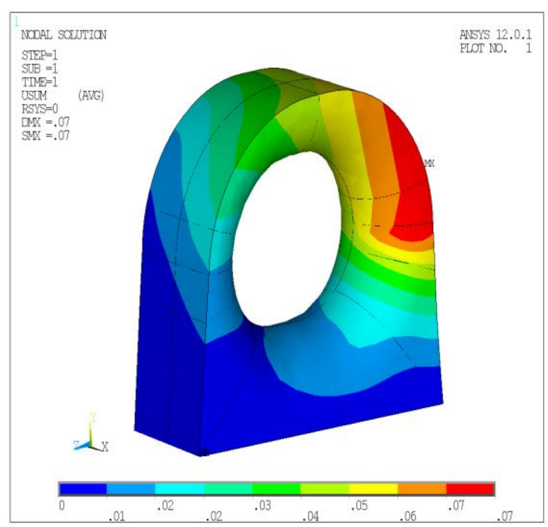


Figure 11: Total deformation plot (inches)

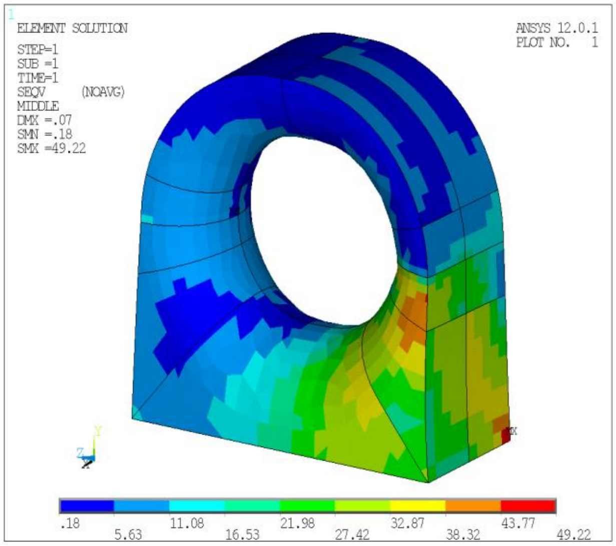


Figure 12: von-Mises stress distribution plot (ksi)

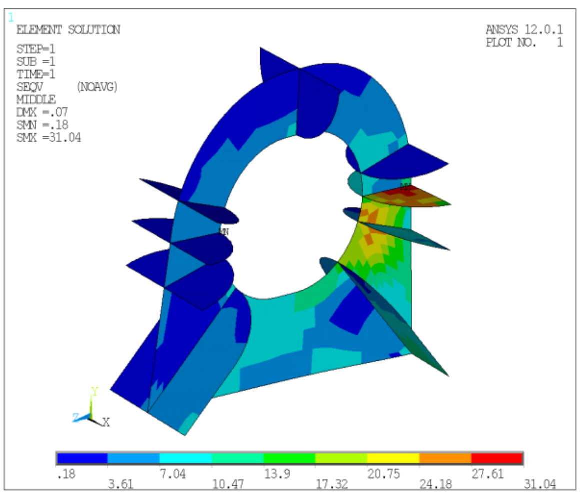


Figure 13: von-Mises stress distribution plot for internal members (ksi)

6. CONCLUSIONS

The strength assessment of the fabricated panama chock was assessed in the present report for the safe working load of 225 T.

From the above design and results, it can be concluded that the emergency towing chocks can be either readily available as a molded piece or can be fabricated using the readily available material in the workshop.

As the obtained stress results are within the allowable limits, the fabricated panama chock can be considered safe for the given safe working load.

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[1] Det Norske Veritas (Norway) – Offshore standard DNV-OS-E301-Position Mooring, 2010.

BIOGRAPHY

K V V Satyanarayana was born in Visakhapatnam. The author earned B.Tech in Mechanical Engineering from Jawaharlal Nehru Technological University and perusing M.Tech from Andhra University, Andhra Pradesh. He worked one year in Keppel FELS offshore services Pvt Limited, Mumbai. He has been working for CYIENT Limited, Visakhapatnam since May 2007. His Current position is Project Leader and is working for Design and analysis of Structural components of drilling rigs.