**Yildiz Technical University,**
**Faculty of Naval Architecture and Maritime**

# [Homework-2]

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## Abstract

In the course of this extensive research, a meticulous analysis has been undertaken to ascertain the cutting and bending stresses encountered by 200 stations constituting a 120-meter-long ship. The study is intricately designed to address not only the challenges associated with launching the ship into the water but also potential injury scenarios that may arise during maritime navigation.

By calculating shear forces and bending stresses, the research endeavors to yield valuable insights into the vessel's overall performance and resilience. This comprehensive examination accentuates the critical importance of assessing stress distributions, particularly in the intricate context of deploying large ships into the open sea and navigating through varied and challenging maritime conditions. The findings from this study are anticipated to contribute significantly to enhancing our understanding of the structural integrity required for ensuring the safety and durability of marine structures, especially those of considerable size and complexity.

**Keywords:** Experiment reports, Writing Abstract, Length of abstract, Ship Launching, Ship accident strenght of ship

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## 1. Introduction [

Design or strength calculations through computer assistance can begin with the mathematical definition of the analyzed model. The ability to perform mathematical modeling on a computer depends on the accurate description of the subject, the characteristics of the chosen method, and the desired precision of the results. This can be achieved either by utilizing existing methods or by creating a new method tailored to the specific requirements.

In the conducted studies of this thesis, the subject revolved around the calculation of unknowns such as area, volume, and mass, along with the resulting forces and force-based stresses. Therefore, established and proven methods in these areas were adopted and applied. It should be noted that the model used in this study was not an assumed generic ship; rather, it was a ship under construction during the analysis. The high degree of parallelism in the results with the classification society to which the ship is affiliated, despite the ship not being a default design, supports the validity of the obtained results. While these findings are robust for the considered scenario, it is important to acknowledge that they may not be directly applicable to different types of specialized ships or scenarios with distinct load distributions.
Comparative results, when applicable, have been provided throughout the study.[1]

## 2. The Method of Analyze

Analysis was conducted in the Python programming language, utilizing data obtained from a hydrostatics assignment for half-breadth and ship dimensions. Subsequently, these values were assigned to appropriate variables in the Python language, calculations were performed, and results were obtained.

```
boy = 120
genislik = 24
draft = 8.73
yogunluk = 1.025
D=13.09
Cb=0.61
```

```
offset = np.array([
        [0.0, 0.0, 0.0, 0.0, 0.0, 0.09, 0.324],
        [0.011, 0.055, 0.071, 0.083, 0.114, 0.335, 0.604],
        [0.047, 0.131, 0.173, 0.218, 0.314, 0.581, 0.813],
        [0.203, 0.343, 0.458, 0.573, 0.772, 0.98, 1.094],
        [0.439, 0.632, 0.809, 0.978, 1.089, 1.151, 1.187],
        [0.693, 0.908, 1.085, 1.18, 1.2, 1.2, 1.199],
        [0.856, 1.049, 1.183, 1.2, 1.2, 1.2, 1.2],
        [0.768, 0.993, 1.151, 1.188, 1.193, 1.191, 1.193],
        [0.502, 0.788, 0.986, 1.066, 1.087, 1.101, 1.123],
        [0.211, 0.484, 0.672, 0.751, 0.787, 0.82, 0.863],
        [0.041, 0.194, 0.295, 0.341, 0.357, 0.374, 0.429],
        [0.013, 0.084, 0.135, 0.149, 0.155, 0.165, 0.207],
        [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.024]])*10     # hidro yarı genişlik değerleri
```

**Figure 1**:Ship size and offset values

### 2.1. Calculations and graphs

### 2.1.2. Ship Accident

Firstly, the half breadths and dimensions of the given ship were offset for 200 stations. Subsequently, Bonjean area values were determined for each offset value.(thanks to Figure 1 Rules)

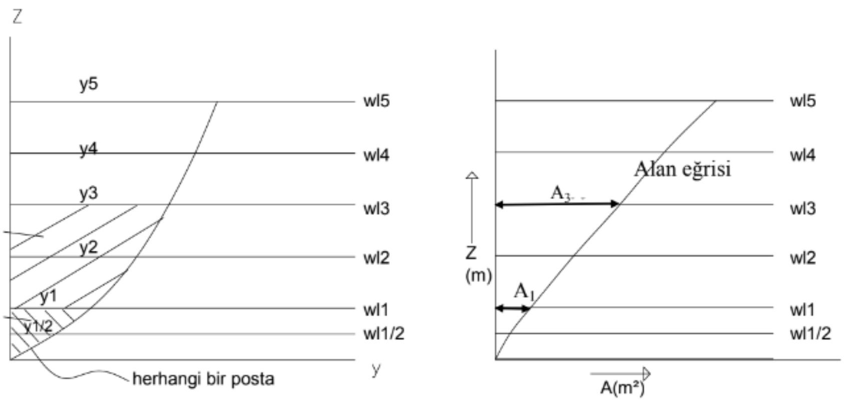


**Figure 2:** Bonjean Curve[2]

The values for 200 posts were calculated individually, and the total values were computed for 6 intervals. The calculations were performed using the 'inter1d' function in Python, which resulted in a smoother transition between the intervals.

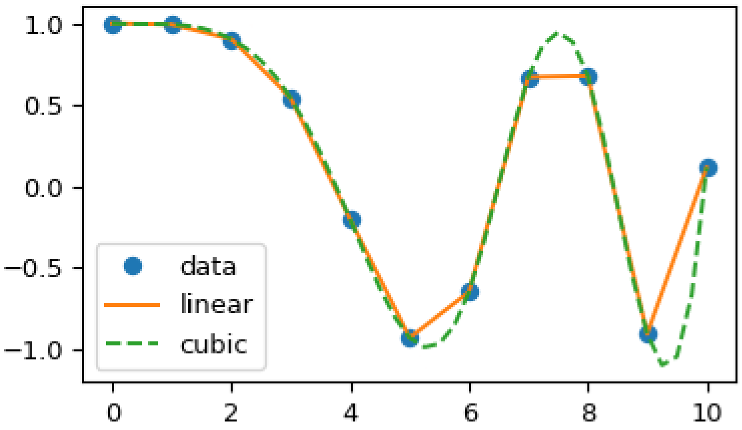


**Figure 3:** Inter1d Example[3]

Then, bonjean area values were calculated in all water lines in all calculated offset values. (Python Code [26-34]. After calculating the area values, the buoyancy was found by multiplying the density with the area value in the ship's bathing water line (WL4) for calm water.The ship displacement was calculated by integrating the buoyant force found along the post with the np.trapz.(Figure 4)

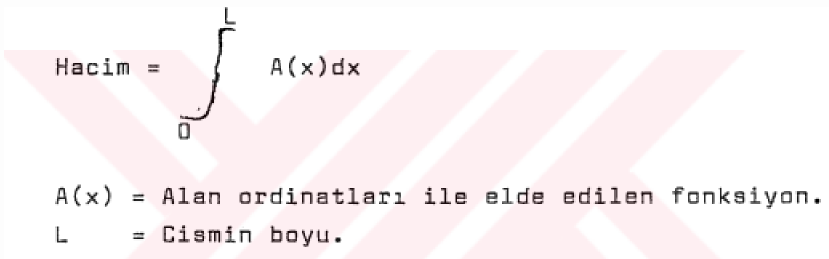


**Figure 4:** Calculation Ship Displacement[4]

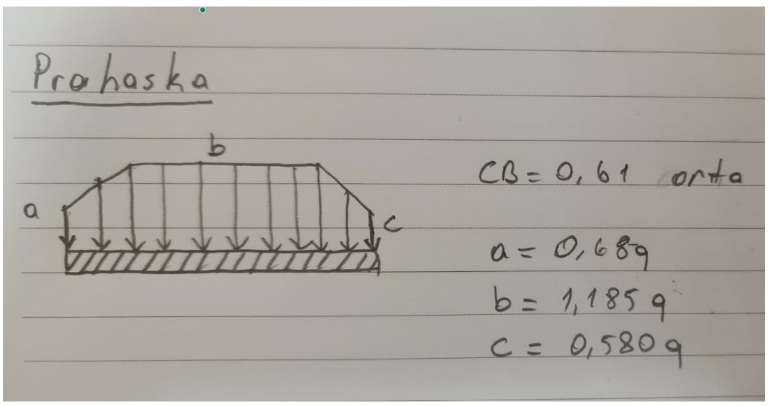


**Figure 5:** Prohaska

After calculating the prohaska, the LCG and LCB values of the ship were calculated. The formulas used in the calculation are given below.

$$LCB = \frac{\int_0^{L_{WL}} xA(x)dx}{\int_0^{L_{WL}} A(x)dx} \qquad \boxed{LCG} = \frac{\int_0^{L_{WL}} \boxed{\mathbf{x.q(x).\,dx}}}{\int_0^{L_{WL}} \boxed{\mathbf{q(x).dx}}}$$

**Figure 6:** LCG,LCB Calculation[5]

**Figure 7:** Accident State [6]

In the case of the accident, LCG-LCB equality was made by taking the area value at the points specified as below as 0. LCG and LCB were then calculated. And the fields of 85-135 mails were considered 0.

```
alan[:, 5][85:130] = np.zeros(45)
ax = alan[:, 5] * rho
qx=prohaskaDagilimi(boy,deplasman_new)
LCG = np.sum(qx * posta) / np.sum(qx)
LCB = np.sum(alan[:, 5] * posta) / np.sum(alan[:, 5])
print(LCG)
print(LCB)
```

```
59.211919327413625
59.39081790407912
```

**Figure 8:** LCG,LCB Accident

By calculating the net force after all the equations are done. Calculations were made for both cases using cumulative trapezoidal.

```
def hesap_su(name,ax,qx,posta):
    px = ax-qx
    if name == "accident" :
            dpx0 = np.array([0, *cumtrapz(px,posta)])
            dpx = dpx0 - dpx0[-1] * posta / boy# LİNEER DÜZELTME (son değer en büyük değerin 0.03 unden küçük)
            ddpx0 = np.array([0, *cumtrapz(dpx,posta)]) # LİNEER DÜZELTME (son değer en büyük değerin 0.06 sından küçük)
            ddpx = ddpx0 - ddpx0[-1] * posta / boy
            Qx = dpx*boy/200
            Mx = ddpx*(boy/200)**2
    elif name =='launching':
        dpx = np.array([0, *cumtrapz(px,  posta)])
        dppx = np.array([0, *cumtrapz(dpx,  posta)])
        Qx = dpx*boy/200
        Mx = dppx*(boy/200)**2
    return Qx,Mx
```

**Figure 9:** Calculation Net Force And Mx,Qx

The calculated Qx value for the injured state is shown in the graph below.

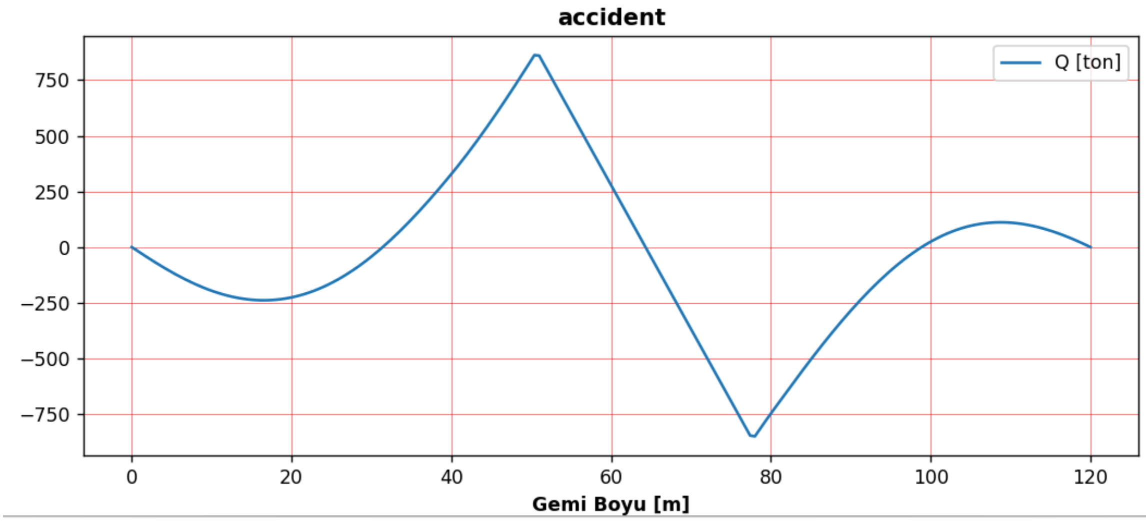


**Figure 9:** Qx Value for Accident

The calculated Mx value for the injured state is shown in the graph below.

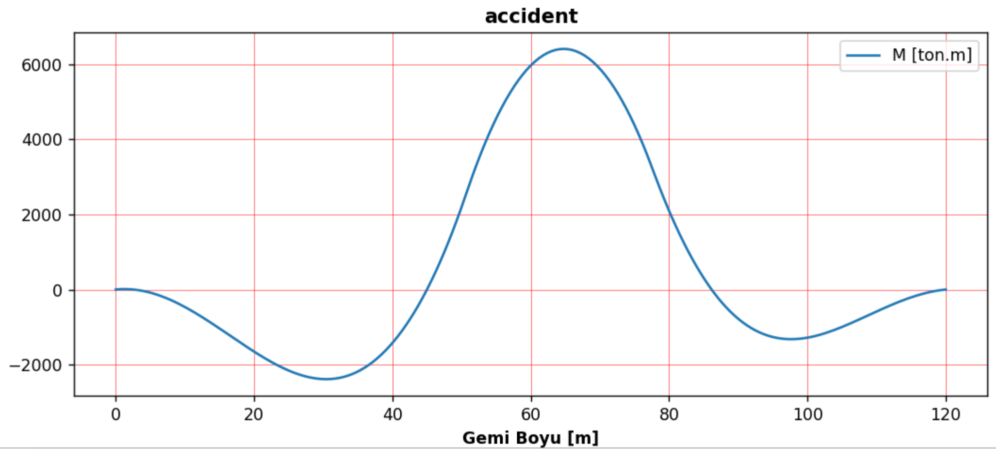

**Figure 10:** Mx Value for Accident

The moment of inertia was calculated as follows, but the stress values were calculated by taking 15% less for the accident state.

$$\text{Between } 0 \text{ and } \frac{L}{20} \rightarrow I(x)=5\times I_{\Phi}\times\frac{x}{L}$$

$$\text{Between } \frac{L}{20} \text{ and } 7\frac{L}{20} \rightarrow I(x)=0{,}25\times I_{\Phi}+\frac{15\times I_{\Phi}}{6L}\left(x-\frac{L}{20}\right)$$

$$\text{Between } 7\frac{L}{20} \text{ and } \frac{15L}{20} \rightarrow I(x)=I_{\Phi}$$

$$\text{Between } 15\frac{L}{20} \text{ and } 19\frac{L}{20} \rightarrow I(x)=I_{\Phi}-2{,}5\frac{I_{\Phi}}{L}\left(x-\frac{15L}{20}\right)$$

$$\text{Between } \frac{19L}{20} \text{ and } \rightarrow I(x)=0{,}5\times I_{\Phi}-\frac{10\times I_{\Phi}}{L}\left(x-\frac{19L}{20}\right)$$

**2.1** The section modulus related to deck and bottom is not to be less than the following minimum value:

$$W_{min} = k \cdot c_o \cdot \mathbf{L}^2 \cdot \mathbf{B} \cdot (C_B + 0{,}7) \cdot c_{RS} \cdot 10^{-6} \quad [m^3]$$

$c_{RS}$ = service range coefficient

= 1,0 for unlimited service range

= 0,95 for restricted service area **RSA (200)**

= 0,85 for restricted service area **RSA (50)**

= 0,80 for restricted service area **RSA (20)**

= 0,75 for restricted service area **RSA (SW)**

$c_0$ = according to Section 4, A.2.2 for unlimited service range ($c_{RW}$ = 1,0)

$$I_y = 3 \cdot 10^{-2} \cdot W \cdot \frac{\mathbf{L}}{k} \quad [m^4]$$

W = see 1. and/or 2.1, the greater value is to be taken

$c_0$ = wave coefficient

$$= \left[\frac{\mathbf{L}}{25} + 4{,}1\right] c_{RW} \quad \text{for } \mathbf{L} < 90 \text{ m}$$

$$= \left[10{,}75 - \left(\frac{300 - \mathbf{L}}{100}\right)^{1{,}5}\right] c_{RW}$$

for $90 \leq \mathbf{L} \leq 300$ m

$$= 10{,}75 \cdot c_{RW} \quad \text{for } \mathbf{L} > 300 \text{ m}$$

**Figure 11:** Moment of Inertia Values[7]

The stress distribution across the entire ship is shown in the graph below. The maximum stress value was calculated as 40 Mpa for the accident condition.

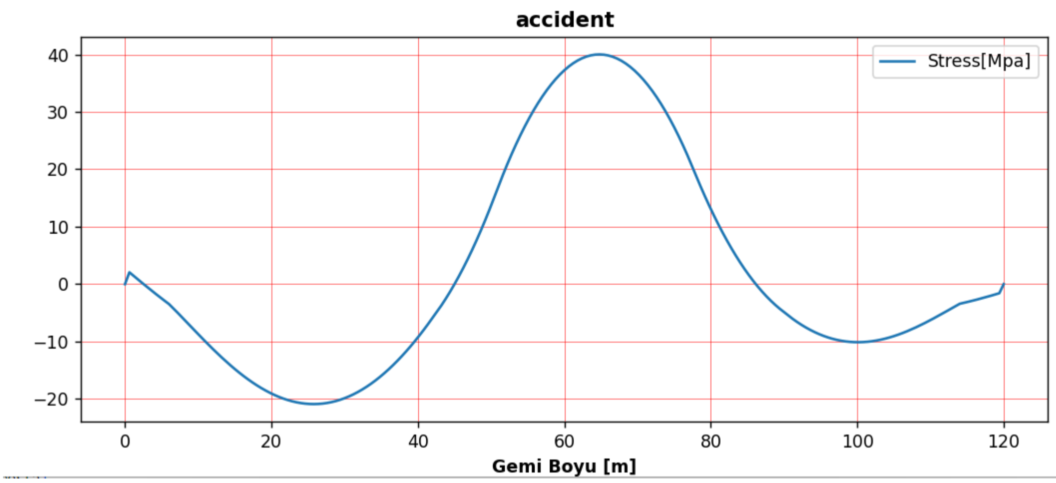

**Figure 12:** Stress Distrubtion

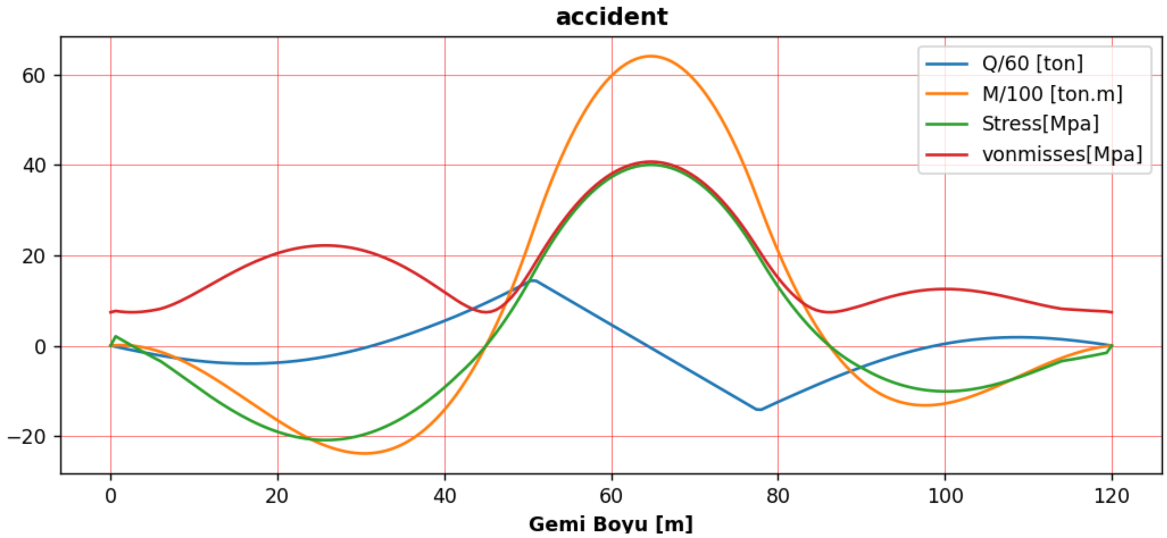


**Figure 12:** All Distrubtion

When choosing the cross-sectional modulus equation, the equation that makes the stress value the largest was taken as a reference. When the cross-sectional modulus was calculated from the formulas above (Figure 11), W = 4.032 was found.Later, the Iy value was calculated and Iy = 1.6128 m^4 was found.

The calculated stress values for accident state are given below.

```
Maksimum Eğilme Gerilmesi = 40.005543809544
```

**Figure 13:** Stress Value

The maximum yield strength value is given as 235 Mpa. It is in the safe zone according to stress values.

### 2.1.2. Ship Launching

Launching is one of the most crucial moments in the construction of a ship. The uncertainty and riskiness of this process depend on the method of launch. The most common approach is to lower the boat from the slipway. There are two different ways of launching based on whether it occurs in the longitudinal or transverse direction: end launching and side launching. Side launching is prevalent in river shipyards due to the limited space and the specific construction of riverboats. For naval shipyards where the available shoreline is limited, and there is ample free space, longitudinal launching is employed. It is essential to identify all potential critical positions that may jeopardize the ship's safety during launching, as the forces exerted on the ship's structure occur during this process.


**Figure 14:** Ship Launching[7]

First of all, the weight of the steel boat was calculated with the following empirical formula and the prohaska distribution was made throughout the entire ship.

$$G = C_s \times N \times \left[1 + \frac{2}{3} \times (C_B - 0.70)\right]$$

$$C_s = (0{,}21 - 0.026 \times \log(N)) \times \left[1 + 0{,}025 \times \left(\frac{L}{D} - 12\right)\right]$$

$$N = LBD$$

G: Steel Hull Weight

**Figure 14:** Steel Hull Weight

Then, LCG calculation was made with the calculated distributed loads. A ksi calculation was made for the LCB account. The area of the ksi values found was found and the LCB calculation was made by calculating the buoyancy. Later, the moments of the LCG and LCB were equalized. In the 168th station, the moments were equalized. Shear force and moments were calculated.

```
M1=(0.9*boy-LCG)*G
print(M1)
egim= 0.044
ksi=np.zeros(201)
Batan_alan=np.zeros(201)
for i in range(169):
    ksi[i]=egim*(168*0.6-posta[i])
    Batan_alan[i]=polinomlar[i](ksi[i])

deplasman_q=Batan_alan*rho  #alanların oluşturduğu deplasman kuvvetleri ton/m
deplasman_new2=np.trapz(deplasman_q,posta)
LCB=np.sum(Batan_alan * posta) / np.sum(Batan_alan)
```

**Figure 15:** LCG-LCB Calculation for Ship Launching

The calculated Qx value for the launching state is shown in the graph below.

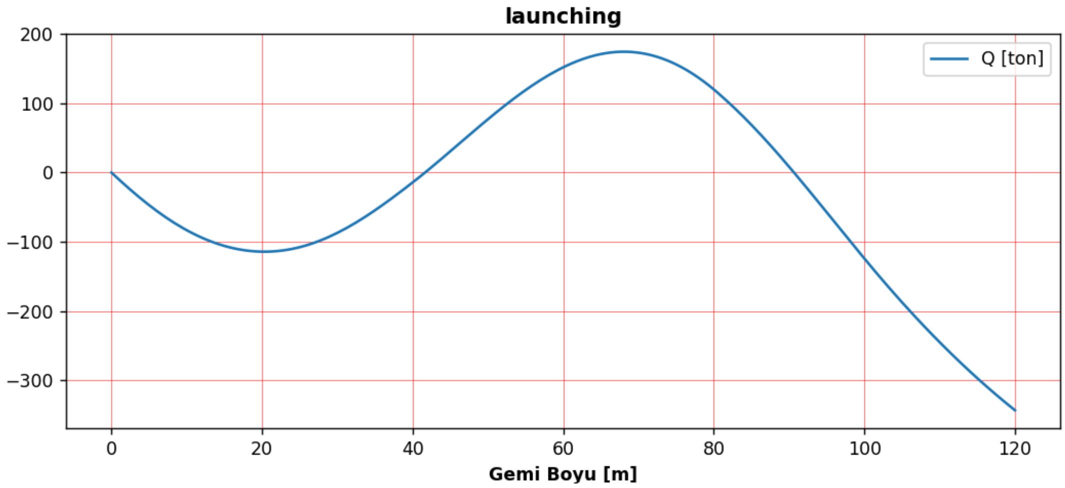


**Figure 16:** Qx Value for Launching

The calculated Mx value for the launching state is shown in the graph below.

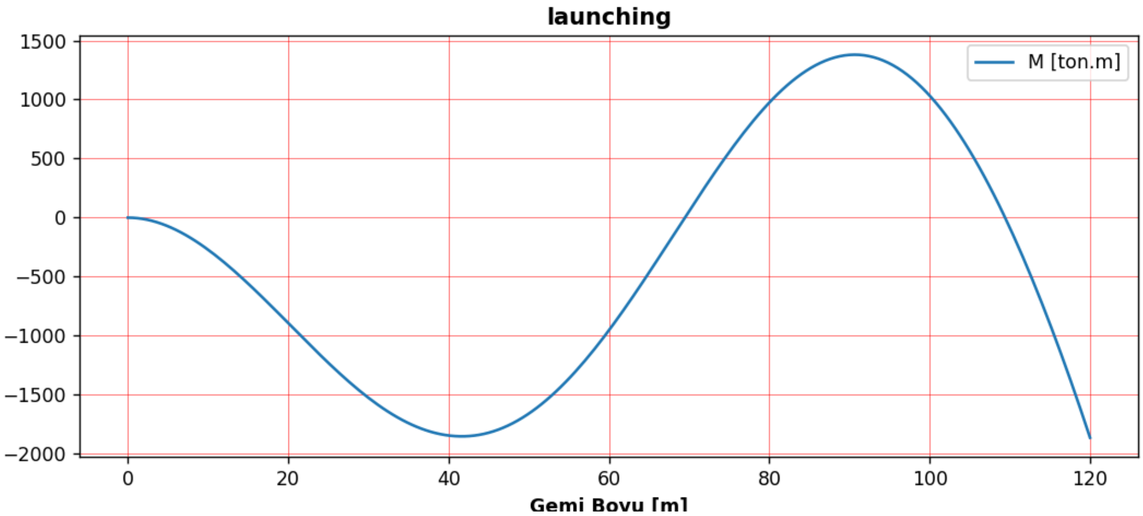


**Figure 17:** Mx Value for Launching

The calculated Qx value for the launching state is shown in the graph below.

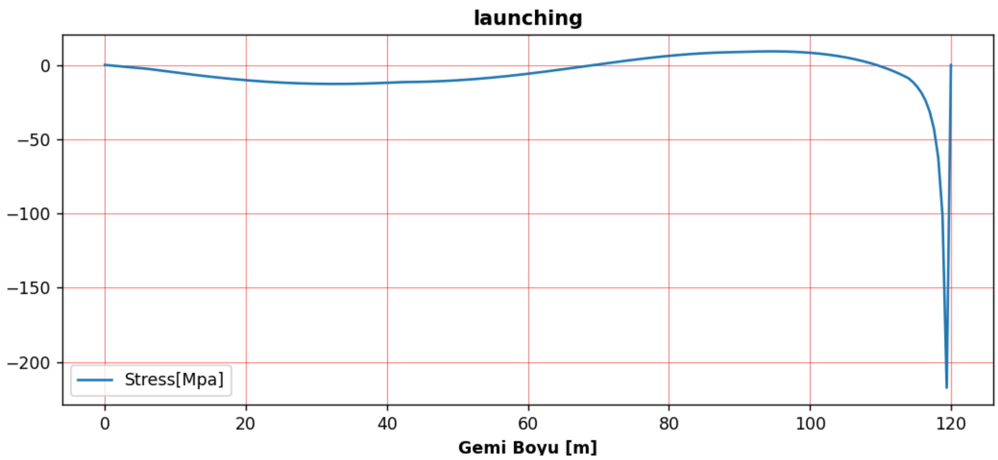


**Figure 18:** Stress Distrubtion

The calculated all values for the launching state is shown in the graph below.

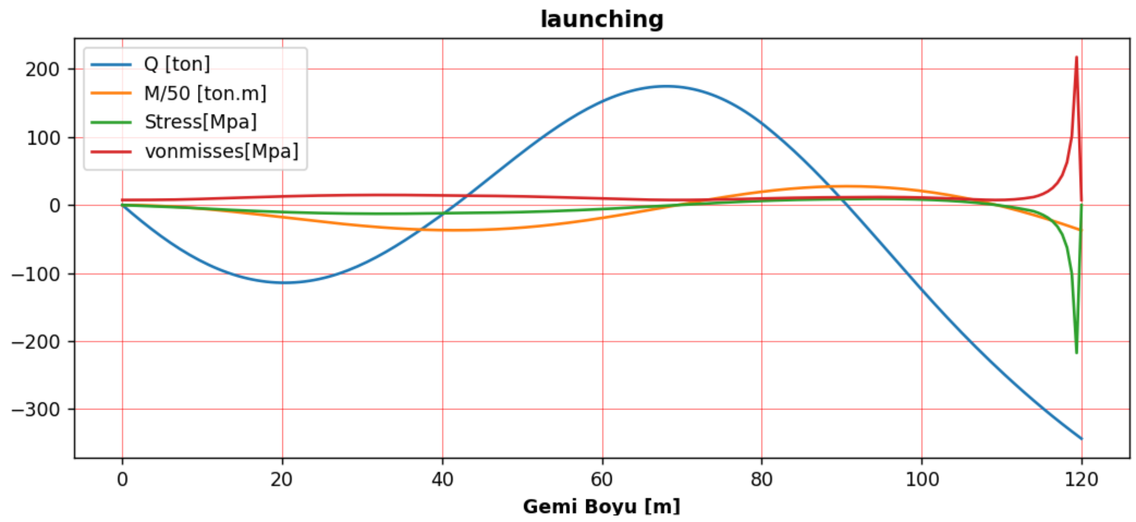


**Figure 19:** All Distrubtion

```
Maksimum Eğilme Gerilmesi = 217.3530867316192
```

### 2.1.3. Finite Element Analysis

#### 2.1.3.1 Create Geomtery

Designed as a square plate, the plate has a side length of 500t. The t value was also found to be L in the root. t=11mm, L=5500mm

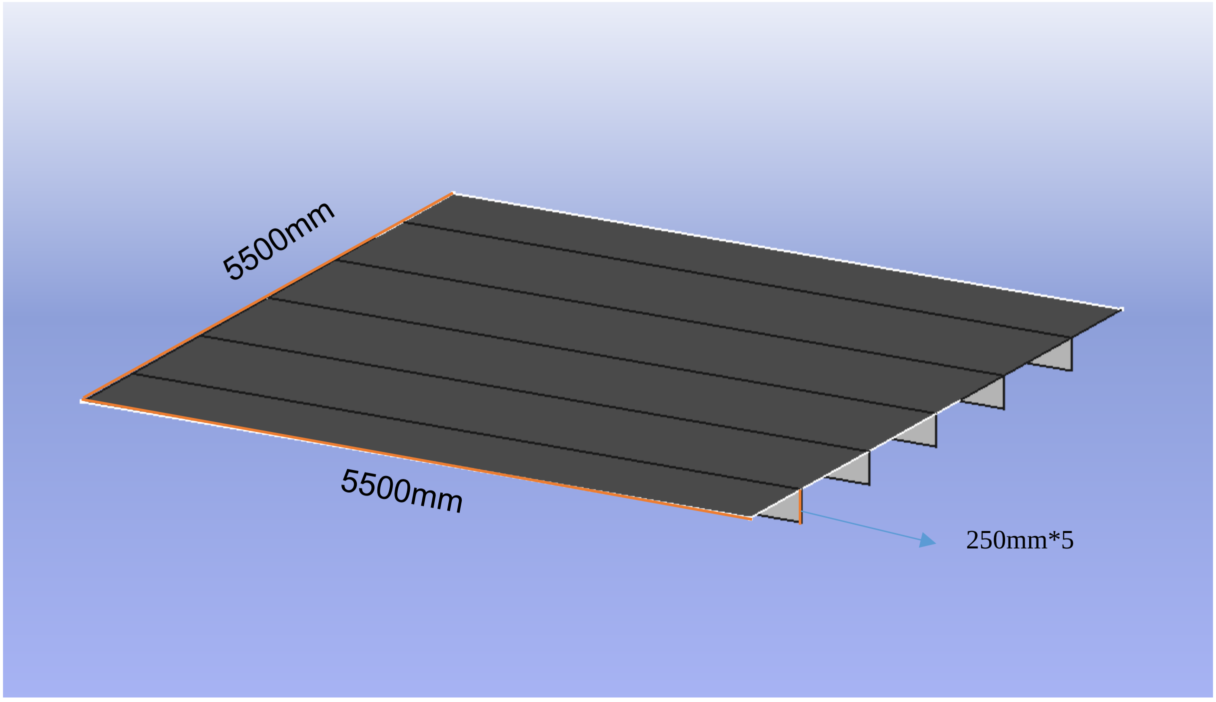


**Figure 20:** Geometry

#### 2.1.3.1 Problem Definition

The maximum stress values in the event of launching and accident were divided by the cross-sectional area and the compressive force was found and defined as the compressive load. The total cross-sectional area was found to be 74250 mm^2.All material ara selected Steel.

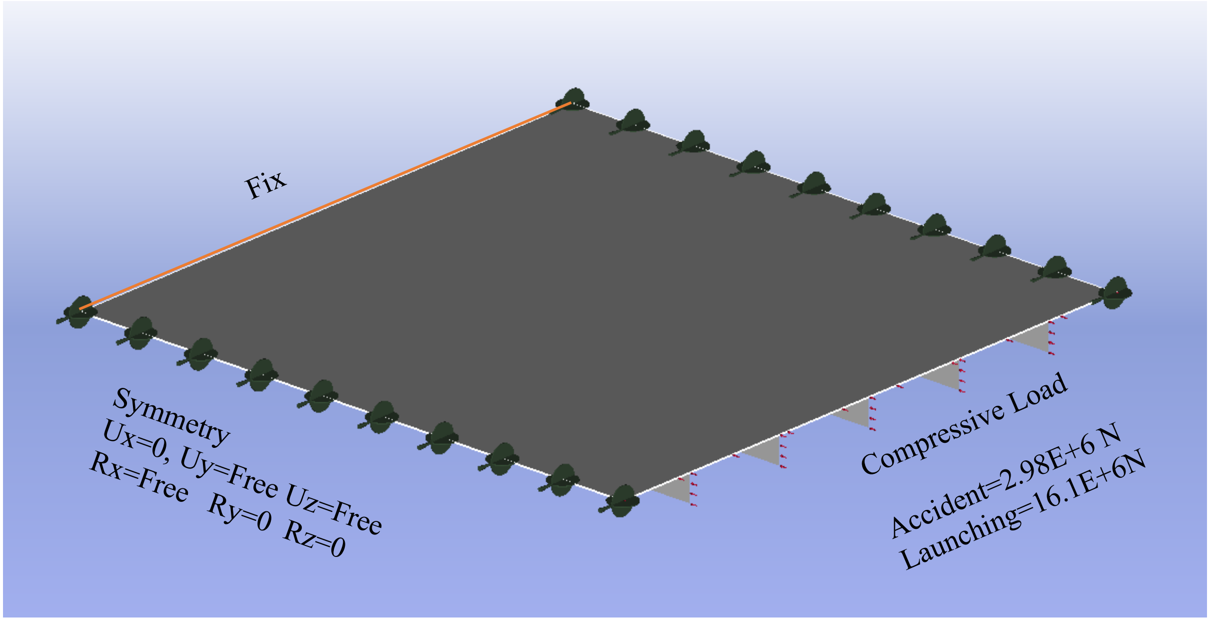


**Figure 21:** Problem Definition

#### 2.1.3.1 Results and Mesh Convergence

Triangular mesh was avoided and quad mesh was discarded. FreeCAD FemByGEN module was used for convergence and mesh values were assigned parameterically. Then the analysis was run and the solution was taken.

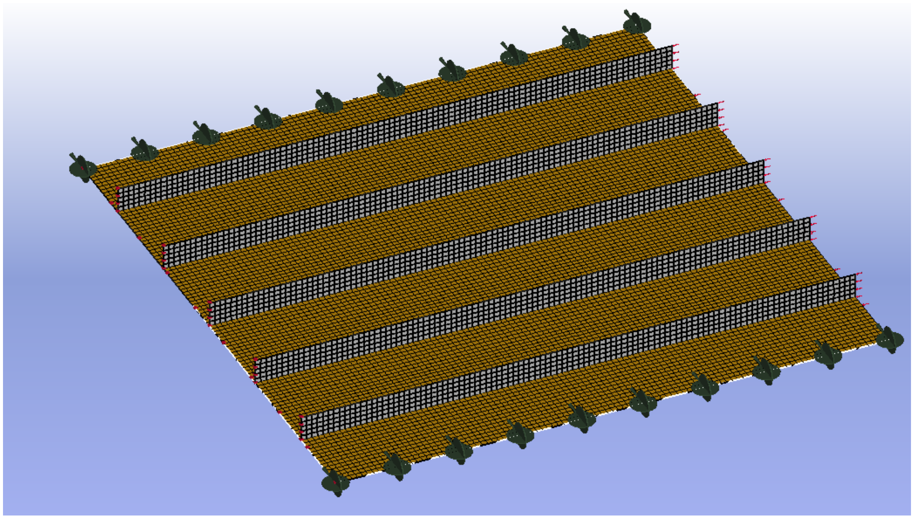

**Figure 22:** Mesh Definition for Accident

Parameterically defined values were generated and Stress and Volume values were found. At the point when the stress values began to converge, the analysis was stopped.

| | | |
|---|---|---|
| 2 | 4.07e+08 | 4.44e+01 |
| 3 | 4.07e+08 | 4.76e+01 |
| 4 | 4.07e+08 | 4.69e+01 |
| 5 | 4.07e+08 | 4.22e+01 |
| 6 | 4.07e+08 | 4.24e+01 |
| 7 | 4.07e+08 | 5.40e+01 |
| 8 | 4.07e+08 | 7.66e+01 |
| 9 | 4.07e+08 | 8.89e+01 |
| 10 | 4.07e+08 | 4.29e+01 |

| Gen | mesh |
|---|---|
| 1 | 30.0 |
| 2 | 54.44444444444444 |
| 3 | 78.88888888888889 |
| 4 | 103.33333333333333 |
| 5 | 127.77777777777777 |
| 6 | 152.22222222222223 |
| 7 | 176.66666666666666 |
| 8 | 201.1111111111111 |
| 9 | 225.55555555555554 |
| 10 | 250.0 |

**Figure 22:** Mesh Convergence for Accident

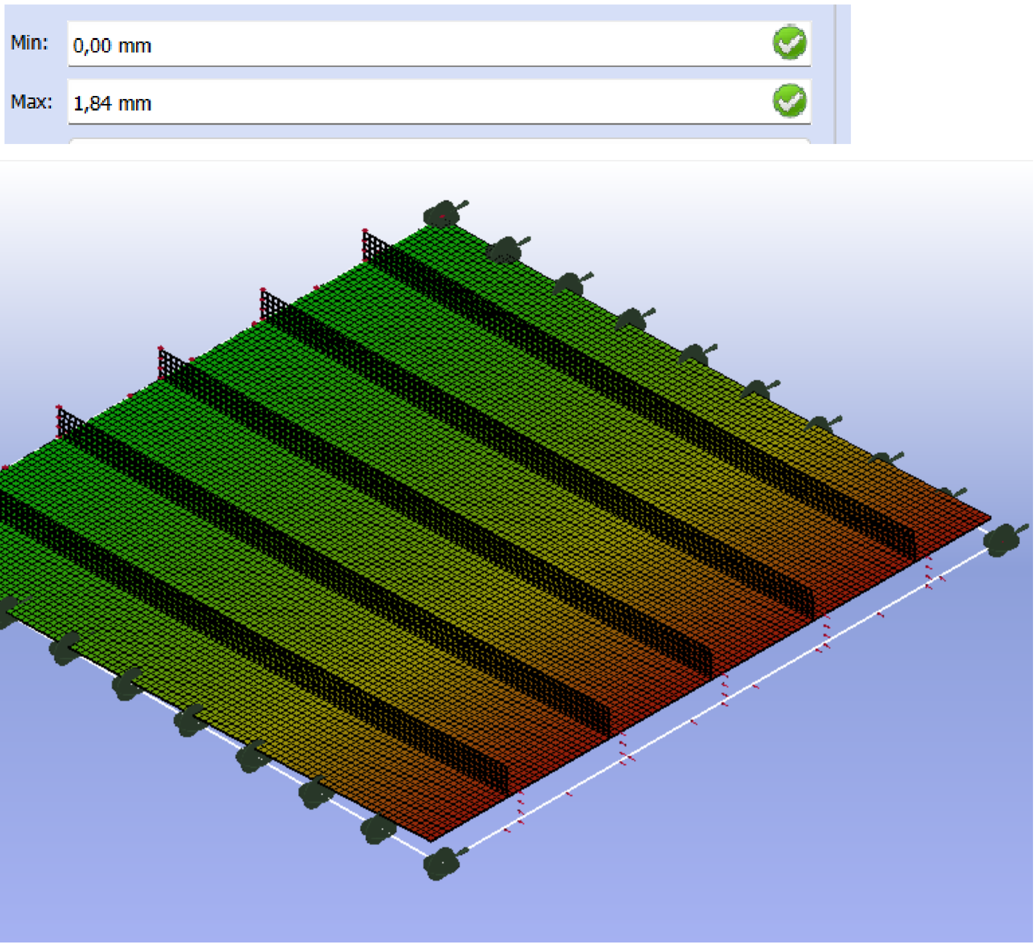


**Figure 23:** Deformation Value for Accident

| | | |
|---|---|---|
| 2 | 4.07e+08 | 2.40e+02 |
| 3 | 4.07e+08 | 2.57e+02 |
| 4 | 4.07e+08 | 2.53e+02 |
| 5 | 4.07e+08 | 2.28e+02 |
| 6 | 4.07e+08 | 2.29e+02 |
| 7 | 4.07e+08 | 2.92e+02 |
| 8 | 4.07e+08 | 4.14e+02 |
| 9 | 4.07e+08 | 4.80e+02 |
| 10 | 4.07e+08 | 2.32e+02 |

| Gen | mesh |
|---|---|
| 1 | 30.0 |
| 2 | 54.44444444444444 |
| 3 | 78.88888888888889 |
| 4 | 103.33333333333333 |
| 5 | 127.77777777777777 |
| 6 | 152.22222222222223 |
| 7 | 176.66666666666666 |
| 8 | 201.11111111111111 |
| 9 | 225.55555555555554 |
| 10 | 250.0 |

**Figure 22:** Mesh Convergence for Launching

| | |
|---|---|
| Min: | 0,00 mm |
| Max: | 9,93 mm |

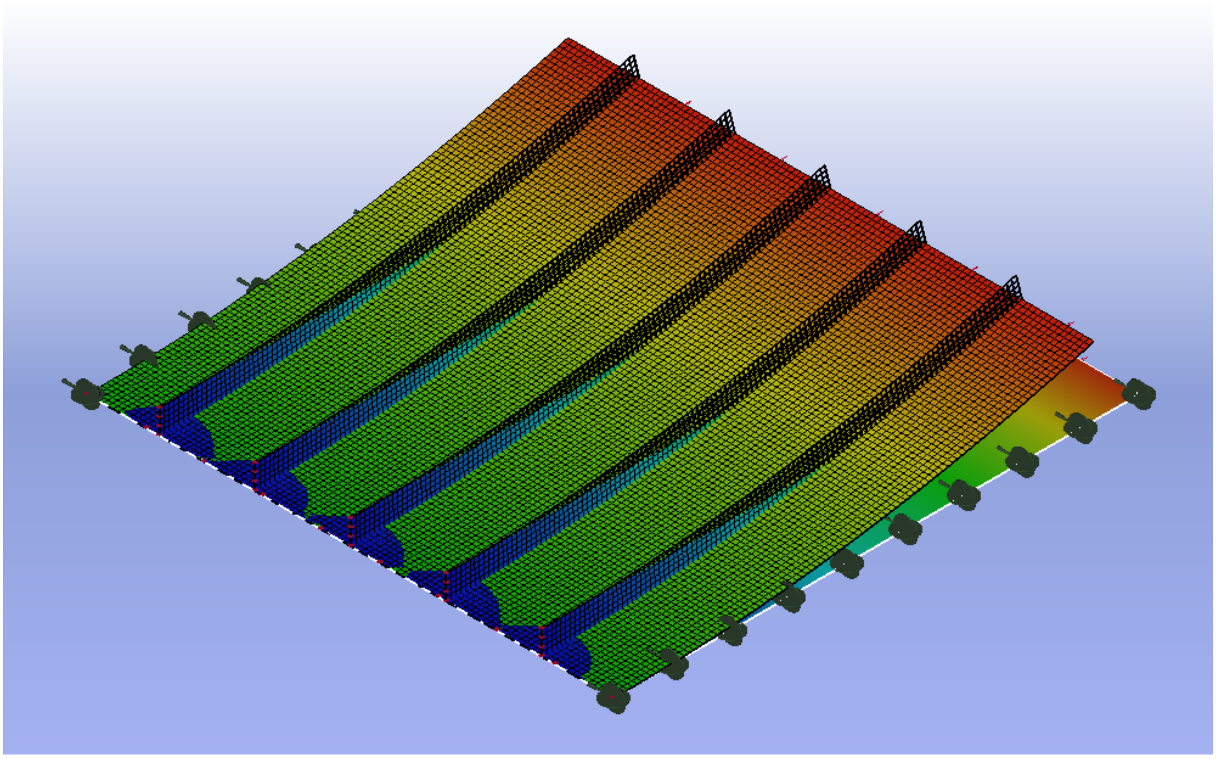

**Figure 25:** Deformation Value for Launching

## 3. Conclusions

All necessary calculations have been made for the moment, shear force and stress values of each post against the loads on the posts of a ship in sea conditions such as accident, launching. Within the framework of all these calculations, the ship was safe in 2 situations. However, since we do not calculate the dynamic fatigue life, it can be misleading to believe in the certainty of the results in these conditions.If we include the dynamic conditions, it may be a more accurate analysis.

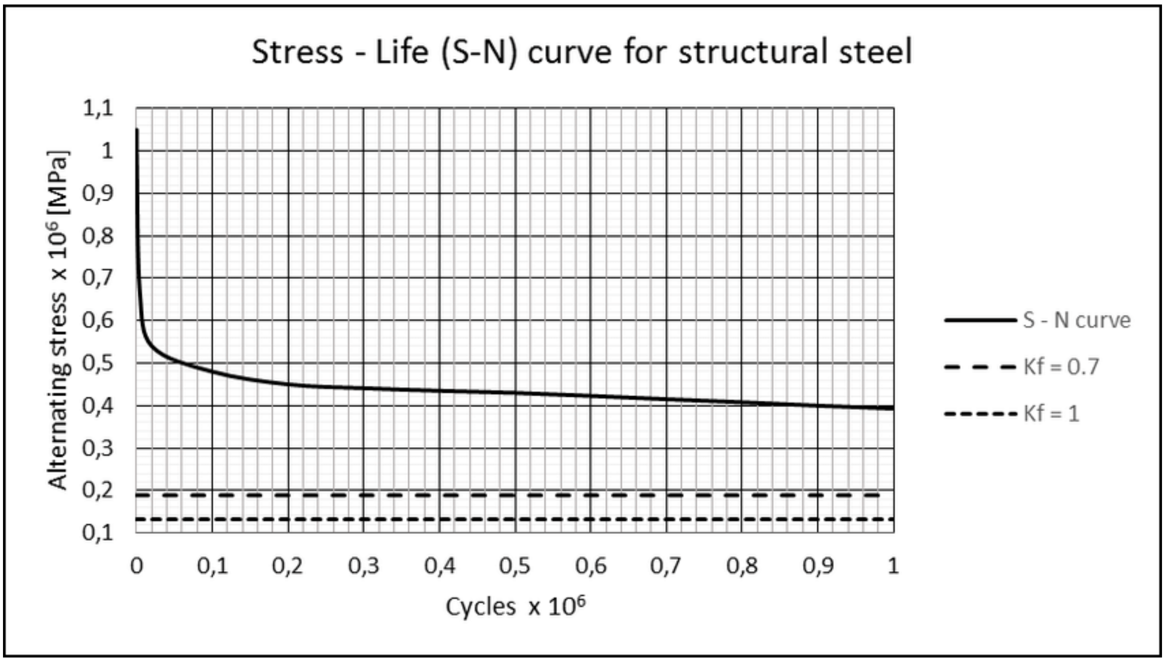


**Figure 26**: S-N Curve for Structral Steel[9]

## References

[1] Longitudinal Strength of Gantry Crane Container Ships [February 1992, Bülent Erdem]

[2] Hidrostatic Curves of ship [Fahri Celik,Avesis]

[3] https://docs.scipy.org/doc/scipy-1.0.0/reference/tutorial/interpolate.html

[4] Longitudinal Strength of Gantry Crane Container Ships [February 1992, Bülent Erdem]

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[7]https://www.google.com/search?q=ship+launching&sca_esv=594777552&tbm=isch&sxsrf=AM9HkKnllK2HQl0auhlOX4_ffRJHseILMg:1704048461706&source=lnms&sa=X&ved=2ahUKEwiisfWZq7qDAxW2VPEDHQZoA-sQ_AUoAXoECAIQAw&biw=1707&bih=811&dpr=1.13#imgrc=cYvWD9ZBETBh9M

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