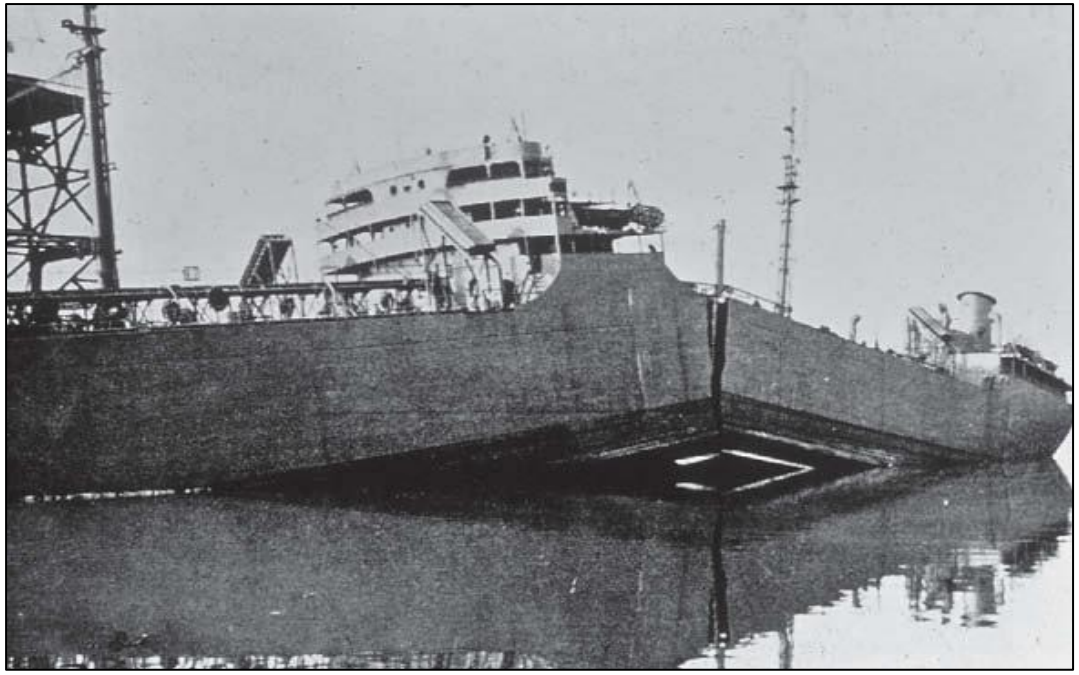
FATIGUE OF SHIPS AND OFFSHORE STRUCTURES

Source: https://www.explorermagazin.de/amstar/amaut_e.htm



Source: https://metallurgyandmaterials.wordpress.com/2015/12/25/liberty-ship-failures/

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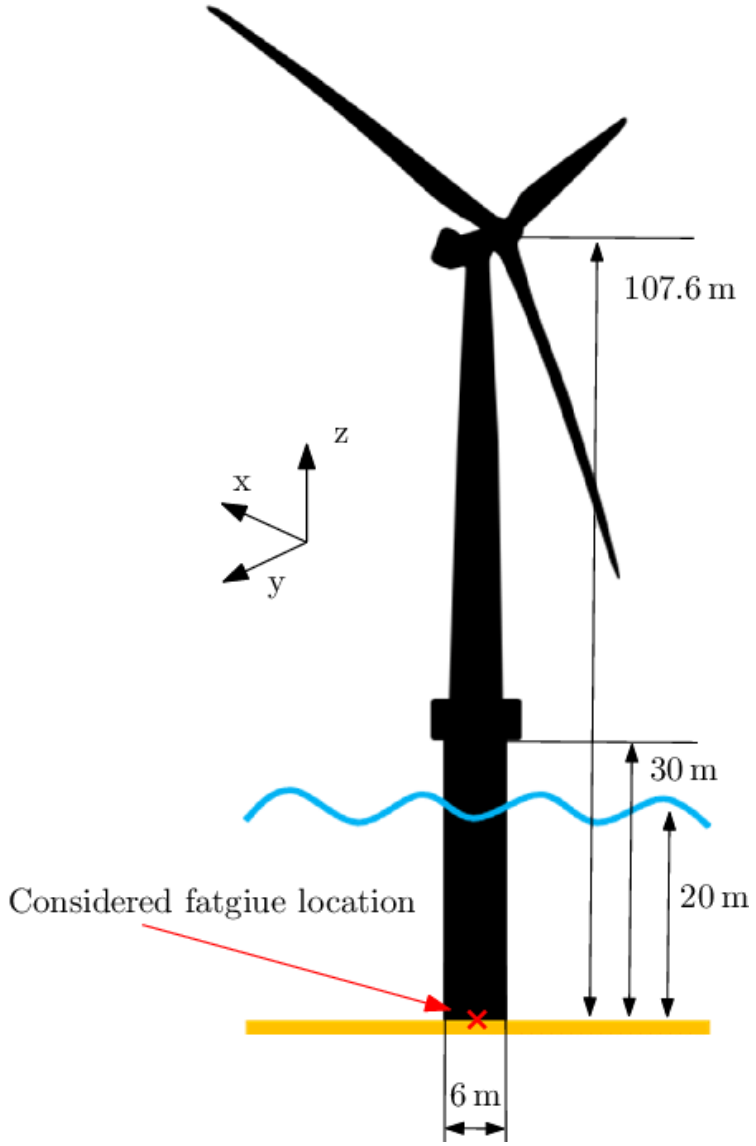


TO DO: Compute the lifetime fatigue damage at the indicated hotspot of NREL 5MW monopile wind turbine.

Geometry of monopile

Outer diameter of monopile = 6 m

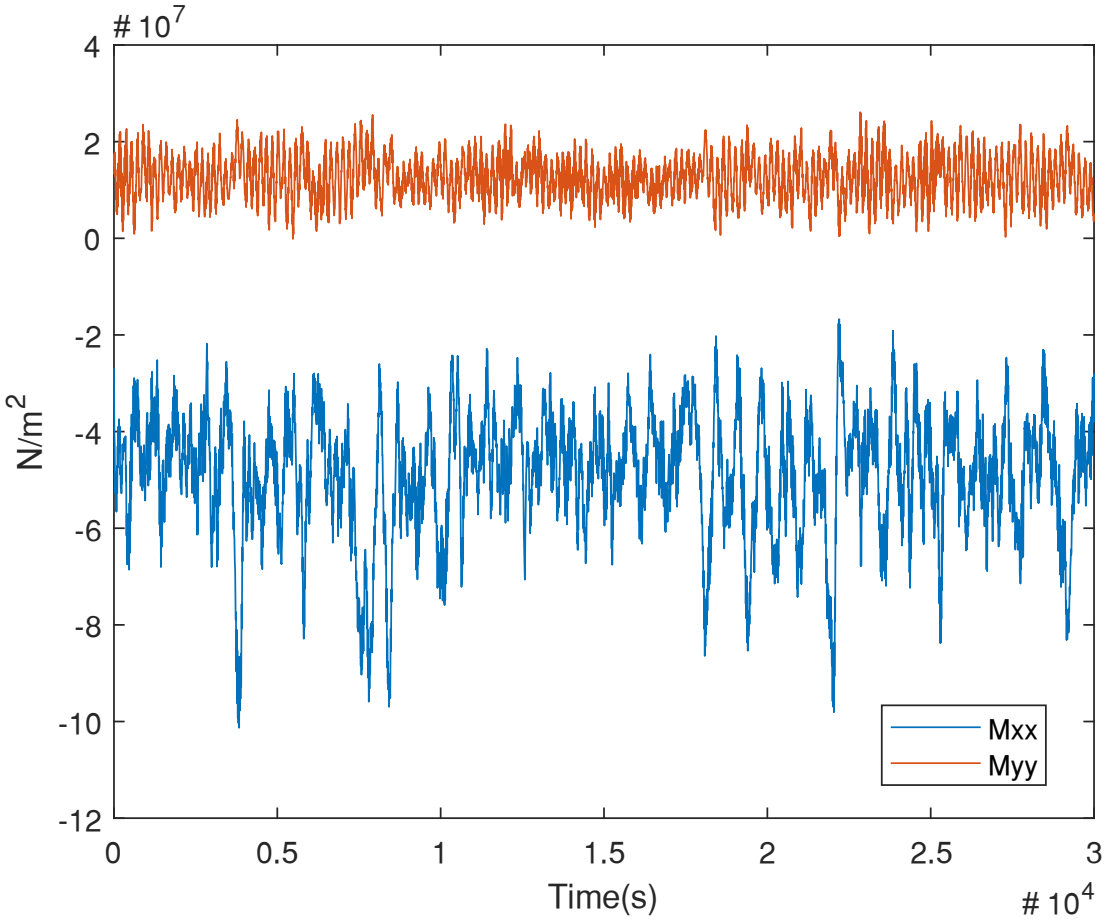
Thickness of monopile = 60 mm

Design lifetime = 20 years

Data given

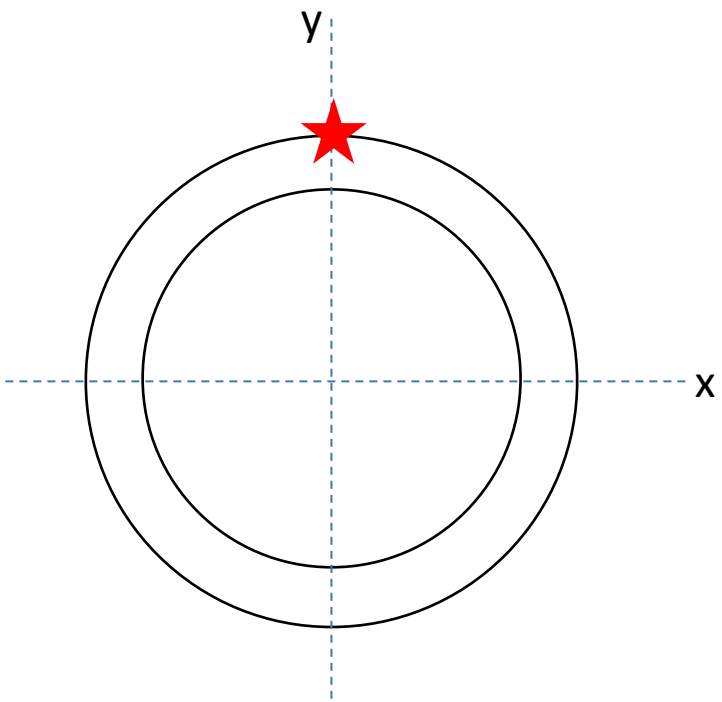
- 100 Simulation files including
  - 10-min recording of reaction force and moments at the mudline (M_{xx}, M_{yy}, F_{zz}) (Units – N, Nm)
  - Sampling frequency is 50 Hz (i.e., 30000 data points for 10 mins)
  - 10-min mean value of environmental and operational conditions (loadcase)

- Probability of occurrence of each 10-min loadcase



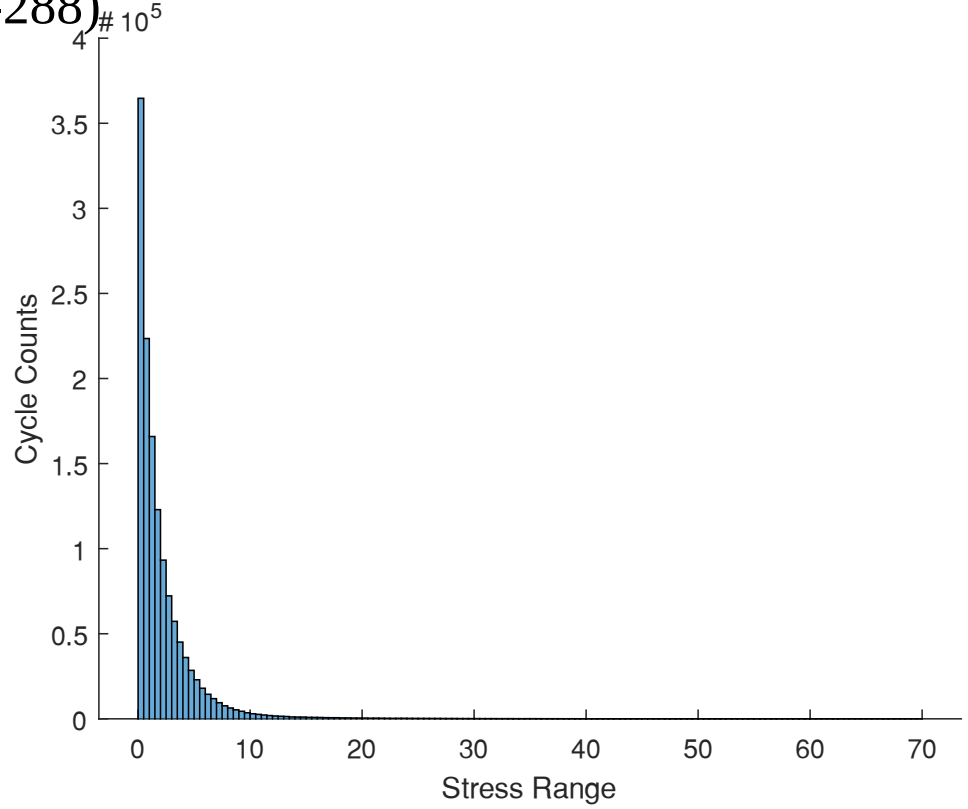
Calculation of nominal stress in time series

$$\sigma = -\frac{M_{xx} * r}{I} - \frac{F_{zz}}{A}$$

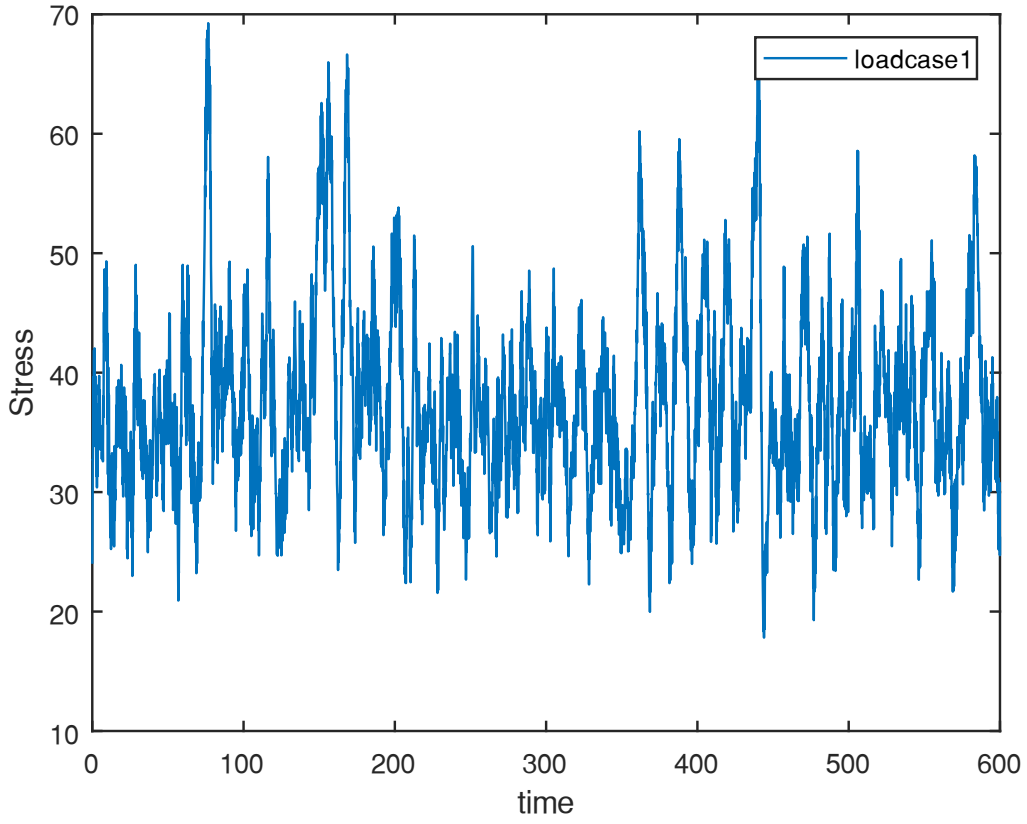


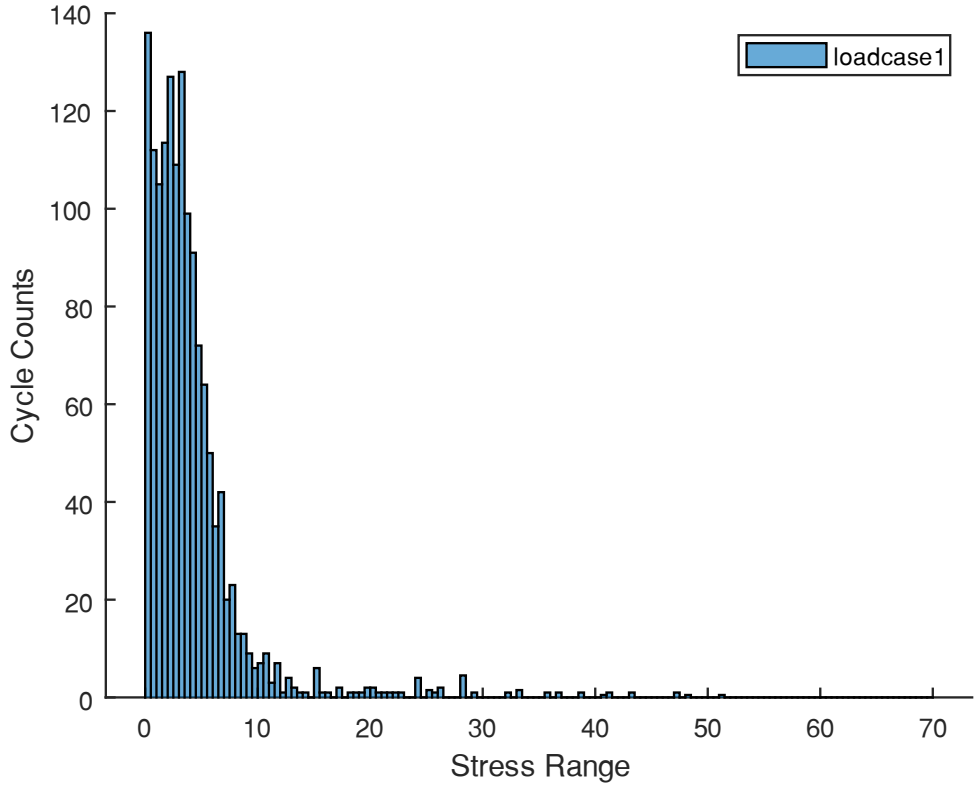
Rainflow Counting

- Given Matlab function: my_rainflow (same syntax as *rainflow*)
- 'Number of edges' and 'binWidth' can be adjusted (line 287-288)



Stress in time series and histogram





Output of rainflow/my_rainflow [C,hist,edges]

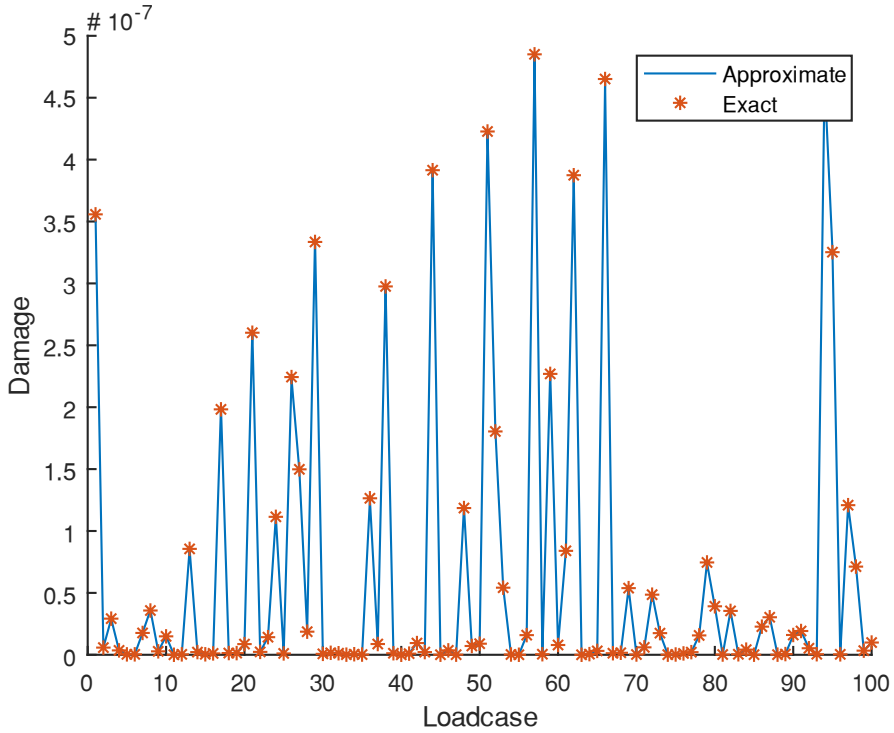
[C,hist,edges] = my_rainflow(**Sigma**,f) or my_rainflow(**Sigma**,**t**)

Table C (Exact)

cycles	range	mean	start	end
1	0.773			
1	0.221			
0.5	3.994			
1	5.676			
1	0.478			
1	2.111			
0.5	4.115			
1	1.162			
1	6.284			
1	4.123			
1	2.179			

Hist, edges (Approximate)

hist	edges
3	0
1	1
2	2
0.5	3
1.5	4
1	5
1	6
	7



Nominal S-N curves for structural detail (Butt weld)

$m1 = 3$

$m2 = 5$

$\log_{10} a_1 = 12.164$

$\log_{10} a_2 = 15.606$

$\Delta\sigma$ (at knuckle point) = 52.63

1. Using the S-N curve provided, calculate the short term 10-min damage for each loadcase.
2. Extrapolate to long term damage for 20 years taking into account the probability of occurrence.