20180226. Offshore structures for hydrocarbon production

TENTATIVE! reference group meeting on 05.03.2018

remember! delivery of ex. set 1 on Blackboard 28.02 kl 23:59.

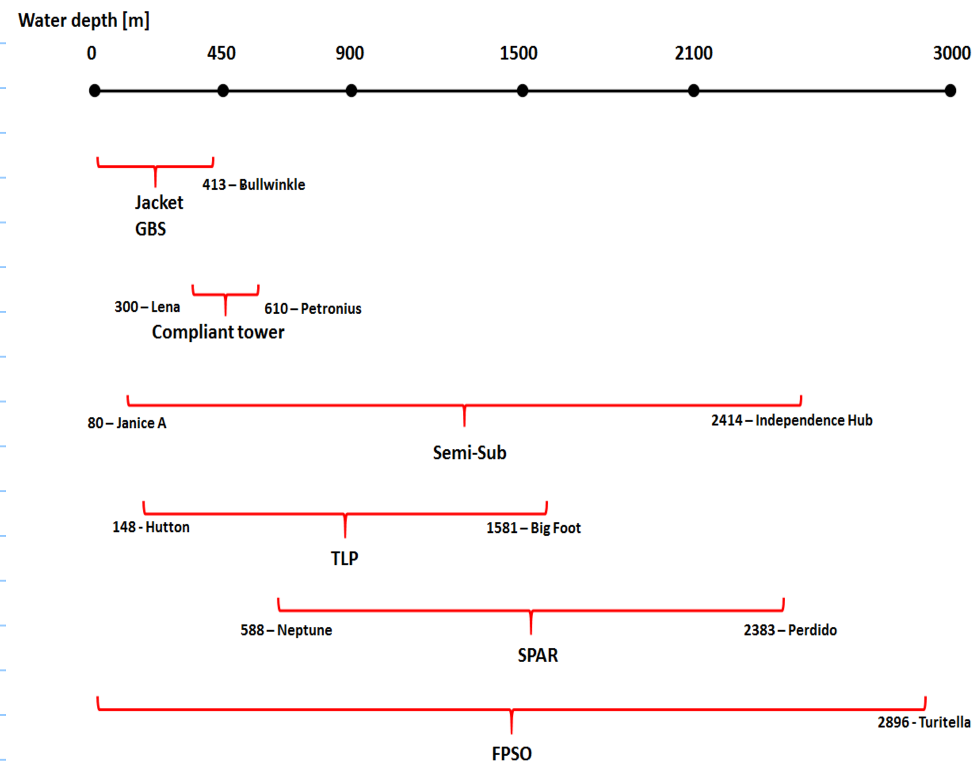
How do we select offshore structures for hydrocarbon production

- water depth
- X-mas tree type { wet / dry }
- well intervention requirements
- Reservoir structure and extent
- future development and expansion plans
- storage needs (oil, condensate)
- marine environment { wind / currents / waves }
- soil conditions
- cost / delivery time
- past experience

• water depth

bottom-supported structures bellow 500-600 m

floating structures → no restrictions




• Storage { if field is in a remote location that might be difficult to access. due to rough weather, etc.

FPSO storage (1 E6 - 3 E6) stb

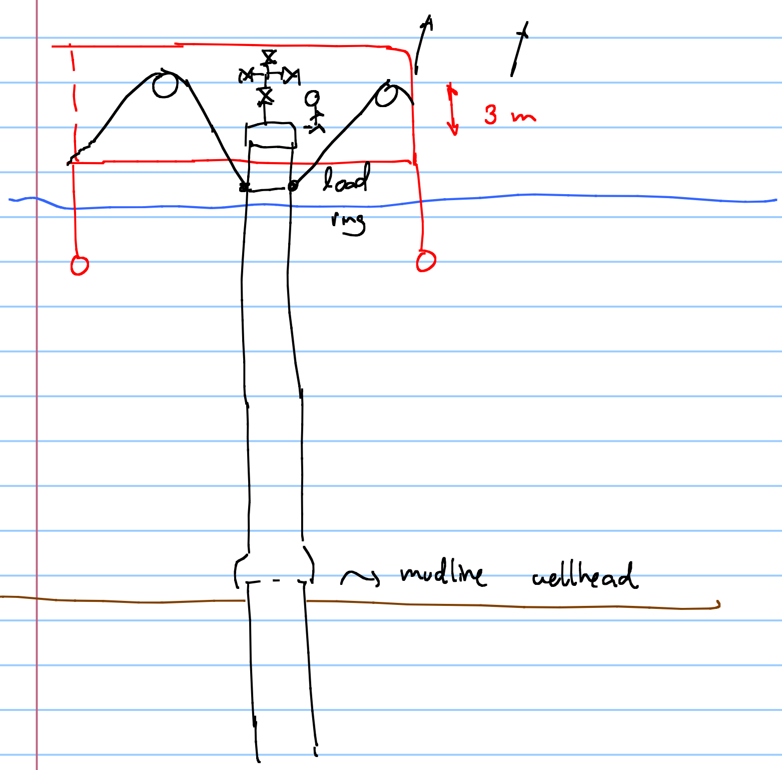
GBS (300000 stb)

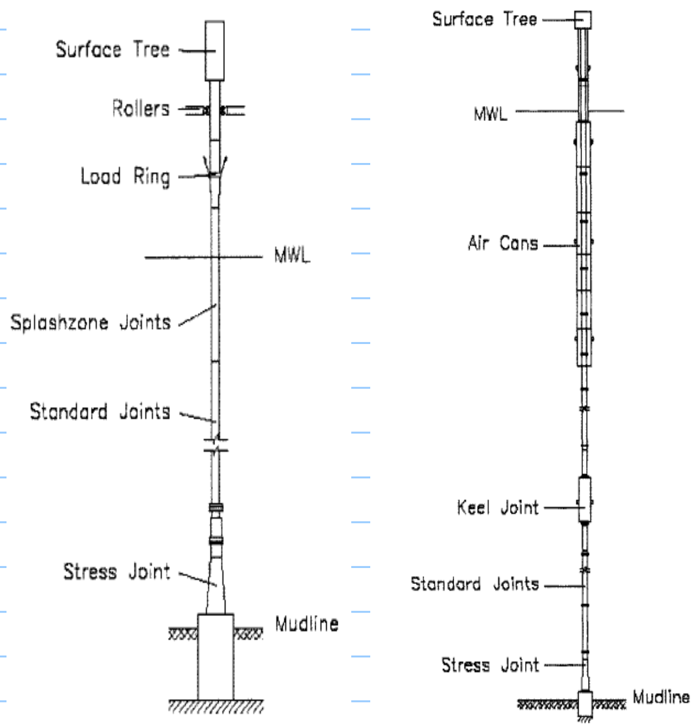
Aasta Hansteen first SPAR with storage (150 000 stb)

- X-mas tree type:
  - Reservoir extent and structure (depends also on Capacity of drilling package)
  - Current record for dry X-mas trees: 1700 m water depth
  - Intervention requirements { artificial lift → dry X-mas trees
    e.g. ESP lifetime is 6 months 1-5 years
  - future field expansion plans (infill drilling)

    Dry X-mas trees are drilled from well bay, and it has limited tree slots for this purpose.
  - severity of flow assurance issues

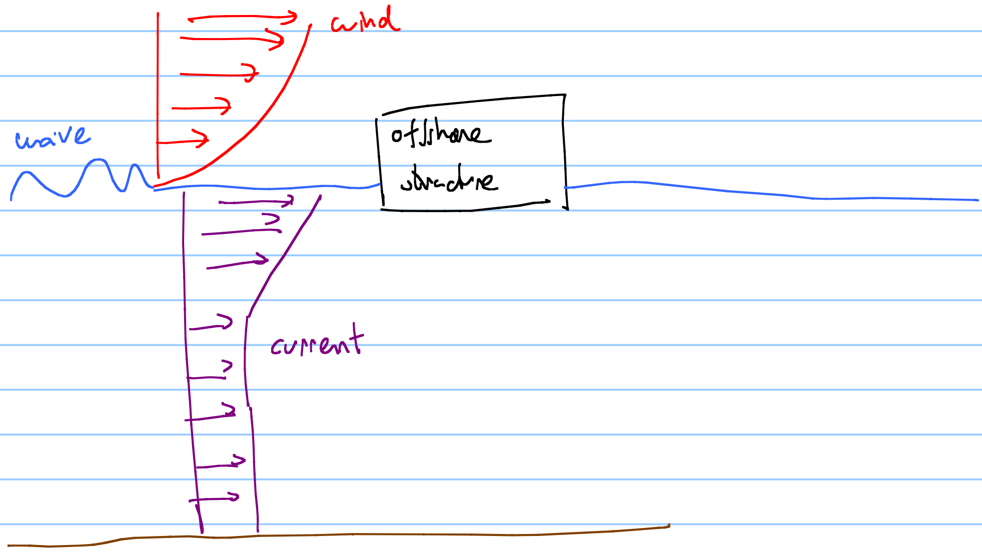
Dry X-mas trees can only be installed in: GBS, Jacket, compliant tower, SPAR, TLP (wells are drilled just like onshore)



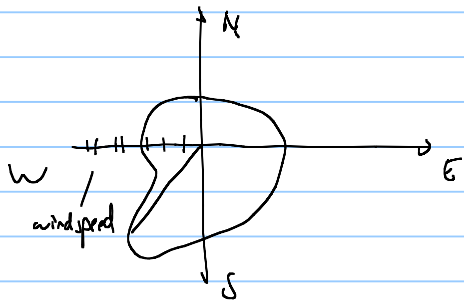



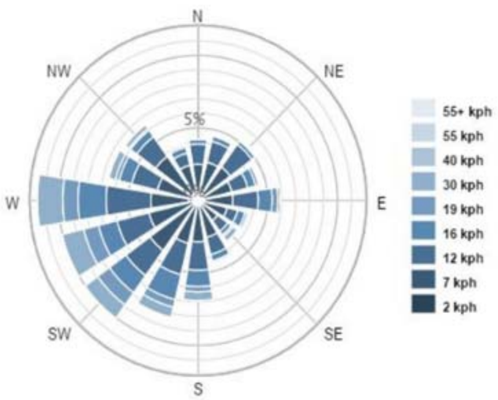
- Marine loads on offshore structure

  - wind



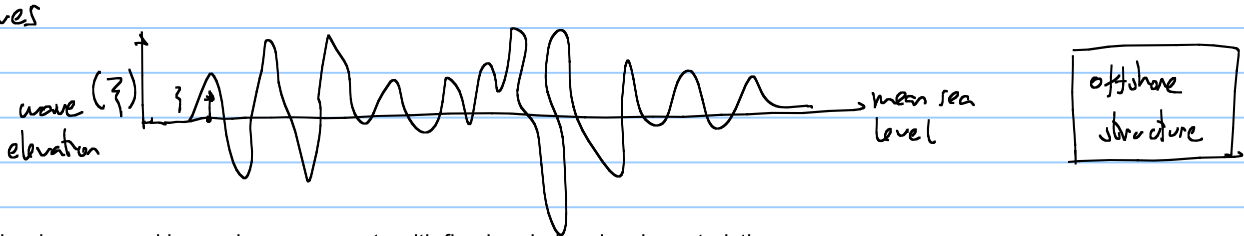

- usually wind is considered constant except for some floating structures, Direction must be taken into account



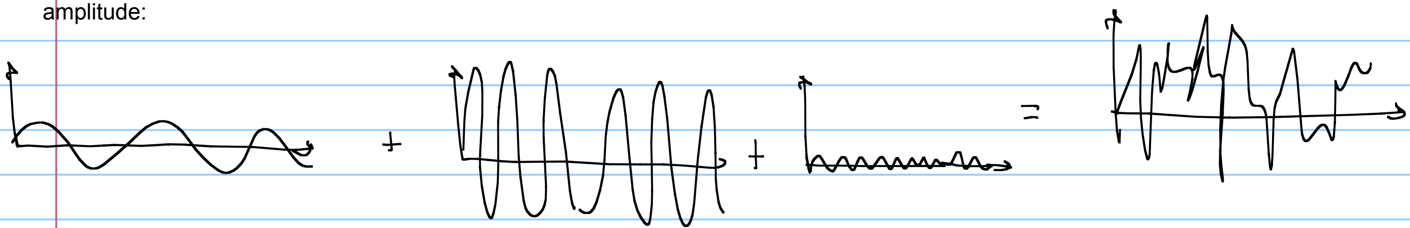




- currents the variation with depth is considered. Slow variation with time. a constant value is used, for example 100 year current

- waves



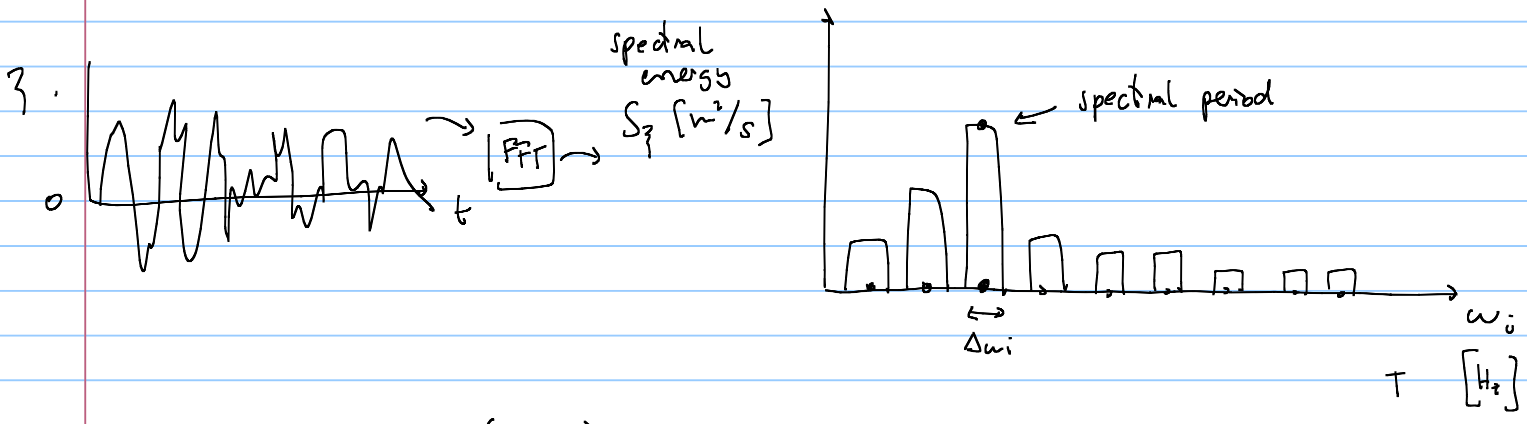

waves can be decomposed in regular components with fixed period and a characteristic amplitude:




$$\zeta(t) = \sum_{i=1}^{N} \zeta_i \sin(\omega_i t + \varepsilon_i)$$

FFT Fast Fourier Transform

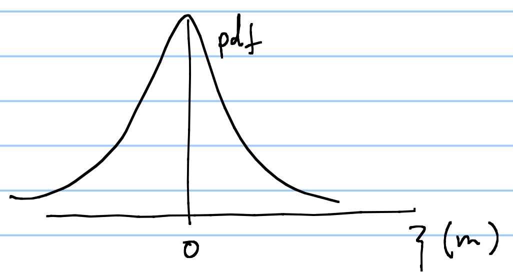
$$\zeta_i = \sqrt{2\, S_{\zeta_i} \cdot \Delta\omega_i}$$

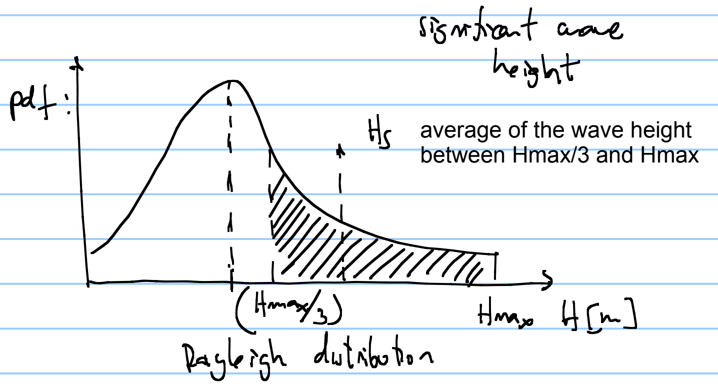



for a given sea state (3 hrs.) it will have a clear dominant period

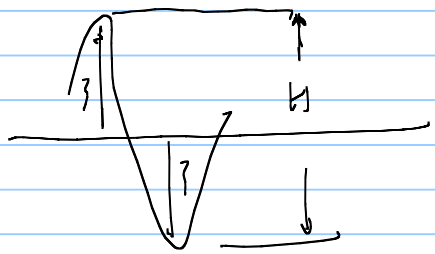
wave data is usually collected { observations; buoys attached to ship (merchant, exploration); weather } at least two years.

in a given sea state, wave elevation is distributed normally around zero "0"




wave height distance between two consecutive crests and valley



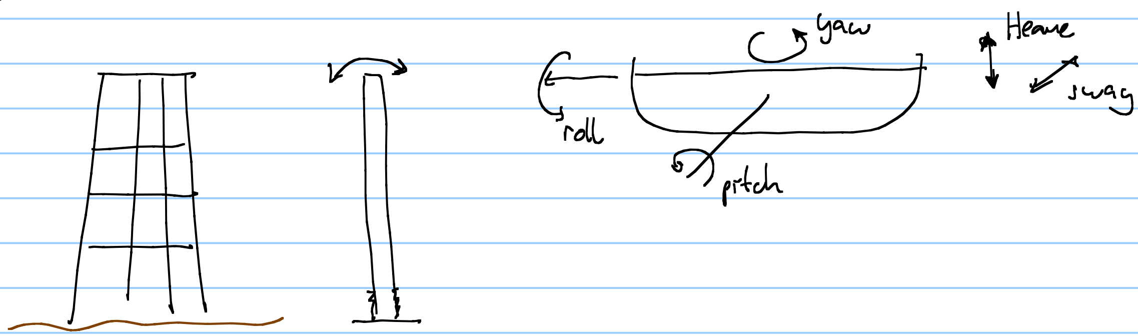

each sea state has an associated period $T_p$ and significant wave height ($H_s$)

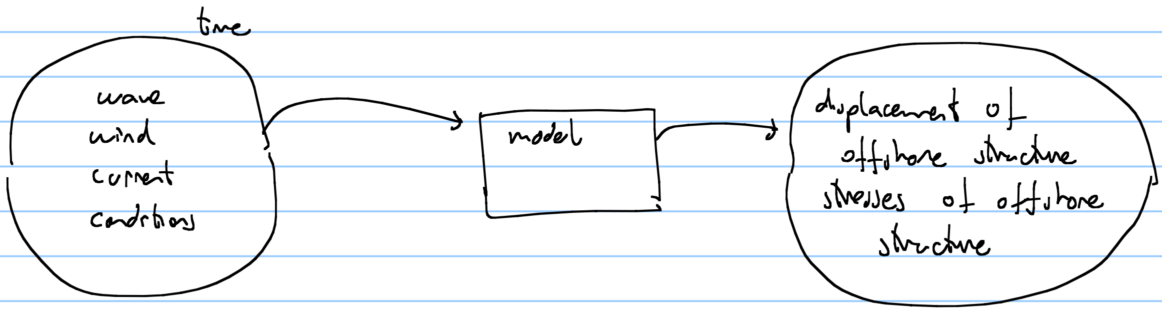
$T_p$ (s)

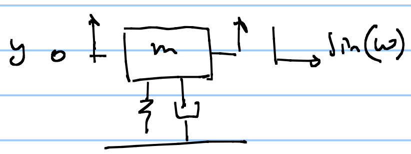
| $H_s$ (m) | 0-3 | 3-4 | 5-6 | | | | 24-25 |
|---|---|---|---|---|---|---|---|
| 0-1 | | | \|\|\|\| | \|\| | \| | | |
| 1-2 | | | | | | | |
| ⋮ | | | | | | | |
| 17-18 | | | | | | | |

| Hs [m] | Spectral Peak period ($T_p$) [s] | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-3 | 3-4 | 4-5 | 5-6 | 6-7 | 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 12-13 | 13-14 | 14-15 | 15-16 | 16-17 | 17-18 | 18-19 | 19-20 | 20-21 | 21-22 | 22-23 | 23-24 | 24-25 | Sum |
| 0-1 | 15 | 290 | 1367 | 2876 | 3716 | 3527 | 2734 | 1849 | 1138 | 656 | 362 | 192 | 101 | 52 | 26 | 13 | 7 | 3 | 2 | 1 | 0 | 0 | 0 | 18927 |
| 1-2 | 1 | 81 | 1153 | 5308 | 12083 | 17323 | 18143 | 15262 | 10980 | 7053 | 4169 | 2316 | 1229 | 631 | 315 | 155 | 75 | 36 | 17 | 8 | 4 | 5 | 1 | 96348 |
| 2-3 | 0 | 2 | 94 | 1050 | 4532 | 10304 | 15020 | 15953 | 13457 | 9752 | 5991 | 3403 | 1795 | 894 | 426 | 197 | 88 | 39 | 17 | 7 | 3 | 1 | 1 | 83026 |
| 3-4 | 0 | 0 | 2 | 72 | 686 | 2782 | 6171 | 8847 | 9189 | 7493 | 5082 | 2991 | 1577 | 762 | 345 | 148 | 61 | 24 | 9 | 4 | 1 | 0 | 0 | 46246 |
| 4-5 | 0 | 0 | 0 | 2 | 51 | 433 | 1645 | 3495 | 4807 | 4750 | 3638 | 2286 | 1229 | 584 | 251 | 100 | 37 | 13 | 5 | 1 | 0 | 0 | 0 | 23327 |
| 5-6 | 0 | 0 | 0 | 0 | 2 | 39 | 294 | 1037 | 2069 | 2664 | 2440 | 1709 | 968 | 463 | 193 | 72 | 25 | 8 | 2 | 1 | 0 | 0 | 0 | 11986 |
| 6-7 | 0 | 0 | 0 | 0 | 0 | 2 | 32 | 215 | 692 | 1264 | 1485 | 1228 | 767 | 382 | 159 | 57 | 18 | 5 | 1 | 0 | 0 | 0 | 0 | 6307 |
| 7-8 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 27 | 157 | 447 | 730 | 762 | 555 | 302 | 130 | 46 | 14 | 4 | 1 | 0 | 0 | 0 | 0 | 3177 |
| 8-9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 23 | 112 | 276 | 392 | 355 | 223 | 104 | 38 | 11 | 3 | 1 | 0 | 0 | 0 | 0 | 1540 |
| 9-10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 19 | 77 | 160 | 192 | 148 | 79 | 31 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 719 |
| 10-11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 16 | 50 | 85 | 85 | 55 | 24 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 327 |
| 11-12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 | 29 | 40 | 33 | 18 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 143 |
| 12-13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 15 | 17 | 12 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 61 |
| 13-14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 7 | 6 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 25 |
| 14-15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 9 |
| 15-16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| 16-17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17-18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 16 | 373 | 2616 | 9308 | 21070 | 34410 | 44041 | 46687 | 42514 | 34212 | 24268 | 15503 | 8892 | 4587 | 2143 | 921 | 372 | 146 | 55 | 22 | 8 | 6 | 2 | 292172 |

- for platforms, height of deck must be defined based on 100-year wave $H_{s100}$
  - use $T_p$ - $H_s$ to calculate loads on offshore structure



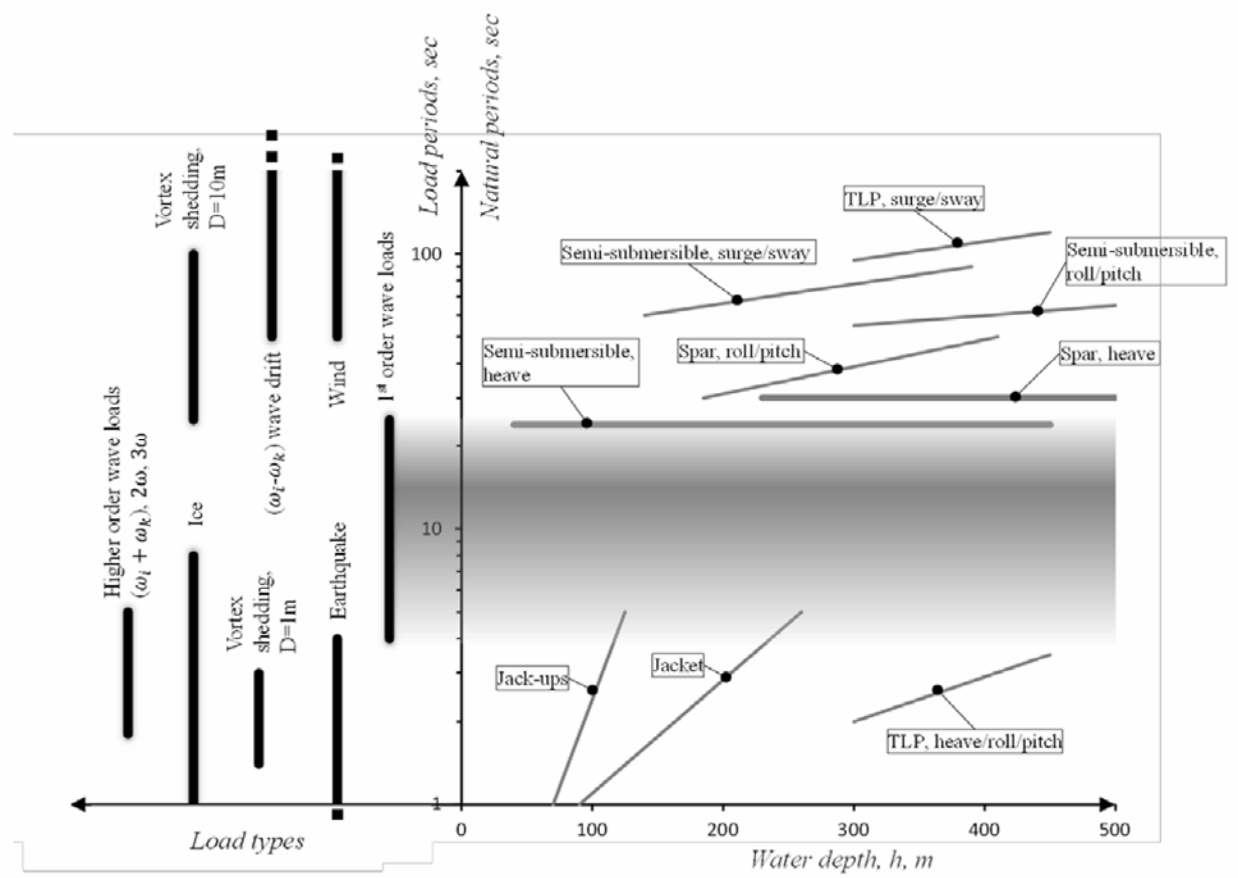




mechanical system analog of a offshore structure


resonance (natural frequency)

Resonance will occur when the excitation frequency is equa
to the natural frequency of the structure (maximum amplituc

Example: natural frequencies of some offshore structures




previous section and applied on the structure. Due to the variability of these loads, there are usually three main design approaches:

- **Design wave:** perform the analysis using the 100 year significant wave height ($H_{S,100}$) and a suitable range of wave periods. If more accurate estimates are not available, the Norwegian standard NORSOK N-003 suggests to take $H_{S,100} = 1.9 \cdot H_S$ and vary the wave period between $\sqrt{6.5 \cdot H_{S,100}} \leq T \leq \sqrt{11 \cdot H_{S,100}}$ .

- **Short term design:** perform the analysis for a 100 year storm of specified duration (3-6 h) with an associated frequency spectrum. This is usually done to predict dynamic loads and stresses on critical load-bearing components.

- **Long term design:** This analysis takes into account the long term varying weather conditions. This is important for fatigue design.