

Introdução aos sistemas de ancoragem

PNV3523: Energias Renováveis no Mar

Tópicos

- Tipos de Sistema de Amarração
- Amarração em catenária
- Forças de deriva em ondas

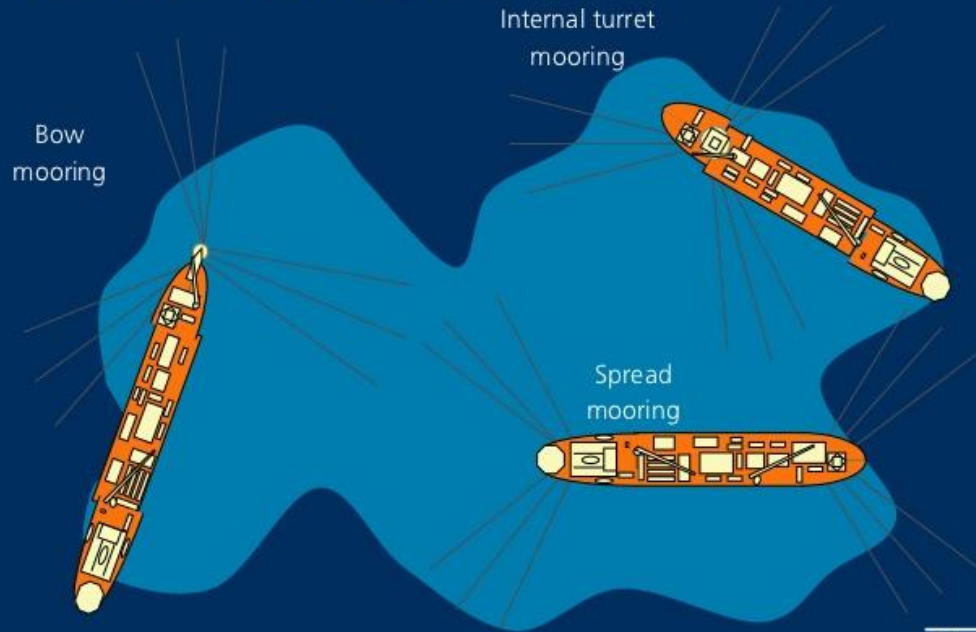
TIPOS DE SISTEMA DE AMARRAÇÃO



[FPSO Cidade de Ilhabela](#)

Lloyd's Register: IQPC 11th Annual FPSO Congress 2010

MOORING ARRANGEMENTS



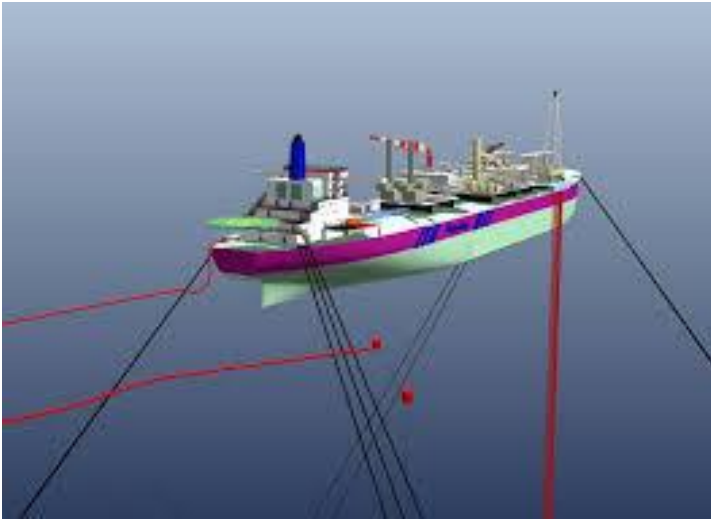
250
YEARS
of service

Lloyd's
Register

LIFE MATTERS

[Lloyds Standards](#)

Spread Mooring Systems - FPSOs



[Bluewater](#)



[Marintech](#)

Spread Mooring Systems - FPSOs



Spread Mooring Systems - FPSOs



FPSO Bertam
Detalhe do fairlead



NYK
Riser balcony

Spread Mooring Systems Equipment & Handling



[detalhe do fairlead](#)

<https://www.youtube.com/watch?v=3dGufmGcvOg>

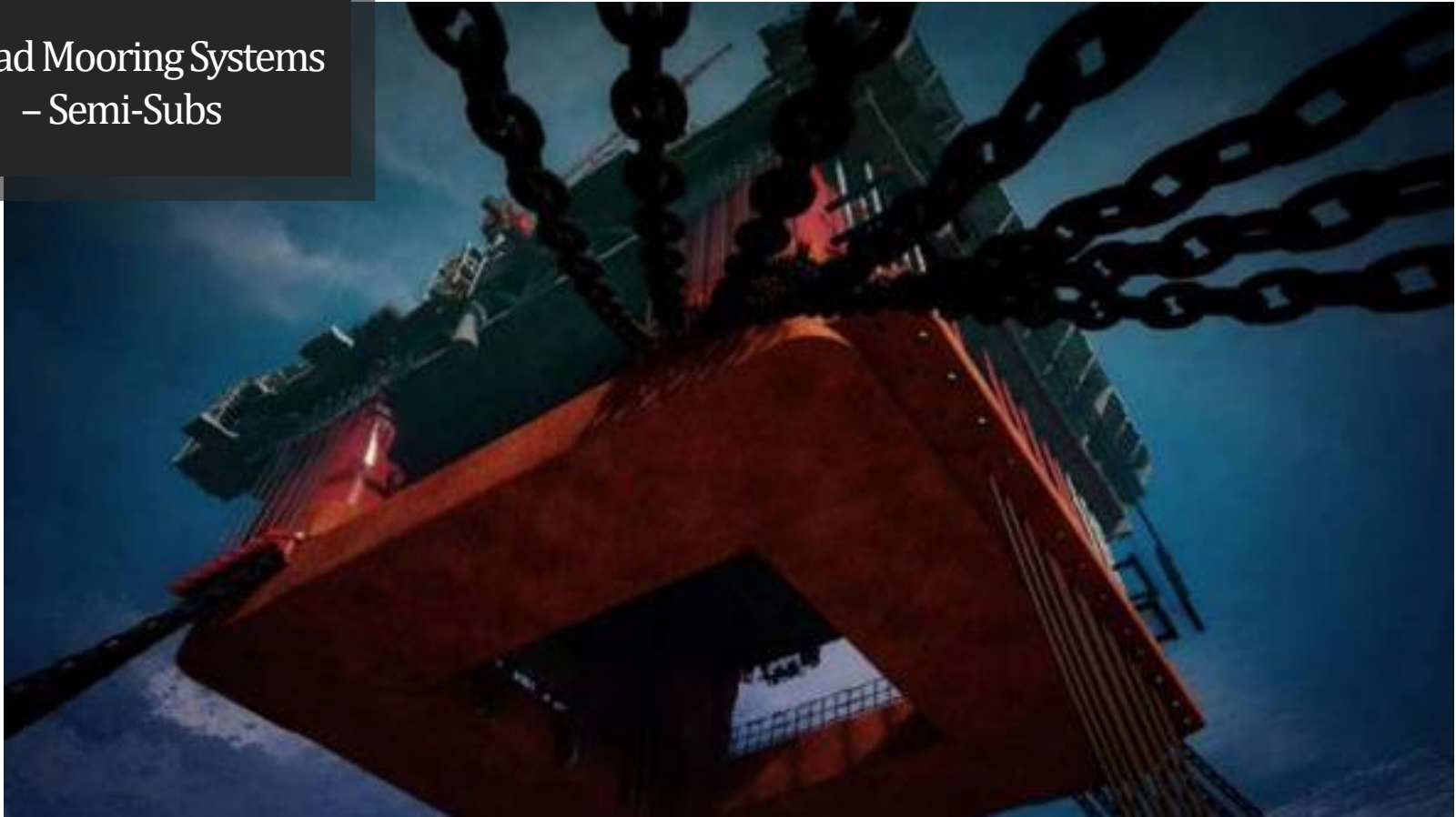
<https://www.youtube.com/watch?v=a8KwJ0v-tKE>



[Royal IHC](#)

Linear chain tensioner

Spread Mooring Systems
– Semi-Subs



Spread Mooring Systems – Semi-Subs



Semi-sub
[Offshore](#)
[Magazine](#)



Turret Mooring - FPSOs

Internal Turret and Bow-thruster

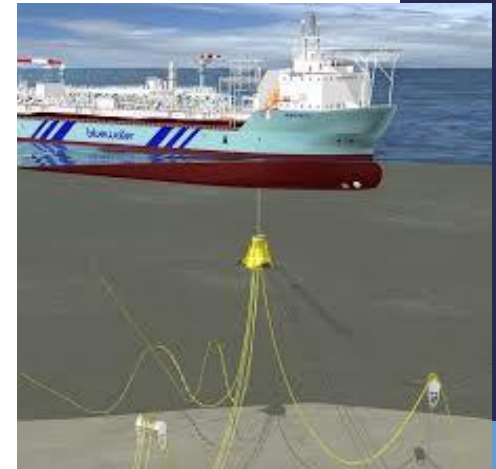
[SBM](#)



Internal Turret
[2B1st Consulting](#)



Turret Mooring
[Sofec](#)



Turret com desconexão
[Bluewater](#)

Turret Mooring - FPSOs

External Turret



External Turret
Ratu Songkhla

Single Point Mooring - FPSOs



Taut-Leg Mooring



Orcina



mooring & anchoring

Catenary vs. Taut Mooring

Catenary

- heavy in deep water
- line horizontal at seabed
- anchor subject to horizontal forces
- restoring forces by line weight

Taut leg

- line non-horizontal at seabed
- anchor sees non-horizontal forces
- restoring forces by line elasticity
- smaller footprint than catenary mooring

catenary system

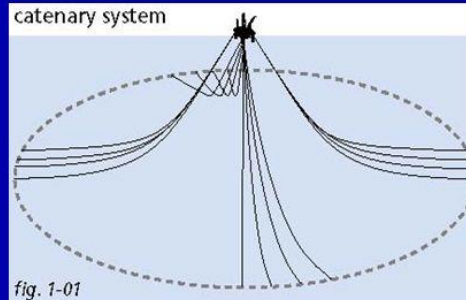


fig. 1-01

Overview of SURF Systems and Analysis

taut leg system

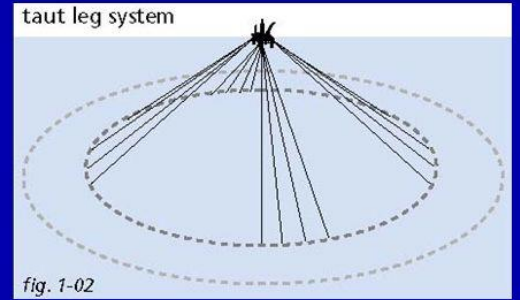
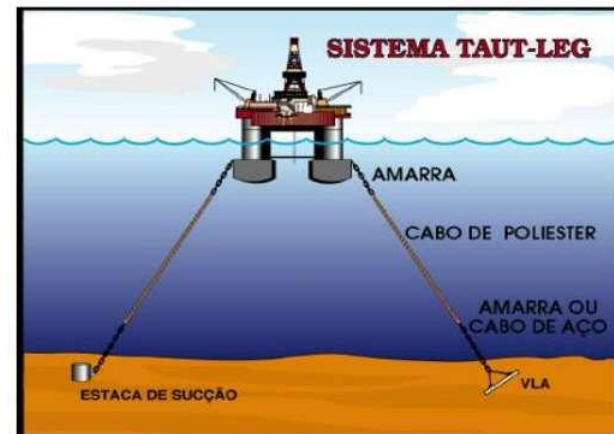
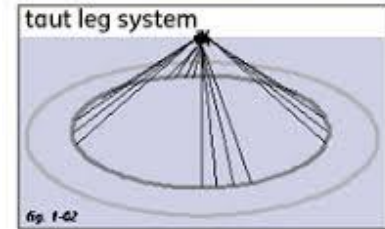
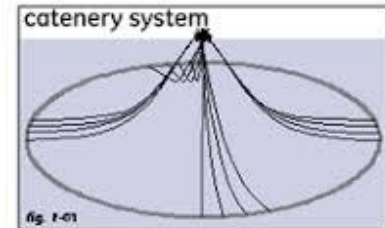
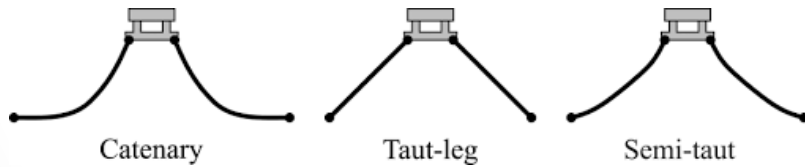
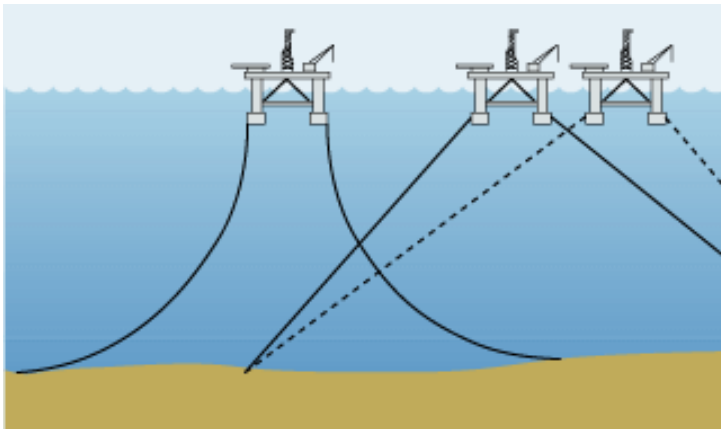


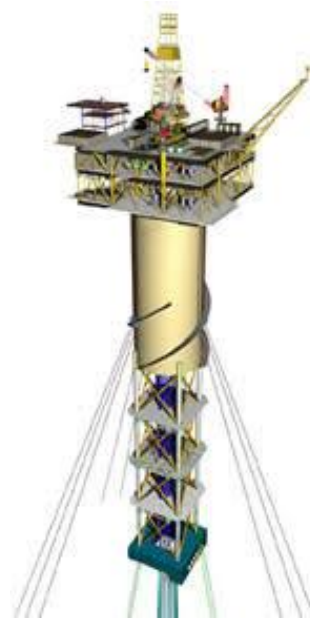
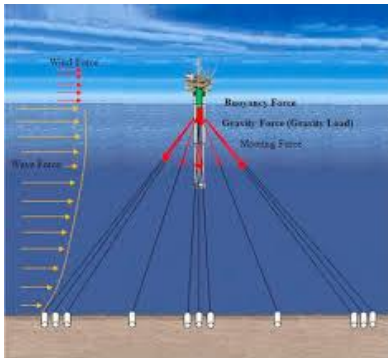
fig. 1-02

Aryatech Marine & Offshore Services

Taut-Leg Mooring



Spars - Mooring





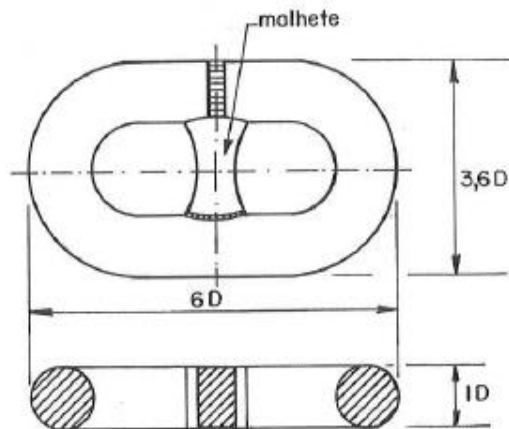
<https://www.youtube.com/watch?v=fJqDyg7aua4>

Floating Offshore Wind Turbines (FOWT) - Mooring

Amarras e cabos de amarração



Amarras e cabos de amarração



| DIÂMETRO DE AMARRA (mm) | PESO LINEAR (KG/m) | DIÂMETRO DE AMARRA (mm) | PESO LINEAR (KG/m) |
|-------------------------|--------------------|-------------------------|--------------------|
| 20.5 | 9.2 | 81 | 143.7 |
| 22 | 10.6 | 84 | 154.5 |
| 24 | 12.6 | 87 | 165.8 |
| 26 | 14.8 | 90 | 177.4 |
| 28 | 17.2 | 92 | 185.4 |
| 30 | 19.7 | 95 | 197.6 |
| 32 | 22.4 | 97 | 206.1 |
| 34 | 25.3 | 100 | 219.0 |
| 36 | 28.4 | 102 | 227.8 |
| 38 | 31.6 | 105 | 241.4 |
| 40 | 35.0 | 107 | 250.7 |
| 42 | 38.6 | 111 | 269.8 |
| 44 | 42.4 | 114 | 284.6 |
| 46 | 46.3 | 117 | 299.8 |
| 48 | 50.4 | 120 | 315.4 |
| 50 | 54.8 | 122 | 326.0 |
| 52 | 59.2 | 124 | 336.7 |
| 54 | 63.8 | 127 | 353.2 |
| 56 | 68.3 | 130 | 370.1 |
| 58 | 73.6 | 132 | 381.6 |
| 60 | 78.8 | 137 | 411.0 |
| 62 | 84.2 | 142 | 441.6 |
| 64 | 89.7 | 147 | 473.2 |
| 66 | 95.4 | 152 | 506.0 |
| 68 | 101.3 | 157 | 539.8 |
| 70 | 107.3 | 162 | 574.7 |
| 73 | 116.7 | 167 | 610.7 |
| 76 | 126.5 | 172 | 647.9 |
| 78 | 133.2 | 177 | 686.1 |

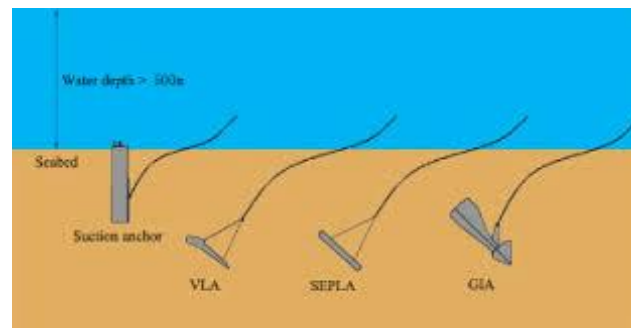
Amarras e cabos de amarração



[Cabos de Amarração - CSL](#)

Âncoras

- Convencionais
- Sucção
- Torpedo



Âncoras offshore convencionais

Matrosov Anchor



Baldt Anchor



**Offshore Anchor
Stevshark Anchor**



Danforth Anchor



Delta Anchor



Pool Anchor



**U.S. Navy
Stockless Anchor**



AC-14 HHP Anchor



Spek Anchor



Admiralty Anchor



JIS Stock Anchor

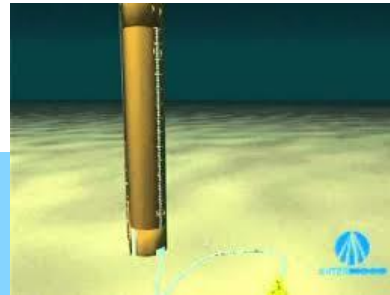
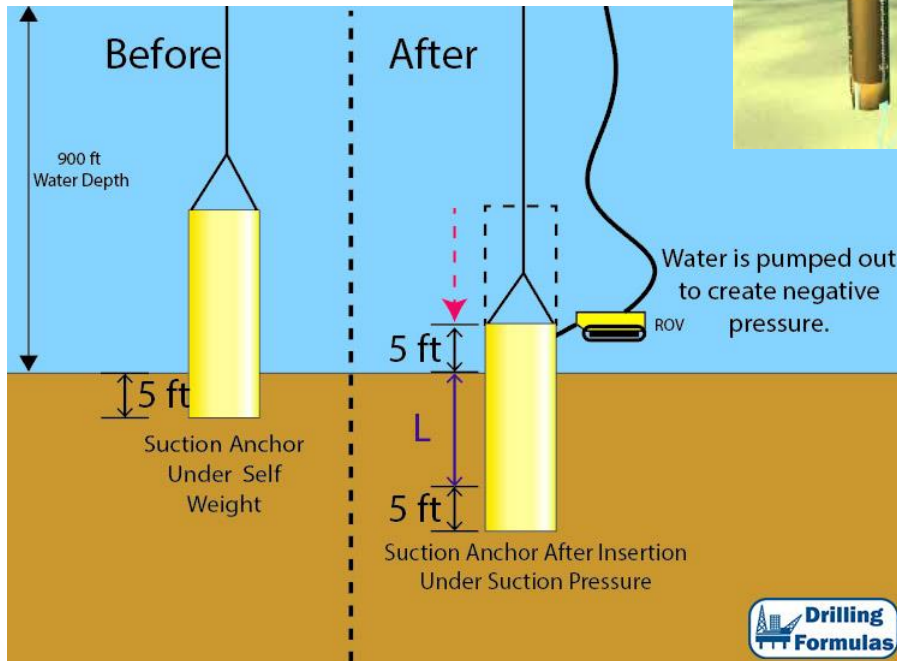


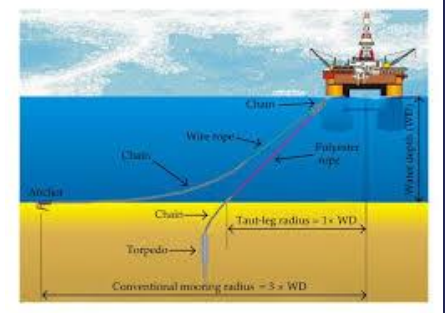
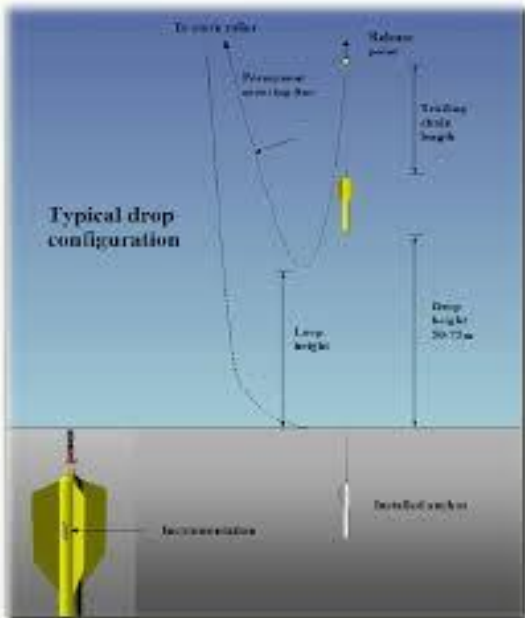
Hall Anchor



<https://www.youtube.com/watch?v=OeGiaBK0Cas>

Âncoras de sucção



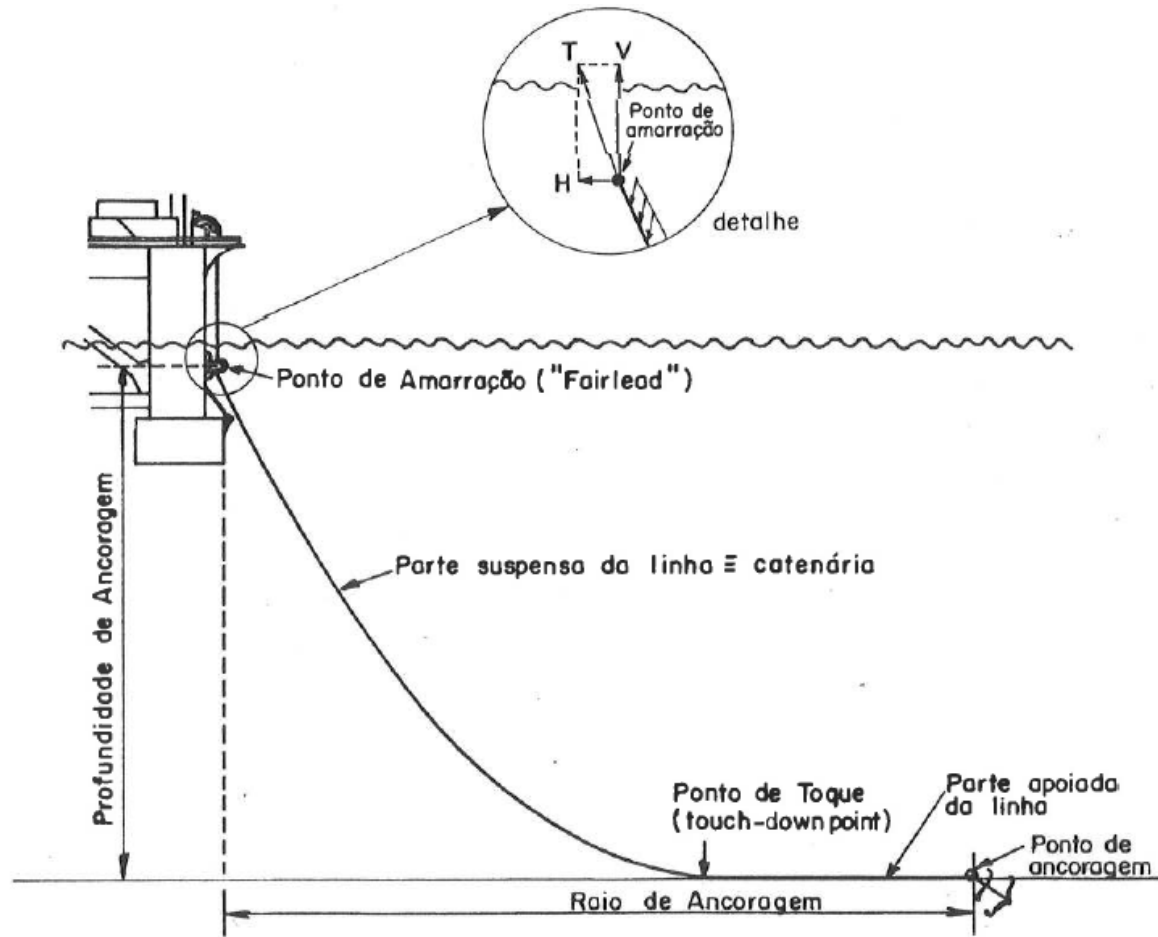


Estaca Torpedo

Torpedo Anchor

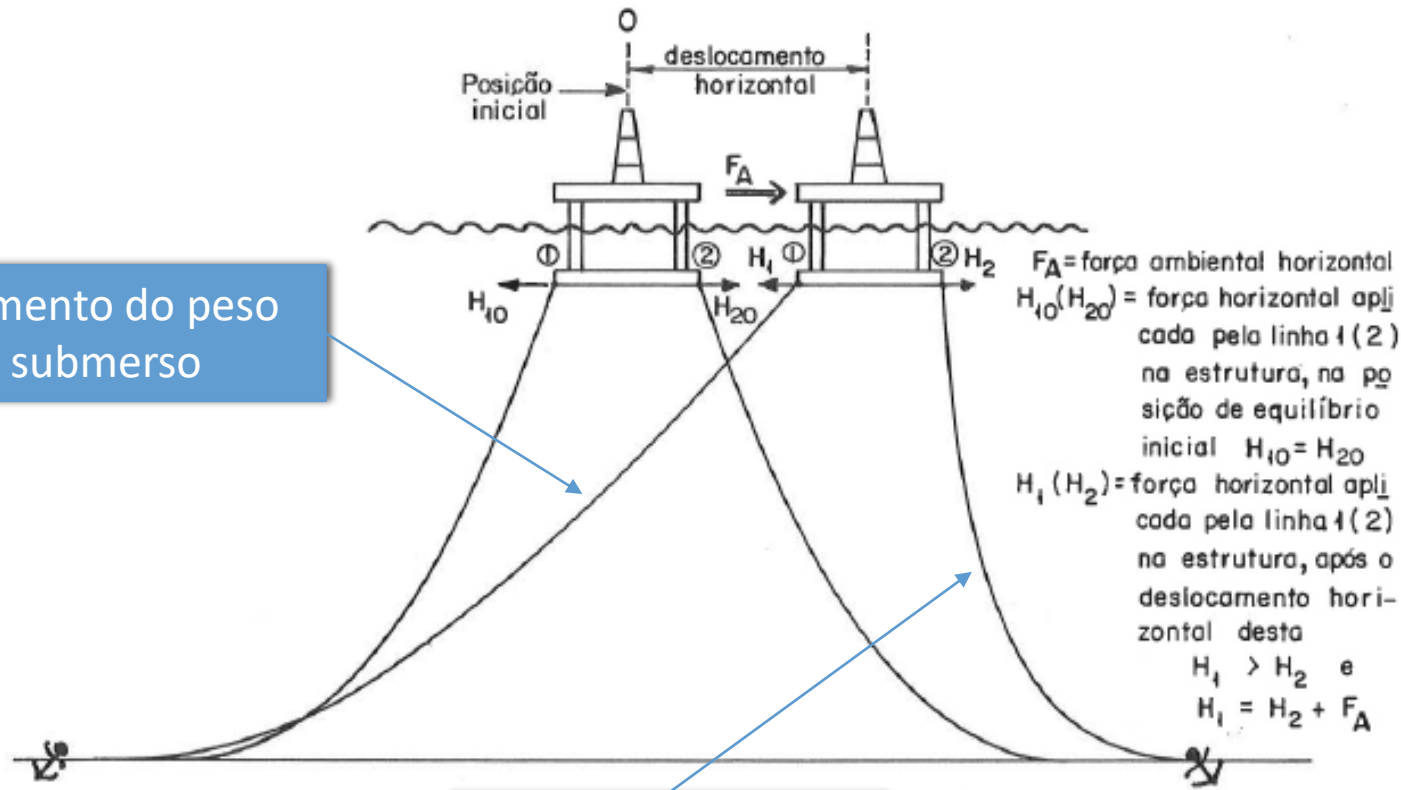
AMARRAÇÃO EM CATENÁRIA

Geometria da catenária



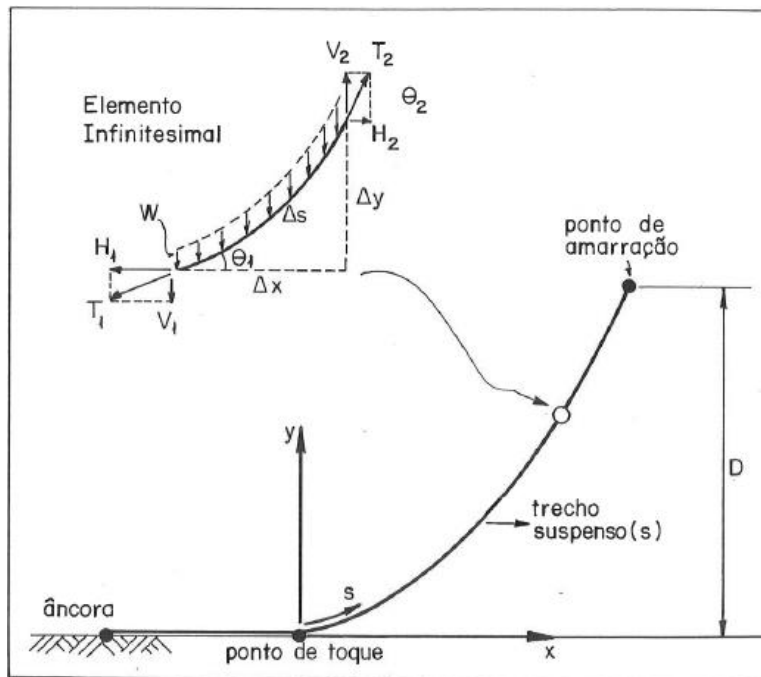
Princípio da amarração em catenária

Aumento do peso submerso



Redução do peso submerso

A equação da catenária



$$y = \frac{H}{w} \cdot \left[\cosh\left(\frac{w \cdot x}{H}\right) - 1 \right]$$

$$s = \frac{H}{w} \cdot \sinh\left(\frac{w \cdot x}{H}\right)$$

$$V = w \cdot s$$

$$T = w \cdot y + H$$

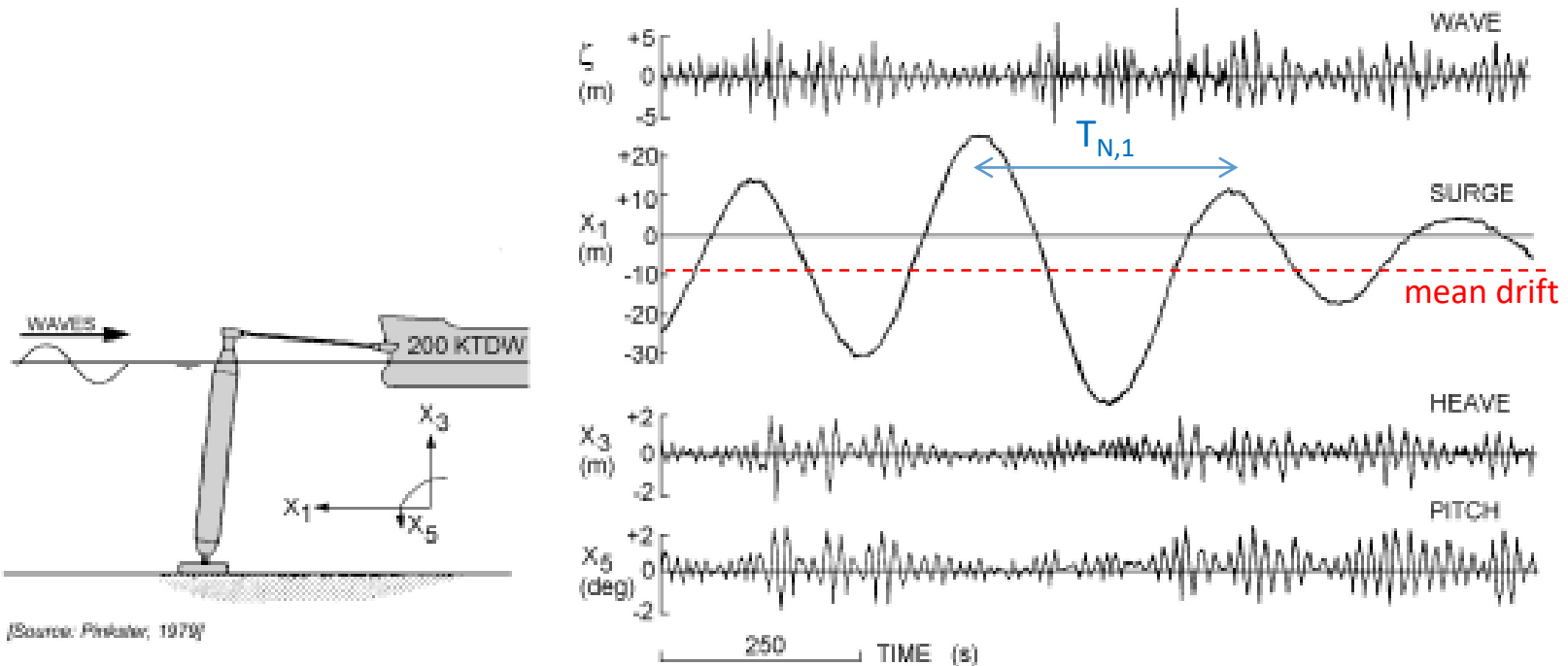
$$T^2 = H^2 + V^2$$

Dimensionamento da amarração

- O dimensionamento do sistema de ancoragem (número de linhas, tipo e peso das linhas, pré-tensão) é balizado por:
 - **Máximo offset** devido às forças ambientais: estático + dinâmico
 - Estático: correnteza + vento + deriva media em ondas
 - Dinâmico: deriva-lenta em ondas
 - Verificação de **tração dinâmica máxima** nas linhas ($T < 0.5 MBL$) considerando condições extremas de mar (movimentos de 1a ordem + movimentos de 2a ordem em ondas)
 - Verificação de **fadiga** baseada em vida útil de projeto

As forças de deriva em ondas

- Sistemas ancorados sujeitos a ondas irregulares:



As forças de deriva em ondas

- Exemplo de simulação:

