Appendix 2 :
Floes' mooring design

1 Introduction

All data given here-below are at model scale.

The aim of this study is to design a soft-mooring for a 1 meter diameter floe made of wood (thickness of 33 mm – draft 18.15mm). The mooring is composed of a vertical cable + springs and is used to maintain the disks in their rest positions between tests so that all tests be started with the same initial configuration. The vertical cable is fixed on basin bottom and at floe center.

The water depth considered is 3 m.

In order to have no interaction between the mooring system and the wave frequency motions, the objective is to design a mooring system with a natural period much higher than the tested wave periods (max. 2s): typ. higher than 10s.

2 References

Ref 1: Hydrodynamique des structures offshore - B. Molin – Editions TECHNIP.

3 Mooring system definition

To define the mooring system two hypotheses are taken:

- The pre-tension To is taken equal to 5% of the disk weight in order to have few impact on the floe draft
- The spring stiffness K is taken less than 0.5% of the hydrostatic stiffness: $\rho*g*S$ (S is the disk surface). Thus, the behavior of the disk in heave direction is not impacted

These two hypotheses lead to:

- To = 7 N
- K = 31 N/m (based on existing springs)

4 Wave drift load

The horizontal mooring natural period and thus the horizontal mooring stiffness have to be computed at the equilibrium position induced by the maximum wave drift load. Indeed at this location, the horizontal stiffness is larger and thus the natural period is lower than at rest position. The maximum wave drift force on the disk is conservatively calculated using the formula hereafter computed for an infinite vertical cylinder (see Ref 1).

$$Fwd = 2/3 * \rho * g * A^2 * R$$

With :

A Maximum wave amplitude to be tested 0.05m.

R Disk radius 0.5m

Thus, the maximum wave drift load is taken equal to: **F_wd = 8.2 N**

5 System restoring force and natural period

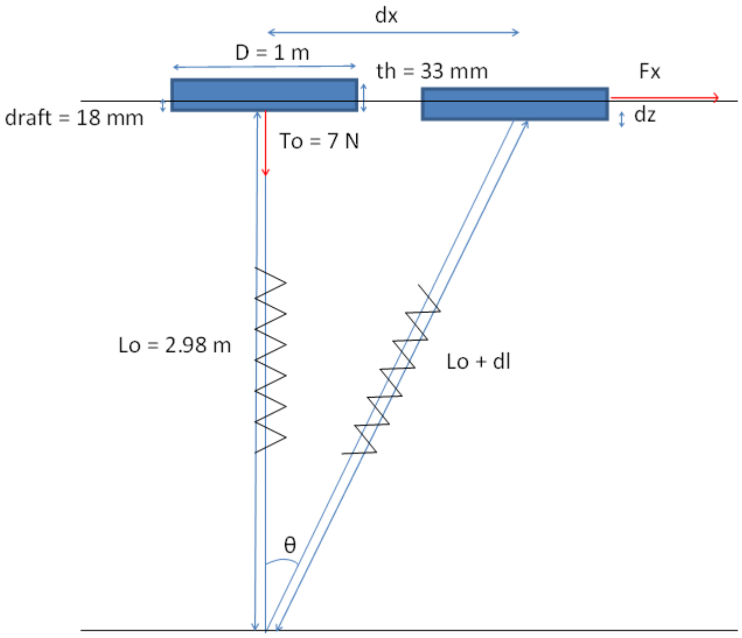


Figure 1: Sketch of the mooring system

The horizontal stiffness Kx is not linear for this system. Restoring force has been computed taking into account the set-down phenomenon: The horizontal displacement induces an increase of the draft (dz). System characteristics are:

- Pretension: 7 N (T0)
- Line stiffness: 31 N/m (K)
- Depth = 3m

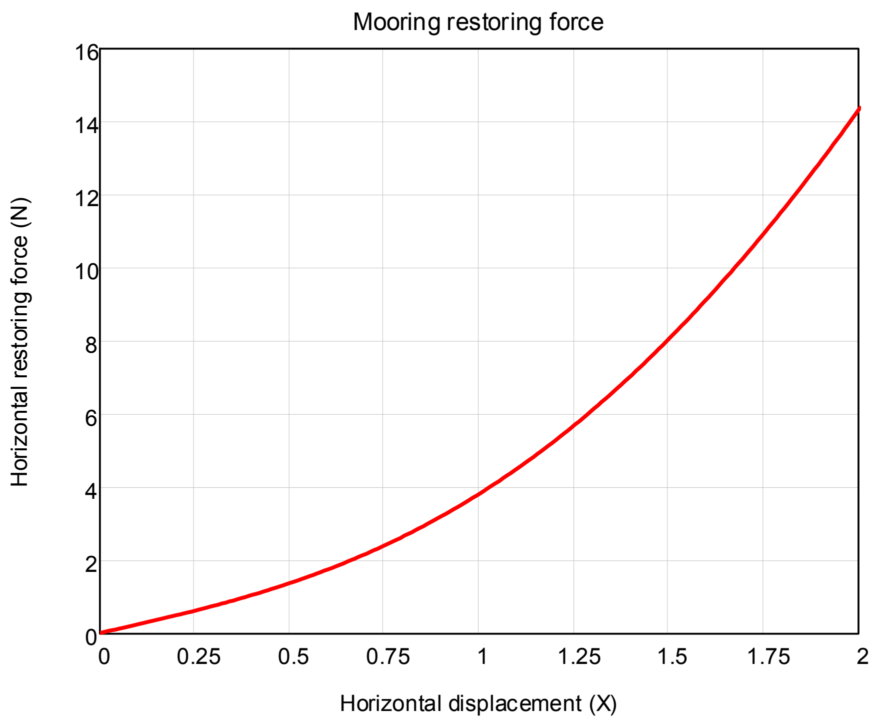


Figure 1: Horizontal stiffness Kx

From this curve, the offset caused by the wave drift force is obtained: **dx_wd =1.5 m**

Then, the system stiffness is extracted at this offset: **K_wd = 10.6 N/m**
Finally the system natural period is computed:

$$\boxed{T_{wd} = 2\pi\sqrt{\frac{M + Ma}{K\_wd}} = 10.3s}$$

With:

M	The floe mass
Ma	The floe added-mass = ρ_{water}*S*d
ρ_{water}	The fresh water density
S	the floe surface
d	the floe draft

At the computed offset the system natural period (10.3s) is much higher than the tested wave period (max. 2s). The designed mooring system will have no impact on the wave frequency motion of the floes and will allow keeping them at the same initial position for all tests.

6 Maximum spring lengthening

Next step is to check that the spring will allow the maximum floe motion.

The maximum spring lengthening is conservatively taken equal to:

dl_max = (dl_wd + dl_surge + dl_heave) * 1.2 = 0.5m

With:

dl_wd	Offset caused by the wave drift force;
dl_surge	Offset caused by surge motions (0.05 m, wave amplitude);
dl_heave	Offset caused by surge motions (0.05 m, wave amplitude);
1.2	is to take a 20% margin.

Maximum spring lengthening should be higher than **0.5m**.

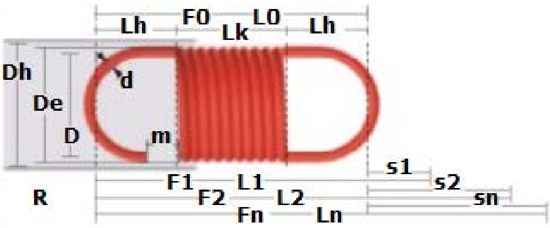
7 Conclusion

To maintain the floes in position the following mooring system is thus proposed:

- Pretension of the line will be 7N
- Line stiffness will be equal to 31N/m ensured by 3 springs with stiffness equal to 93N/m mounted in-line. Maximum lengthening of the system is 609mm which is higher than 500mm. Detailed characteristics are provided in table below:

Ref	d	De	L0	Lk	Lh	F0	Fn	K	sn	W
	[mm]	[mm]	[mm]	[mm]	[mm]	[N]	[N]	[N/mm]	[mm]	[g]
RZ-081E-05I	0.9	12.5	54.7	36.5	9.13	0.9	19.8	0.093	203	7.56

Table 1 : Spring characteristics



All dimensions are illustrated in drawings.

- F0 Initial tension
- Fn Maximum tension
- K Stiffness
- Sn Maximum lengthening
- W Weight

The design mooring system will allow keeping the floes in location between tests. Consequently, the tests will be performed with the same initial ''MIZ geometry''.

In addition, this mooring system will have very little impact on the floe wave frequency behaviour.