Designing for Slamming Loads on Composite Vessels RINA 25-05-2017

Valerio Corniani C.Eng MRINA – Chairman of RINA NSW

Static Load

Dynamic Load

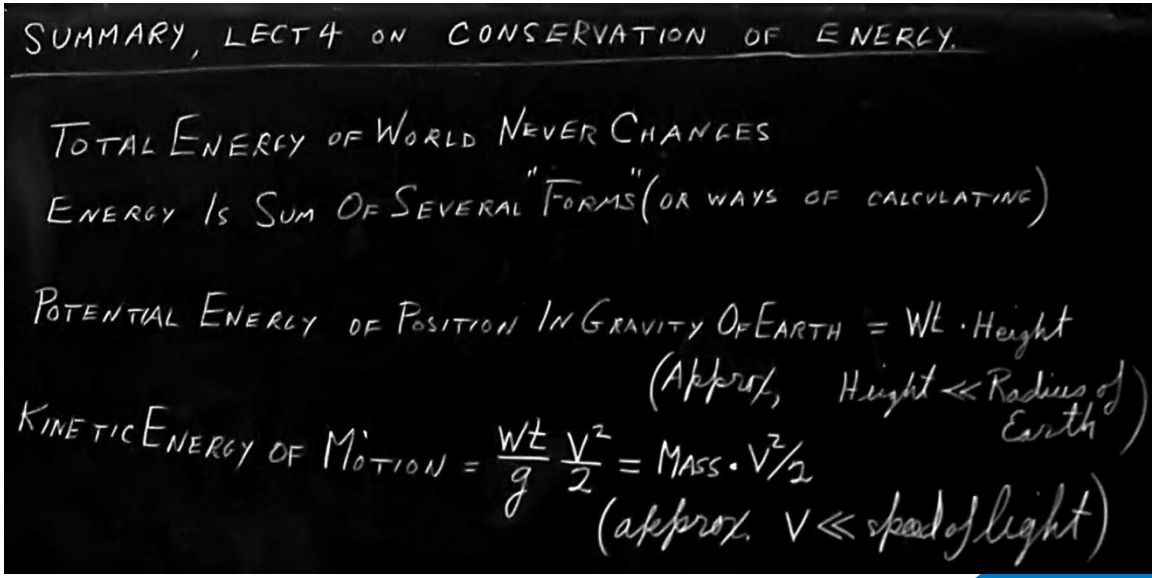
Slamming is a Dynamic Load

Law of Conservation of Energy

Energy can neither be created nor destroyed; rather, it transforms from one form to another.

Types of Energy:

- Elastic potential energy
- Gravitational pot. energy
- Kinetic energy
- Thermal energy
- Electromagnetic energy
- Chemical energy
- Nuclear energy



Gravitational potential energy

Gravitational potential energy > Kinetic energy

Kinetic energy > Elastic potential energy

Elastic potential energy

Elastic potential energy > Kinetic energy

Kinetic energy > Gravitational potential energy

Gravitational potential energy

Gravitational pot. Energy

=

Elastic pot. Energy

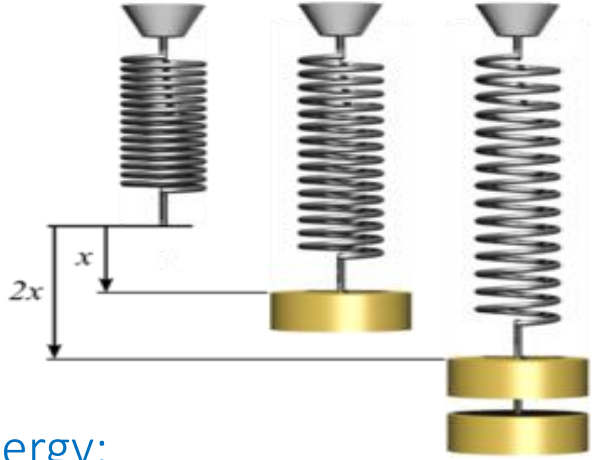
Elastic behaviour

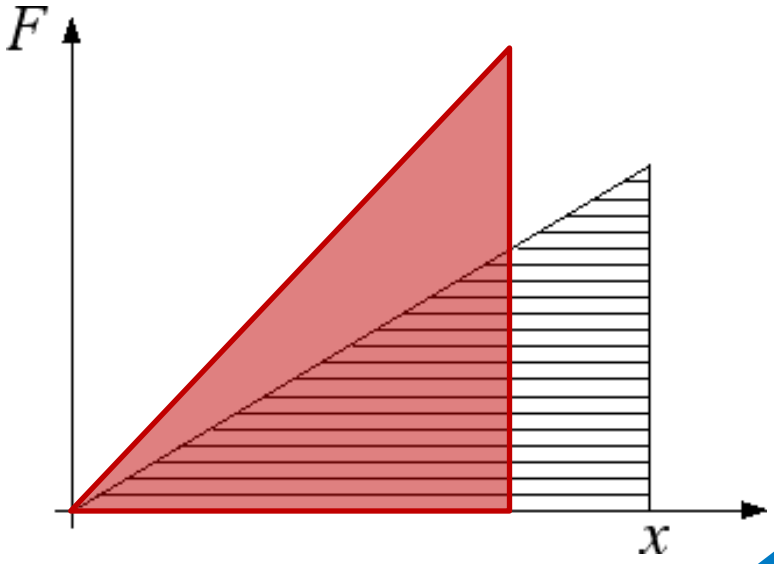
Hooke's law:

$$F = k\,x$$

k: stiffness

x: elongation





Elastic potential energy:

$$E_{max} = \tfrac{1}{2}\, F_{max}\, x_{max} = \tfrac{1}{2}\, F_{max}^{2} / k$$

Gravitational pot. Energy = Elastic pot. energy

$$mgh = \tfrac{1}{2}\, F_{max}^{2} / k$$

m: mass

h: hight

VESSELS

- Energy absorbed by the water (hull shape)

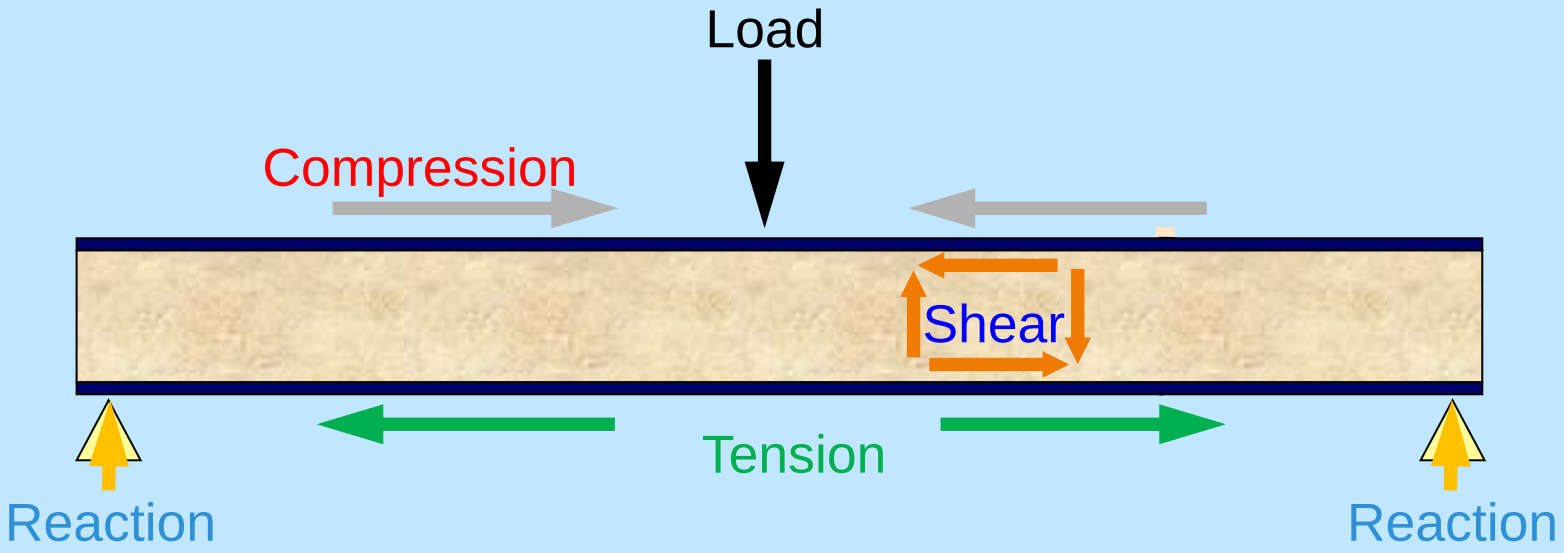
- Energy absorbed by the Hull (hull structure)

Hull or Water?

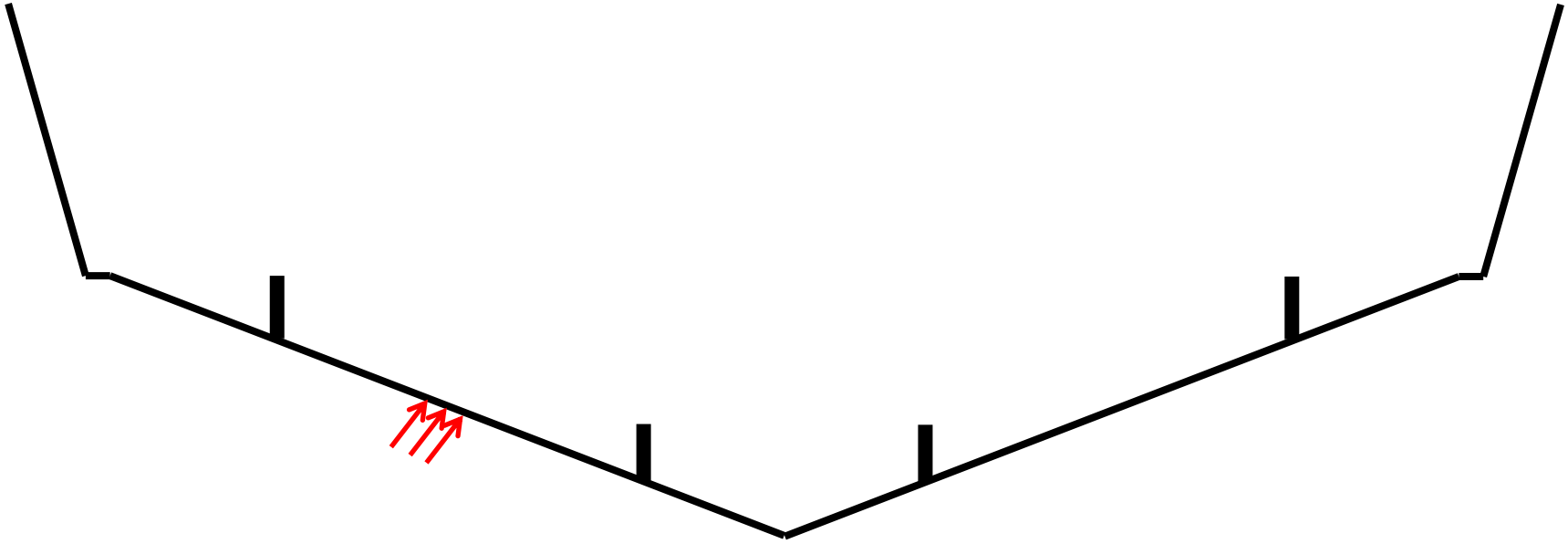
Hull shape

Hull structure

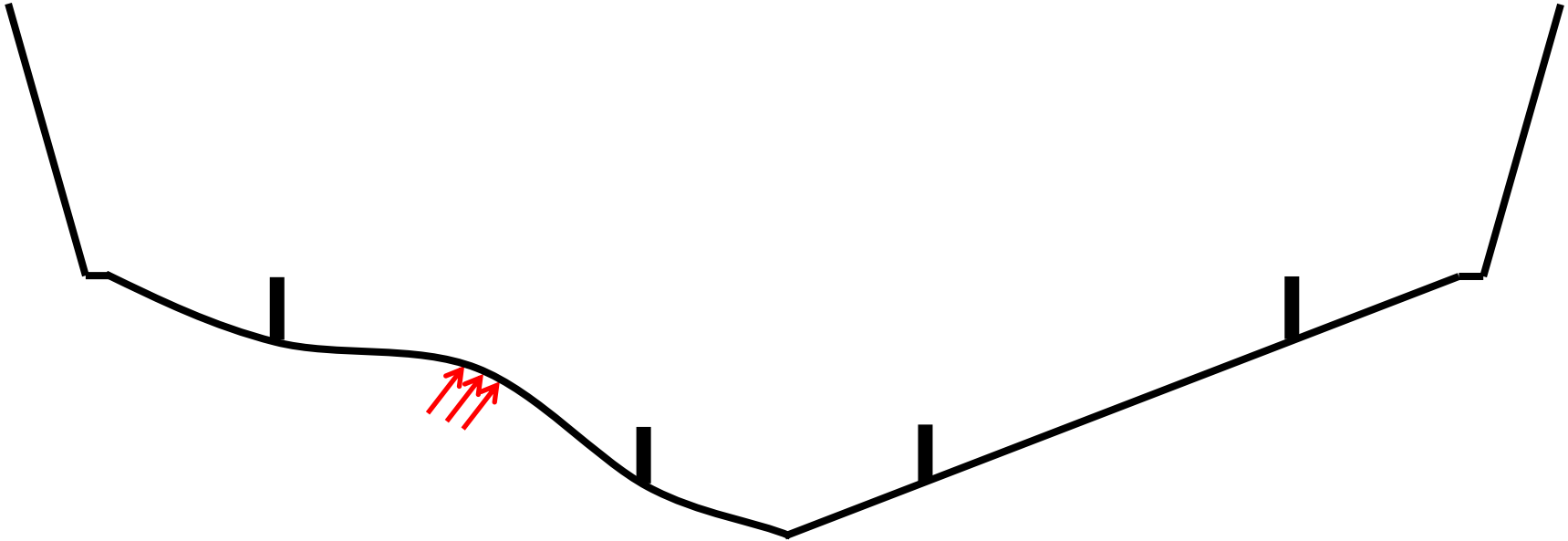
Sandwich Panel



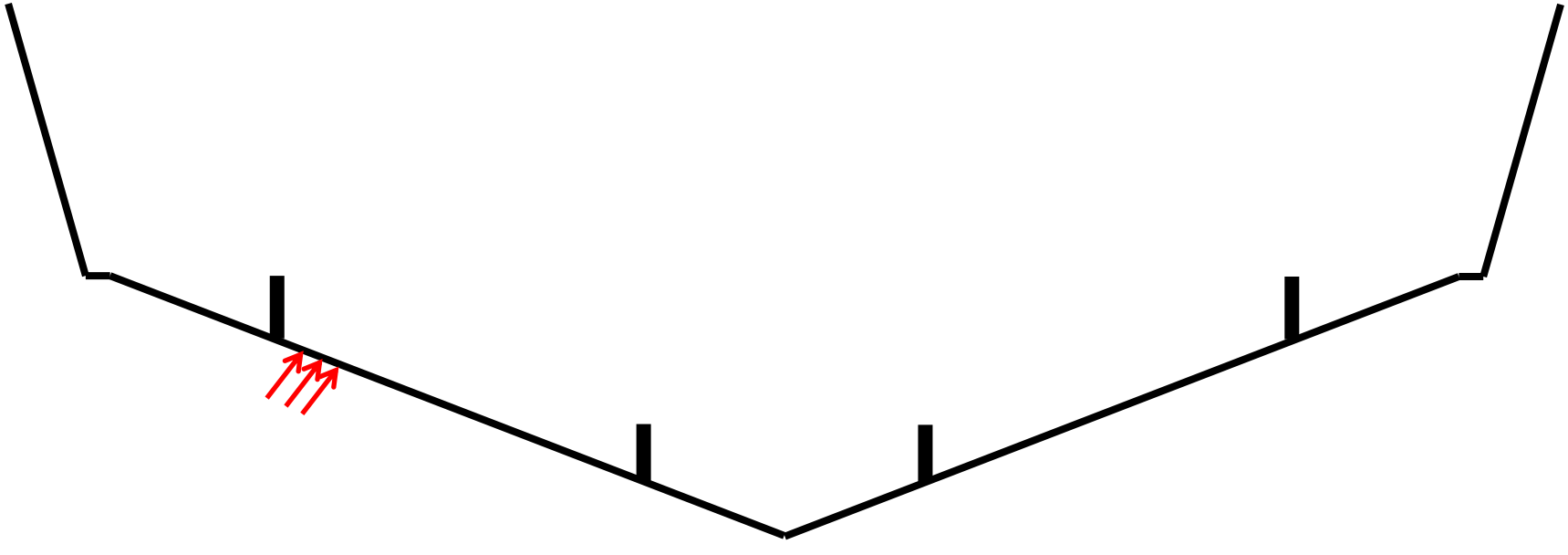
Slamming in the middle of a panel



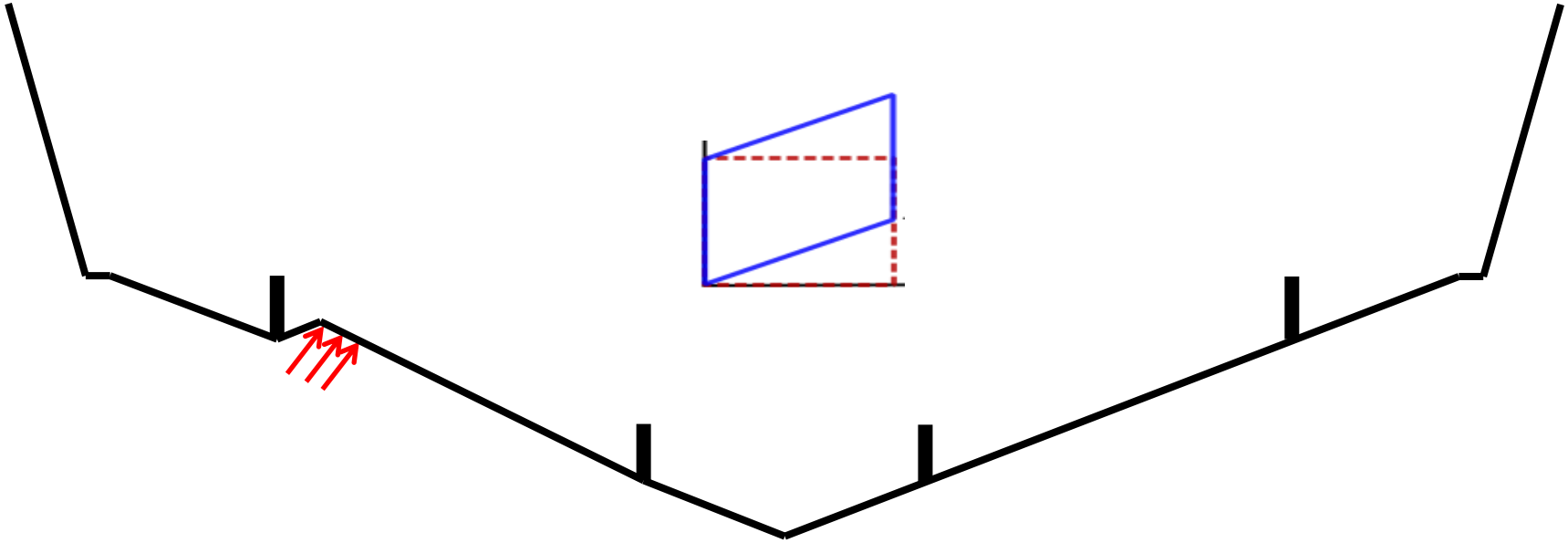
Slamming in the middle of a panel



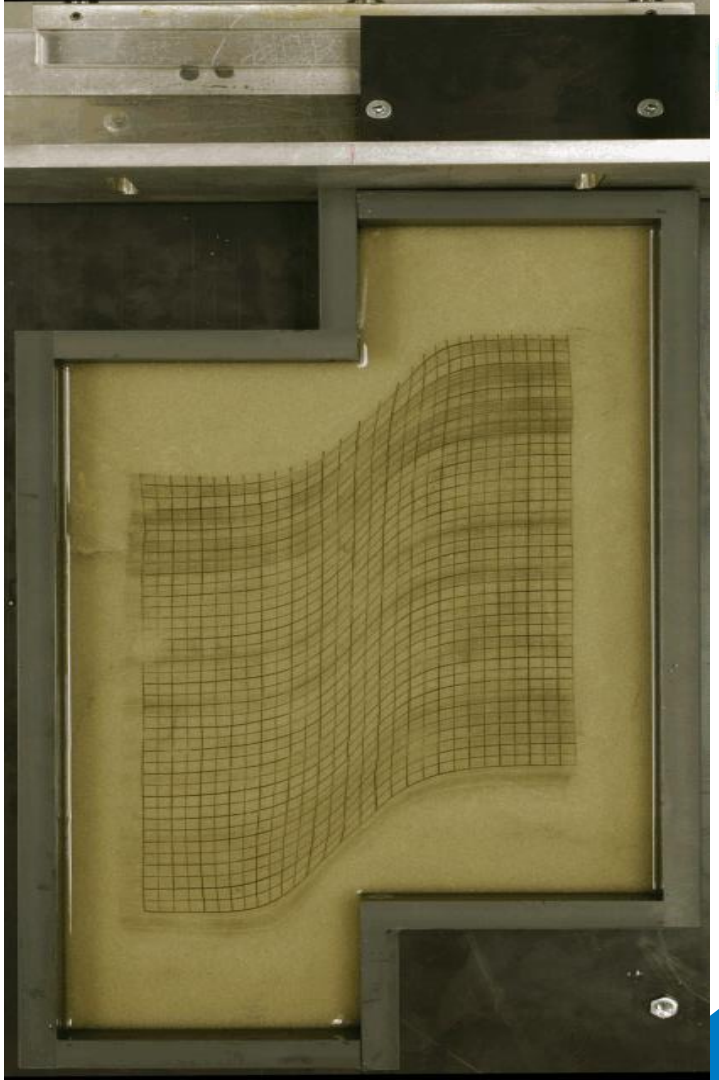
Slamming close to a support



Slamming close to a support



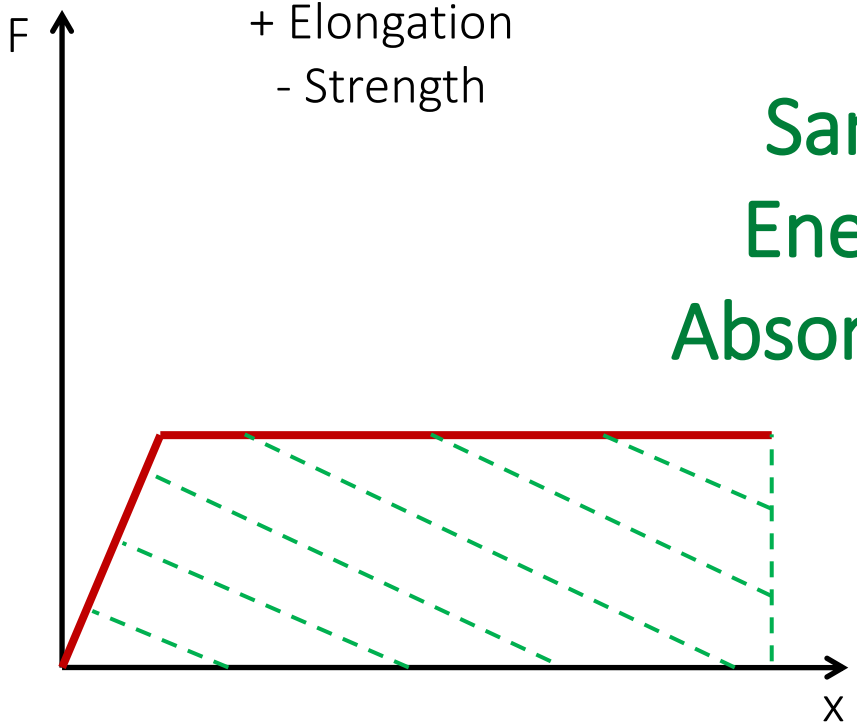
Energy absorbtion through Core Shear



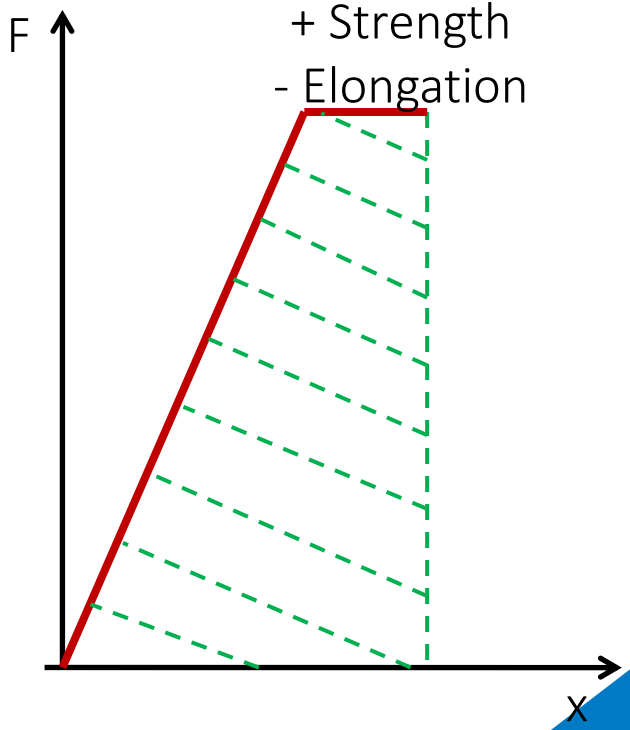
Design rules

- ISO 12215: lower safety factor for cores of elongation >35% everywhere
- GL: lower safety factor for cores of elongation >35% hull and wt bhds
- ABS: lower safety factor for cores of elongation >40% everywhere
- DNV: approval for slamming

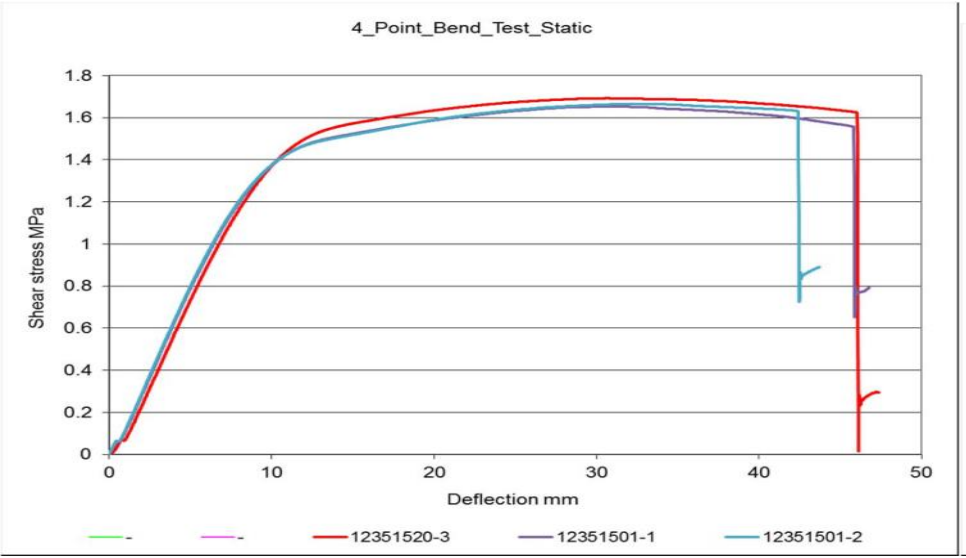
Do not confuse
Energy Absorbtion with Elongation

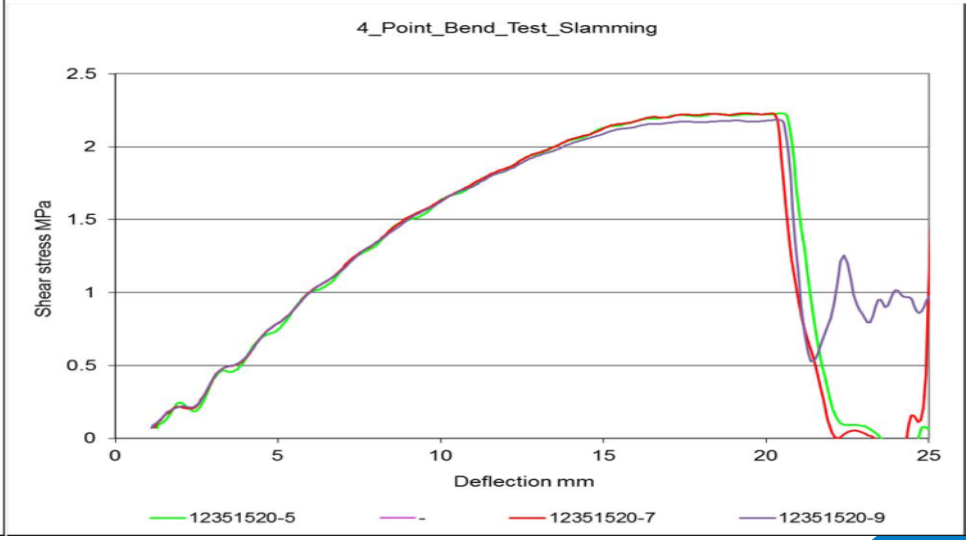


Same
Energy
Absorbtion



DNV Slamming Approval: Divinycell HM





DNV·GL

TYPE APPROVAL CERTIFICATE

Certificate No: **K-6252**
File No: **332.40**
Job Id: **262.1-018646-1**

This is to certify:

That the Sandwich Core Materials

with type designation(s)
Divinycell® HM; HM80, HM100, HM130

Issued to
DIAB AB
LAHOLM, Sweden

is found to comply with
Det Norske Veritas' Rules for Classification of High Speed, Light Craft and Naval Surface Craft
Det Norske Veritas' Type Approval Programme 1-501.10, 2009, Sandwich Core Materials
Det Norske Veritas Standards' for Certification No. 2.21, Craft, 2010
Det Norske Veritas' Standards for Certification No. 2.20, Lifeboats and Rescue Boats, 2007

Application :

For use in marine vessels according to stated Rules/Standard. The core material is approved for use in areas exposed to slamming and slamming fatigue.

This Certificate is valid until **2019-06-30**.
Issued at **Høvik** on **2015-04-27**

DNV GL local station: **Gothenburg**

Approval Engineer: **Gisle Hersvik**

for **DNV GL**

Martin Strande
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

Product description

Divinycell® HM: HM80, HM100 and HM130.

Core material for sandwich construction. A resilient, closed cell, foam sheet consisting of a polymeric alloy of a cross-linked aromatic polyurea and a linear vinyl polymer with dimensional stability at temperatures up to 100°C.

The manufacturer has given the following values;

Properties	Test Method	HM80	HM100	HM130		
Tensile strength	ASTM D1623	2,2	2,5	3,5	min.	MPa
Tensile modulus	ASTM D1623	80	105	135	min.	MPa
Compressive strength, 23°C	ASTM D1621	1,15	1,65	2,4	nom.	MPa
Compressive strength, 23°C	ASTM D1621	1,4	2,0	3,0	min.	MPa
Compressive modulus, 23°C	ASTM D1621-B-73	100	135	170	nom.	MPa
Compressive modulus, 23°C	ASTM D1621-B-73	80	115	145	min.	MPa
Shear strength	ASTM C273	1,15	1,6	2,2	nom.	MPa
Shear strength	ASTM C273	0,96	1,4	1,9	min.	MPa
Shear modulus	ASTM C273	27	35	50	nom.	MPa
Shear modulus	ASTM C273	22	28	40	min.	MPa

[2] Not tested to slamming and slamming fatigue requirements, however, please refer to DNV's Rules for Classification of High Speed, Light Craft and Naval Surface Craft (2013), Pt.3 Ch.4, Sec.5, A105.

Remarks:
The adhesive system used in the slamming tests is POLYLITE® 506-647 (a polyester resin)
Standards used for Type Testing are others than required in the Standards/Rules.

Application/Limitation

The core materials are approved for use in areas exposed to slamming and slamming fatigue.

Type Approval documentation
Tests carried out

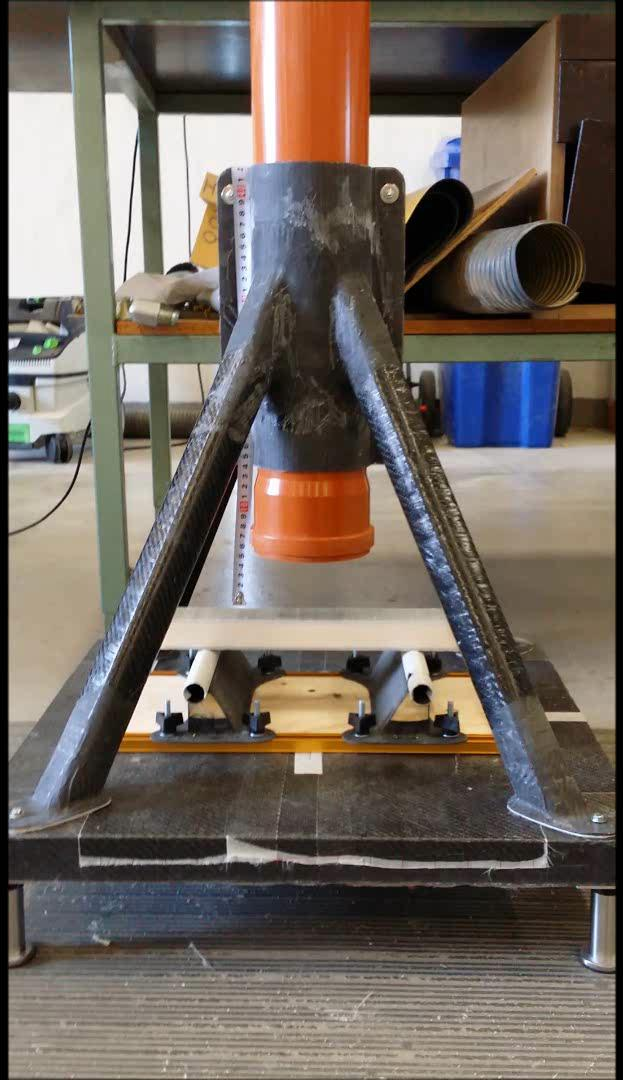
Type Testing carried out in accordance with **Type Approval documentation**, according to:
- DNV's Standard for Certification No. 1.9, Type Approval Programme no. 1-501.10, including the tests in accordance with DNV's Slamming and Slamming Fatigue Grade Requirements.

Marking of product

Product shall be marked with *manufacturer's name*: **DIAB AB, Laholm, Sweden** and *type designation*.

The marking is to be carried out in such a way that it is visible, legible and indelible. The marking of product is to enable traceability to the DNV GL Type Approval Certificate.

Periodical assessment



Questions?

valerio.corniani@au.diabgroup.com