MCEDD

DEEPWATER DEVELOPMENT

28 - 30 March 2023 | Millennium Gloucester Hotel | London, UK

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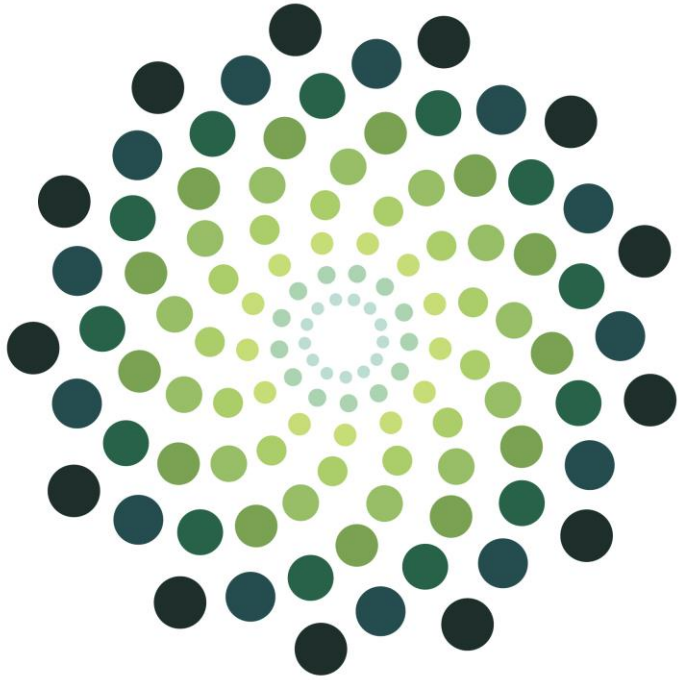


GRP – Material Qualification and its use as Modular Support for Pipeline

MCEDD – 30.03.2023

Jon Inge Brattekås, SVP Market & Technology

Agenda for MCEDD

- CSUB – a composite specialist EPC supplier
- What is a composite and how do we manufacture a composite structure?
- Qualification and testing of Composite Materials
- Some examples of Subsea Solutions
- Modular and Adjustable Pipeline Support solutions

Who is CSUB

Company key facts

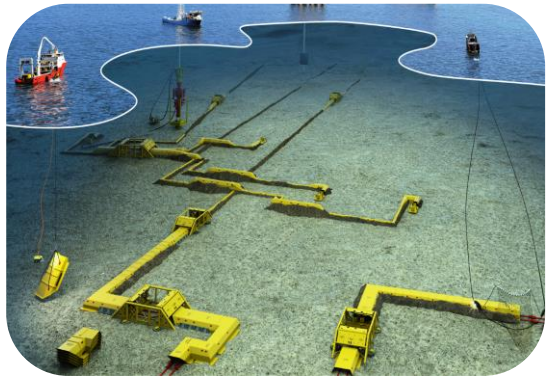
EPC supplier founded in 1995

250 employees

Certified since 2008

ISO 9001 = ISO 14001
ISO 45001

Based in Norway and Lithuania



Subsea Protection/Support

Aquaculture Tanks/Process

Renewable – Floating Solar

Civil – Bridges / Floating Swimming Pools

CSUB mission

We reduce cost and carbon footprints through better solutions in composite material

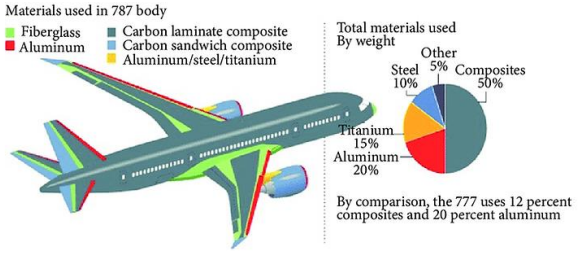
Client base

Our subsea clients

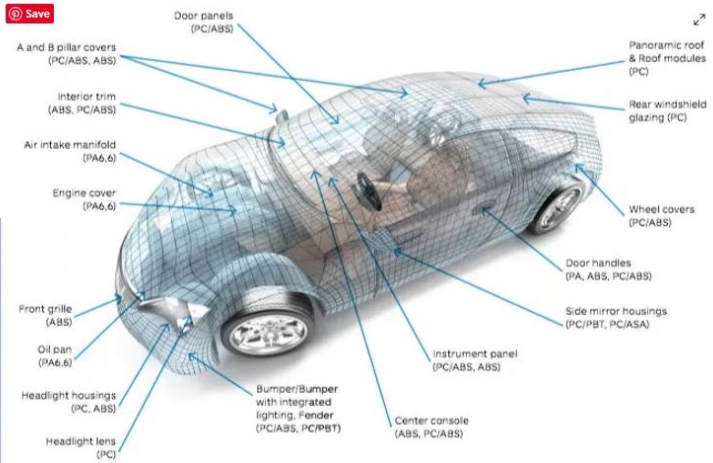
CSUB has delivered more than 10.000 GRP structures/parts to subsea applications since 1995

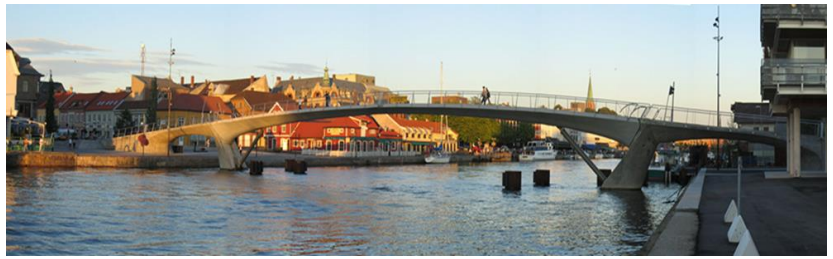
Todays use of composite materials

- Transportation
- Sports and recreation
- Pipe & Tank
- Marine
- Infrastructure



- Aerospace
- Architecture
- Automotive
- Energy Production

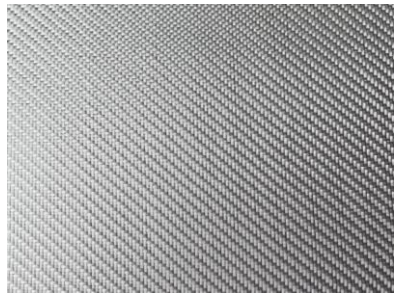




What is a composite?

Definition according to Encyclopedia Britannica

Composite material a solid material that results when **two or more different substances**, each with its own characteristics, are combined to create a new substance whose properties are superior to those of the original components.



Fiber

+

Polyester

=

CSUB uses primarily GRP – Glass fiber Reinforced Polyester (note - Polymer)

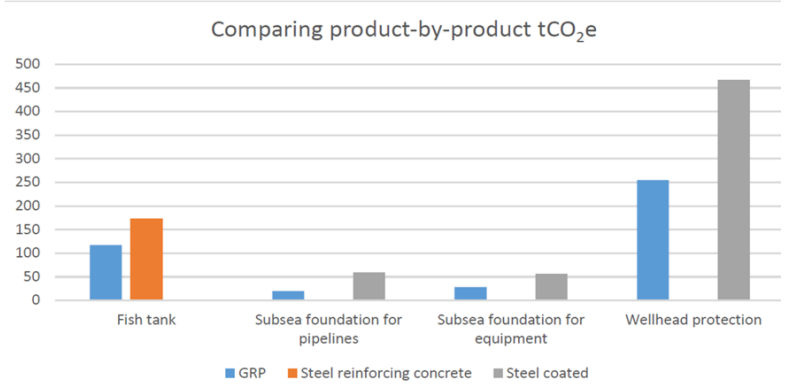
Key characteristics:

- **Strength as steel**
- **Lower E modulus than steel**
- **No corrosion**

Composite Material – Benefits – Why use it

Carbon Footprint

- Reduced Carbon Footprint
- Approx 50% CO2 footprint compared to steel, mainly due to lower weight.

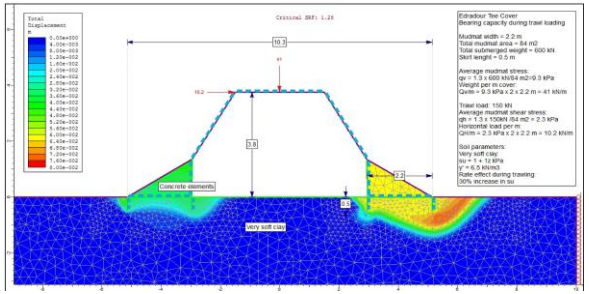


Stackability

- Reduced campaigns
- Reduce freight cost
- Deployment

Low Weight

- Normally 1/3 of steel
- Reduced vessel crane requirement
- Less impact on soil



Other Advantages

- Design Life >50 yrs
- Low life of field cost – no maintenance
- Short delivery time as raw materials are normally on stock
- Cost savings – normally competitive cost compared to steel solutions + cost saving for transport and installation

Material Qualification

DNV-ST-C501 – Composite “bible”
Been in use since 2003

DNV-RP-B302 Effects on Mechanical Properties of Polymers and Composite Materials. New Recommended Practice to determine design life of Composite Materials.

Each manufacturer needs to build their database with test results for each combination of fiber and resin from each supplier

Standards for loads and load input is given from NORSOK U-001 standards or ISO Standard 13628

Composite Material - Testing

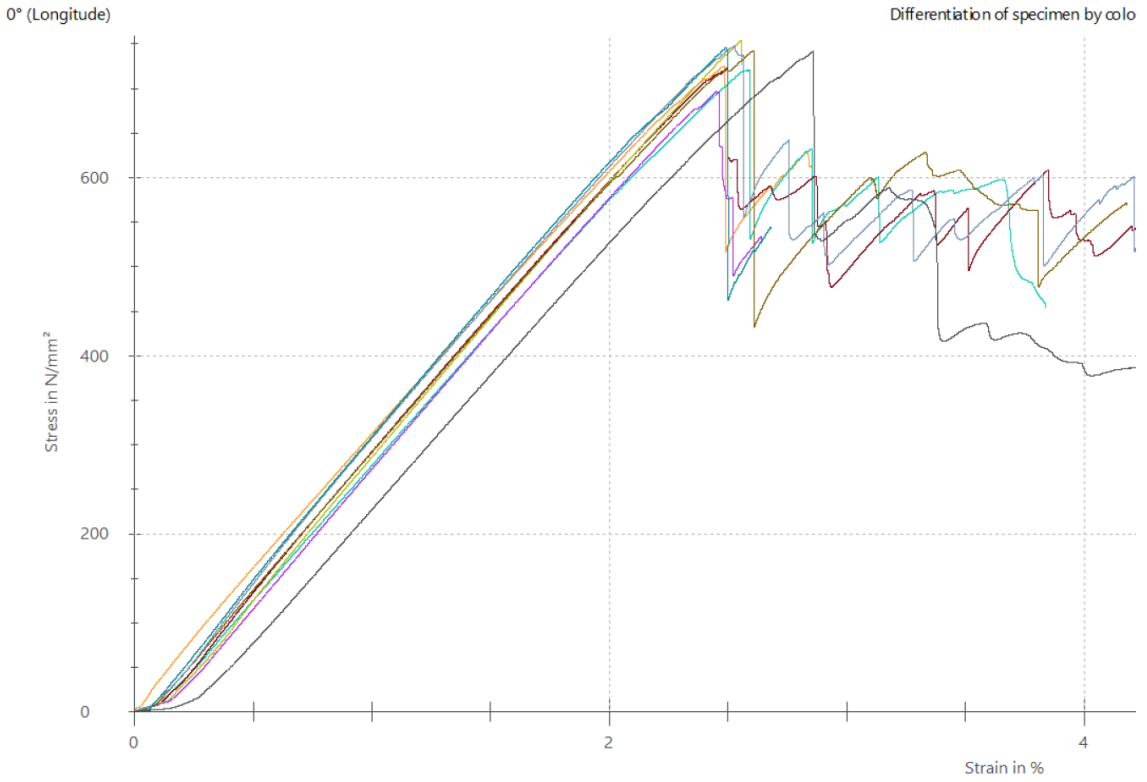
Component testing

Type of test	Results	Test standard	Valid test results	Specimen size [mm]*	Laminate lay-up
Tensile E-modulus and strength, longitudinal	EX, XT	ASTM D3039, ISO 527	15	250x25x5	A
Tensile E-modulus and strength, transverse	EY, YT	ASTM D3039, ISO 527	15	250x25x5	A
Compressive strength, longitudinal	XC	ASTM D6641, ISO 14126	15	140x25x7.5	B
Compressive strength, transverse	YC	ASTM D6641, ISO 14126	15	140x25x7.5	B
In-plane shear modulus	GXY, (SXY)	ASTM D3518, ISO 14129	15	250x25x5	C
In-plane shear strength	SXY	ASTM D7078	15	(76x56x5)	C
Interlaminar shear strength	ILSS	ASTM D2344, ISO 14130	15	30x10x5***	A
Fibre fraction, weight ratio	W_f	ASTM D2584	3	25x25x5	A
Density	P	ASTM D792	3	25x25x5	A
The following tests are only required when specified:					
Impact strength, longitudinal	[kJ/m²]	ISO 179-1	5	80x10x4	A**
Impact strength, transverse	[kJ/m²]	ISO 179-1	5	80x10x4	A**
Water absorption		ISO 62	3		A
Microscopic characterisation of voids		Check and calculate void fraction. Characteristic photo of cross-section.	3	Grind and polish cross-section	B

Testing of composite materials according to recognized standards as shown in table above.
Results of testing used as basis for structural analysis according to DNV-ST-C501 standard

Composite Material - Testing

Figure 9 Compressive strength - transverse



Composite Material – Long Term Testing

Testing performed according to:
DNV-RP-B302 Effects on Mechanical Properties of Polymers and Composite Materials.

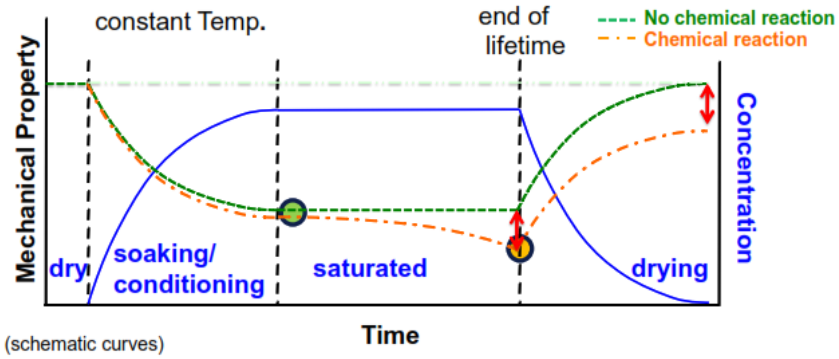


Figure 2-1: Schematic showing the change of a mechanical property with time due to saturating of the material with a fluid and chemical reaction with the material.

Figure showing principle of testing of laminates to determine evt degradation and assess design life.

Main goal of test is to determine:

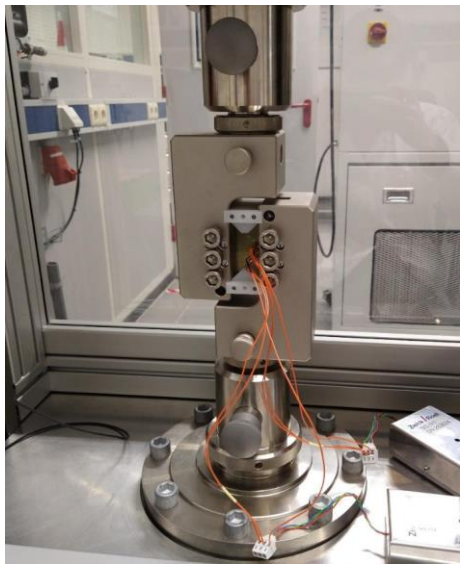
1. Drop in Mechanical Properties with saturation.
2. Mechanical Properties return to original value after drying.
3. If drop in dried value, chemical degradation is present.

Composite Material – Long Term Testing - summary

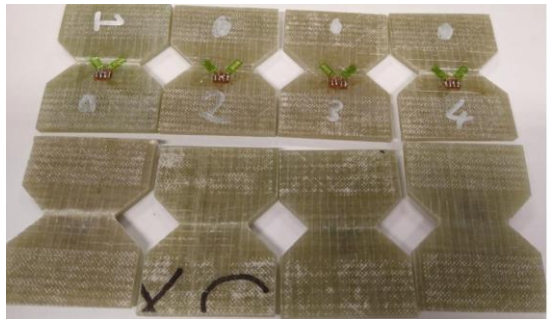
	Dry	Wet	Dried
E-Module	39452	39524	40205
Tension	900	900	900
InterLaminar Shear Strength	42,5	41,58	42,34
In-plane Shear	71,06	66,96	72,57

All values in MPa

All values are equal or higher after saturation and drying. No chemical degradation present



Example of In-Plane shear test – butterfly test



DNV

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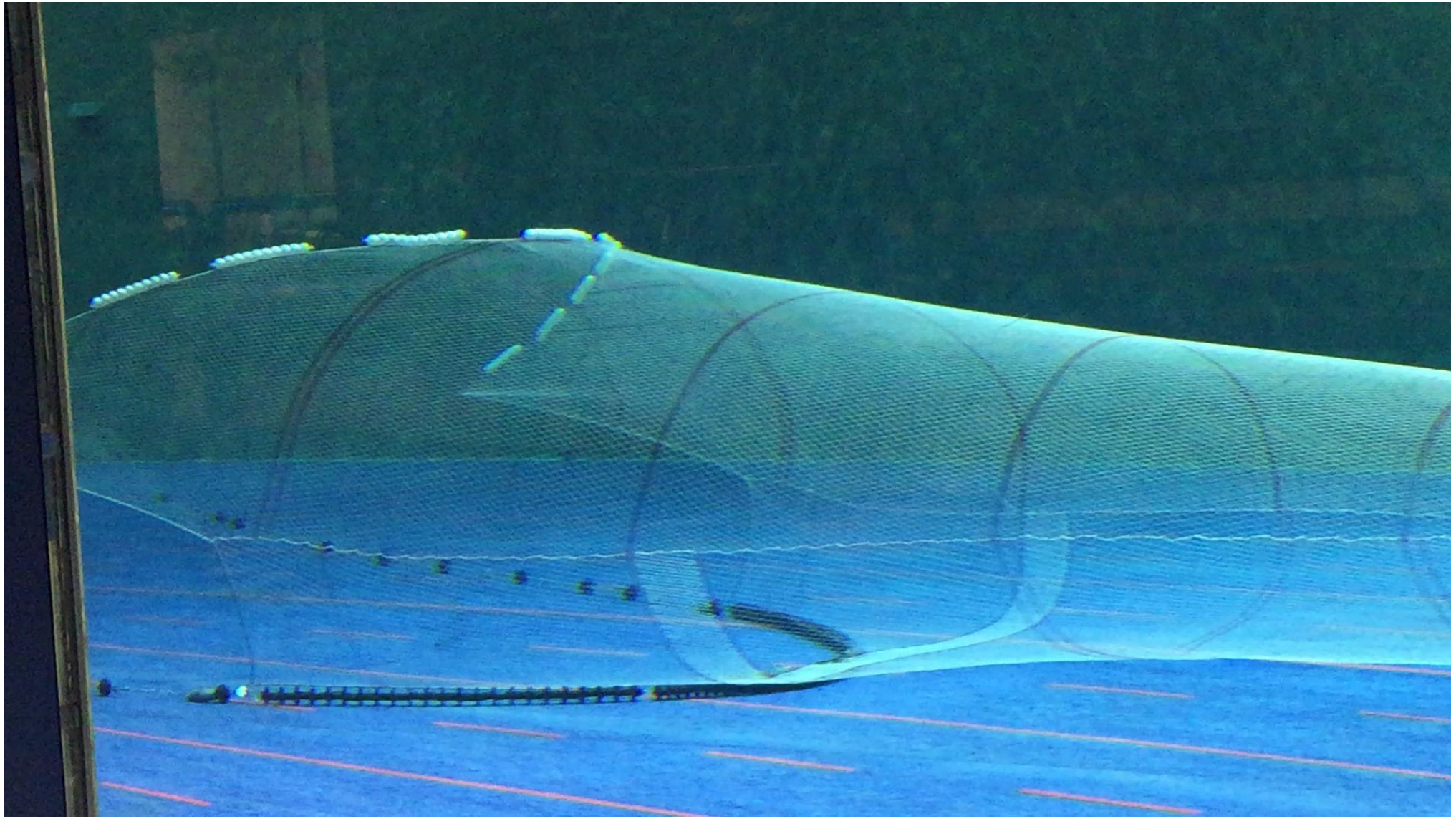
Date: 2022-11-014 **Our reference**: 1735230 **Your reference**: Email from CSUB dated of 2022-02-02

Letter of Endorsement

CSUB AS has provided glass-fibre-reinforced-plastic (GFRP) composite products and solutions for the oil & gas and renewable industries for about two decades. Over the years, DNV has been involved in several of the CSUB engineering projects, where verifications of the material properties, structural design, production as well as production inspection were essential. Through this work, CSUB products and solutions have demonstrated to be based on durable materials, reliable designs, production quality, in line with best industry practices and compliant with international standards, such as the DNV-ST-C501 on Composite Components.

Regarding GRFP composite materials, DNV's experience and opinion is that GFRP of recognised quality is proven to not be harmful to marine environment, has very low degradation rate in seawater and is proven for use in offshore applications.

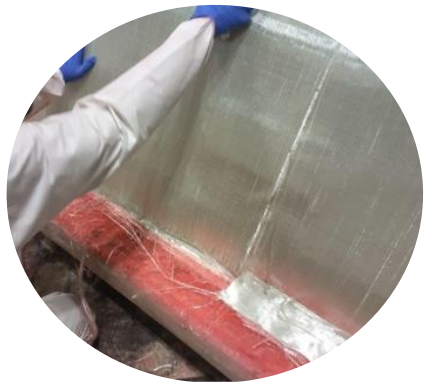
Trawlability



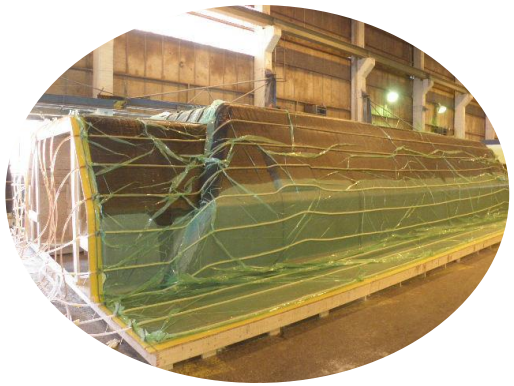
Functional testing

Vacuum Injection Manufacturing process

Mould construction



Fiber lay up



Injection of resin

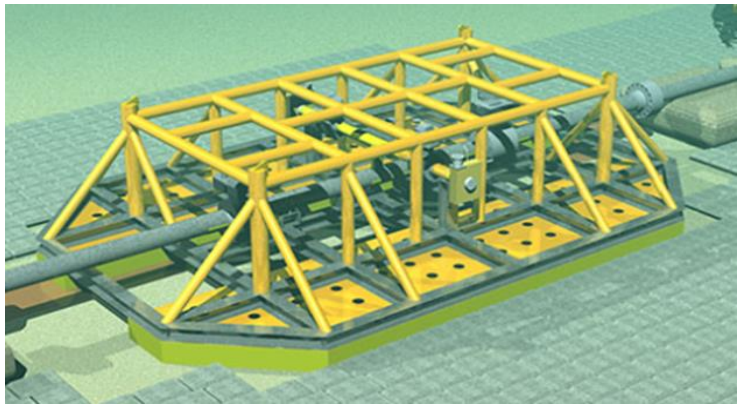
Finishing work (cutting and coating)

Factory Acceptance test

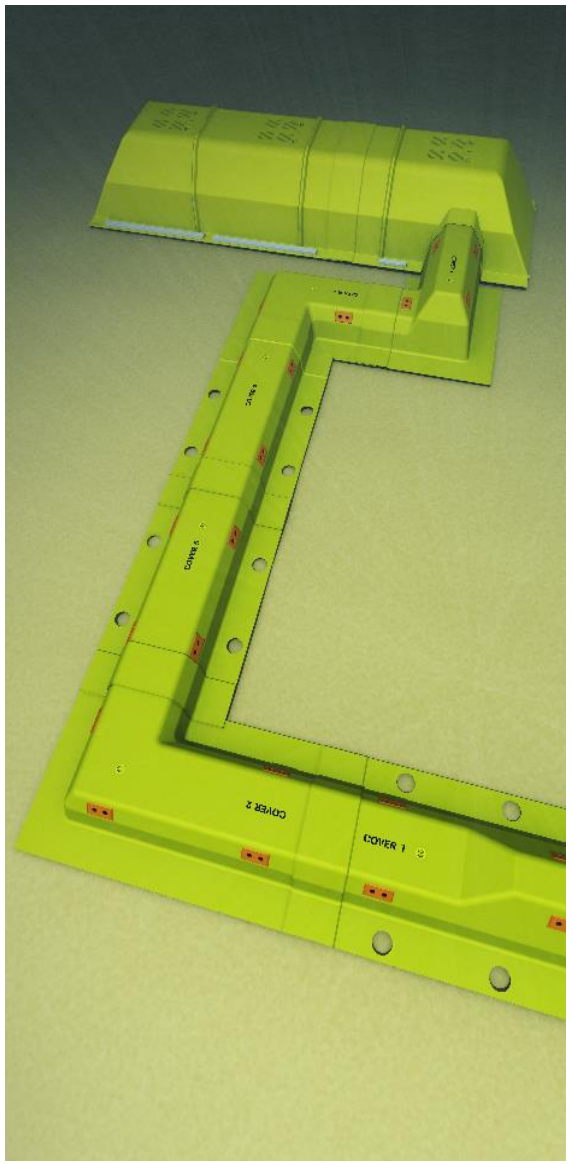
Simple covers: 3 days mould construction and 2 days production
Large complex structures: 2-3 weeks mould construction and 2-3 weeks production

Large Protection Structures

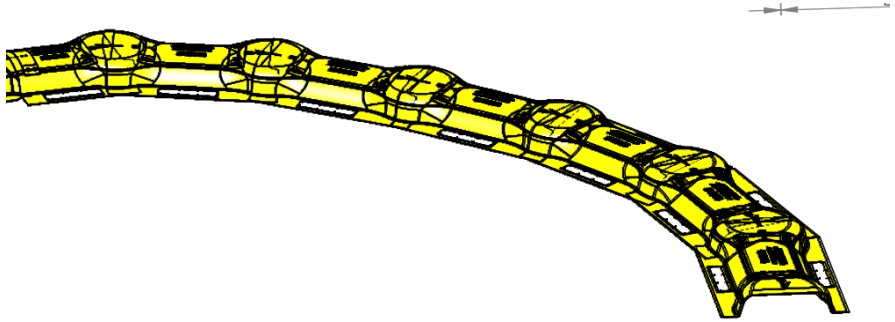
Wellhead Protection, PLEM/PLET/ILT protection

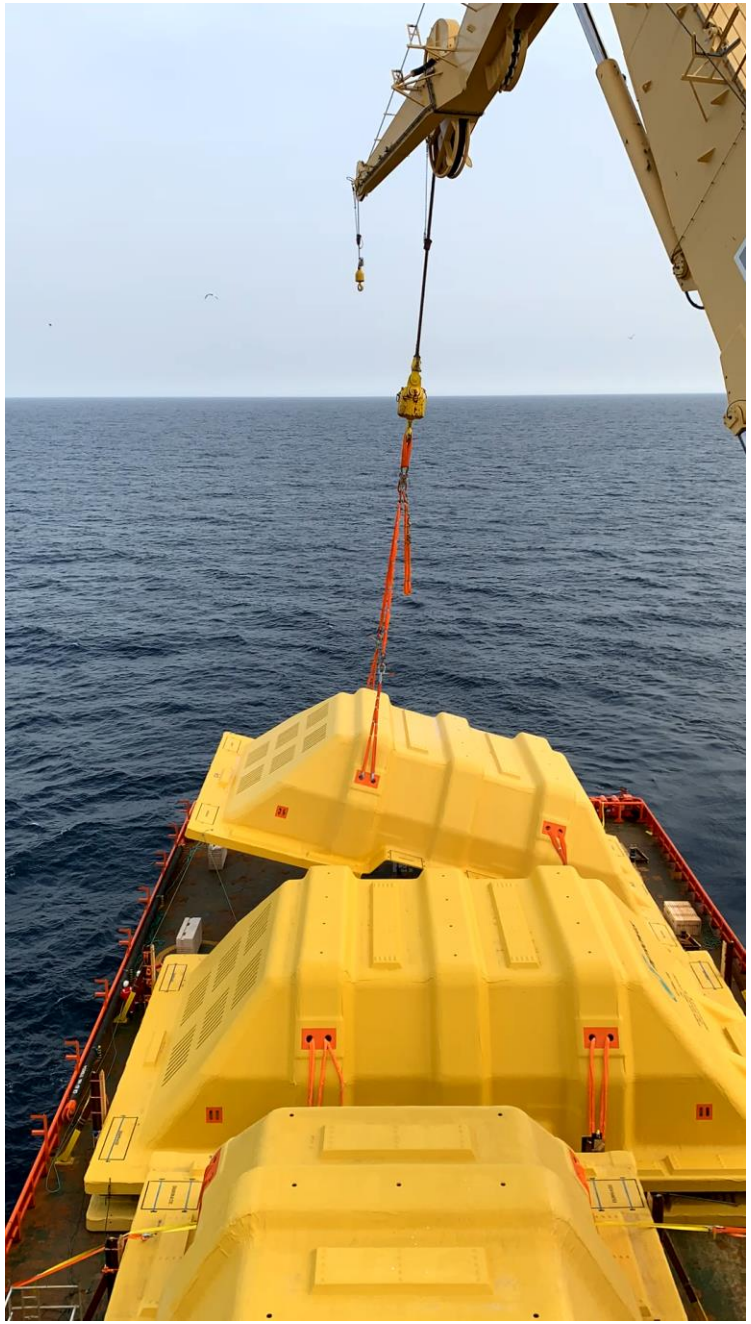


Protection structures – pipelines and equipment



For Freespan protection to touchdown of expansion areas





Protection structures

Abandoned well structures beeing installed at Chinguetti field by Oceaninstaller for Petronas winter 2023. Lifetime – 50 yrs++++

Subsea Pipeline Solutions

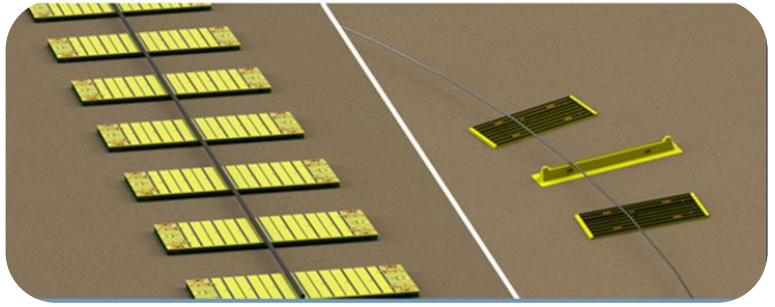



Cable/Flexible crossings

Rigid Pipe Crossing

Pipe Support


Pipeline Mattresses



Buckling Initiator

Case – Modular Adjustable Pipeline Support

The solution

A **modular** concept based on GRP material

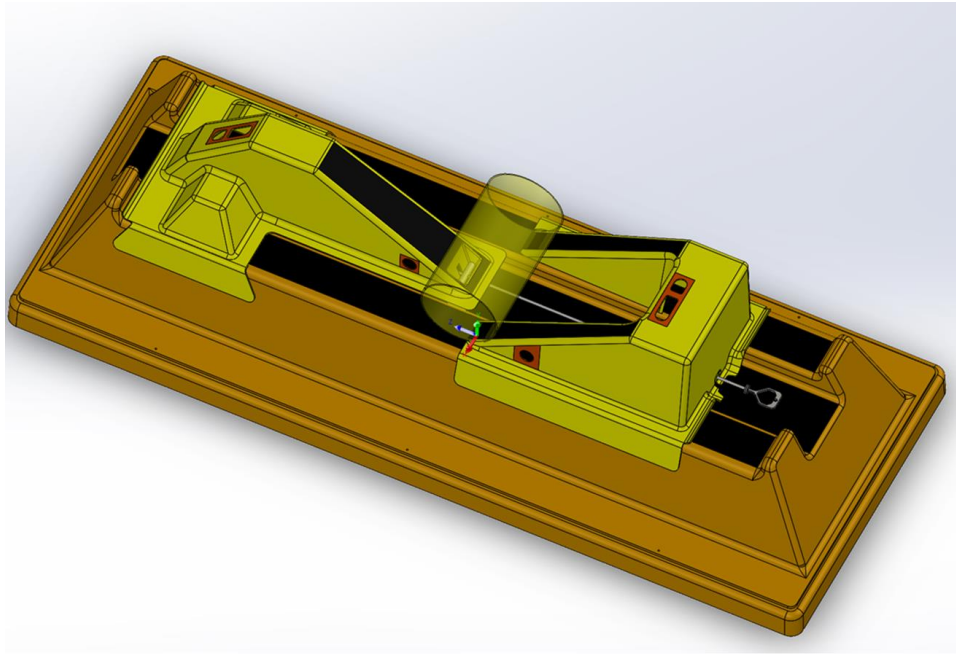
Base support with slidable wedges to allow for adjustable height

Insert can be included for additional height adjustments

Low weight of support ease the installation and allow for sliding underneath existing pipeline

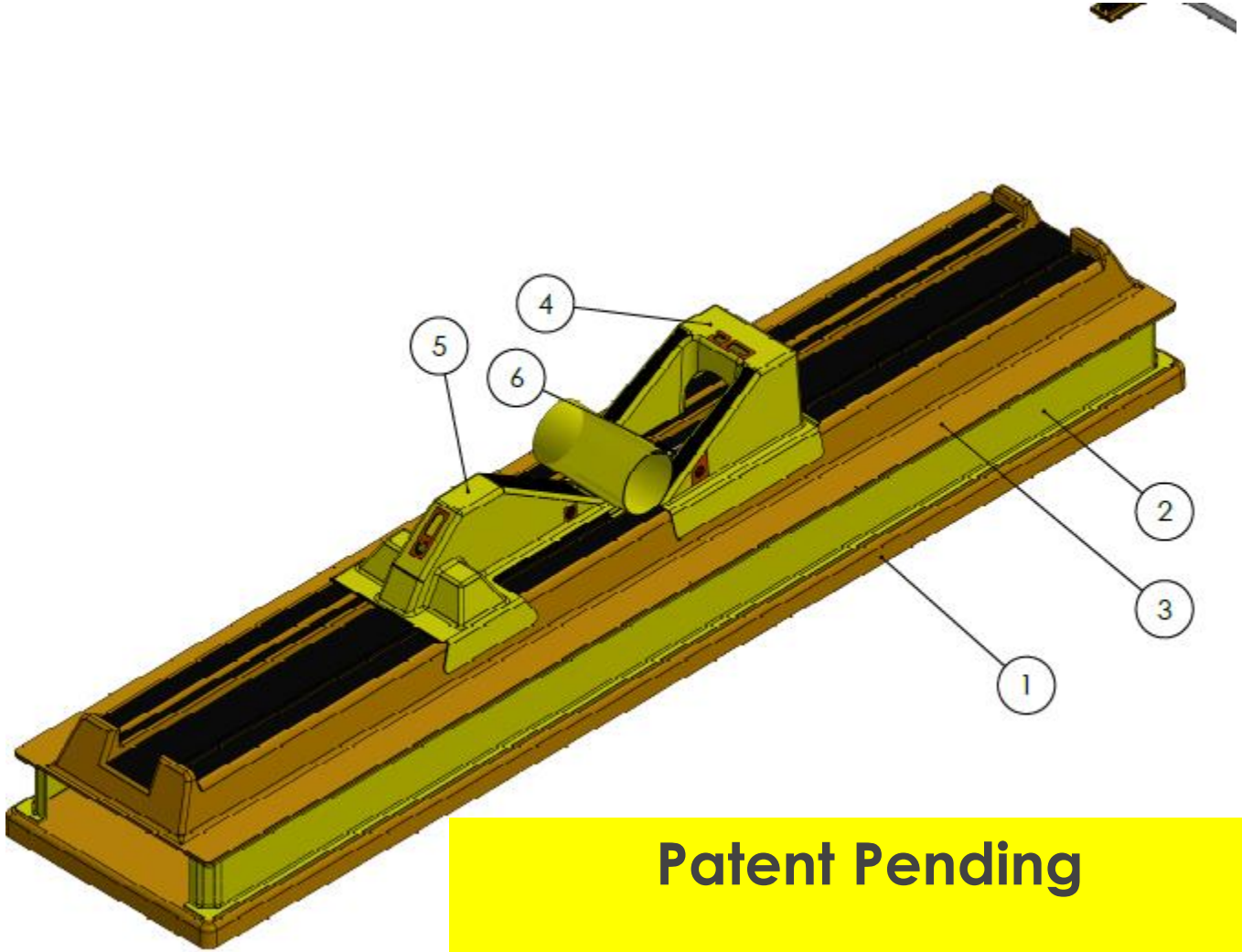
Low weight of wedges allow for **ROV/diver to push** until contact with pipeline is achieved. Then secured with tightening device.

No requirement for corrosion protection



To be used for crossings and freespan supports

Modular Adjustable Pipeline Support



Patent Pending

Modular solution

- **Foundation (1)**
- **Extension (2)**
- **Base Structure (3)**
- **Wedges for height adjustment**

This Pipeline support can handle various height as a modular systems - LEGO principle

Modular Adjustable Pipeline Support as Freespan correction

- Pipeline can have undesirable free span after installation due to seabed unevenness, scouring during operation or other reasons.
- Uncertain exact height between pipeline and soil is a challenge
- Pipeline need to be supported to avoid ViV or max freespan length is exceeded
- Support solution shall be durable over time

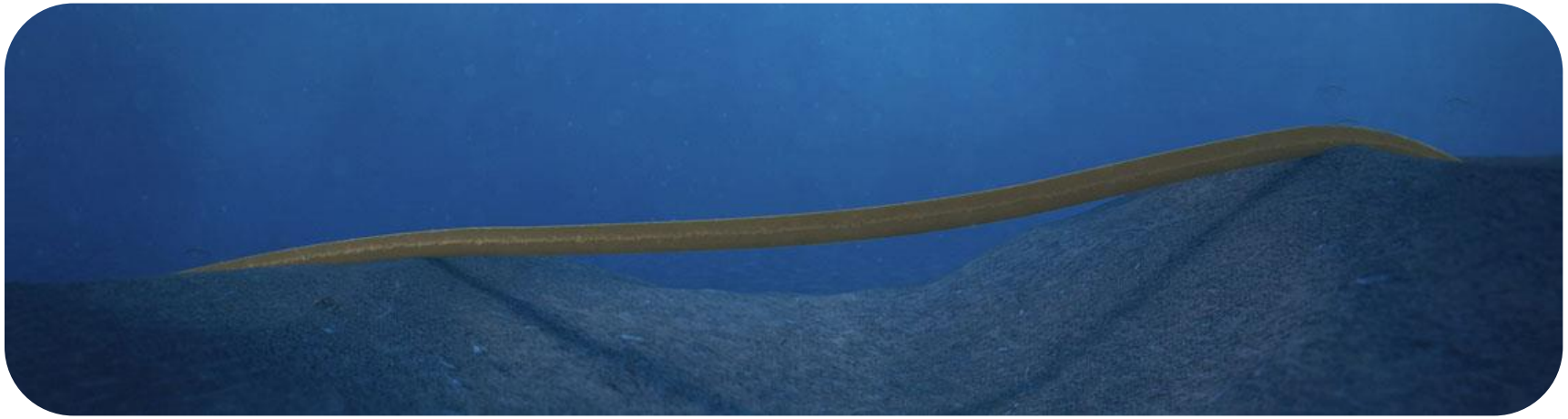
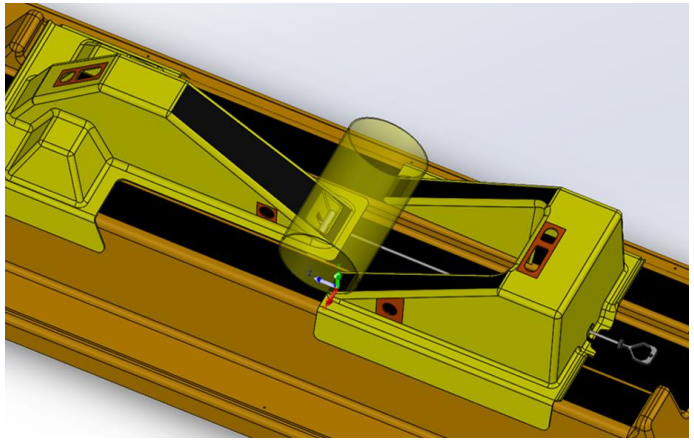


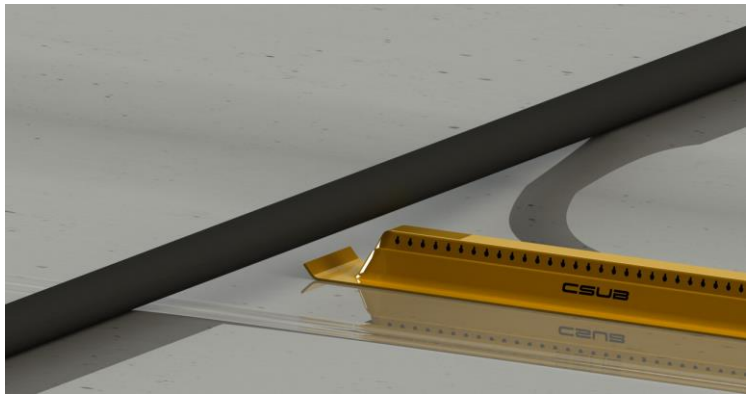
Image courtesy of DNV

Modular Adjustable Pipeline Support as Freespan correction

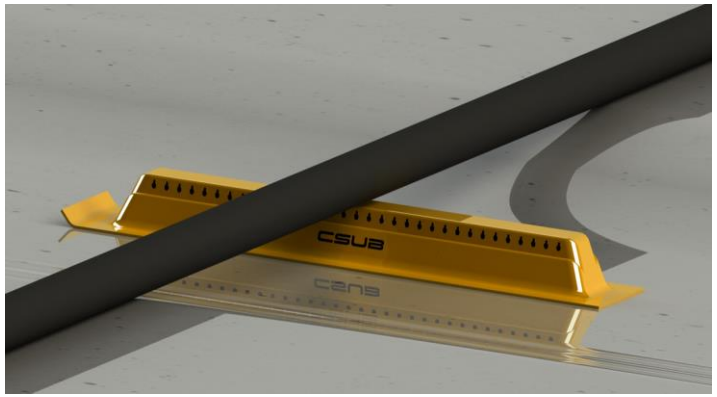
- Can be adjusted in height at vessel prior to deployment using Extension part to match freespan height
- Can be installed without lifting the pipeline
- Tightening device operated by ROV or diver



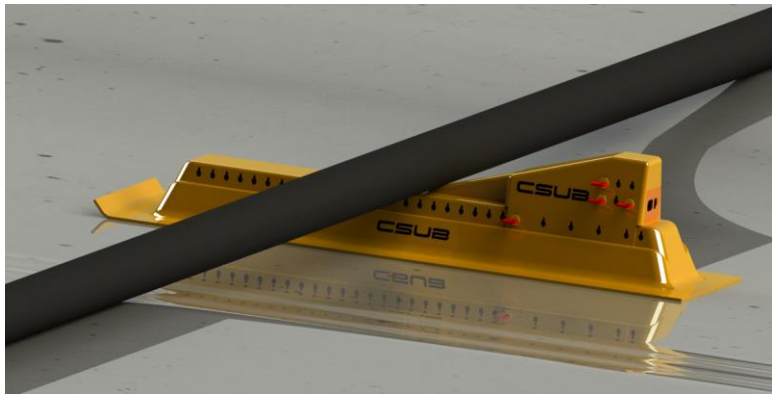
Case - Freespan correction supports



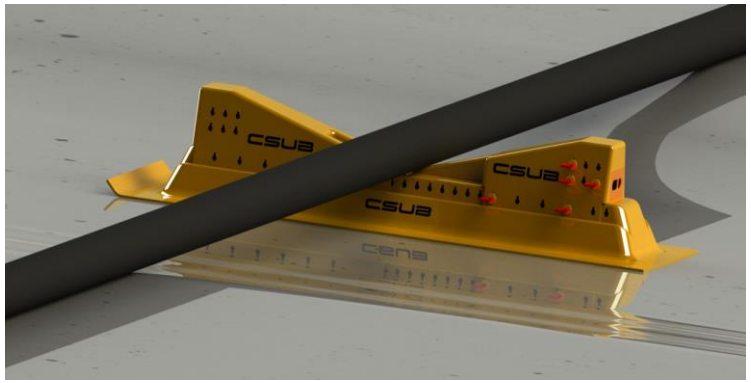
Step 1:
Prepare for sliding



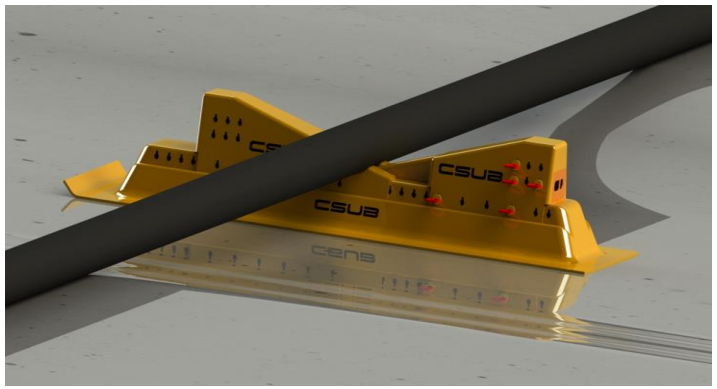
Step 2:
Slide under main support



Step 3:
Install wedge 1



Step 4:
Install wedge 2

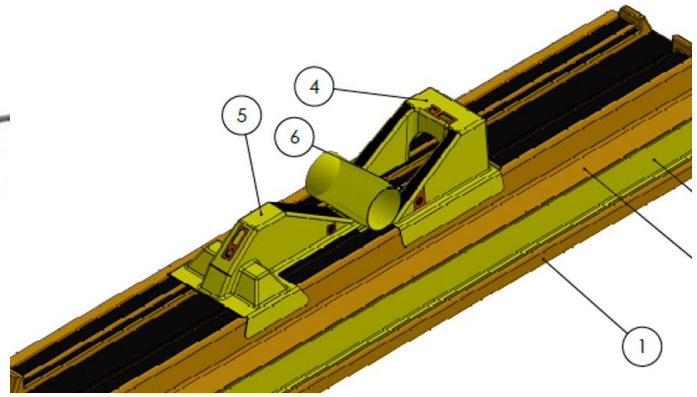


Step 5:
Lock and tighten wedges

Installation completed

Modular Adjustable Pipeline Support as Rigid Pipeline Crossing

- Rigid pipeline crossings can be challenging
  - Support heights vary
  - Several designs need to be engineered and fabricated.
- Uneven seabed, contact for all supports might not be obtained.
- Support Height
  - Lowest support – use Foundation and Base structure
  - For higher supports – add add extension
  - Fine adjustment after installation if pipe Insert
- PEHD material on top of wedges/between wedge and base structure ensure low friction and high wear and tear resistance.
- Wedges/pipe can move sideways to allow for lateral movement due to thermal expansion of pipeline



Status of CSUB Modular Pipeline Support system

- First prototype fabricated and tested
- Improved prototype under fabrication, to be tested in April
- Ready for market before summer 2023

Thank you for your attention ☺

Questions?

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