

2nd Tdyn RamSeries Training Session

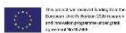


Time	Content
9:45h	Reception of the session attendees
10:00h	Beginning of the session
	Tdyn RamSeries Advanced Tools
11:00h	Coffe <i>break</i>
11:15h	Tdyn RamSeries applied case 1
12:30h	Tdyn RamSeries applied case 2
13:30	Questions and comments
13:45h	End of session

- ✓ Composite and laminate materials within Tdyn library:
 - Generation/management.
 - Importing/exporting materials' database.
- ✓ Specific numerical tools implemented in Fibre4Yards: Custom connection modelling
- ✓ Definition of directional local axes over complex geometries.
- ✓ FEA Non-Linear Dynamic Analysis applied to vessels.
- ✓ Fatigue Damage Assessment on composites and laminate materials:
 - Brief description of theory.
 - Brief description of methodology.

Composite materials in Tdyn RamSeries

COMPASS
www.compassis.com



Analysis

Simulation dimension: 3D

Analysis type: Static Analysis

Material constitutive model: Linear materials

Geometric constitutive model: Linear geometry

Boundary conditions: Linear boundary cond.

Use Laminate/Composite materials

Internal triangular element: Drill-Rot

Marine tools

Fatigue damage assessment

SN curves file: ./problemtypes/comj

Beam P-Delta

Linearized prebuckling analysis

element types

Element types

Beams

Shells

Solids

Cables

Membranes

- Materials and properties
 - Beams
 - Shells
 - Custom properties
 - Physical properties
 - Steel
 - Concrete
 - Solid
 - Plasticity
 - Orthotropic**
 - Generic
 - IM6_Carb_Epoxy
 - E_Glass_Epoxy_Ortho
 - M_Carb_Poly
 - Aramid_Poly
 - FRP reinforcement
 - FRP matrix
 - Composite layer
 - Laminate**
 - sample_laminate_Serial_Parallel
 - sample_laminate_Heterogeneous
 - sample_laminate_Classic
 - Custom stiffness

- ✓ Based on Class Societies rules.
- ✓ Rule of Mixtures theory.
- ✓ Allows to customize the properties of the layers, and create laminates.



Composite laminate

Laminate definition

Laminate name: sample_laminate_Classic

Constitutive model: Classic

Material: E_Glass_Epoxy_Ortho

Sequence: 1 [45,-45]s

Number of layers: 2 Fiber angle: 0 deg

Thickness: 0.0 m

Previously defined laminates

Existing laminates: sample_laminate_Serial_Parallel

Total laminate thickness

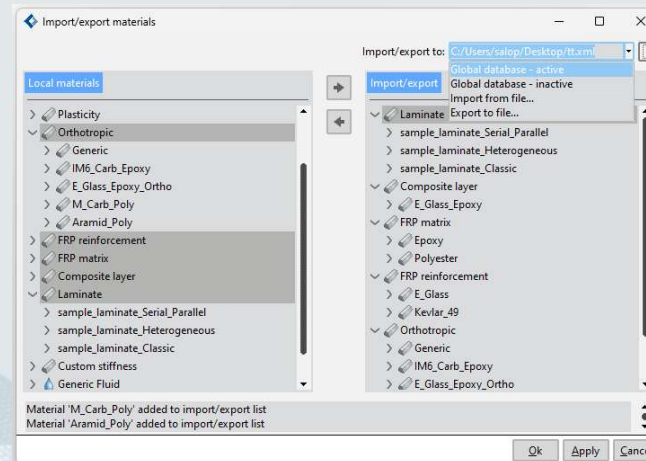
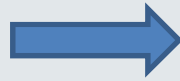
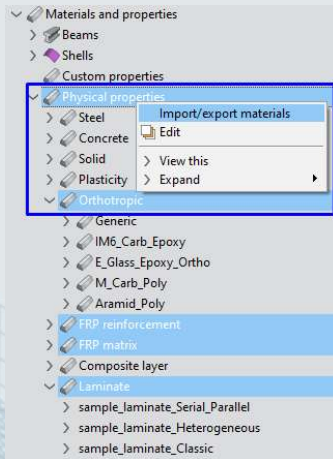
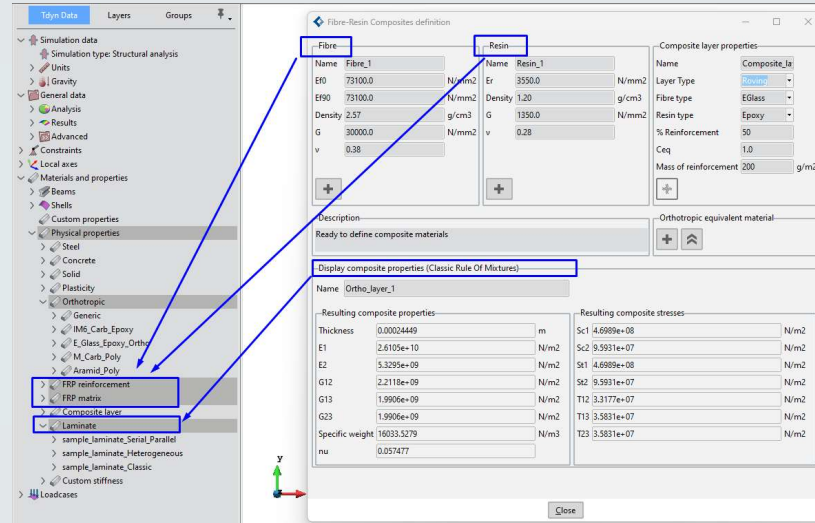
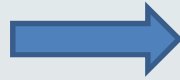
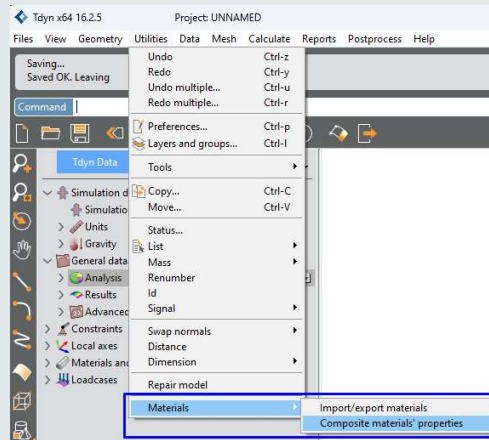
Total thickness: 0.0020874 m

Laminate composition

Material	Angle	Thickness	Layers
E_Gla...	0	0.0004576	2
IM6...	45	0.0005861	2

Visual description

Ok Cancel



Create function for A

Function variables

Matrix value for A

Matrix value for A

A _{1,1} :	0.3	A _{1,2} :	0.0	A _{1,3} :	0.0
A _{2,1} :	0.0	A _{2,2} :	0.3	A _{2,3} :	0.0
A _{3,1} :	0.0	A _{3,2} :	0.0	A _{3,3} :	0.3

Ok Cancel

Create function for B

Function variables

Matrix value for B

Matrix value for B

B _{1,1} :	0.3	B _{1,2} :	0.0	B _{1,3} :	0.0
B _{2,1} :	0.0	B _{2,2} :	0.3	B _{2,3} :	0.0
B _{3,1} :	0.0	B _{3,2} :	0.0	B _{3,3} :	0.3

Ok Cancel

Create function for B

Function variables

Matrix value for B

Matrix value for B

B _{1,1} :	0.3	B _{1,2} :	0.0	B _{1,3} :	0.0
B _{2,1} :	0.0	B _{2,2} :	0.3	B _{2,3} :	0.0
B _{3,1} :	0.0	B _{3,2} :	0.0	B _{3,3} :	0.3

Ok Cancel

Create function for D

Function variables

Matrix value for D

Matrix value for D

D _{1,1} :	0.3	D _{1,2} :	0.0	D _{1,3} :	0.0
D _{2,1} :	0.0	D _{2,2} :	0.3	D _{2,3} :	0.0
D _{3,1} :	0.0	D _{3,2} :	0.0	D _{3,3} :	0.3

Ok Cancel

Create function for H

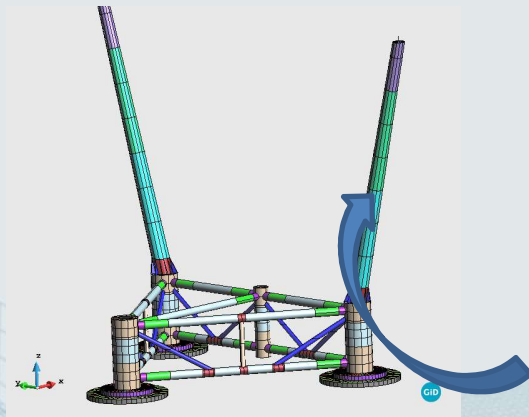
Function variables

Matrix value for H

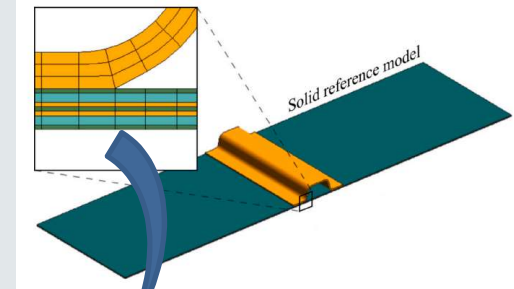
Matrix value for H

H _{1,1} :	0.3	H _{1,2} :	0.0
H _{2,1} :	0.0	H _{2,2} :	0.3

Ok Cancel



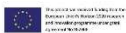
$$\begin{bmatrix} A & B & 0 \\ B & D & 0 \\ 0 & 0 & H \end{bmatrix}$$



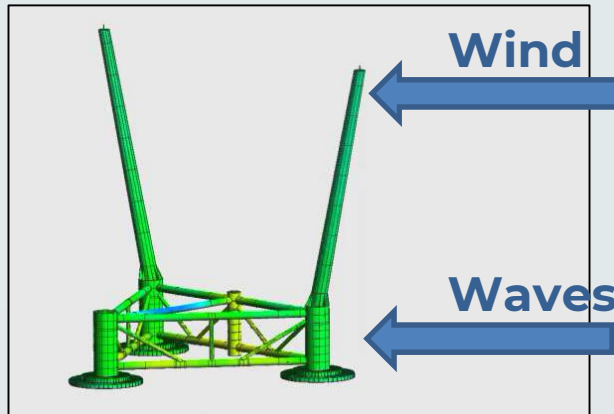
F. Turon, F. Otero, X. Martinez. "Multi-scale procedure for the mechanical analysis of composite laminate structures considering mixed boundary conditions". Composite Structures. Vol 322, 15 October 2023. 117343.

Fatigue Damage Assessment for composite and laminate materials

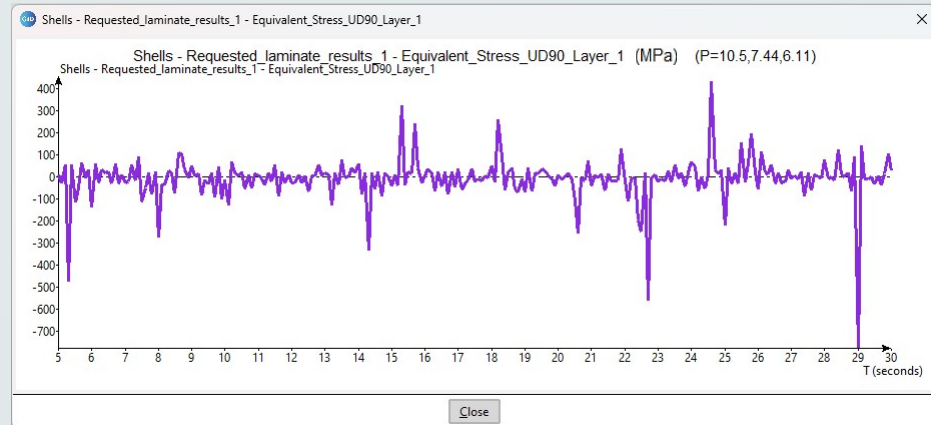
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Step 1: Dynamic analysis: time domain



Step 2: Obtaining stress history



Step 3: Rainflow counting



Step 4: Computing damage

$$d = \sum_{h=1}^M \sum_{m=1}^R \frac{n_{h,m}}{N_{h,m}} \cdot \left[\frac{t_h^{tot}}{t_h^{sim}} \right] \cdot DFF \leq 1$$

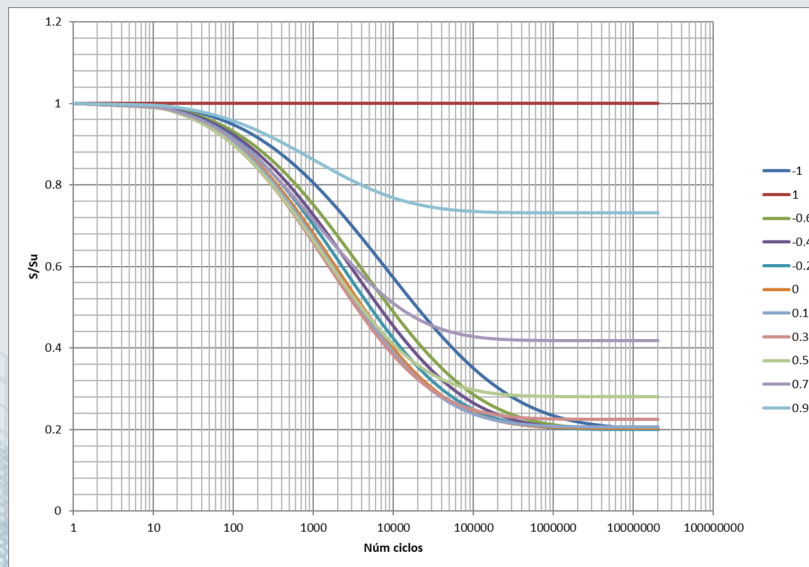
Failure criteria - Equivalent stress

(Based on anisotropic mapping)

$$(\sigma - N)_{UD90} \equiv (\sigma - N)_{matrix} \longrightarrow \sigma_{UD90} \equiv \sigma_{eq} = \sqrt{\sigma_2^2 + (f_{12} \cdot \sigma_{12})^2}$$

S-N fatigue life curves

$$S_{(R, N_{cycles})} = S_{th(R)} + (S_u - S_{th(R)}) * \exp(-ALFAT_{(R)} * \log_{10}(N_{cycles})^{BETAF})$$



$$R = \frac{\sigma_{min}}{\sigma_{max}}$$

General data

- Analysis
 - Simulation dimension: 3D
 - Element types
 - Analysis type: **Dynamic Analysis**
 - Material constitutive model: **Linear materials**
 - Geometric constitutive model: **Non-Linear geometry**
 - Boundary conditions: Linear boundary conds.
 - Use Laminate/Composite materials: 1
 - Internal triangular element: Drill-Rot
 - Marine tools: 0
 - Fatigue damage assessment: 0
 - SN curves file:
 - Beam P-Delta: 0
 - Initial Configuration: 0
 - Non-Linear analysis data**
 - General
 - Solver control: Load control
 - Conv. tolerance: 0.01
 - Iteration type: Full Newton-Raphson
 - Max iterations: 10
 - Dynamic analysis data**
 - General
 - Type: Direct integration
 - Δt : f(Interpolation fun...)
 - Number of steps: 100
 - Integration method
 - Integration method: Implicit (Energy Conserving/De
 - Alpha E-C/D (α): 0.1
 - Initial conditions: None
 - Damping Data
 - Damping type: Rayleigh damping
 - Damping ratio: 0.05
 - αM : f(Interpolation fun...)
 - αK : 0.003

LOADS

Loadcases menu:

- Combined LC
- Self_weight
- ballast
- main_engine
- water_jets
- hydrost
- dyn_press_TdynCFD
- batteries
- generator
- zodiac
- FO
- grey_water
- crew
- tender

CONSTRAINTS

Constraints menu:

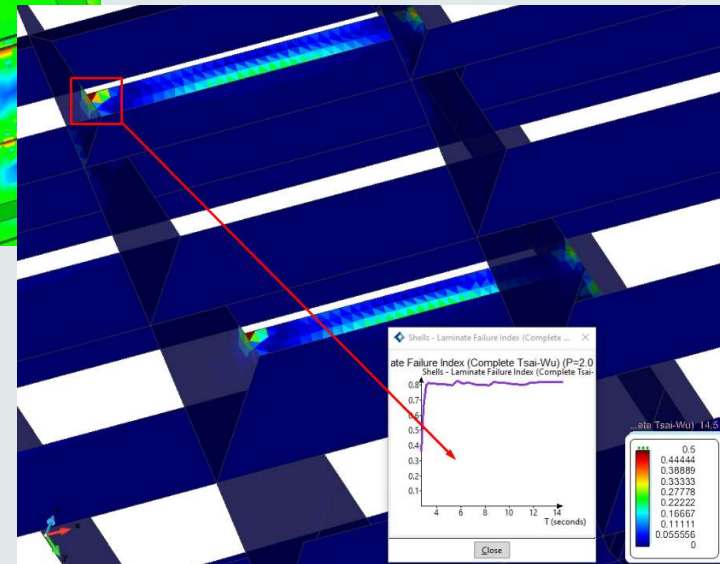
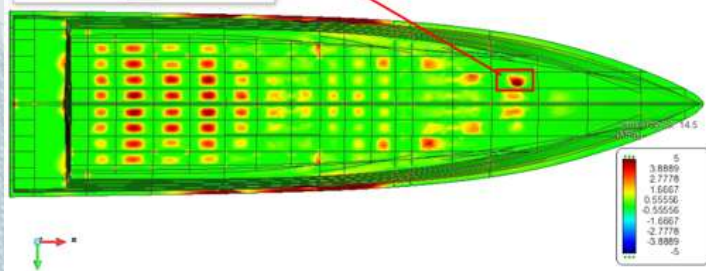
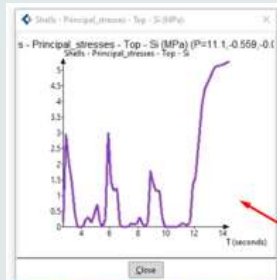
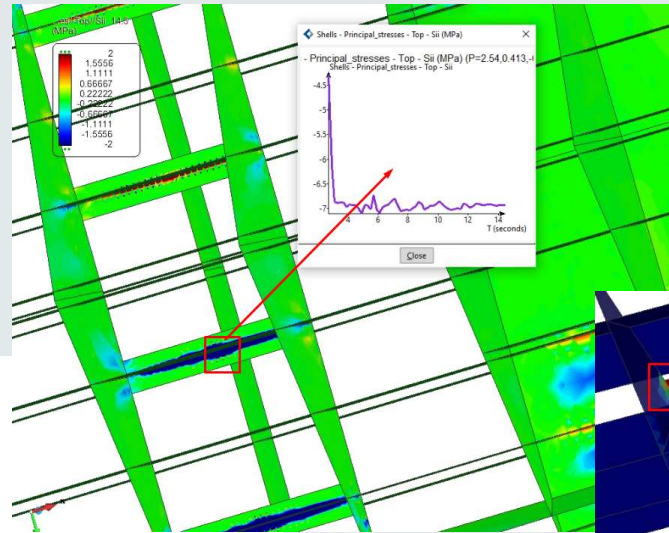
- Fixed constraints
 - group: fix_anchorships
 - Activation
 - Constraint 1
 - Constraint 1
 - Constraint 0
 - Constraint 0
 - Constraint 0
 - Constraint 0
 - local area: 0
 - Values

MATERIALS

Material Properties:

- Material: PFCFR0_type
- Constitutive model: Elastic
- Material: PFCFR0_type
- Sequence: 1
- Number of layers: 2
- Thickness: 0.000000
- Fiber angle: 90 deg

RESULTS





Shaping Tomorrow with
Advanced Simulation
Engineering

Thank You!

