DYNAMIC STRUCTURAL ANALYSIS OF A LARGE-DIA. RISER CONSISTING OF LAMINATED COMPOSITE MATERIAL WITH A HYBRID NUMERICAL SCHEME

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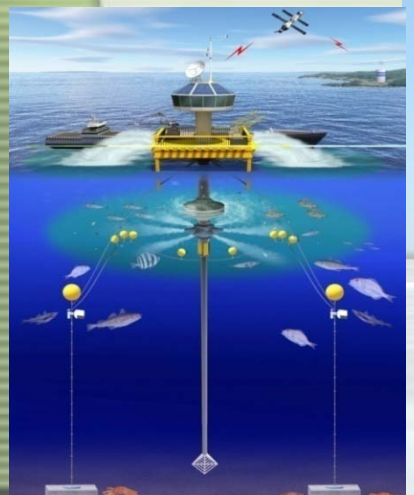
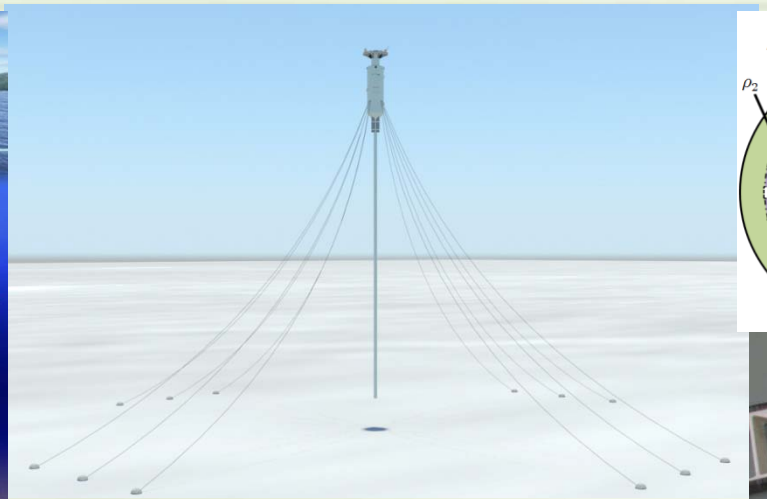
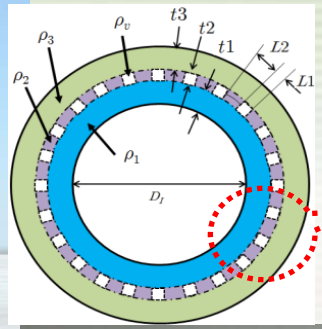
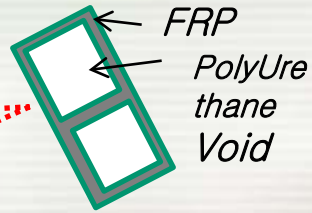
INTRODUCTION

- **OTEC with Large diameter riser**
  - **Needs a large amount of chilling seawater to surface**
  - **Riser with 10m of diameter in commercial scale**









Characteristics of a large diameter riser

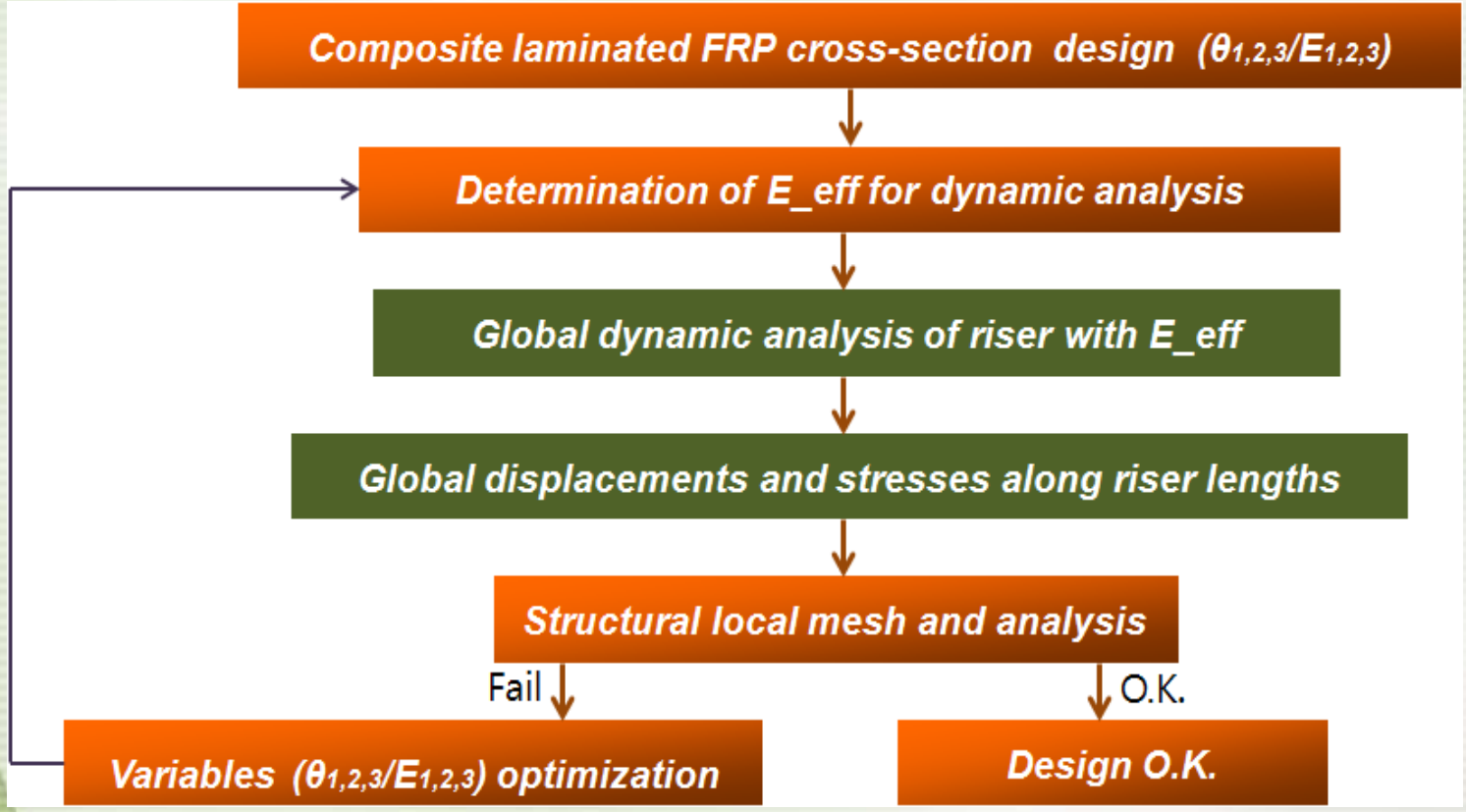
- **Large diameter riser for OTEC in commercial**
  - **Thick and fiber composite with various laminate**
  - **Different elastic and shear modulus according to fiber orientation**
  - **Non-linear or non uniform stress distribution along its thickness**
- **Assessment of the safety of a fiber-composite large diameter riser**
  - **Local static structural as well as global dynamic analysis should be performed**

In this study

- **Development of numerical analysis method to assess the safety of a large diameter riser in laminated-composite**
  - **New method to solve global dynamic behavior equation in combination with the local static structural equation**

Numerical analysis

General procedure to analyze riser behavior, including local structural analysis



Results and discussion

Case study

➢ General description

▪ **To assess the safety of a laminated composite riser subjected to harsh ocean environmental load and surface platform motion.**

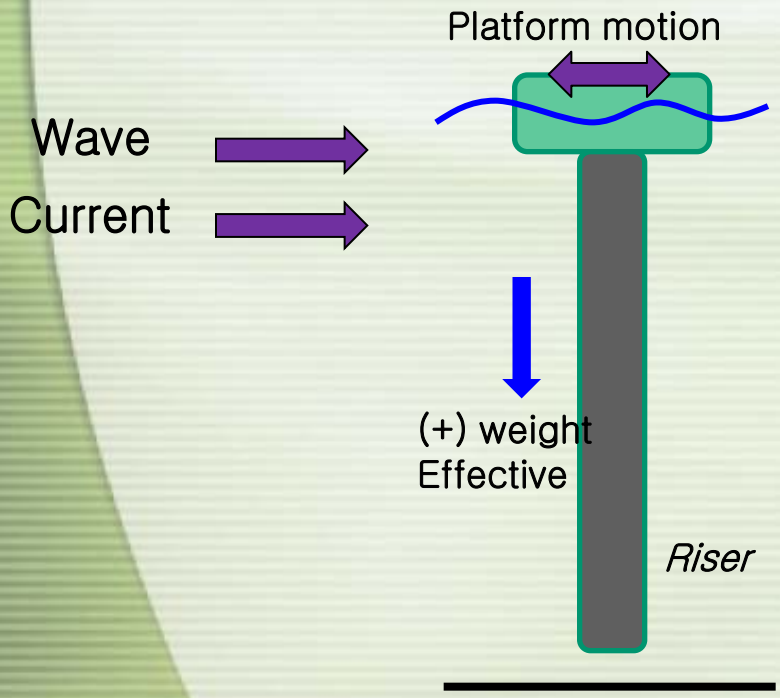


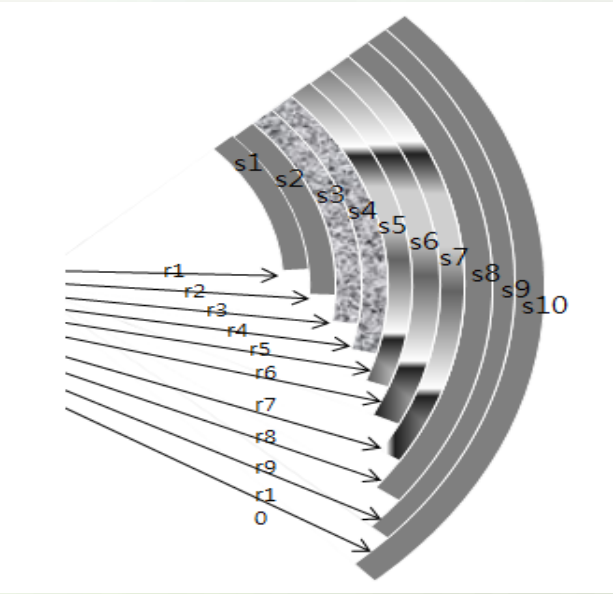
Table 3 Basic data of riser model

Outer diameter of riser, m	10.2
Thickness, m	0.1
Water depth	1,100
Allowable stress, MPa	180
Wave period, s	15
Wave height, m	10
Current at surface, m/s	1.0
Top tension, MN	16.5

➢ Cross-section property

- 4 layers with 10 laminates
- 0.1m of thickness, 0.01 m of laminate thickne
- 3 kinds of material ; fiber and soft epoxy

Laminate No. (s)	E1	E2	G12	v12	v13	Fiber orie.	Allowable str.(MP)
S1,2	3.4e9	2.7e8	2.7e8	0.45	0.29	45	1E2
S3,4	1e7	1e7	1.1e5	0.3	0.3	0	5E0
S5,6,7	7e11	7e8	1.1e7	0.25	0.25	0	3E2
S8,9,10	3.4e9	2.7e8	2.7e8	0.45	0.29	45	1E2



➢ Eigenvalue analysis

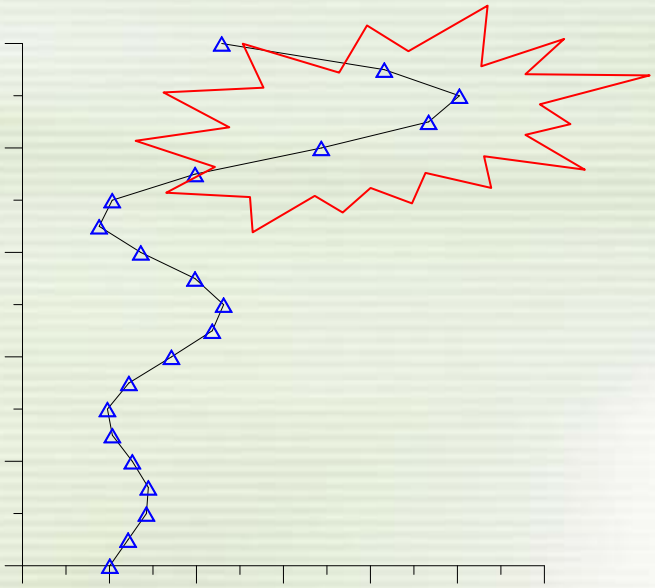
- 1st to 5th natural periods deviates from high energy regions of ocean wave
- Good characteristics in dynamics

Mode No.	Natural period (s)
1	394.8529
2	147.5126
3	69.6100
4	39.2429
5	24.8616
6	17.0476
7	12.3759
8	9.3786
9	7.3490
10	5.9154

Result for global dynamic analysis

➢ Distribution of combined stresses along riser length

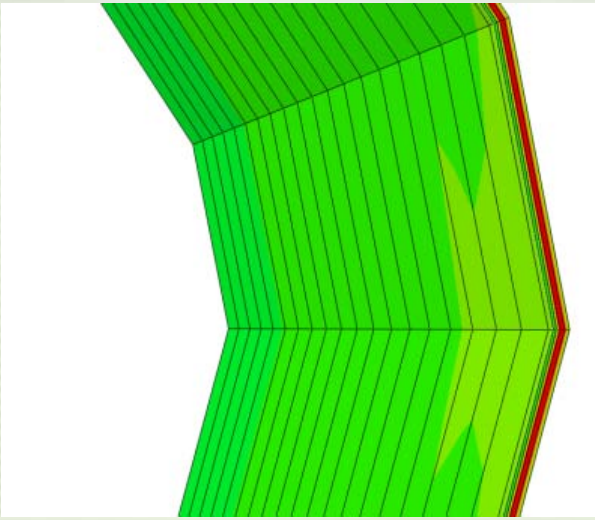
- Larger combined stress near top of a riser
- High wave region near the sea surface and top excitation
- Zero stress at the bottom end of a riser

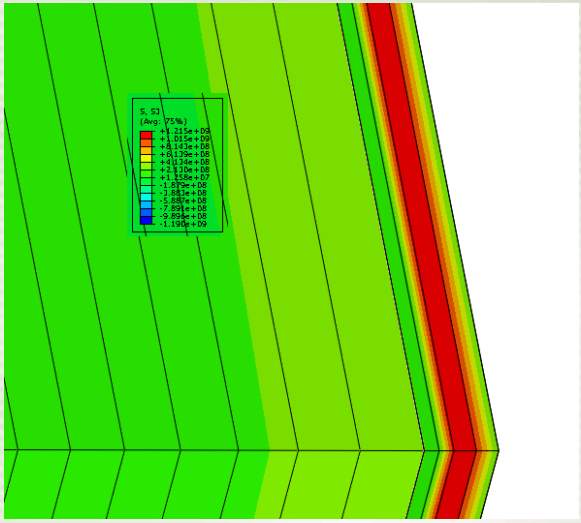


Result for local structural analysis

➢ Stresses contours on the laminates

- **Red color on middle laminates : larger stress bet. Inner and outer laminates**
- **The results of a laminated composite riser do not follow the general pattern**





Result for local structural analysis

➢ Stress distribution on all laminates

- The largest stress on laminate 7 with the largest elastic stiffness
- Larger stress for outer laminate owing to the longer distance
- The smallest stress on laminate 4 with the smallest elastic stiffness

Conclusions

- A hybrid numerical scheme was developed to investigate the safety of a large-diameter riser made of a laminated composite material.
- It is found that the local structural analysis on laminates as well as global dynamic analysis on a composite riser are require to certify safety
- The developed hybrid numerical tool can contribute to structural safety verification for large-diameter risers composed of laminated composites.