2015 **SIMULIA** Regional User Meeting **Korea**

Seoul Intercontinental COEX Hotel

October 23rd , 2015

Simulation powers Innovation

Key Simulation Analysis for Composite Materials

2015/10/23
김선영 과장

3DEXPERIENCE®

복합재란?

- ▶ 두 가지 이상의 재료가 조합되어 물리적 혹은 화학적으로 서로 다른 상을 형성하면서 보다 유효한 기능을 발현하는 재료
  - ▷ 모재/기지재 (Matrix)
  - ▷ 보강재 (Reinforcement)/충전재 (Filler)

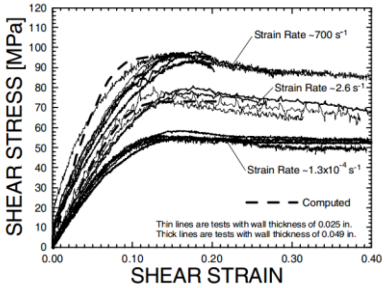
Matrix

Reinforcement/Filler

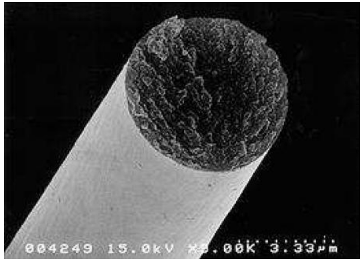
Composite

복합재의 구성 요소

- ▶ **모재/기지재 (Matrix)**
  - ▷ 상대적으로 낮은 강성
  - ▷ 연성 재료
  - ▷ 등방성 물질
  - ▷ 비선형 특성
  - ▷ 시간 의존적 물성 특성

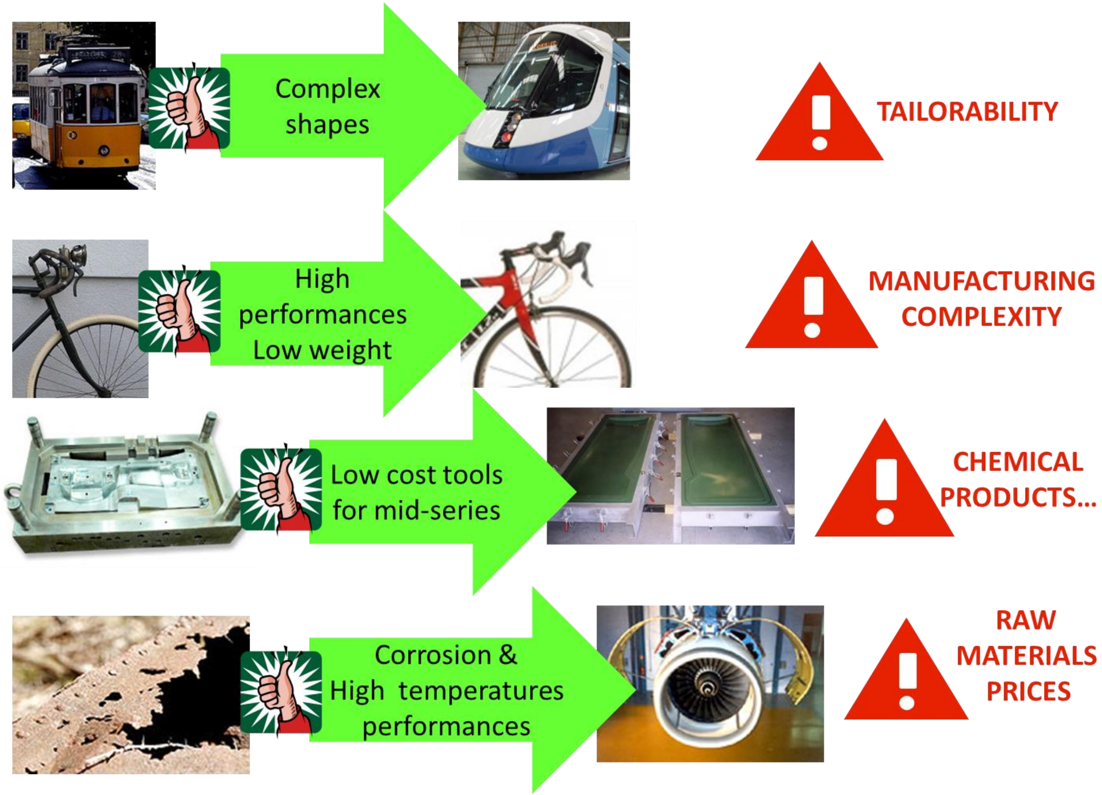


- ▶ **보강재 (Reinforcement/Filler)**
  - ▷ 상대적으로 높은 강성
  - ▷ 취성 재료
  - ▷ 섬유류
    - ▸ 유리섬유
    - ▸ 탄소섬유
    - ▸ 아라미드
  - ▷ 레진류
    - ▸ 에폭시
    - ▸ 폴리에스테르, 폴리프로필렌



복합재의 특성

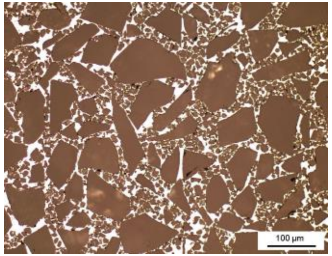
- ▶ 복잡한 형상 모델
- ▶ 높은 강성 및 강도
- ▶ 무게 감소
- ▶ 비용 절감
- ▶ 피로 저항 개선
- ▶ 충격 완화
- ▶ 에너지 흡수

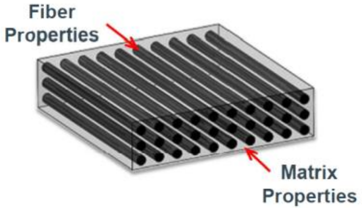


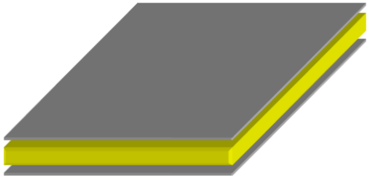
복합재의 종류

복합재료

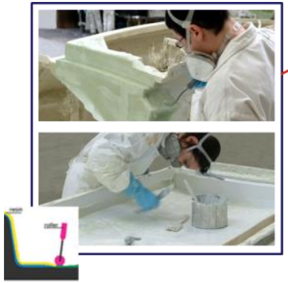
- 입자강화재료
- 섬유강화재료
- 구조복합재료





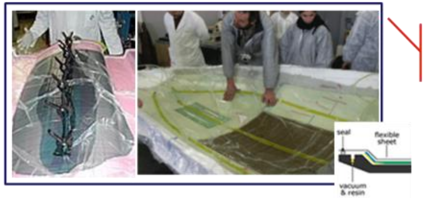


복합재 제작 방식 – 섬유강화 복합재료



Contact molding:
Dry fibers Lay up + resin manual application

RTM (Resin Transfer Molding)
Dry fibers Lay up + resin injection in a mold

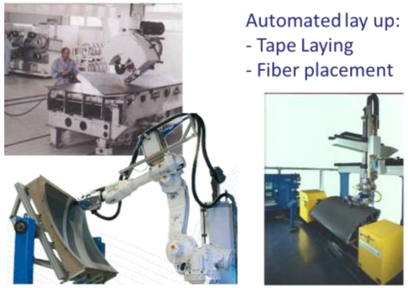


Infusion
Dry fibers Lay up + plastic vacuum
+ Resin infusion

습식 공정(Wet Process)

Hand Lay-up with preimpregnated fibers

Automated lay up:
- Tape Laying
- Fiber placement



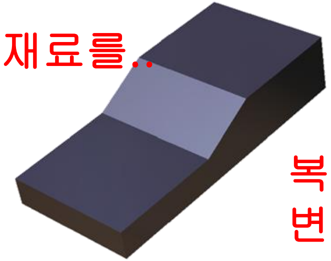
\+

Curing

건식 공정(Dry Process)

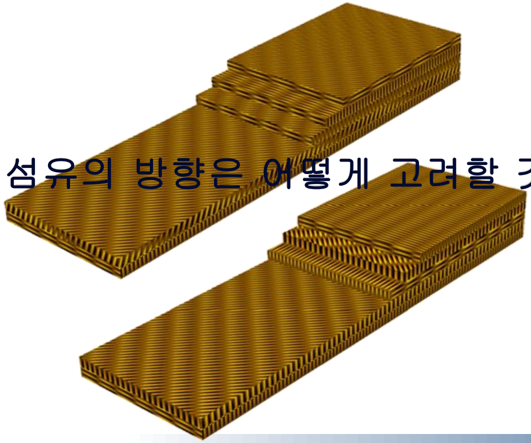
복합재 제작 및 모델링 주요 이슈

금속 재료를..

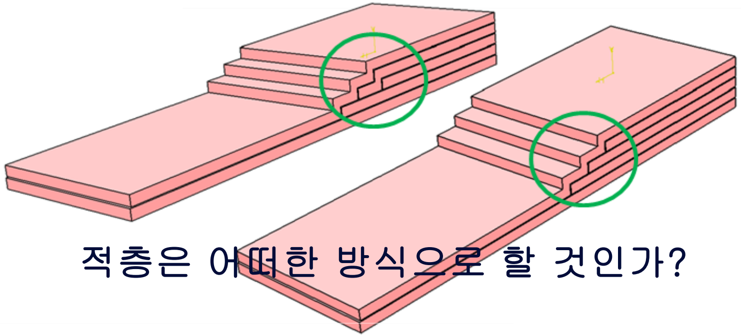


복합 재료로
변환하려면..?

기본 재료는 어떤 것을 선택할 것인가?

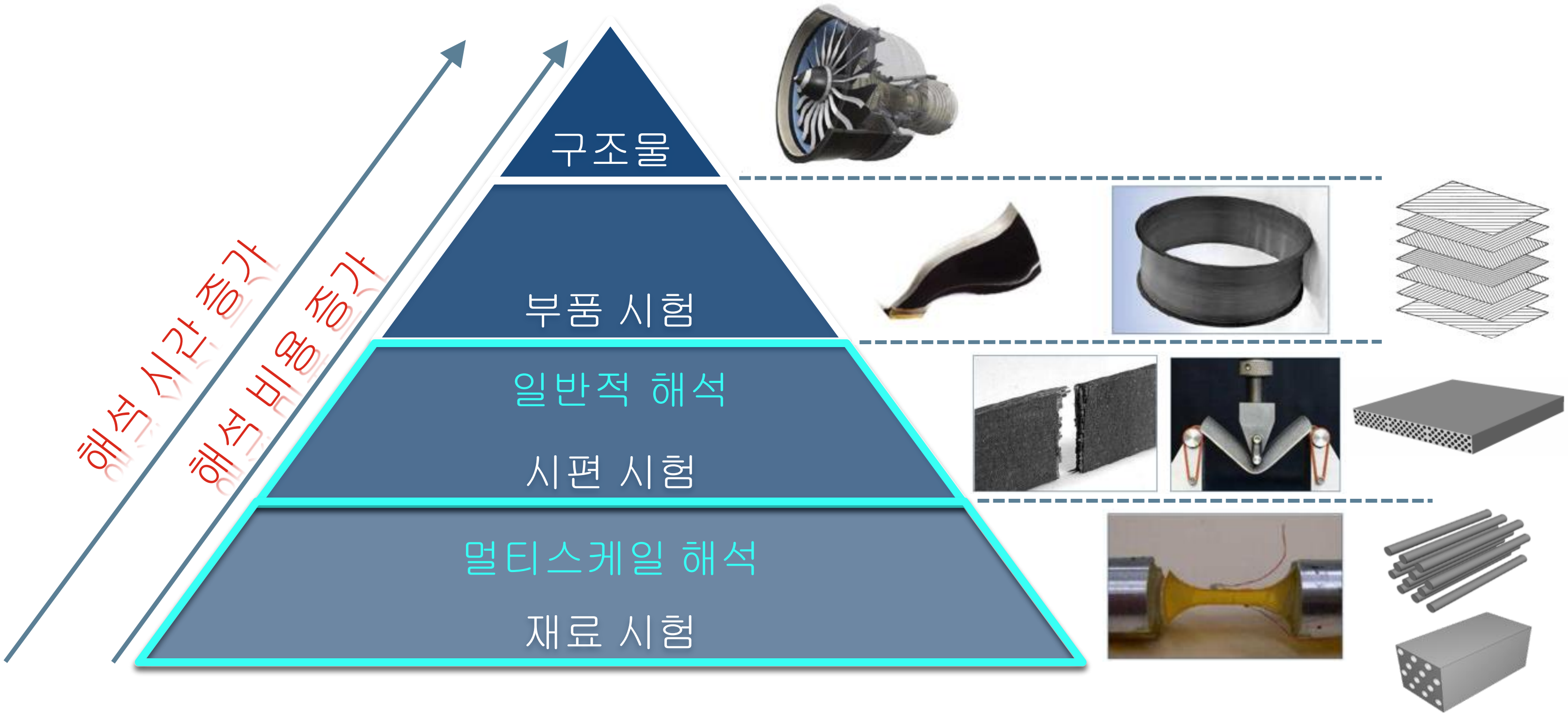


섬유의 방향은 어떻게 고려할 것인가?

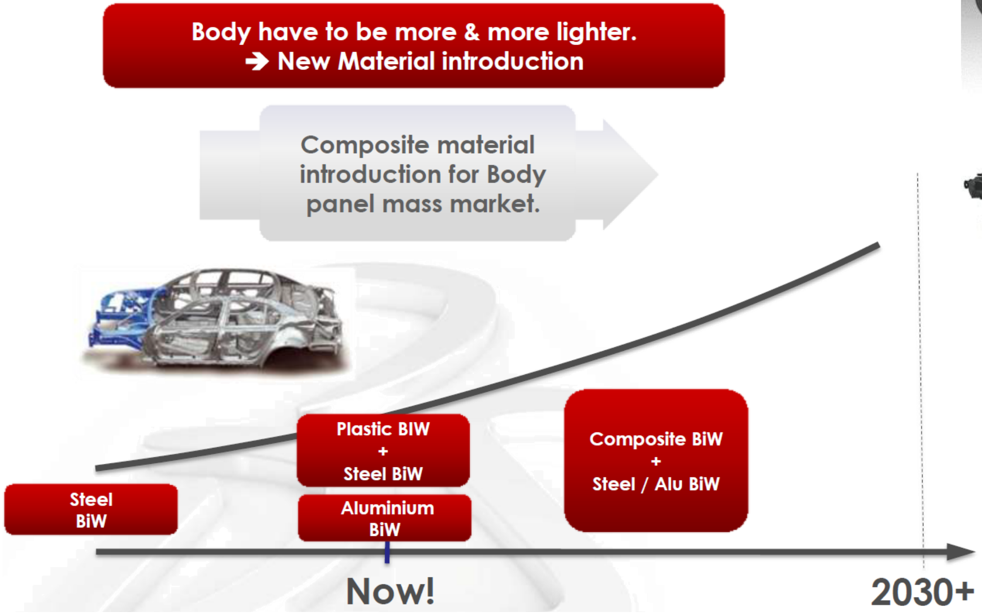


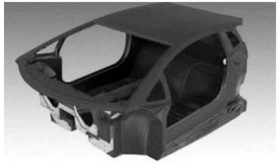
적층은 어떠한 방식으로 할 것인가?

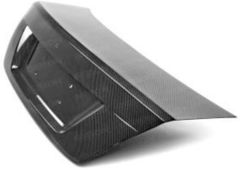
복합재의 해석적 접근



복합재 해석 동향 – 자동차 분야



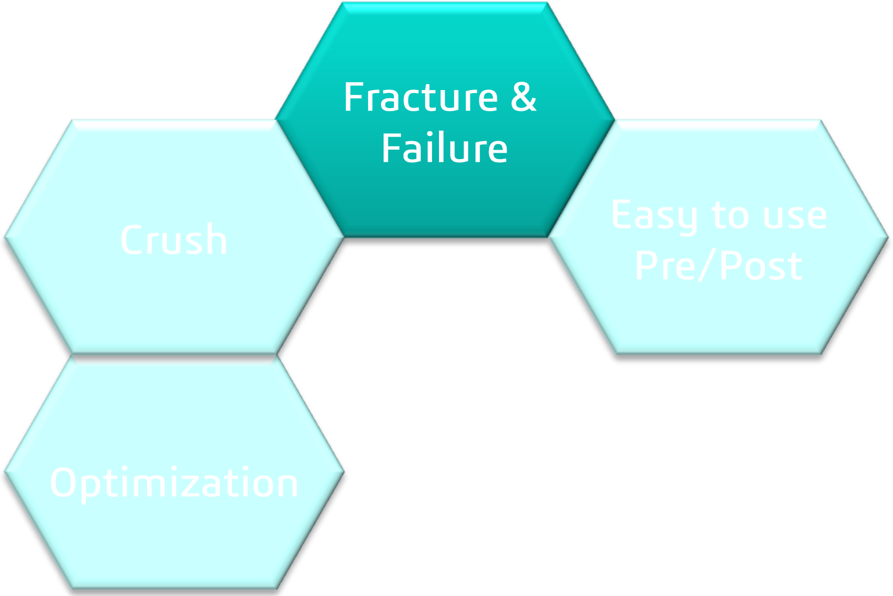




Key Simulation Domains for Composites

- Fracture & Failure
- Crush
- Easy to use Pre/Post
- Optimization
- Design Analysis
- Manufacturability and Draping

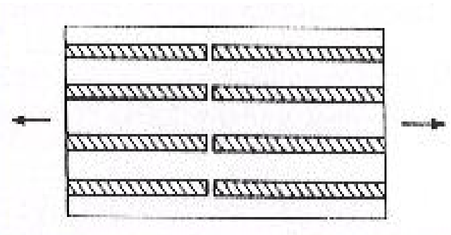
Key Simulation Domains for Composites



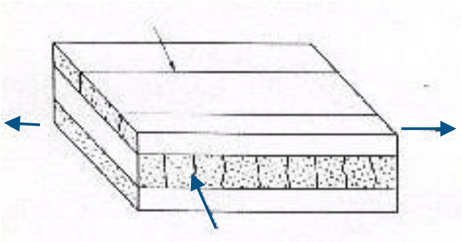
Composites Fracture & Failure

복합재 파손 모델

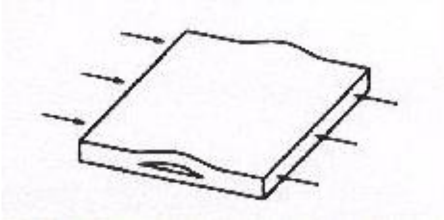
- ▶ 층내 파손 **(Ply Failure)**
  - ▷ Maximum stress/strain
  - ▷ Tsai-Hill
  - ▷ Tasi-Wu
  - ▷ Azzi-Tsai-Hill
  - ▷ Hashin
  - ▷ Puck
- ▶ 층간 박리 **(Delamination)**
  - ▷ Virtual Crack Closure Technique
  - ▷ Cohesive Element



Fiber failure



Matrix failure

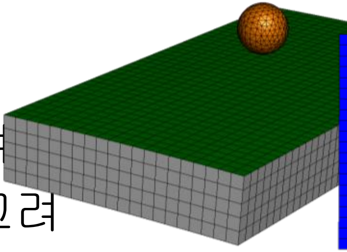


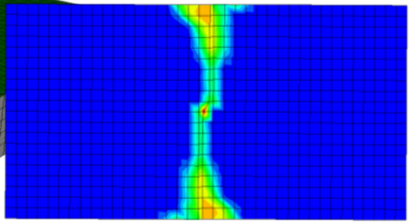
Delamination

Composites Fracture / Failure

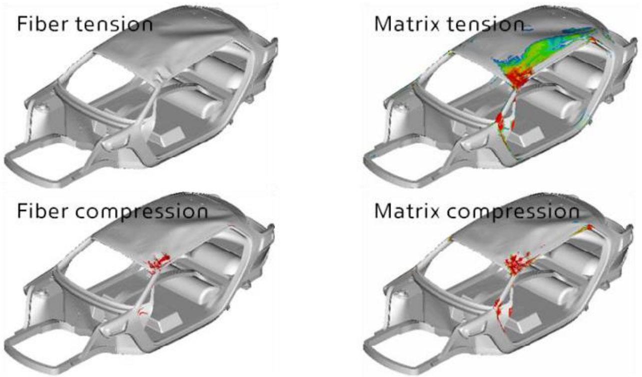
섬유 강화 복합재의 모재/보강재 균열 모델

- ▶ **Hashin** 이론 기반
  - ▷섬유의 장력/압축력에 의한 파손 인자 고려
  - ▷모재부의 장력/압축력에 의한 파손 인자 고려





- ▶ 초기 균열 및 균열 진전 모델 정의 가능

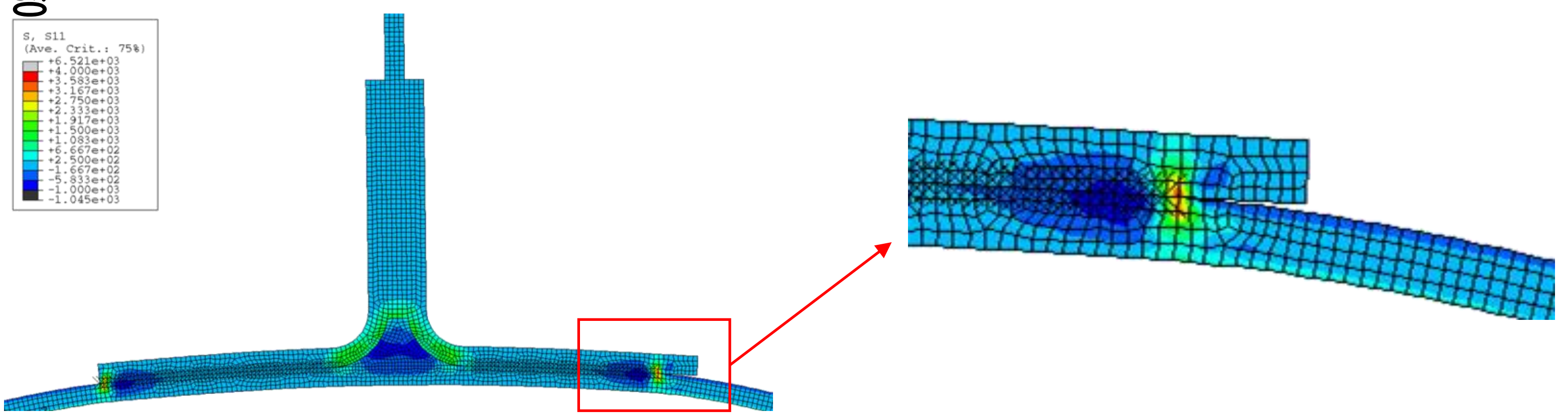


- ▶ 균열 전 상태는 선형 탄성 거동으로 정의

Composites Fracture / Failure

Virtual Crack Closure Technique (VCCT)

- 개발 동기 : 항공기 복합재 구조물의 파손 해석
  - 복합재 적층 구조물 및 대형 접합 구조물의 개발 비용 감소 목적
- 잘 정의된 초기 결함이 있는 상태에서 선형탄성파손 이론에 따라 층 분리 진행

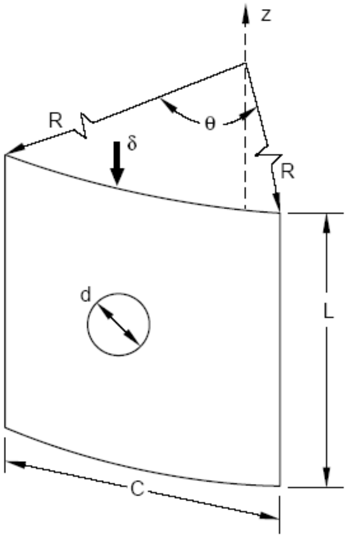


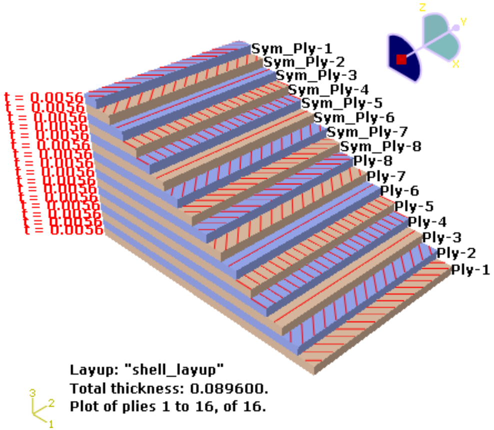
Composites Fracture / Failure

그 외 파손 관련 예 - Buckling

▶ 적층 쉘 형태의 섬유 강화 복합재에서 고려 대상

▶ 복합재 구조물의 최적 경량화에서 주로 이슈화





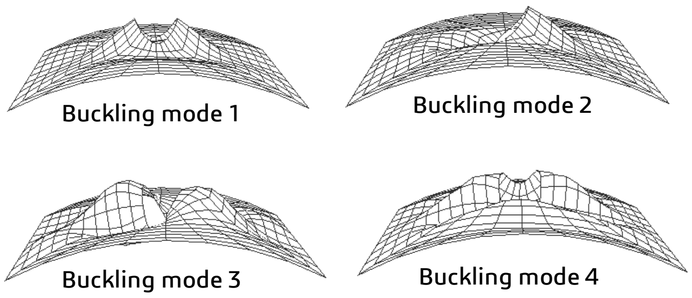
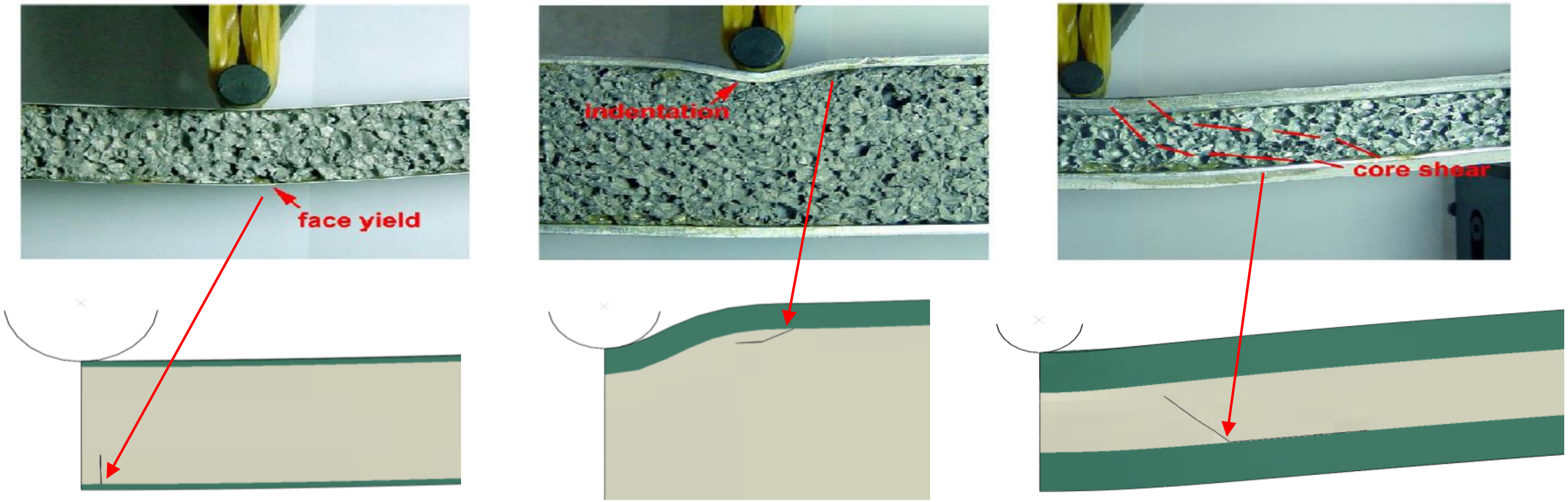


	Plate Buckling Loads (psi)	
	[(45, −45, 90, 0)s]s	[90(8)]s
Mode 1	25121	18249
Mode 2	25910	18859
Mode 3	27368	21146
Mode 4	34053	24536
Mode 5	40365	25522

Composites Fracture / Failure

*그 외 파손 관련 예 – **eXtended Finite Element Method (XFEM)***

- ▶ **3차원 곡면에서의 정지 균열 모델링 가능**
- ▶ **Mesh와 독립적인 3차원 균열 진전 모델링 가능**

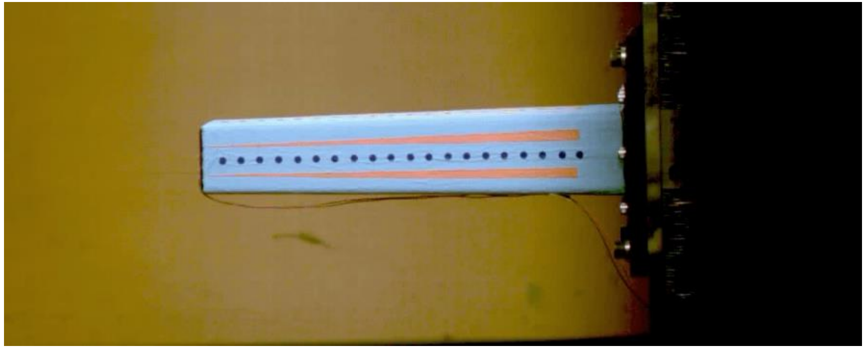


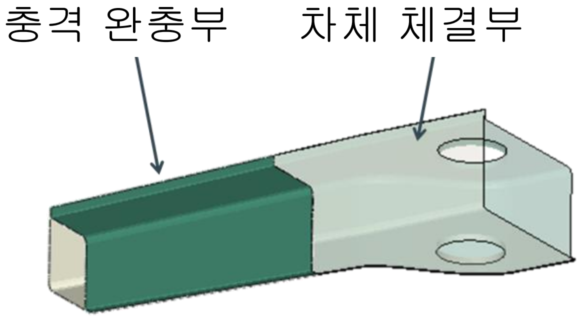
Key Simulation Domains for Composites

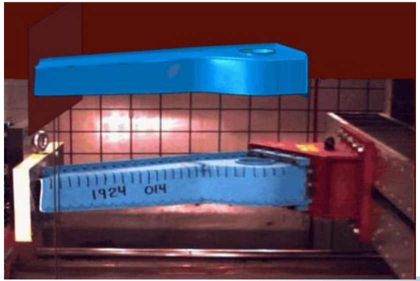
- Fracture & Failure
- Crush
- Easy to use Pre/Post
- Optimization

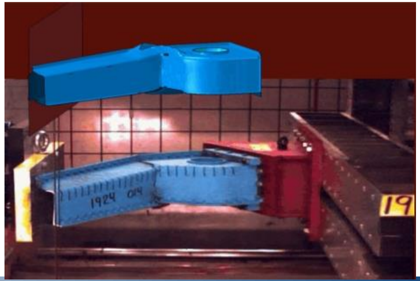
Composites Crush

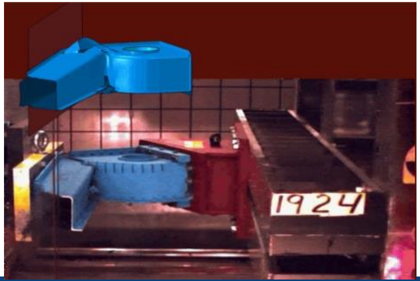
내충격성 해석(Crashworthiness)





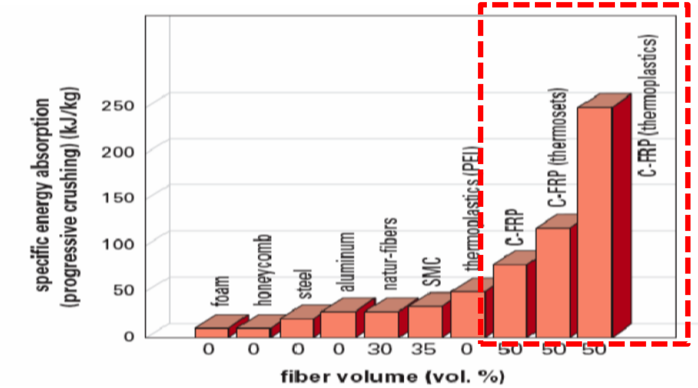


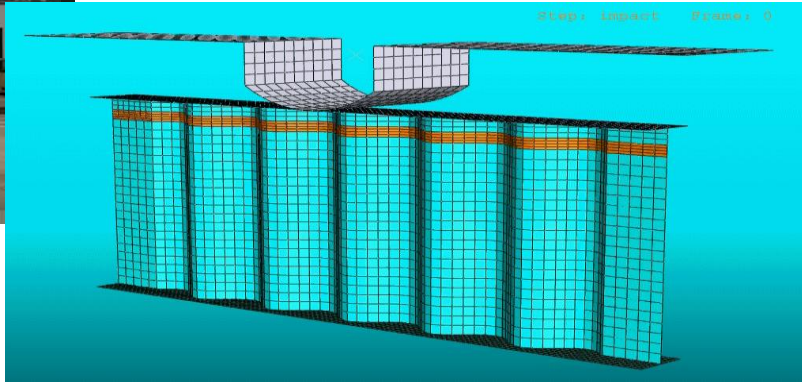




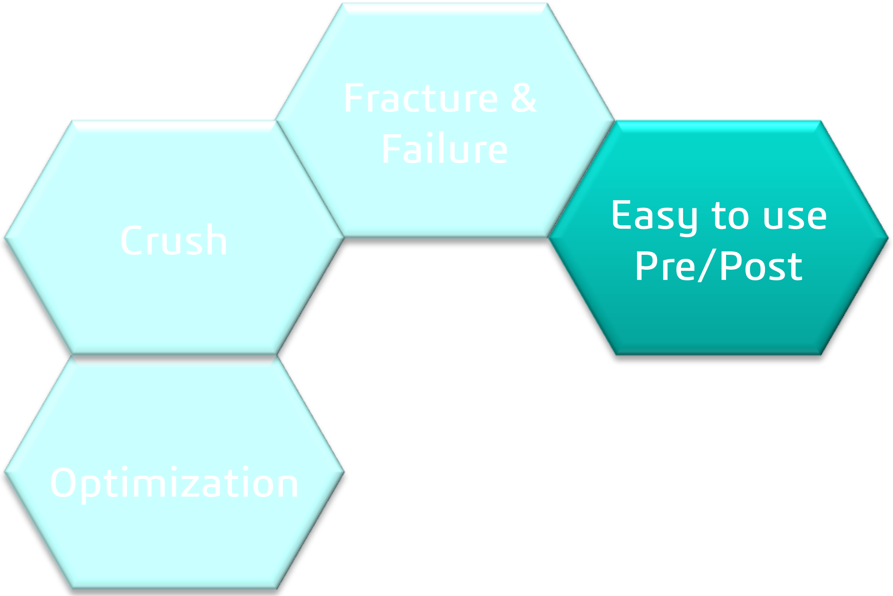
Composites Crush

내충격성 해석(Crashworthiness)





Key Simulation Domains for Composites



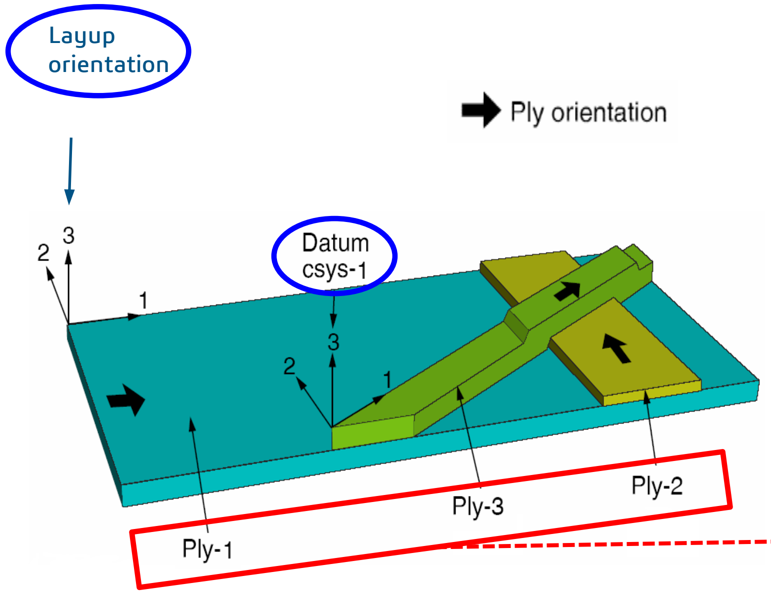
Easy to use Pre/Post

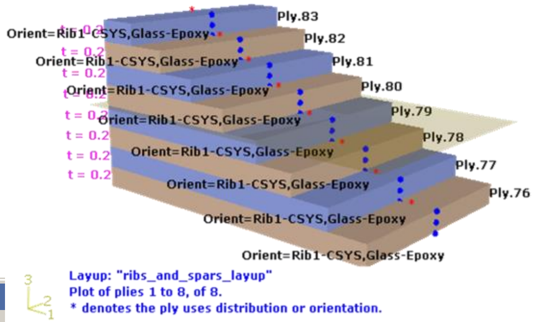
- **Abaqus/CAE**
  - ▷ Composite Layup
  - ▷ Composite Modeler for Abaqus/CAE
  - ▷ Wound Composite Modeler
  - ▷ CZone for Abaqus

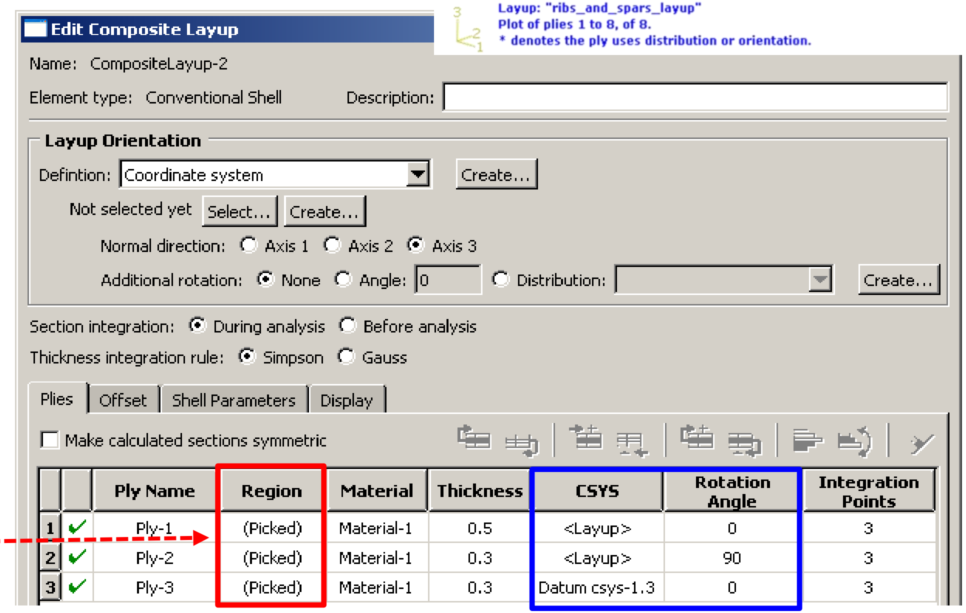
- **3DEXPERIENCE Platform**
  - ▷ Composite Design
  - ▷ Composite Manufacturing Preparation
  - ▷ Composites Braiding

Easy to use Pre/Post

Abaqus/CAE : Composite Layup

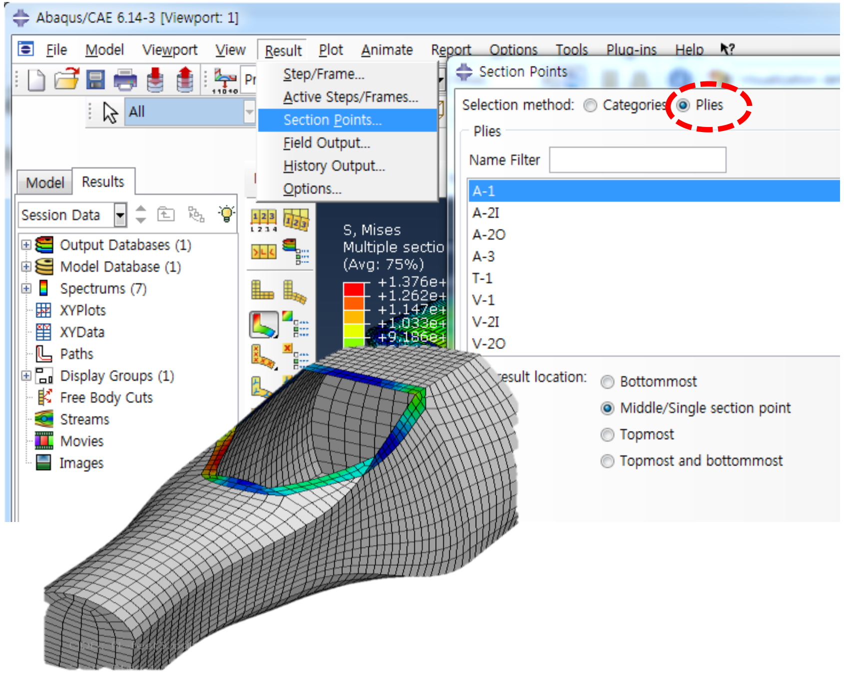


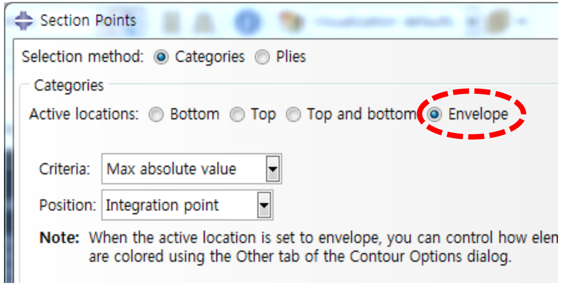


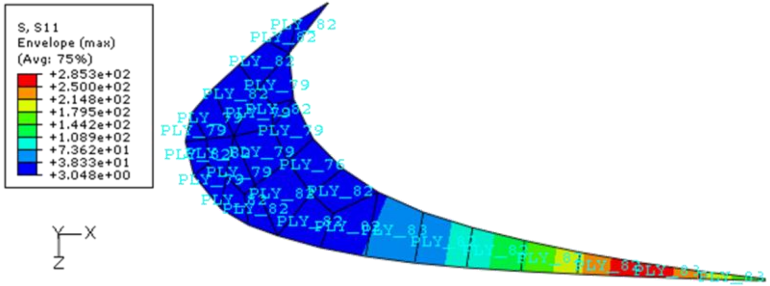


Easy to use Pre/Post

Abaqus/CAE : Visualization

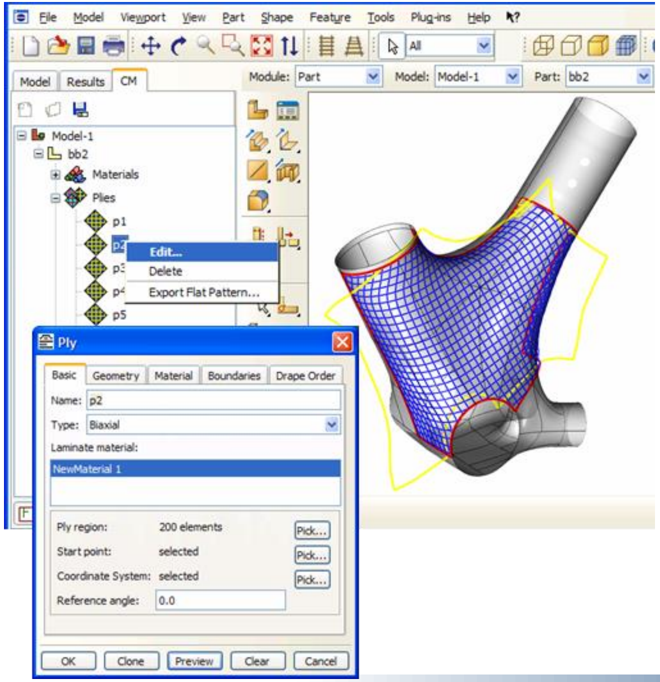


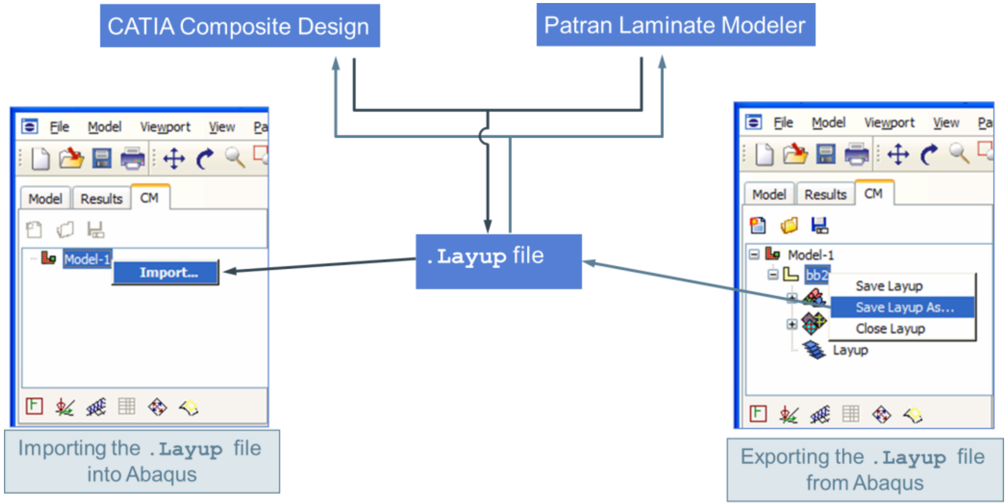




Easy to use Pre/Post

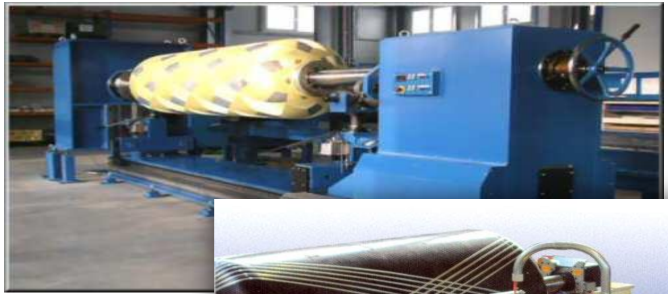
Add-on : Composite Modeler for Abaqus/CAE

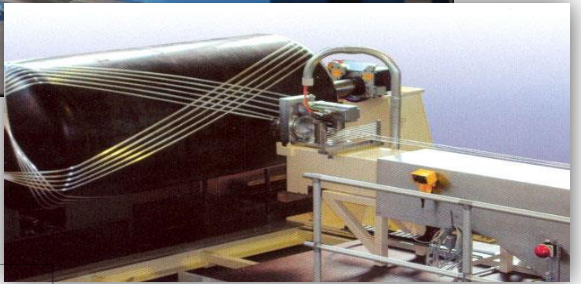


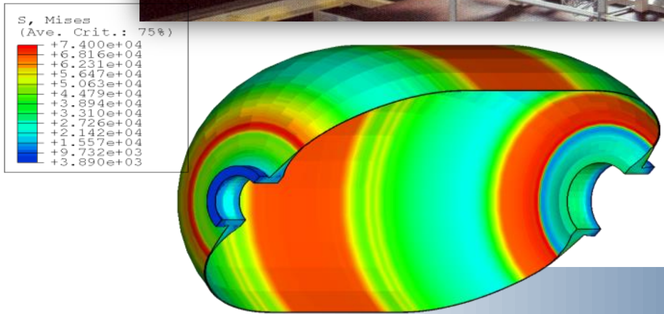


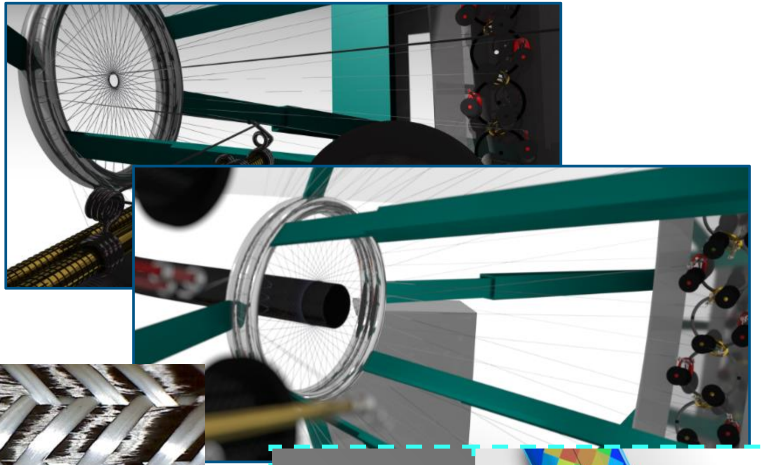
Easy to use Pre/Post

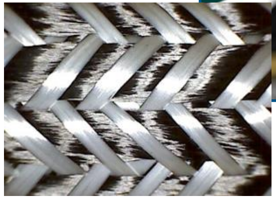
Filament Wound Pressure Vessels



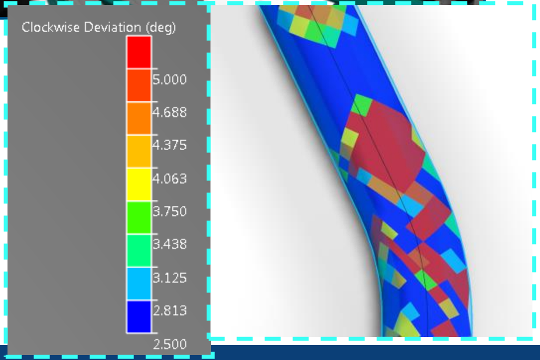




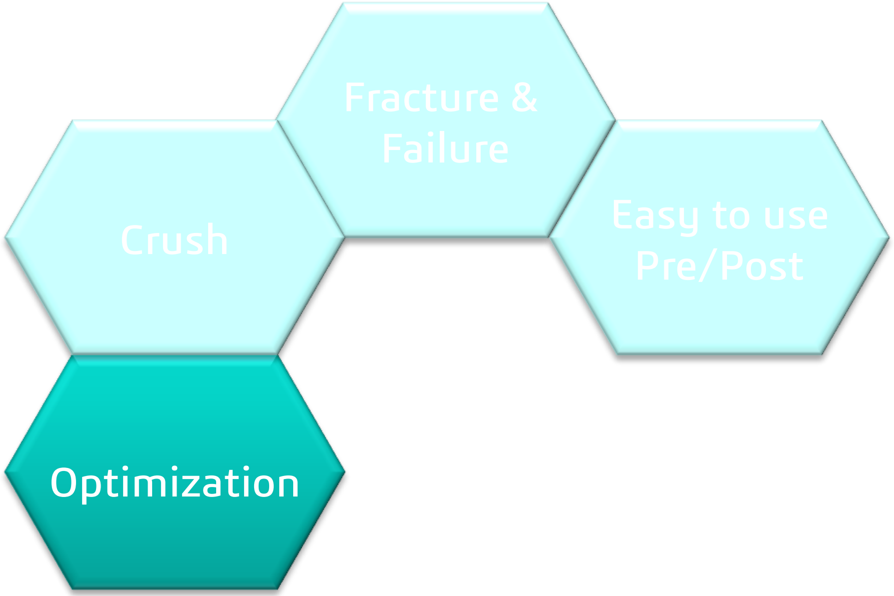




Composite Braiding



Key Simulation Domains for Composites



Optimization

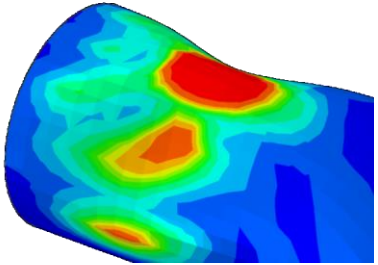
- ▶ 왜 복합재 해석 설계 시 최적화가 필요한 것인가?
  - ▷ 설계 신뢰성 향상
  - ▷ 비용 대비 성능 향상

- ▶ 어떻게 복합재 구조물을 FEA를 통하여 최적화할 수 있는가?
  - ▷ Non-parametric Optimization (Tosca)
  - ▷ Process Automation & Design Optimization (Isight)

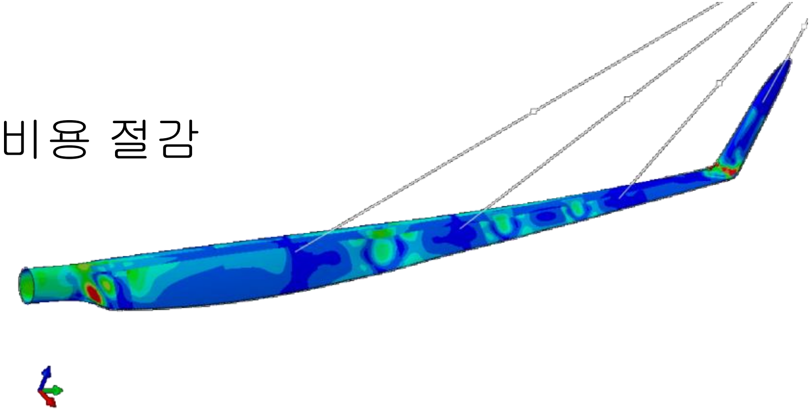
Optimization

풍력 발전기 블레이드의 최적화

- ▶ 문제 제기
  - ▷풍력 발전기 블레이드의 좌굴
  - ▷층간 박리 및 균열 발생



- ▶ 최적화 목적
  - ▷블레이드의 무게 감소를 통한 생산 비용 절감
  - ▷무게 대비 성능 최적화

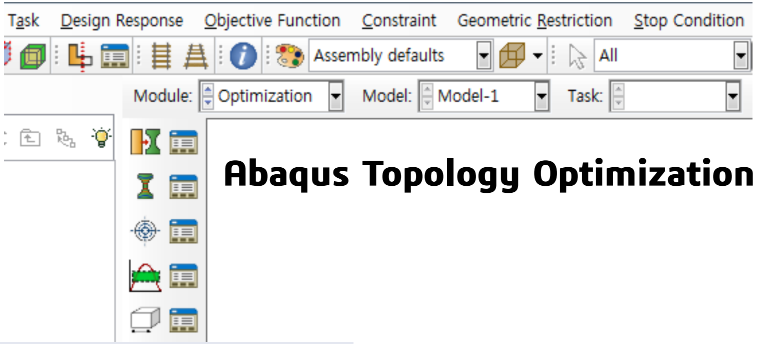


Optimization

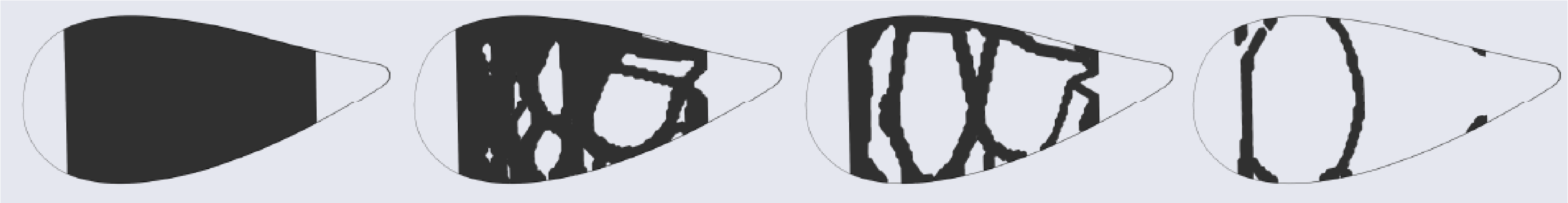
Tosca

▶ 위상 형상 최적화

▶ 블레이드 및 웹 무게 감소



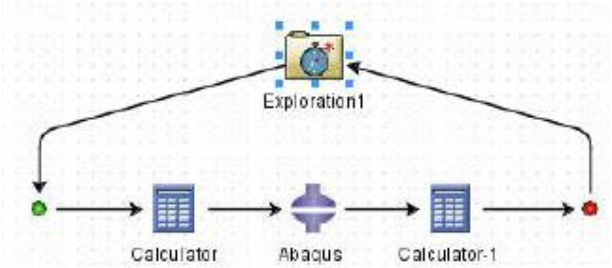
Abaqus Topology Optimization

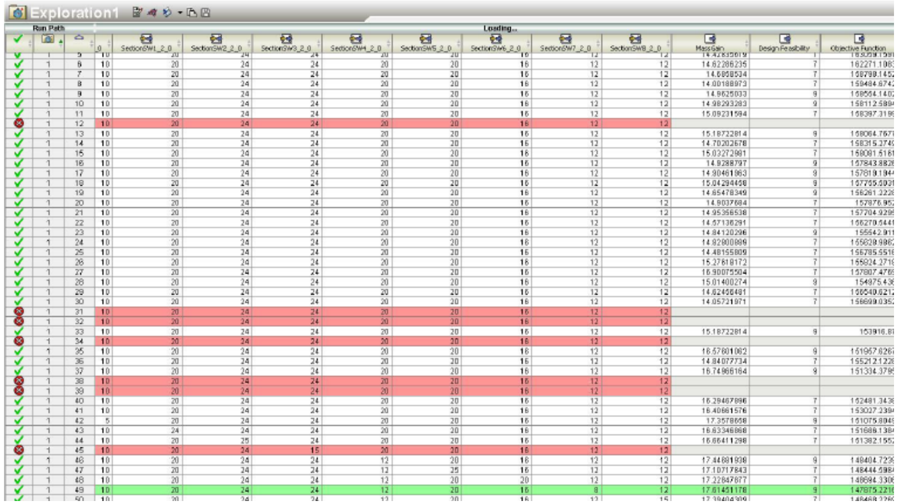


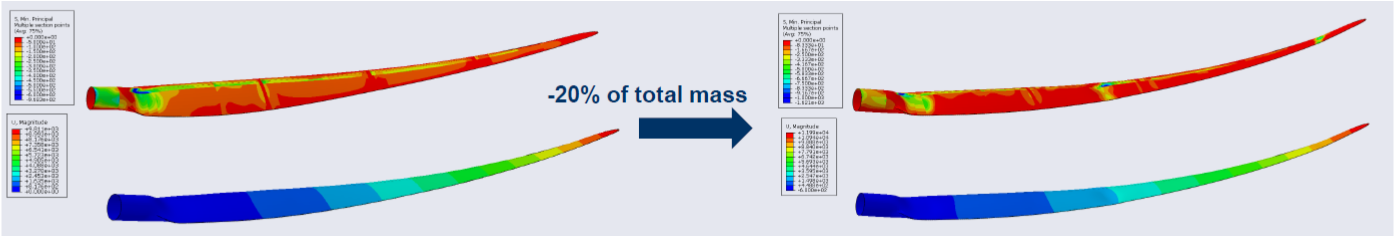
Optimization

Isight

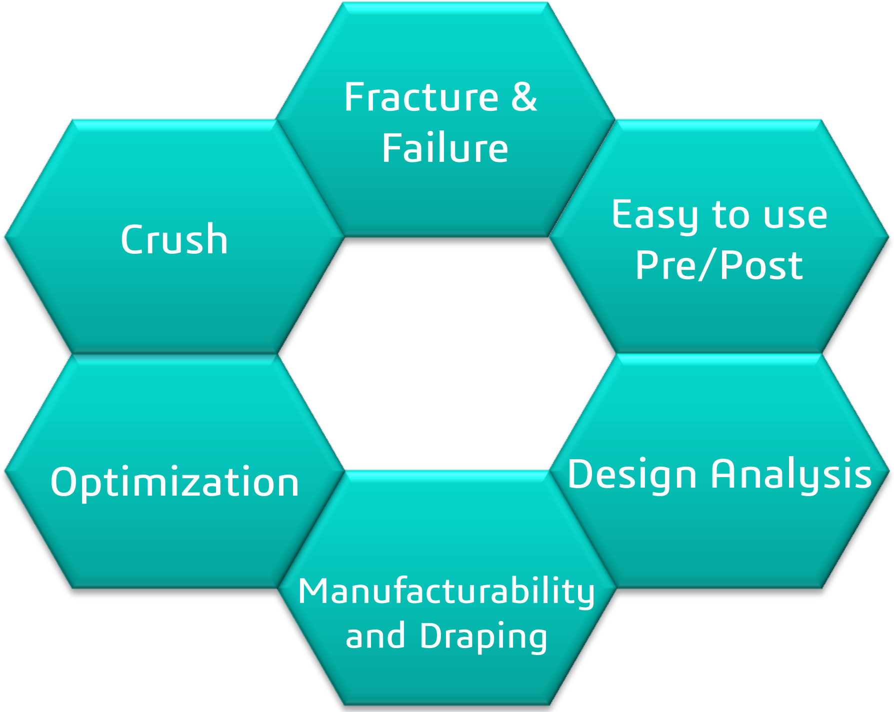
- ▶ 파라메트릭 최적화
- ▶ 무게 감소 및 최대 응력 유지







Key Simulation Domains for Composites



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