

# 예제로 쉽게 배우는 Ansys LS-DYNA

## 3. ALE를 적용한 유체와 구조의 충돌해석

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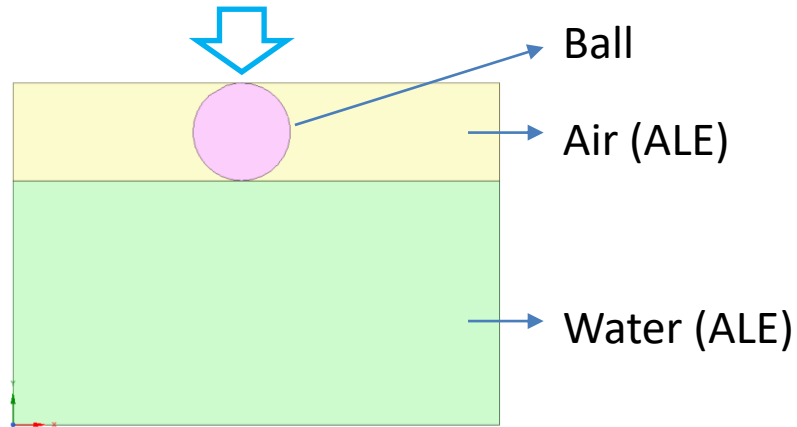
## Contents

1. 개요
2. 전처리
3. 해석 & 후처리

# 1. 개요

# 1. 개요

## 해석 모델



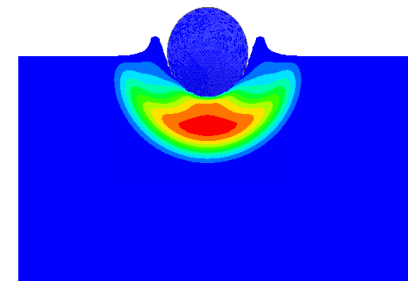
## 목표

Workbench LS-DYNA 사용자 환경을 익히고  
ALE 기법을 적용하여 FSI 해석을 수행하고 해석 결과  
살펴보기

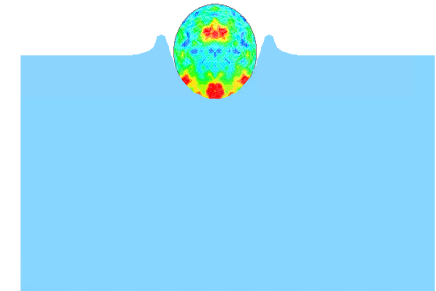
## 과정

1. Workbench LS-DYNA Analysis System 생성
2. 단위 시스템 및 재료 속성 선택
3. 3D 모델 가져오고 ALE 격자 생성
4. 하중 및 구속조건, 해석 옵션 설정
5. 해석
6. 결과 확인 하기

## 결과



Pressure

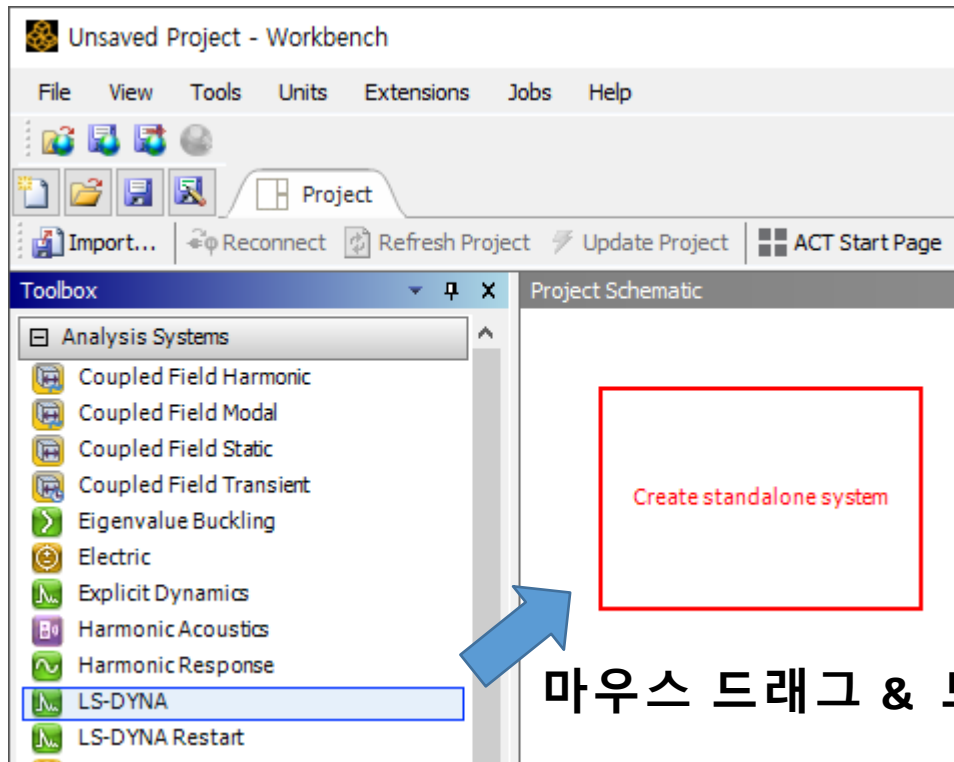


Stress

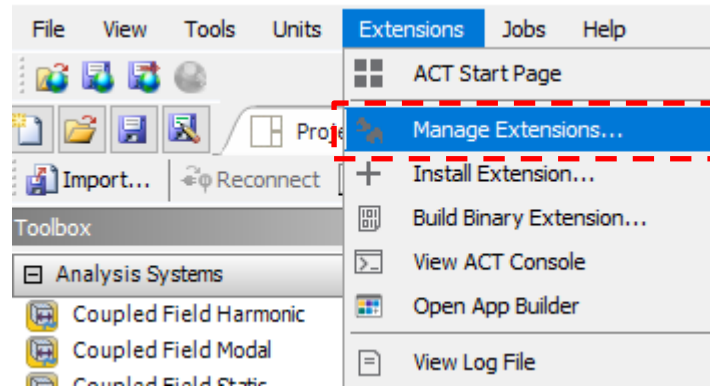
## 2. 전처리

## 2. 전처리

### • Workbench LS-DYNA 해석 시스템 생성



마우스 드래그 & 드롭



Extensions Manager

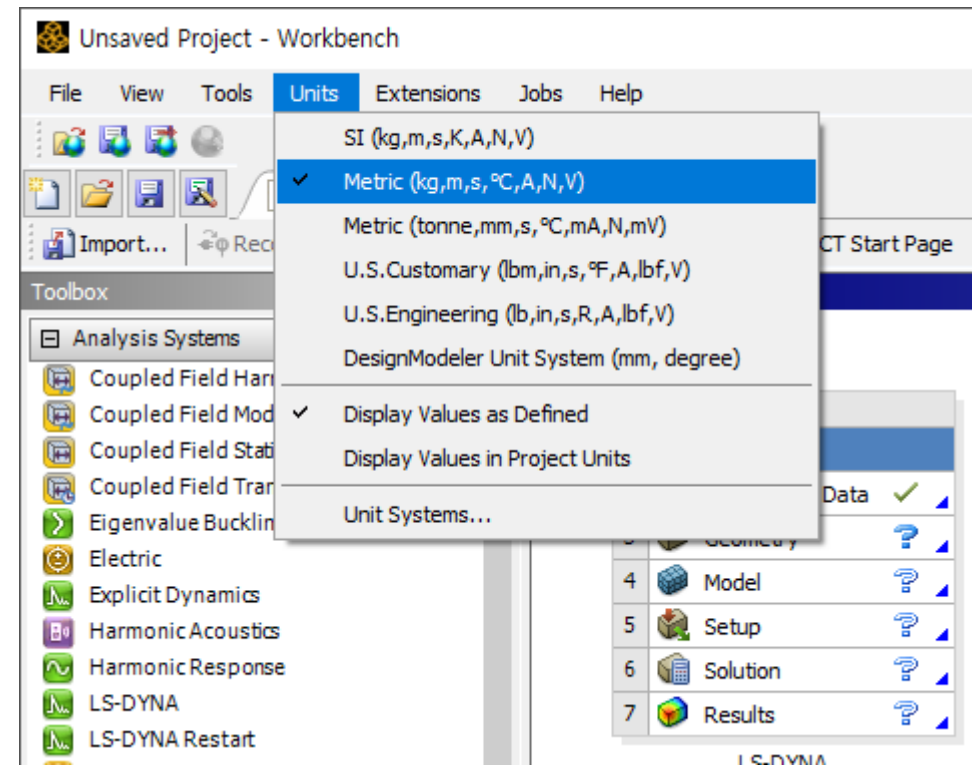
Loaded	Extensions	Type	Version
<input type="checkbox"/>	AqwaCosimulation	Binary	2023.1
<input type="checkbox"/>	EnSight	Binary	2022.2
<input type="checkbox"/>	EnSight Forte	Binary	2022.2
<input type="checkbox"/>	EulerRemapping	Binary	2023.1
<input checked="" type="checkbox"/>	keywordmanager	Binary	2022.2
<input type="checkbox"/>	RestartAnalysis	Binary	2023.1

Keyword manager Extension 추가

## 2. 전처리

### • 단위 시스템 확인

- 해석에 사용할 단위 시스템 선택
- 해석에서 주요하게 사용되는 단위들을 미리 정의된 단위 시스템 그룹을 선택함으로써 설정할 수 있음



## 2. 전처리

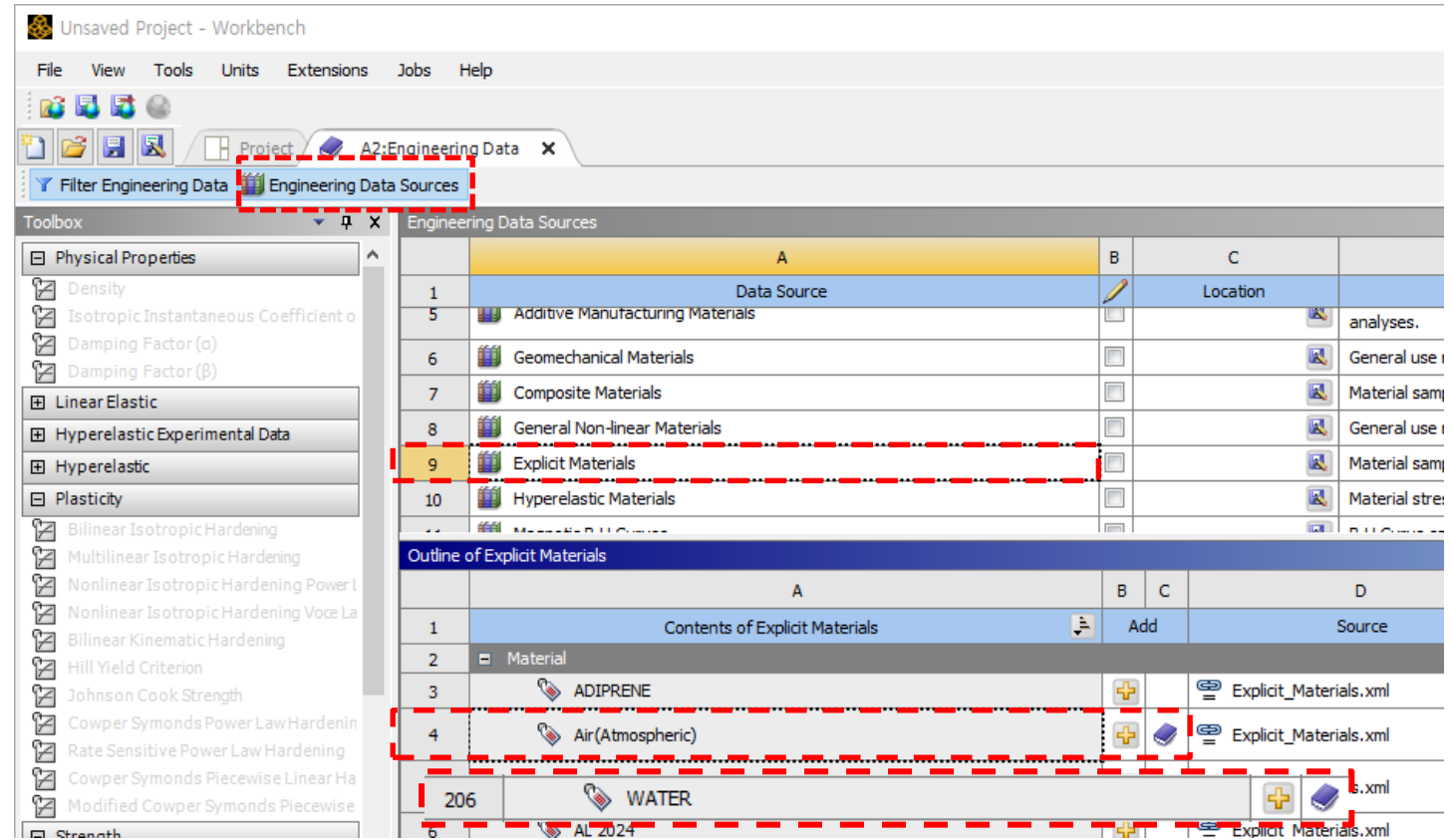
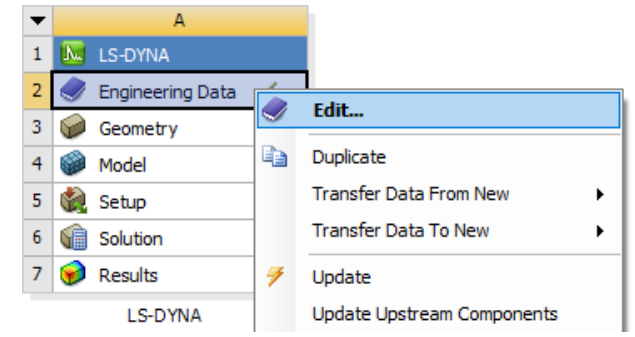
### • 재료 모델 생성

➤ Engineering Data에서 마우스 우클릭 후 “Edit” (또는 더블 클릭)

➤ Engineering Data Sources 활성화

➤ Explicit Materials > **Air** > Add

➤ Explicit Materials > **Water** > Add

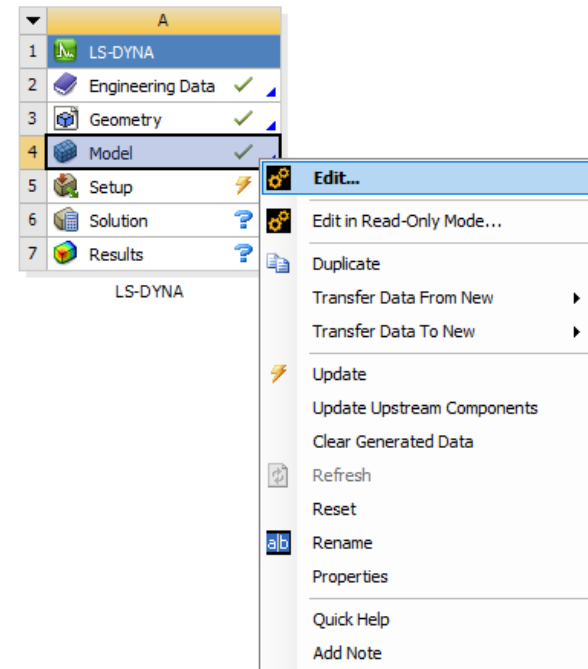
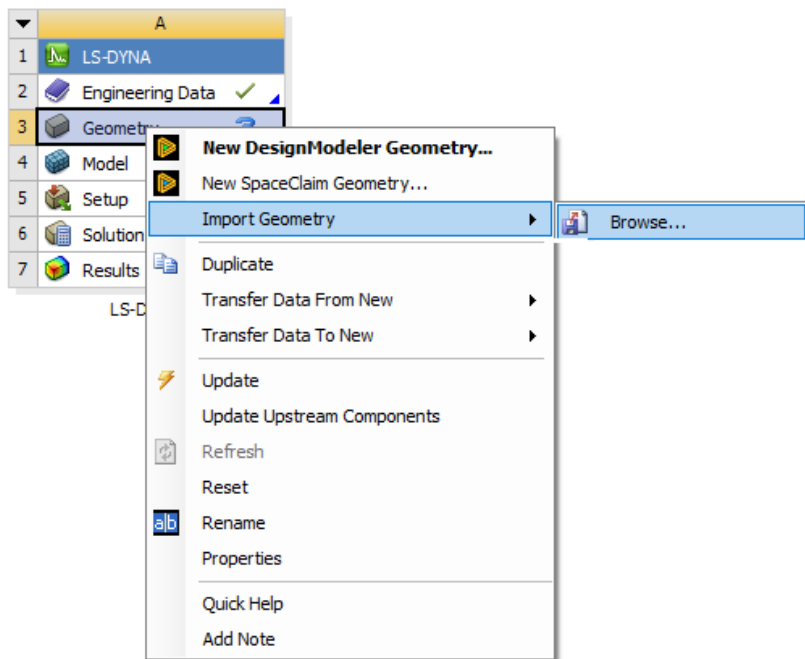
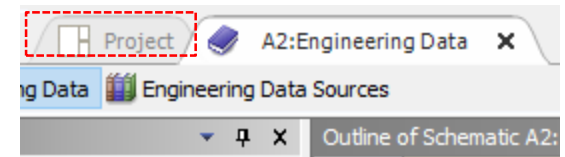




## 2. 전처리

### • CAD모델 가져오기 및 WB LS-DYNA 실행

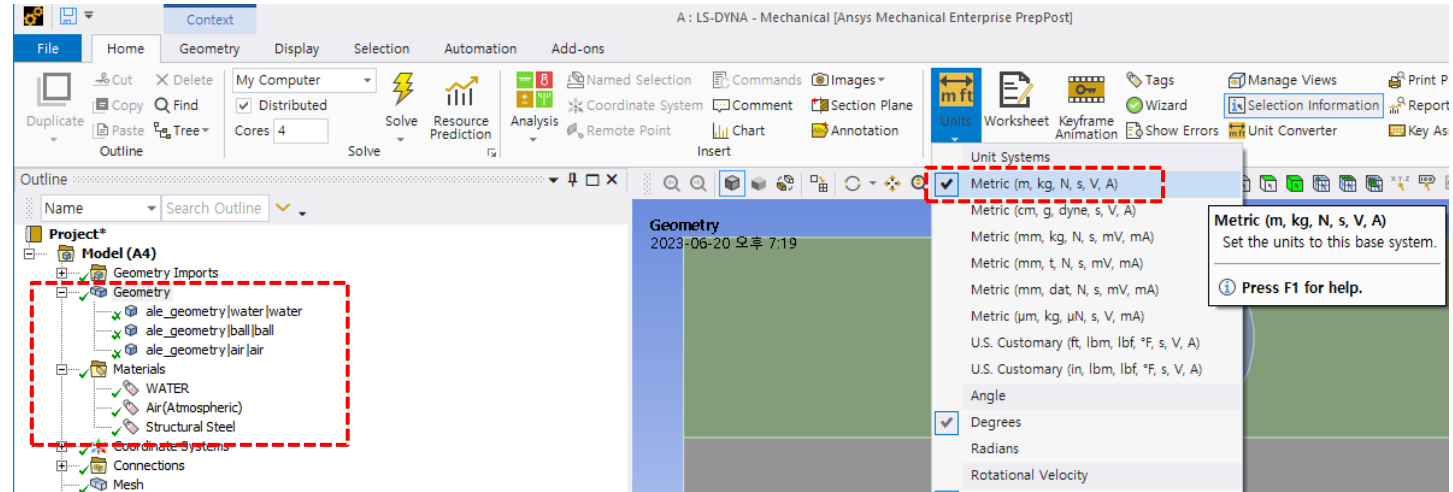
- “Project” 탭을 클릭하여 Project 화면으로 전환
- “Geometry” 항목에서 CAD 모델 가져오기(“ale\_geo.stp”)
- “Model”에서 마우스 우클릭 후 Workbench LS-DYNA 실행



## 2. 전처리

### • 단위 확인 및 재료모델 적용

- Workbench LS-DYNA가 실행되면  
단위 시스템 재 확인



- 각 파트를 클릭 후 재료 물성 변경

→ water : WATER

→ ball : Structural Steel

→ air : Air(Atmospheric)

Details of "ale_geometry water water"	
Graphics Properties	
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Frame	Lagrangian
Material	
Assignment	WATER
Bounding Box	
Properties	
Statistics	

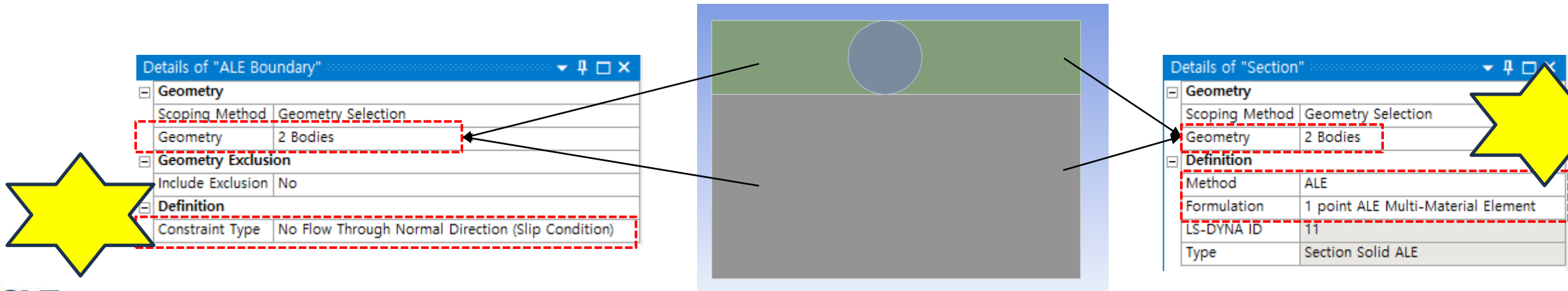
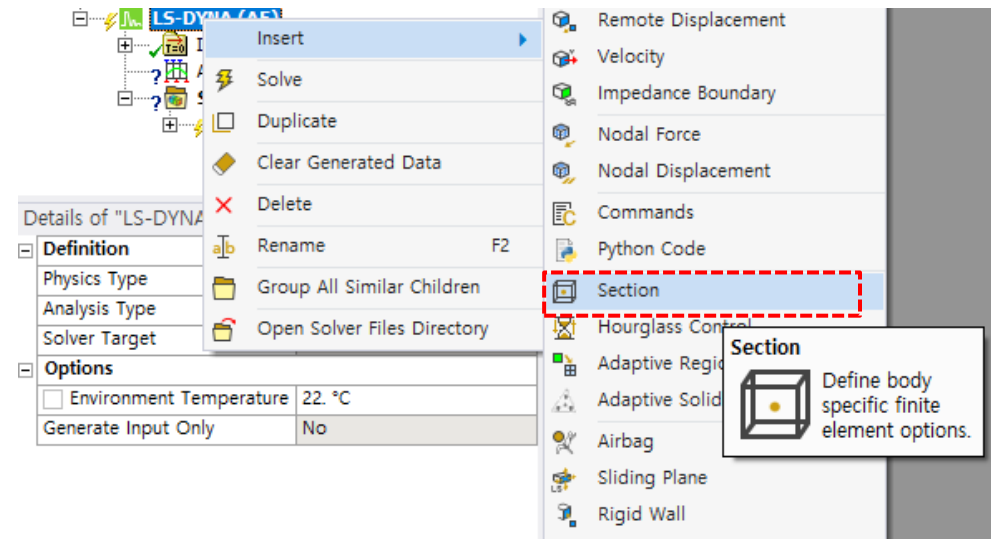
Details of "ale_geometry ball ball"	
Graphics Properties	
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Frame	Lagrangian
Material	
Assignment	Structural Steel
Bounding Box	
Properties	
Statistics	

Details of "ale_geometry air air"	
Graphics Properties	
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Frame	Lagrangian
Material	
Assignment	Air(Atmospheric)
Bounding Box	
Properties	
Statistics	

## 2. 전처리

### • ALE 속성 설정

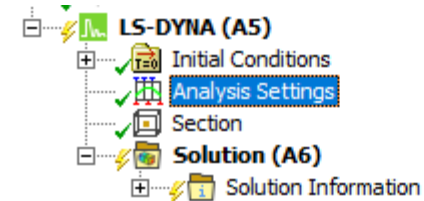
- “water”, “air”에 대해 ALE 속성 적용
- LS-DYNA 우클릭 > Insert > **Section** 생성
  - “water”, “air” 두개의 바디를 선택하여 입력
  - Method : ALE 로 변경
  - Formulation : 1 point ALE Multi-Material Element 변경
- LS-DYNA 우클릭 > Insert > **ALE Boundary** 생성



## 2. 전처리

### • 해석 옵션 정의

- **End time** 설정 : 0.002 s
- Unit System : **mks** 선택
- 다른 설정은 Default 사용



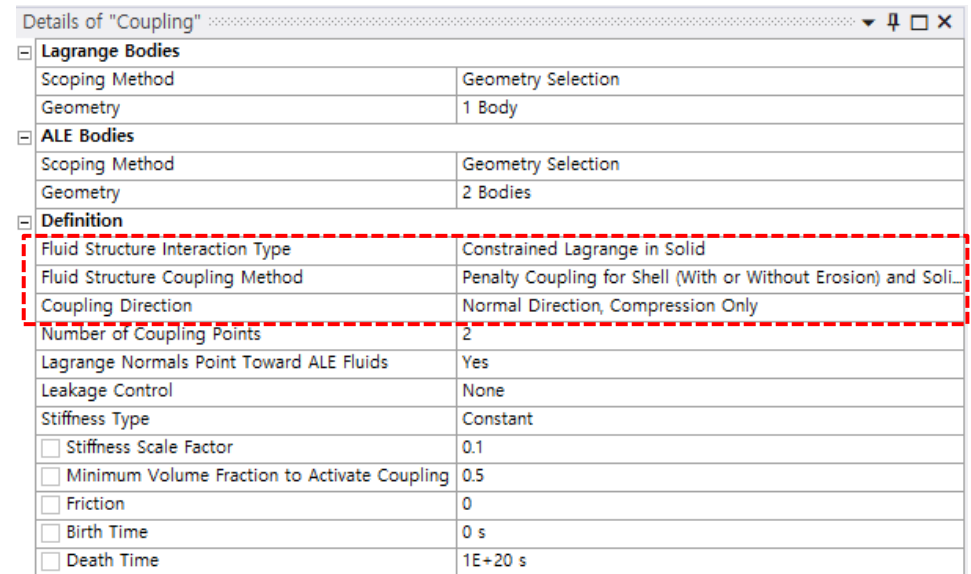
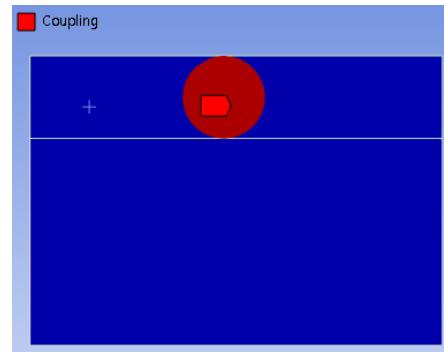
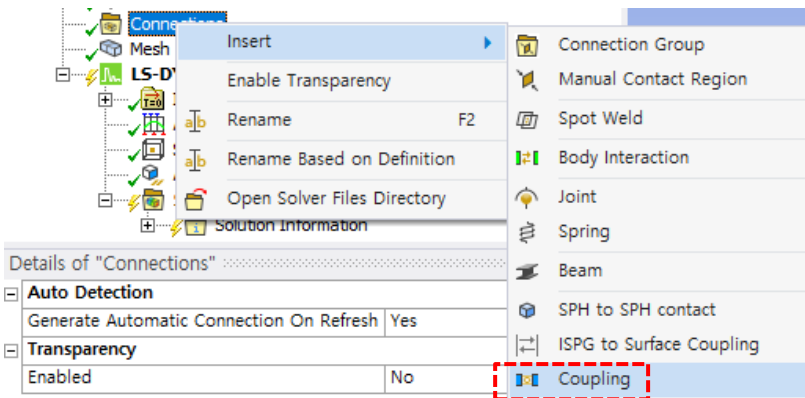
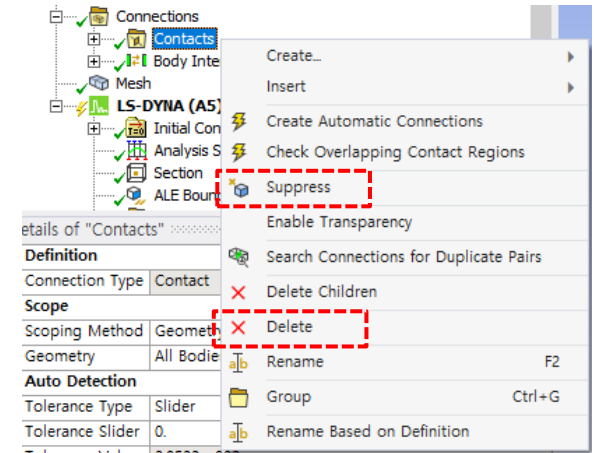
Step Controls	
End Time	0.002 s
Time Step Safety Factor	0.9
Maximum Number Of Cycles	10000000
Automatic Mass Scaling	No
Number of Cases	0
CPU and Memory Management	
Memory Allocation	Program Controlled
Number Of CPUS	1
Processing Type	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Solver Precision	Program Controlled
Unit System	mks
Explicit Solution Only	Yes
Invariant Node Numbering	Off
Second Order Stress Update	No
Solver Version	Program Controlled

## 2. 전처리

### • 접촉 조건 정의

➤ “Connection” 메뉴에서 자동 생성된 접촉 → Suppress 또는 Delete

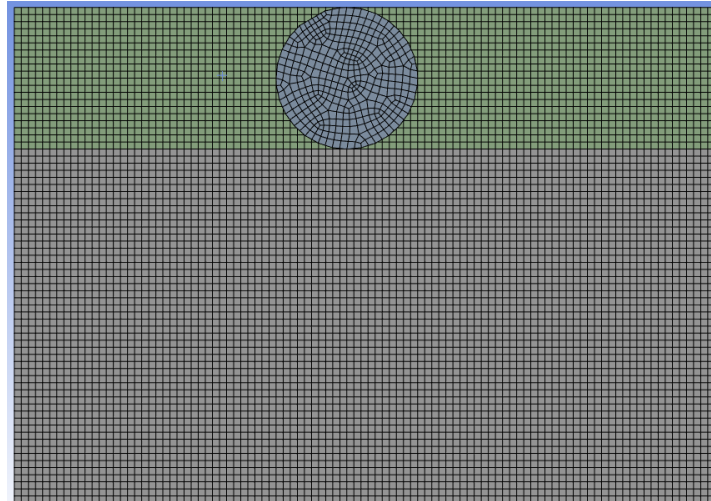
➤ Connections > Insert > **Coupling** 생성



## 2. 전처리

### • 격자 생성

- “Mesh”메뉴에서 Element Size를 **0.01 m**로 변경
- Mesh > Insert > Method 생성
  - **Body 전체** 선택
  - Method : **MultiZone** 선택
- “Mesh”에서 우클릭하여 “Generate Mesh”를 실행
- 생성된 격자 확인



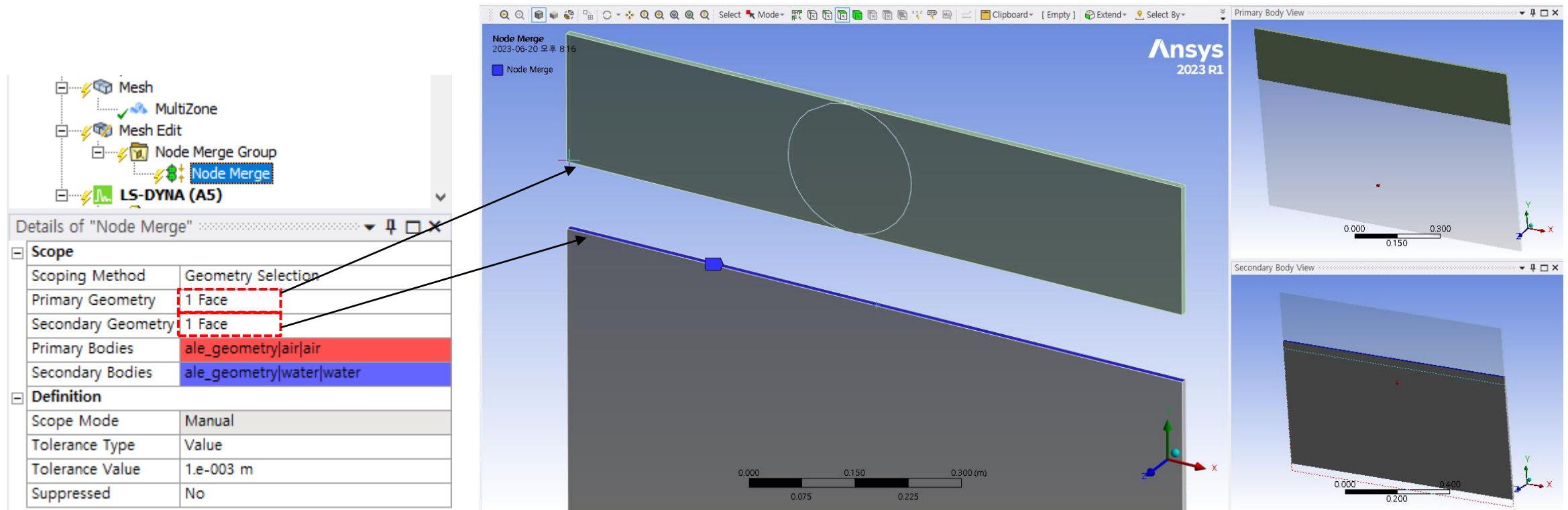
Details of "Mesh"	
[-] Display	
Display Style	Use Geometry Setting
[-] Defaults	
Physics Preference	Explicit
Element Order	Linear
<input type="checkbox"/> Element Size	1.e-002 m
[+] Sizing	
[+] Quality	
[+] Inflation	
[+] Advanced	
[+] Statistics	

Details of "MultiZone" - Method	
[-] Scope	
Scoping Method	Geometry Selection
Geometry	3 Bodies
[-] Definition	
Suppressed	No
Method	MultiZone

## 2. 전처리

### • 격자 생성

- ALE 격자 절점 공유
- Mesh > Insert > **Node Merge** 생성  
→ 절점이 공유될 영역 face 선택

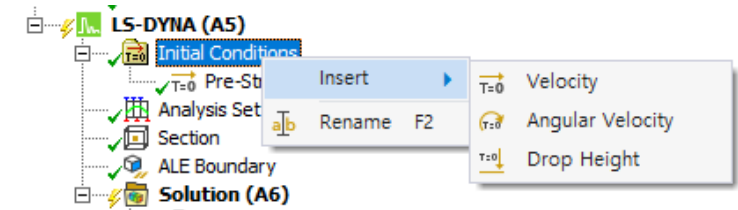


## 2. 전처리

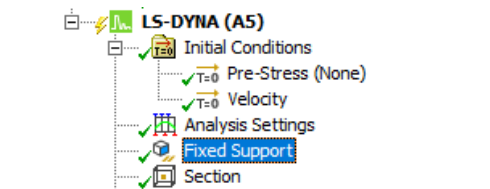
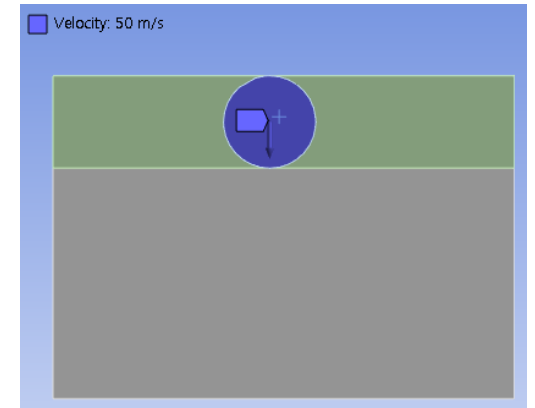
### • 경계조건 설정

- Initial Conditions > Insert > Velocity 선택  
→ ball 바디 선택  
→ 속도 : Y 방향 -50 m/s

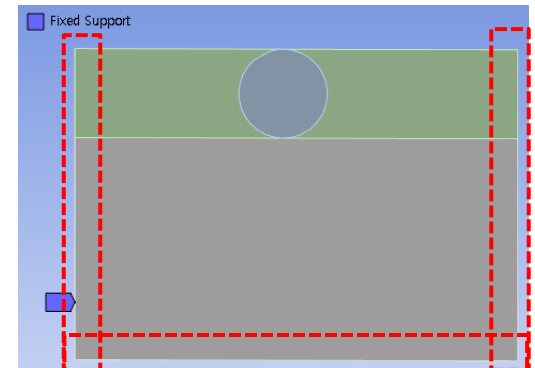
- LS-DYNA > Insert > **Fixed Support**  
→ 외곽 5 face 선택



Details of "Velocity"	
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Input Type	Velocity
Pre-Stress Environment	None Available
Define By	Components
Coordinate System	Global Coordinate System
<input type="checkbox"/> X Component	0. m/s
<input checked="" type="checkbox"/> Y Component	-50. m/s
<input type="checkbox"/> Z Component	0. m/s
Case Number	All Cases
Suppressed	No



Details of "Fixed Support"	
Scope	
Scoping Method	Geometry Selection
Geometry	5 Faces
Definition	
Type	Fixed Support
Suppressed	No

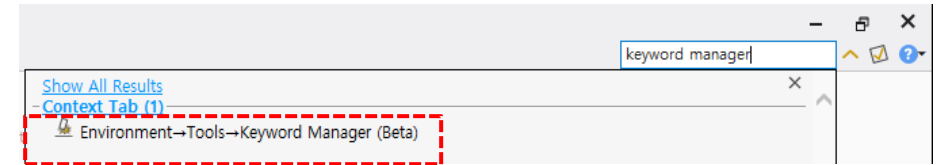




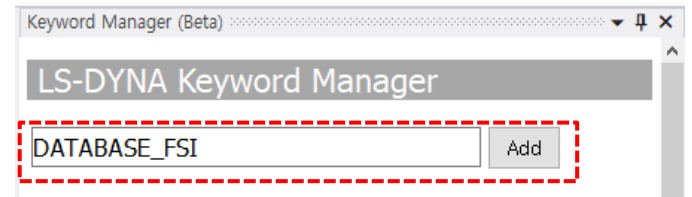
## 2. 전처리

### • FSI 관련 ASCII 데이터 저장

➤ Quick Launch 창 > **Keyword Manager** 입력 > 기능 활성화



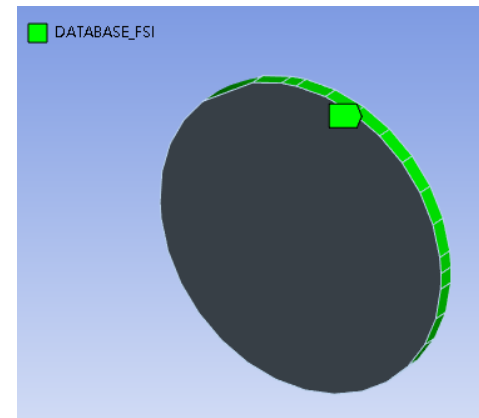
➤ 검색창 > **DATABASE\_FSI** 추가



→ 저장 간격 입력 : **1e-6**

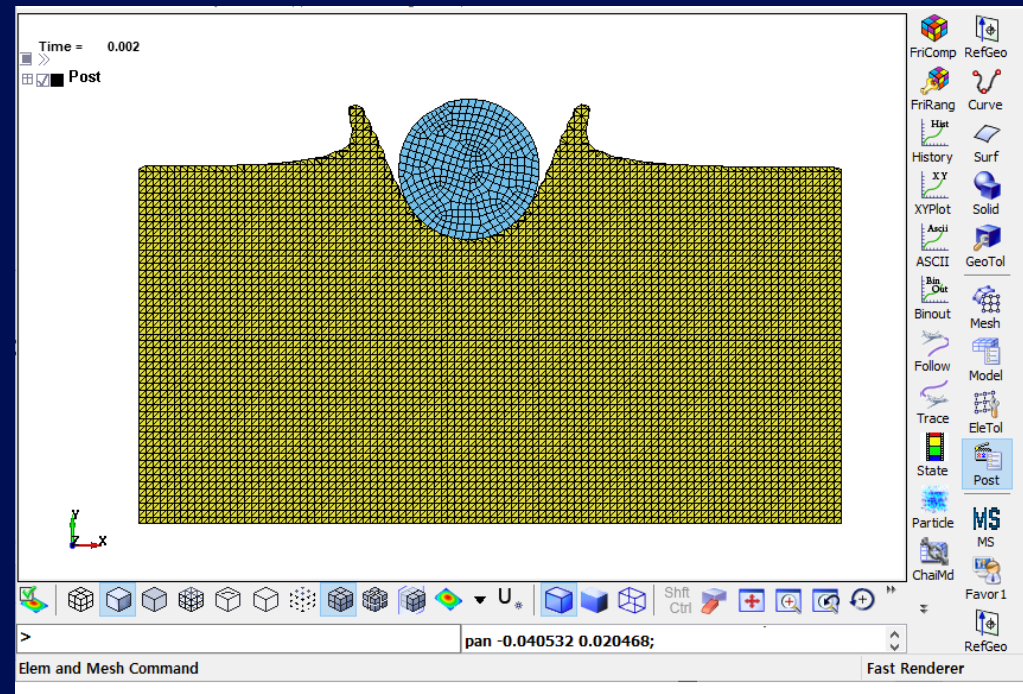
→ Surface : **Set ID** 입력(커플링에 사용된 라그랑지안 Set ID)

→ Set Type : **Segment Set** (Ball의 Surface 선택)



Details of "DATABASE_FSI"	
<b>Definition</b>	
UnitSystem	mks
<b>Card 1</b>	
<input type="checkbox"/> Output interval	1E-06
Flag for binary output	ASCII file is written
<b>Card 2</b>	
Surface	1
Set type	Segment set.
Switch from a corresponding *ALE_FSI_SWITCH...	0
For airbag application only	0
Set consisting of the nodes on which the mom...	0
Coordinate system	0
<b>Set</b>	
Scoping Method	Geometry Selection
Geometry	31 Faces

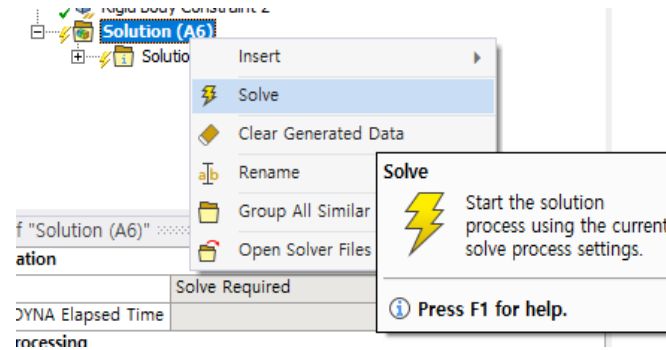
# 3. 해석 & 후처리



# 3. 해석 & 후처리

## • 해석

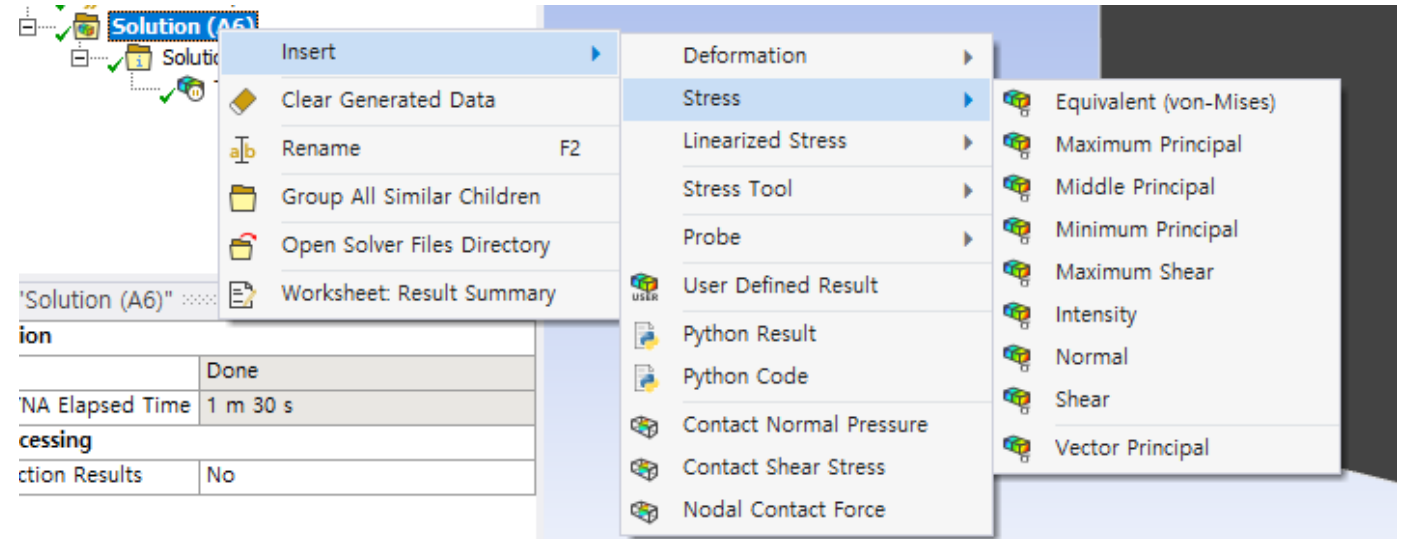
- "Solution"메뉴 > 우클릭 > "Solve" 실행



## • 결과 보기

- "Solution"메뉴에서 원하는 결과 항목 추가하여 결과 확인

→ FE 요소, **Ball** 파트만 결과 확인

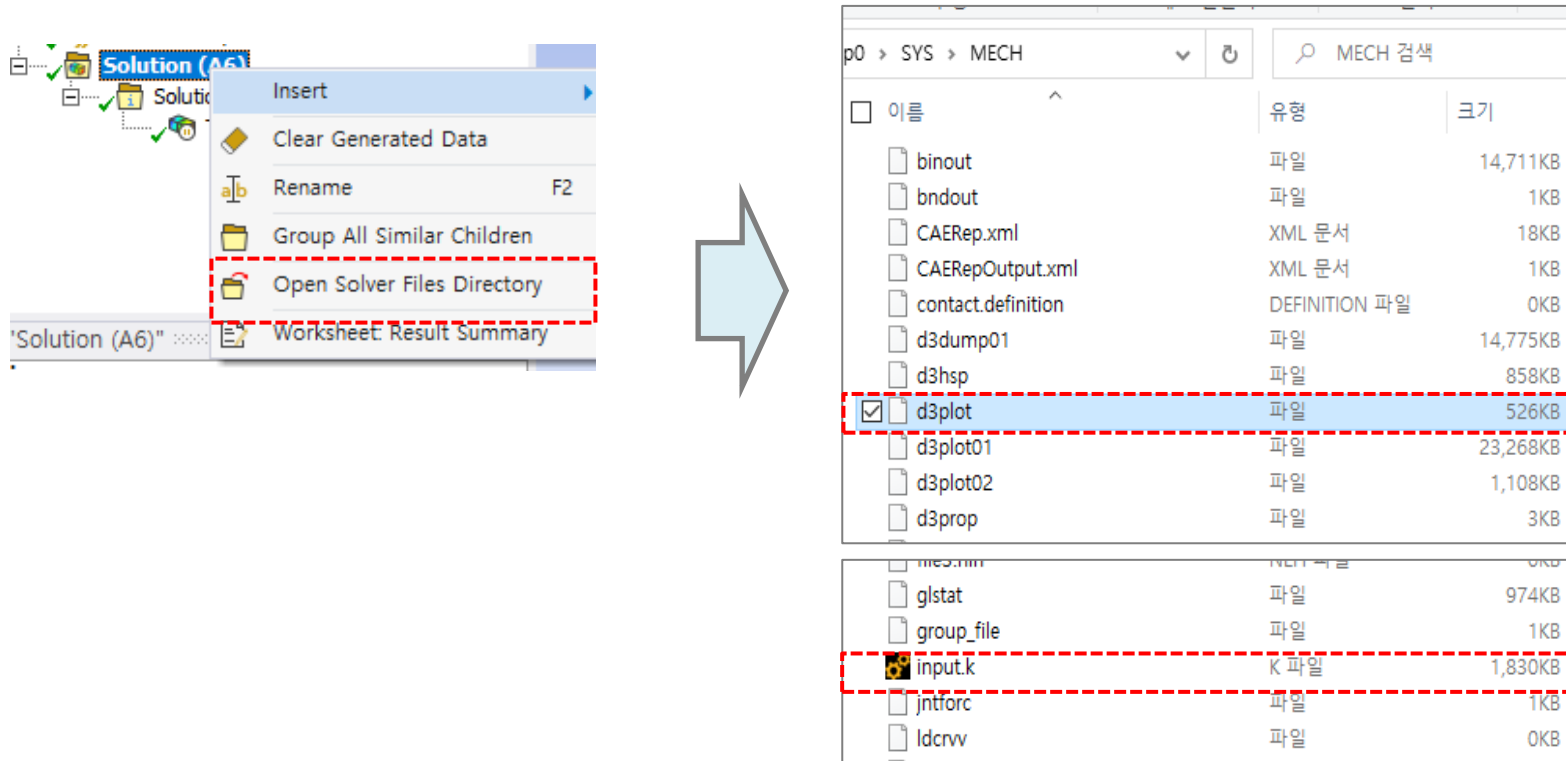


### 3. 해석 & 후처리

#### • 결과 보기 (LS-PrePost 활용)

➤ LS-PrePost를 사용하여 다양한 ALE 결과 확인

➤ Solution > 우클릭 > "Open Solver Files Directory" 열기 : 해석 작업 폴더



The image shows a two-step process. On the left, a context menu is open over a 'Solution (A6)' folder, with 'Open Solver Files Directory' highlighted by a red dashed box. A large blue arrow points to the right, where a Windows File Explorer window is open to the path 'p0 > SYS > MECH'. The file list is as follows:


이름	유형	크기
binout	파일	14,711KB
bndout	파일	1KB
CAERep.xml	XML 문서	18KB
CAERepOutput.xml	XML 문서	1KB
contact.definition	DEFINITION 파일	0KB
d3dump01	파일	14,775KB
d3hsp	파일	858KB
<input checked="" type="checkbox"/> d3plot	파일	526KB
d3plot01	파일	23,268KB
d3plot02	파일	1,108KB
d3prop	파일	3KB
mes.msh	FILE 파일	0KB
glstat	파일	974KB
group_file	파일	1KB
<input checked="" type="checkbox"/> input.k	K 파일	1,830KB
jntforc	파일	1KB
ldcrv	파일	0KB

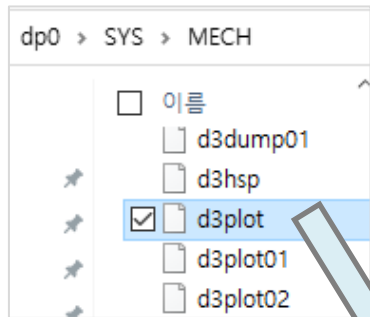
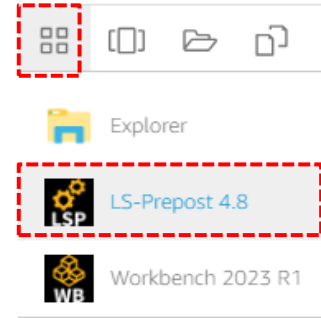
→ LS-DYNA 결과 파일 : d3plot

→ LS-DYNA Input 파일

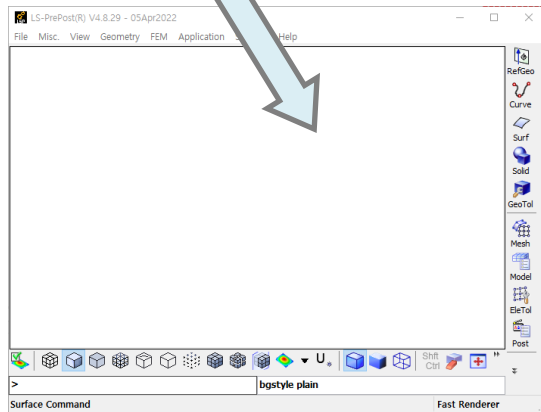
# 3. 해석 & 후처리

## • 결과 보기 (LS-PrePost 활용)

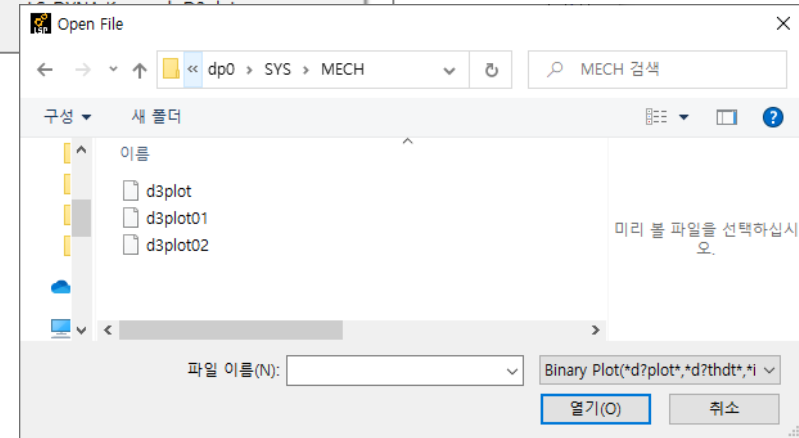
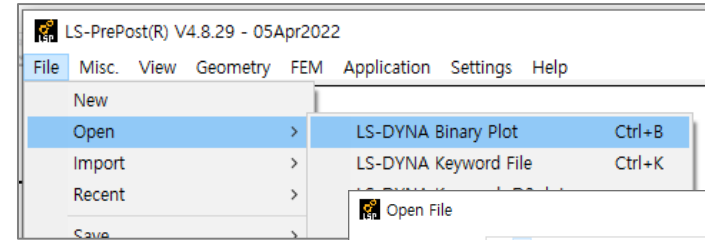
➤ **LS-PrePost** 실행 : exZone(체험존) 좌측 상단  아이콘 > LS-PrePost 클릭



해석 작업 폴더의 d3plot을  
마우스 드래그 & 드롭



또는




실행된 LS-PrePost에서

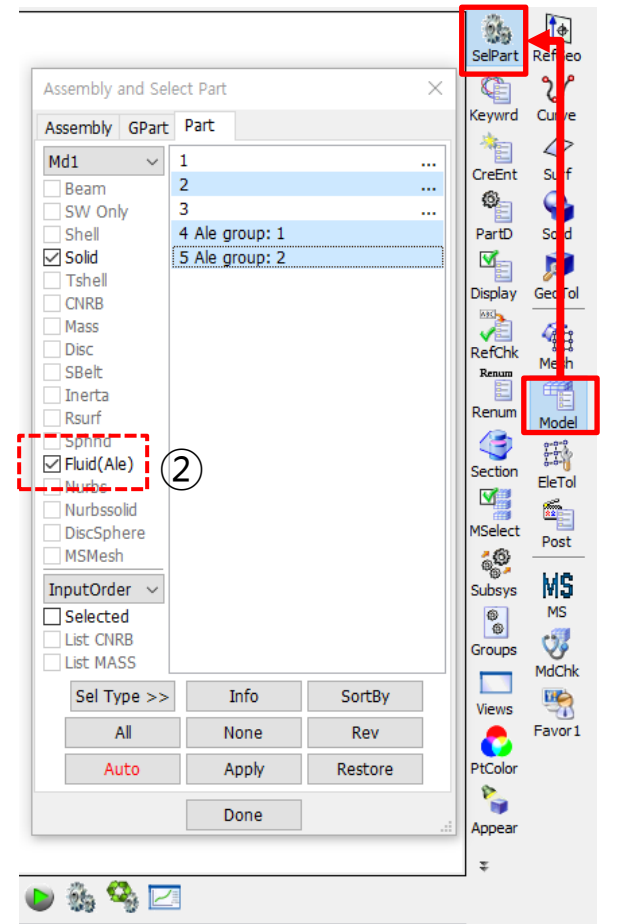
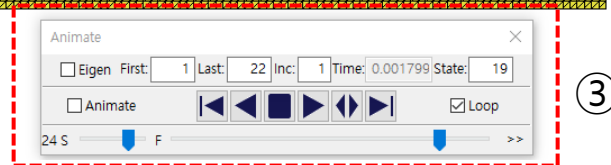
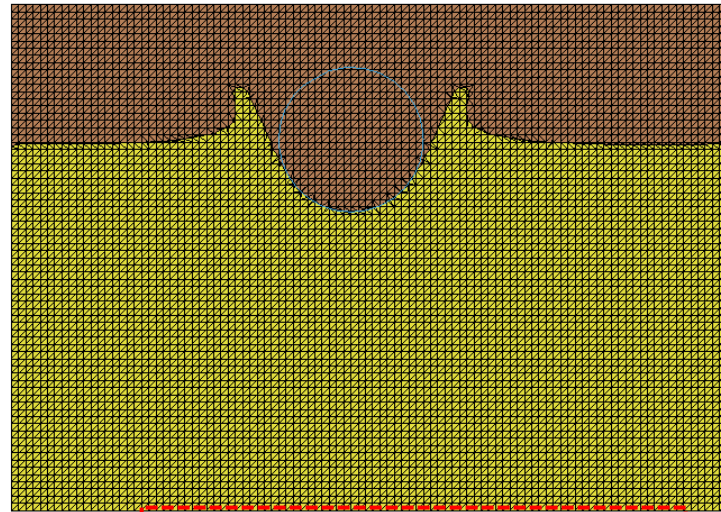
**File > Open > 해석작업 폴더의 “d3plot” 열기**

# 3. 해석 & 후처리

## • 결과 보기 (LS-PrePost 활용)

### ➤ ALE 파트 활성화

- 1) F2 단축키 또는 우측 툴바의 SelPart 아이콘  클릭
- 2) Fluid(Ale) 체크 & Ball 파트와 ALE 그룹만 활성 시각화
- 3) 애니메이션 재생하여 거동 확인



①

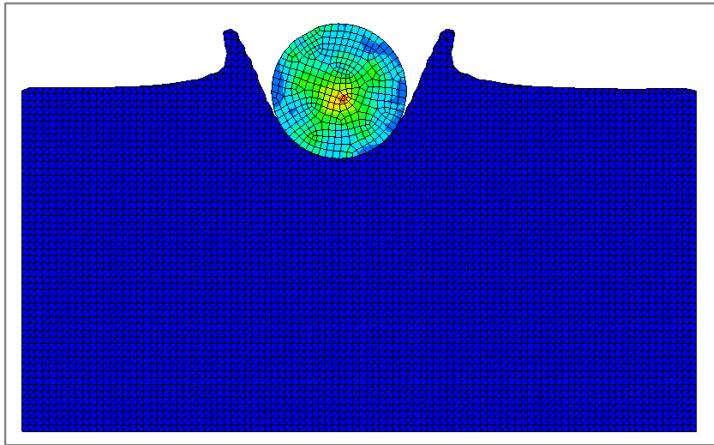
②

③

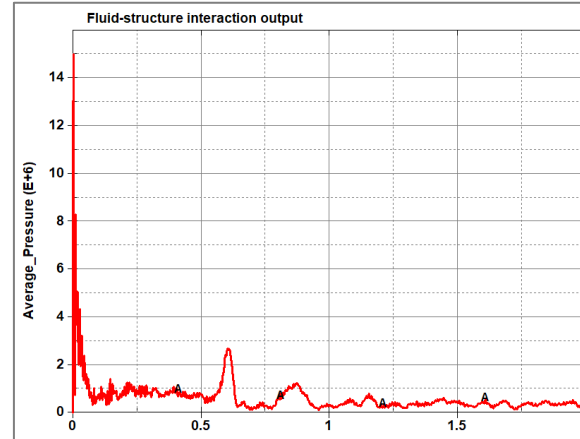
# 3. 해석 & 후처리

## • 결과 보기 (LS-PrePost 활용)

- Post > Fricomp : 프린지 결과 확인
- Psot > Ascii > dbfsi : fsi 그래프 결과 확인



①



②

