

减震结构大震弹塑性分析





目录 CONTENTS

- 01** 塑性铰的分类与定义
- 02** 纤维铰的定义与应用
- 03** 墙铰与分层壳
- 04** 非线性动力时程工况
- 05** 结果查看

01

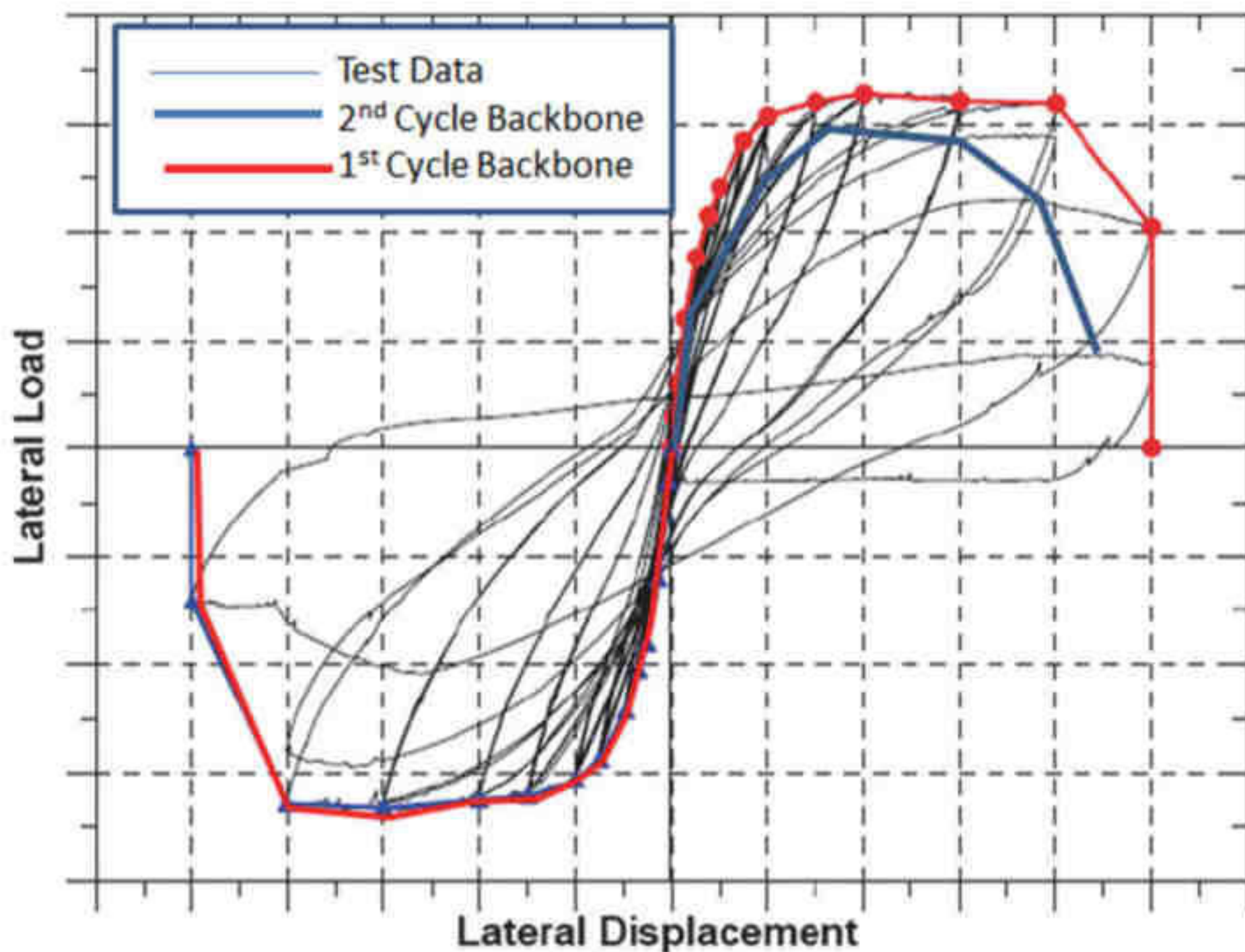
塑性铰的分类与定义

- ◆ 塑性铰的三要素
- ◆ 延性铰与脆性铰
- ◆ 基于ASCE41的默认铰定义
- ◆ 塑性铰的优缺点



塑性铰的三要素

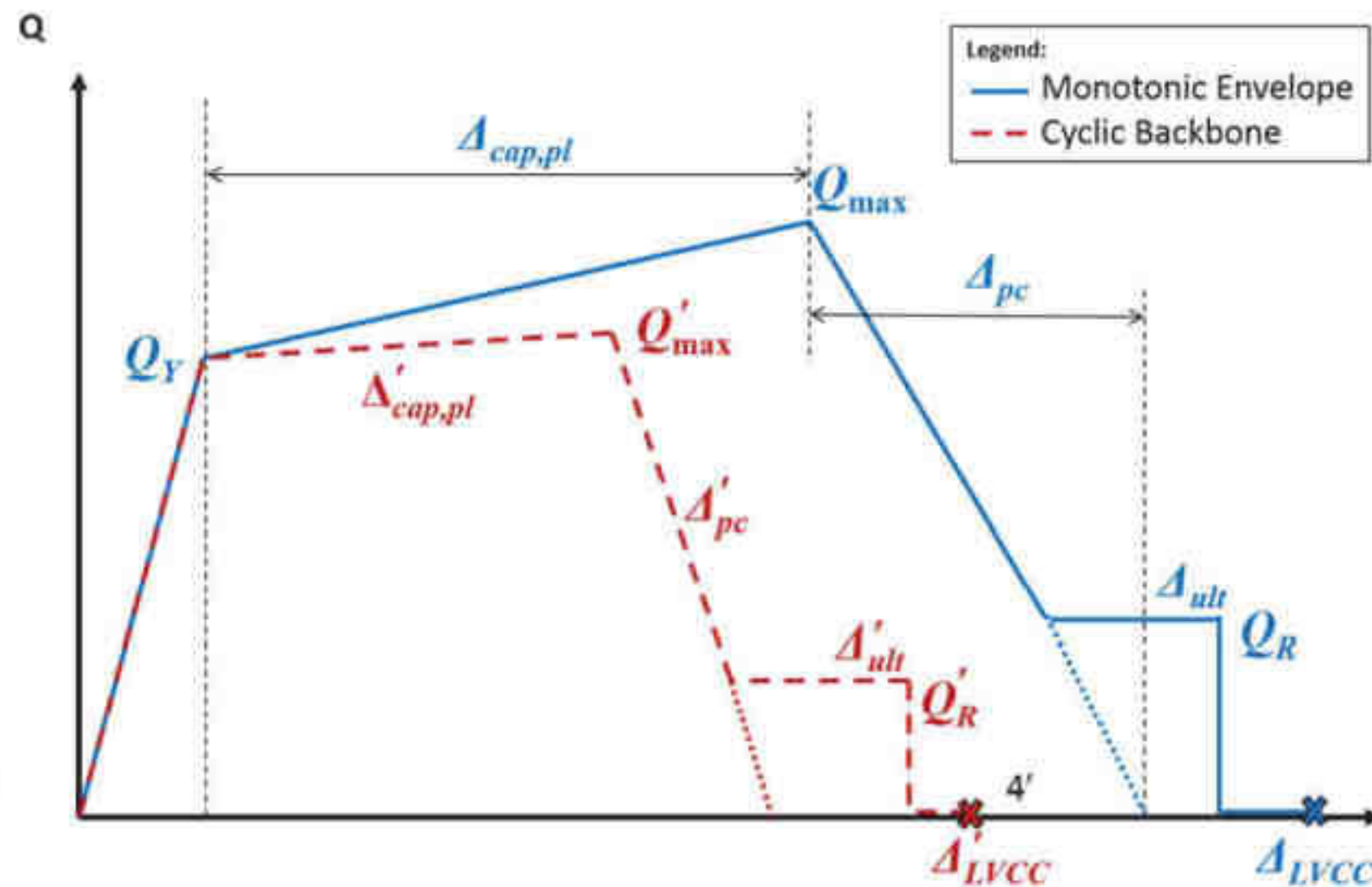
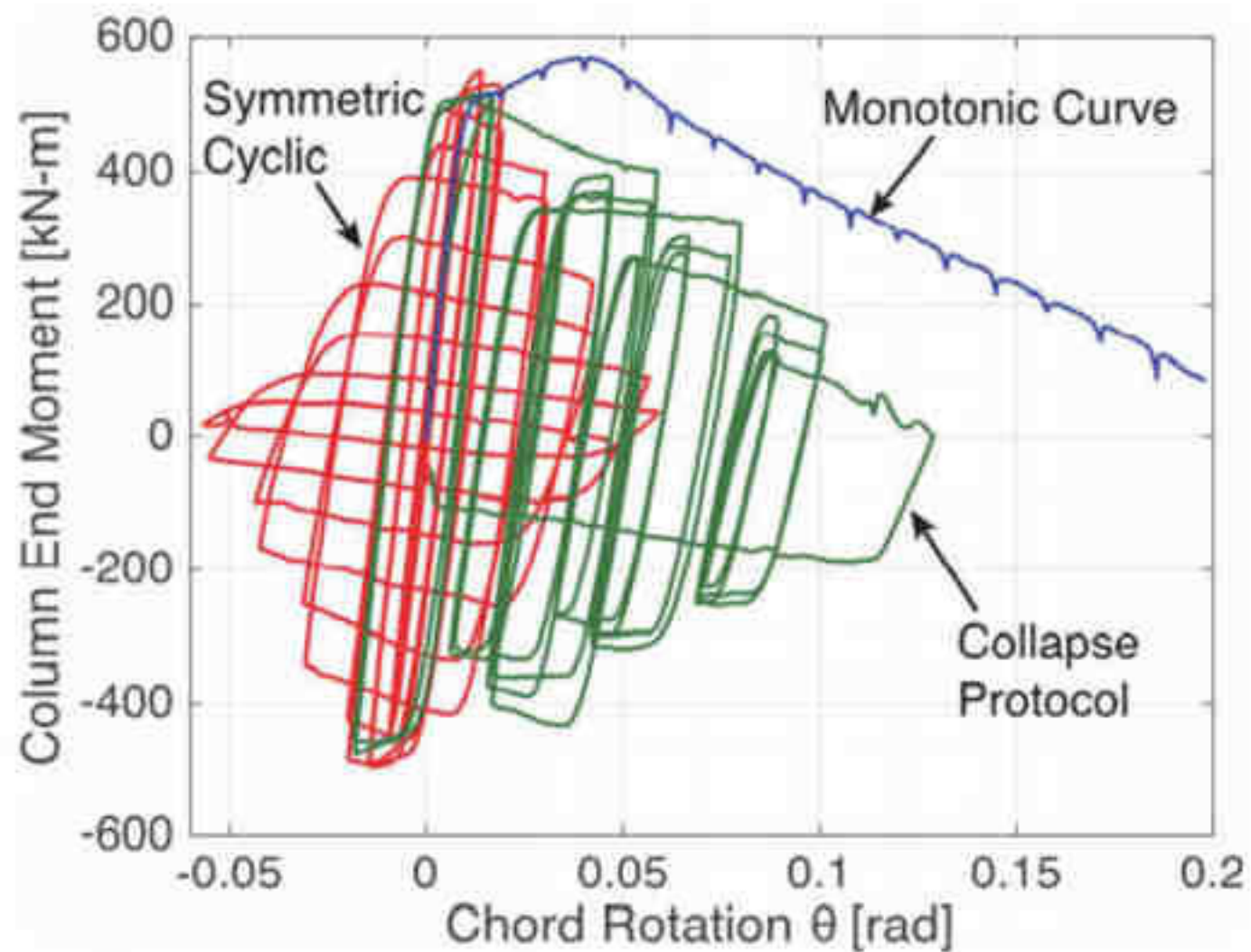
◇ 骨架曲线





塑性铰的要素一

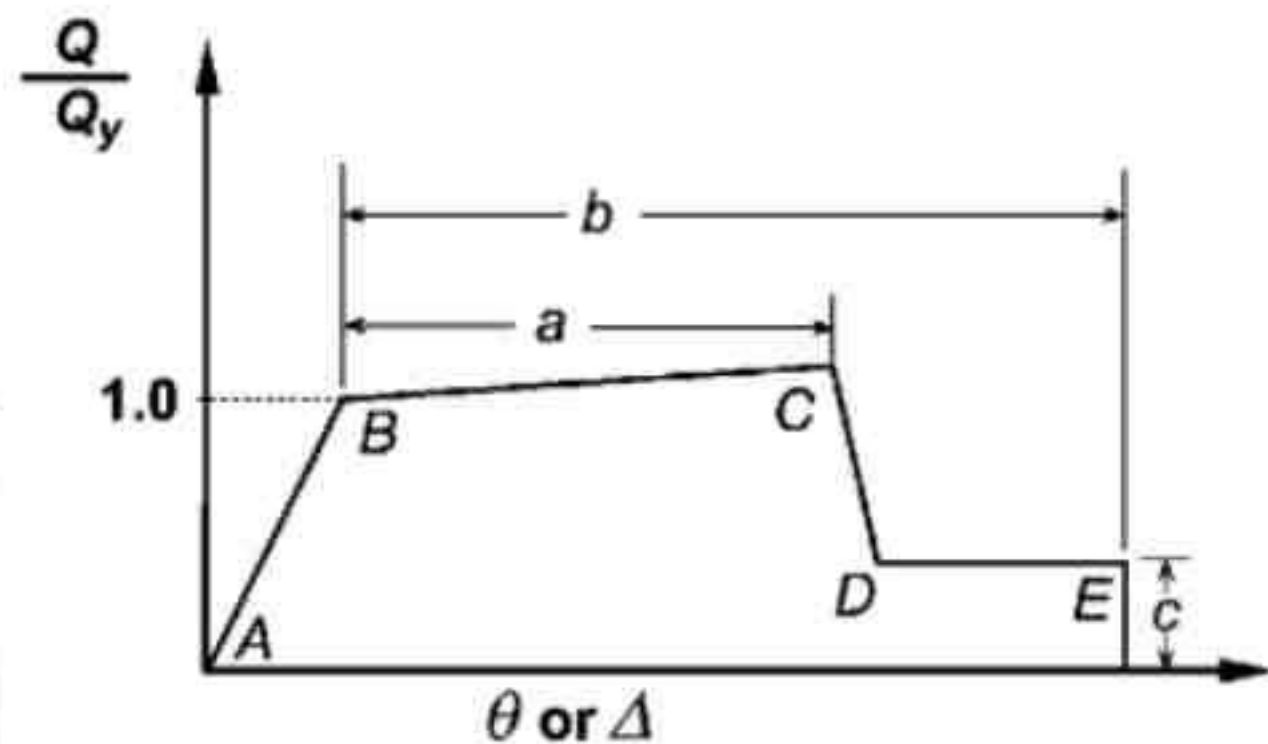
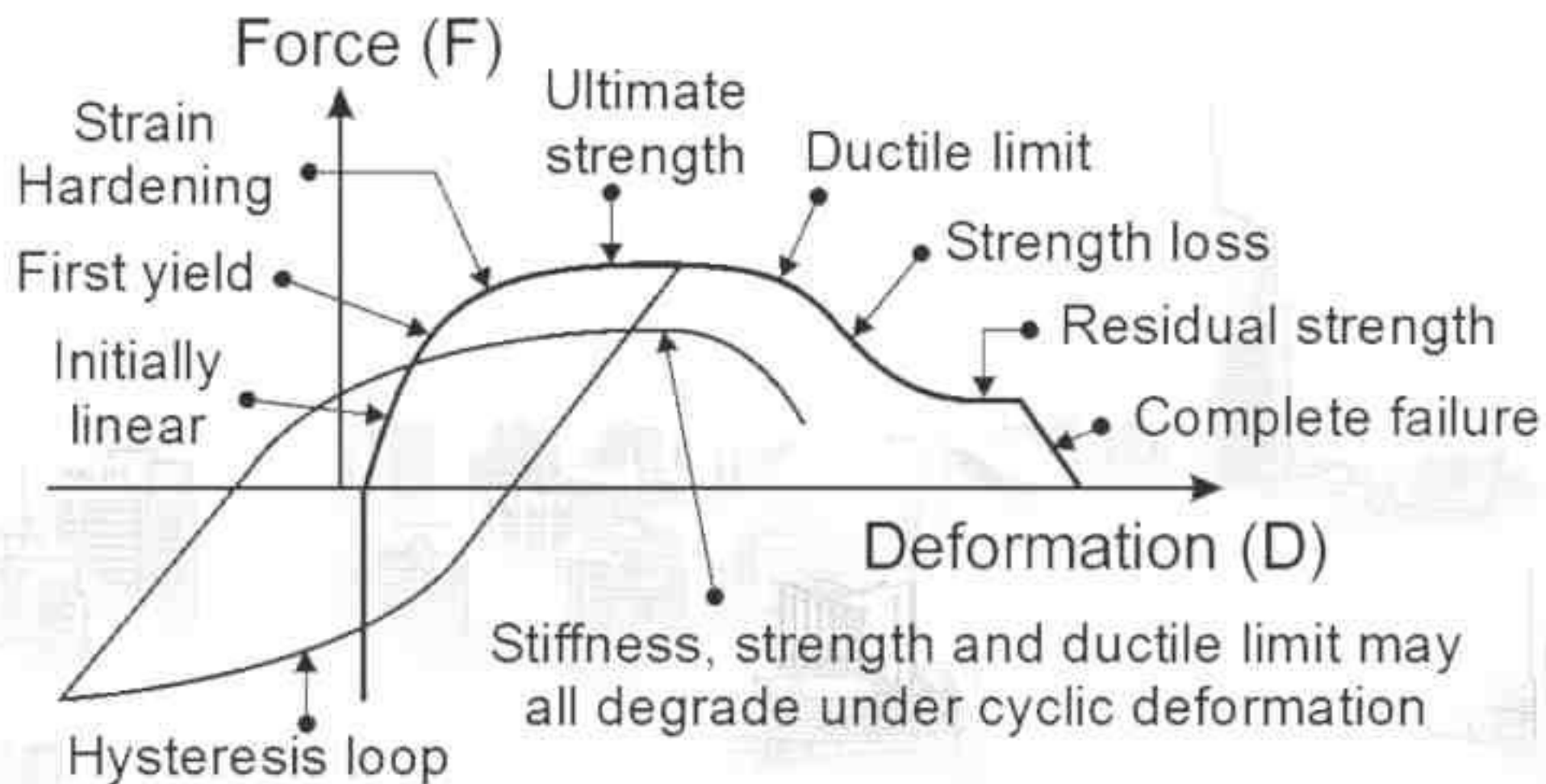
◇ 骨架曲线





塑性铰的要素一

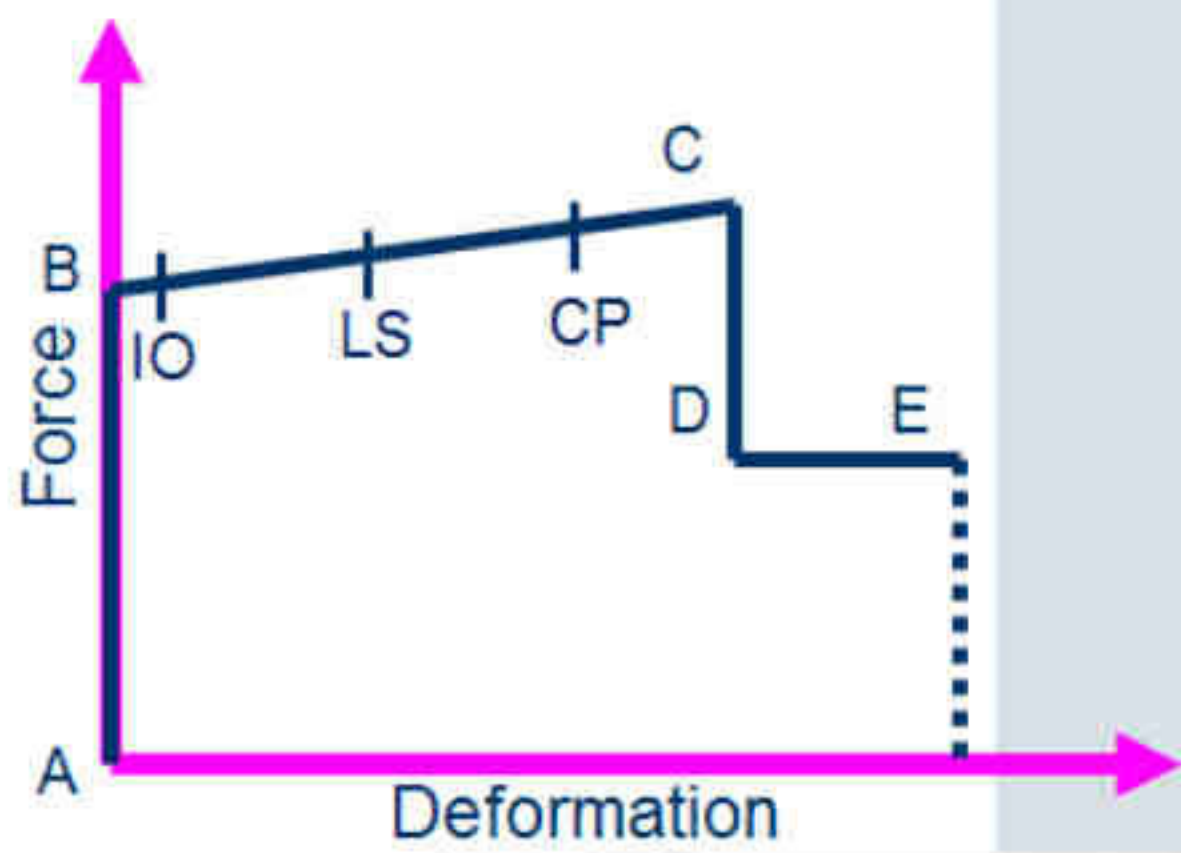
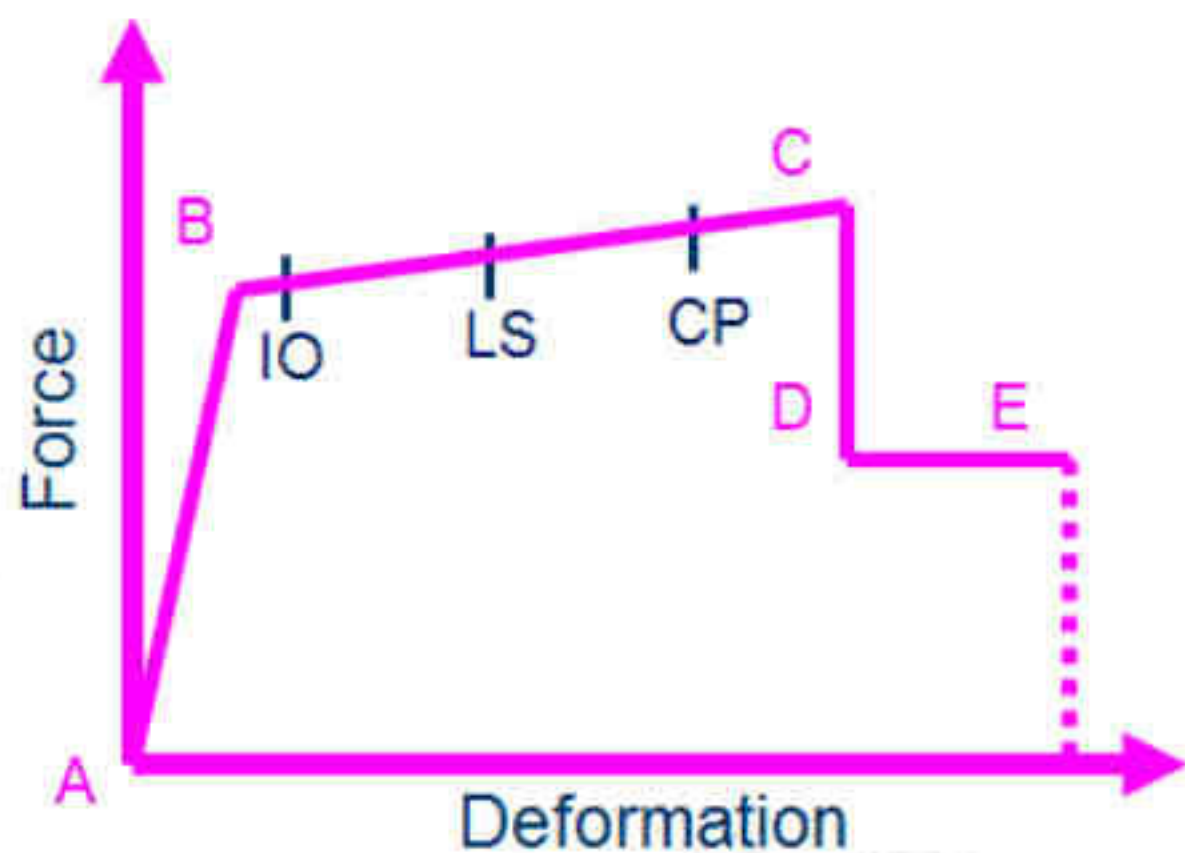
◇ 骨架曲线





塑性铰的要素一

◇ 骨架曲线





塑性铰的要素一

◇ 典型的塑性铰骨架曲线



M3铰



P铰



塑性铰的要素一

◇ 典型的塑性铰骨架曲线

弯矩-转角数据 C1000124H111 - Interacting P-M2-M3

选择曲线
轴力 -3285.6745 角度 0

弯矩-转角数据

点	弯矩/屈服弯矩	转角/SF
A	0	0
B	1	0
C	1.12	3.234112
D	0.2	3.266453
E	0.2	4.851169

当前曲线-曲线 #33
轴力 M3, 角度 #1

可接受准则 (塑性变形/SF)

- 立即使用 (IO) 0.203132
- 生命安全 (LS) 2.425304
- 防止倒塌 (CP) 3.234112

在曲线中显示

3D 视图
平面角 315 deg 轴力
立面角 35 deg
孔径角 0 deg

P-M2-M3 相关面的定义 C1000124H111

自定义相关面选择

曲线数量 10
相关曲线上点 11

比例系数(对全部曲线适用)

第一和最后一点(对全部曲线适用)

点	P	M2	M3
1	-4.957384	0	0
11	1	0	0

相关面的要求 - 非强制

- 至少指定 3 个 P-M2-M3 曲线
- P 轴为正弯矩增加
- 每条曲线必须是凸的, 相关面必须与是凸的曲面无关的

相关曲线数据

点	P/SF	M2/SF	M3/SF
1	-4.957384	0	0
2	-4.795091	0.238	0
3	-4.574472	0.472	0
4	-4.352948	0.708	0
5	-4.131423	0.944	0
6	0	1	0
7	0.2	0.944	0
8	0.4	0.708	0
9	0.6	0.472	0
10	0.8	0.238	0
11	1	0	0

3D 视图
平面 deg 310
轴角 deg 25
孔径 deg 0

显示全部线
 隐藏 P 方向线
 隐藏 M2-M3 线

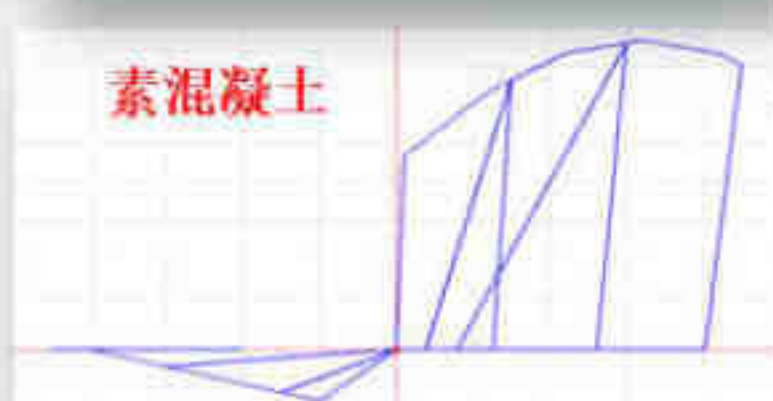
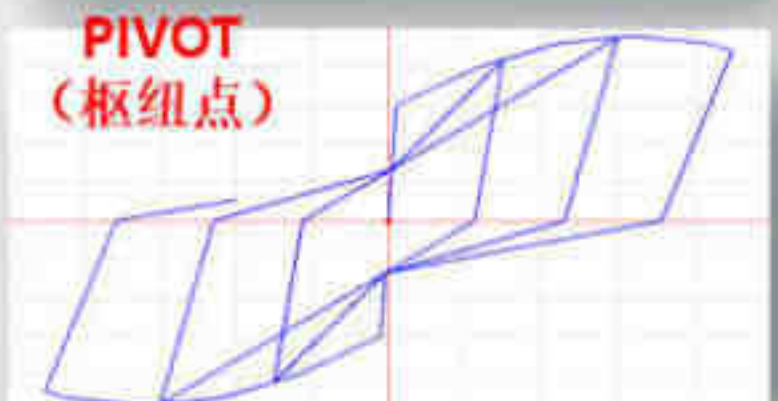
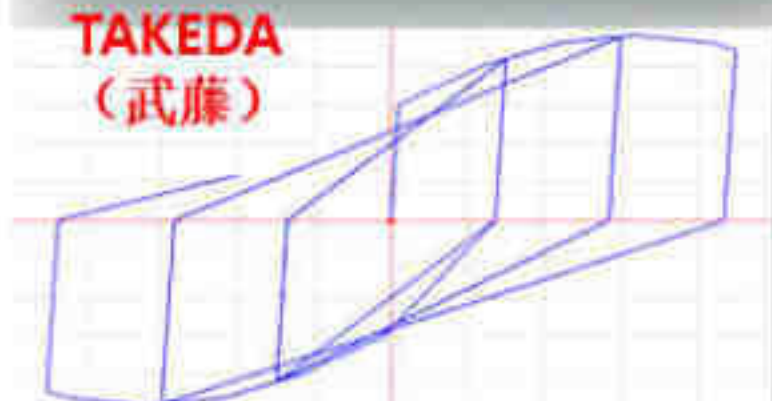
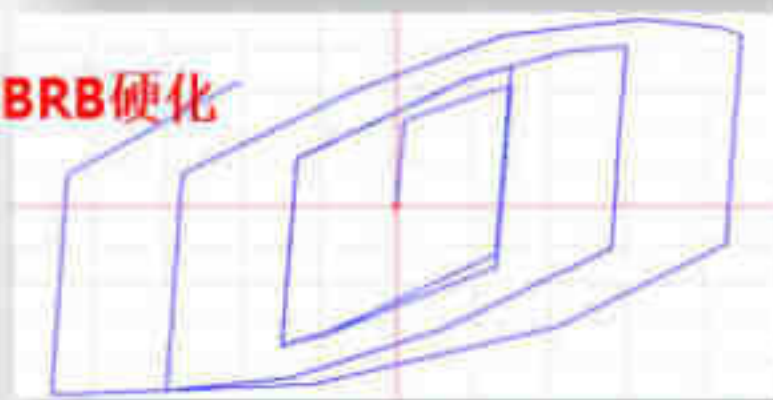
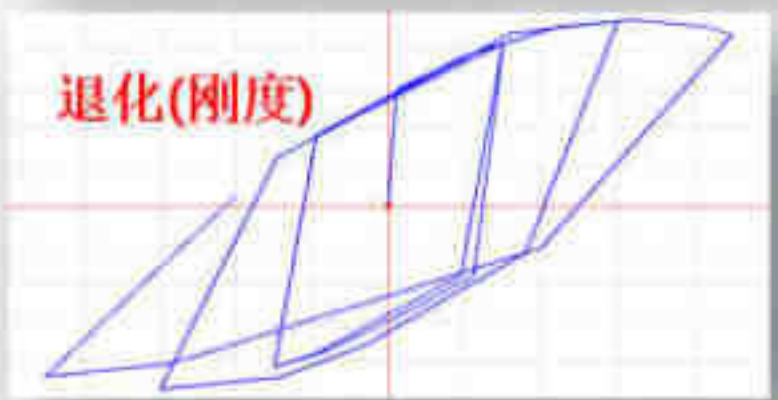
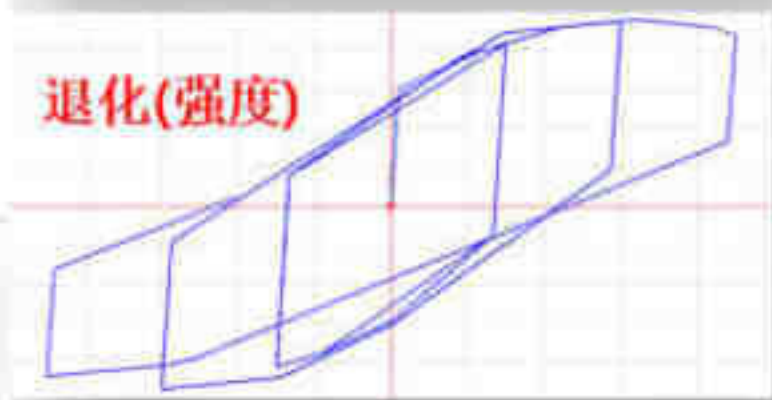
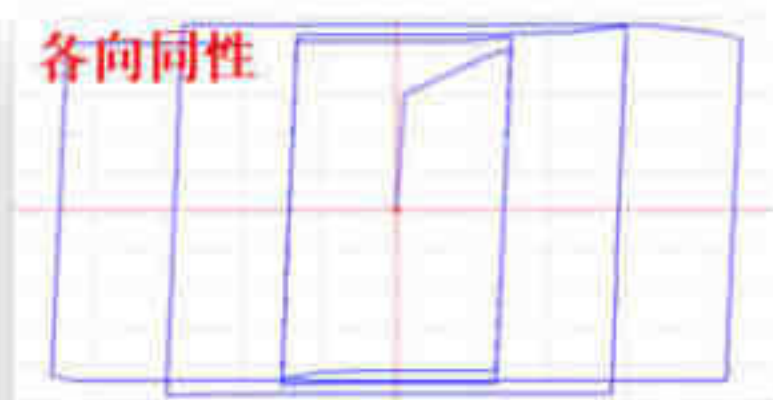
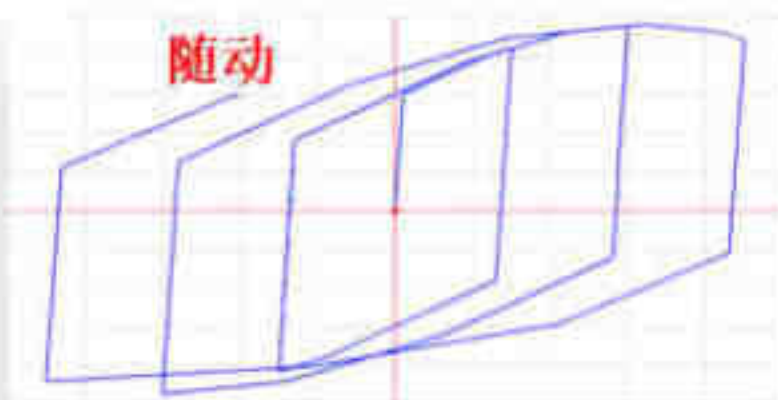
激活当前曲线

P-M2-M3 铰



塑性铰的要素二

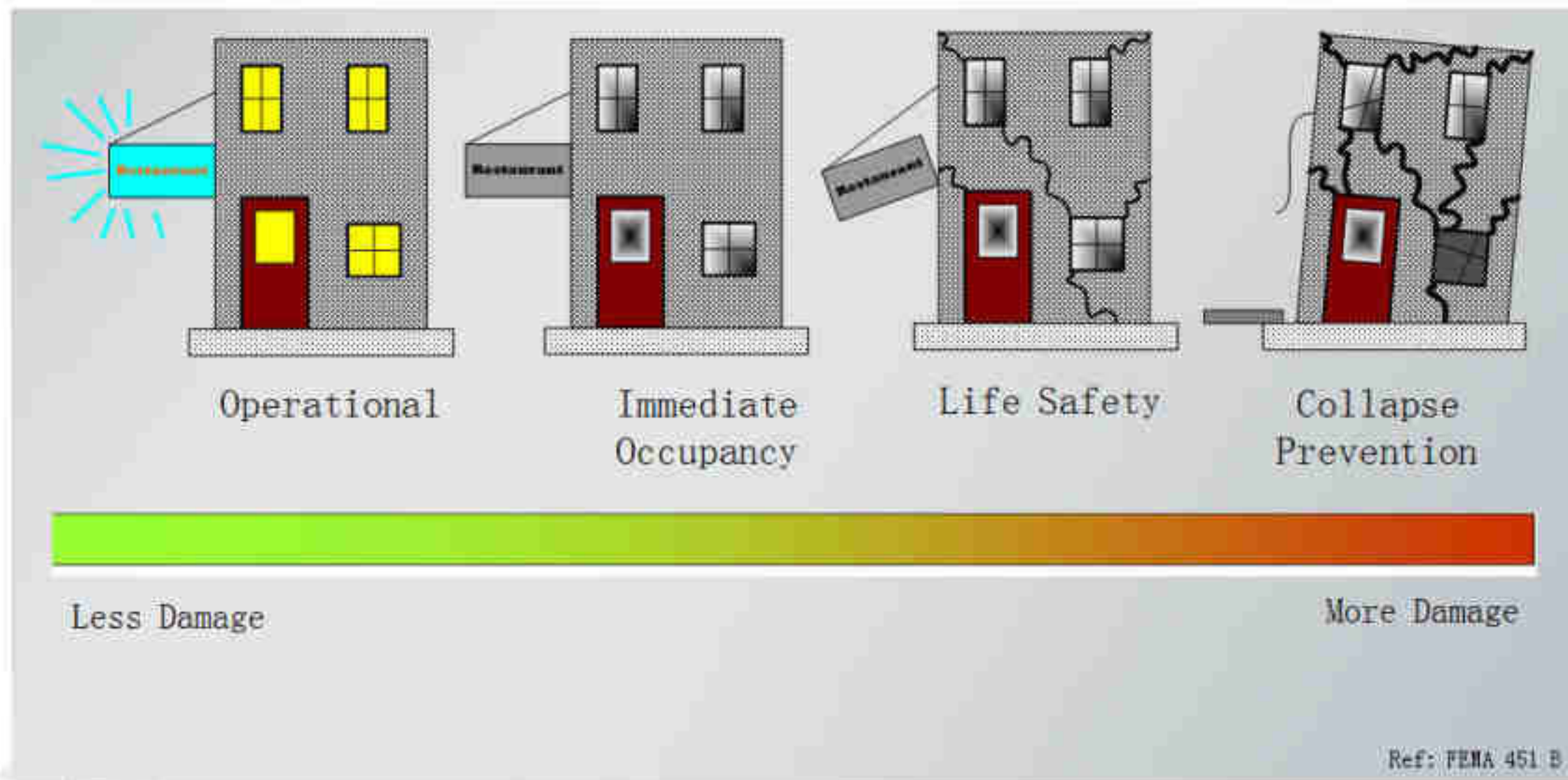
◇ 滞回曲线





塑性铰的要素三

◇ 可接受准则



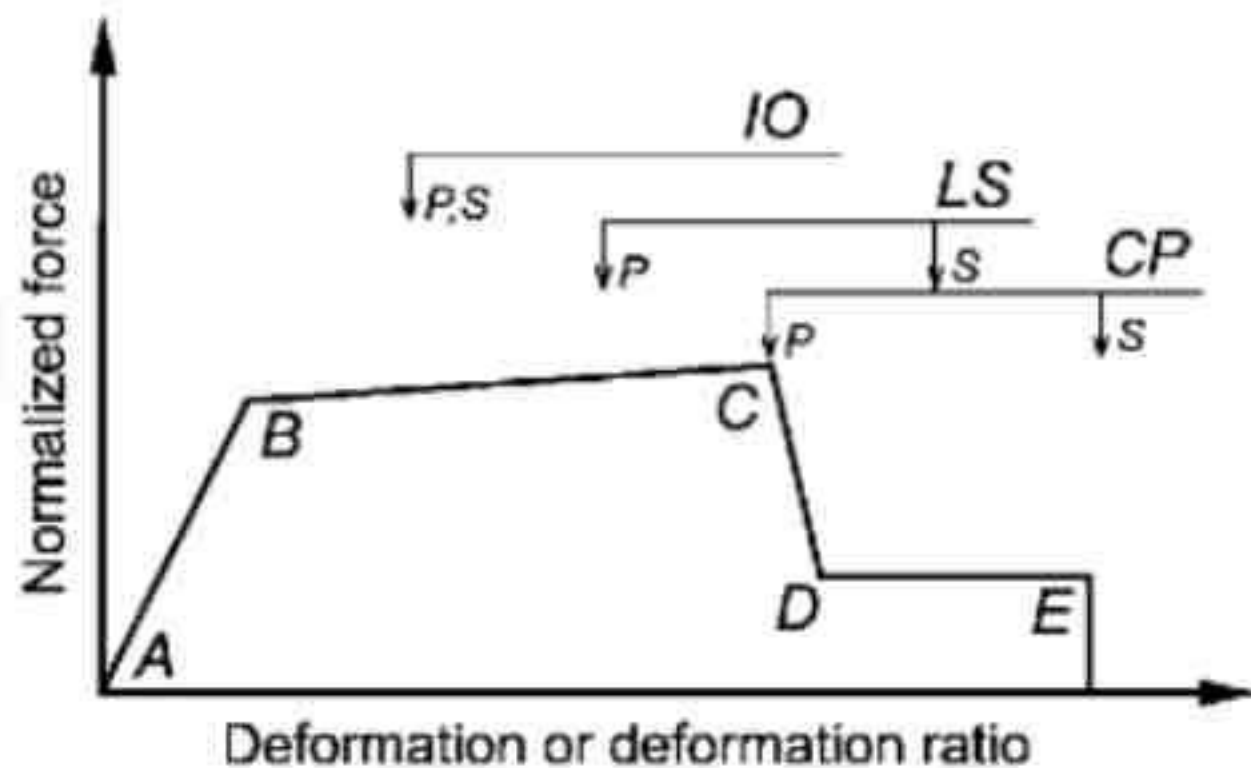
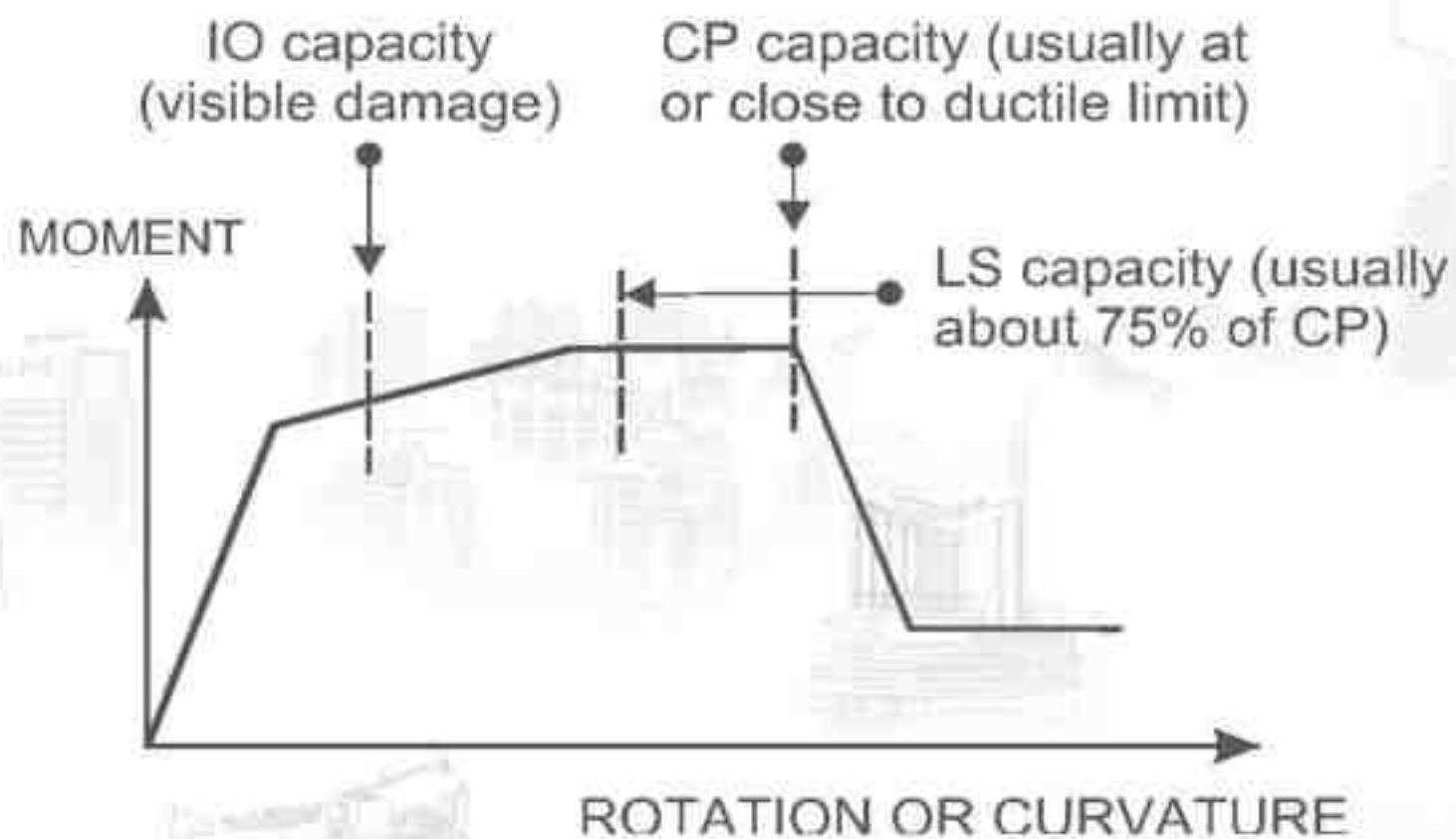


塑性铰的要素三

◇ 可接受准则

◇ 依照相关规范确定，不同版本规范差异很大。

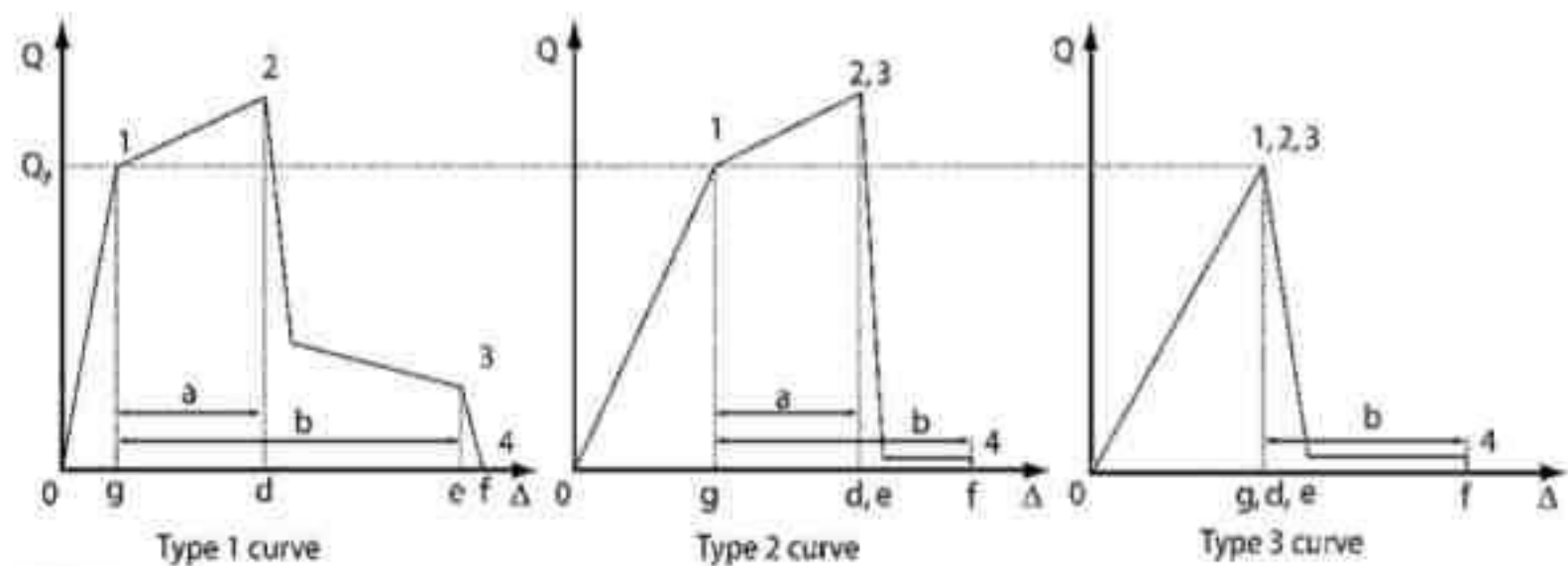
◇ 大多数情况使用变形指标，也可采用力指标。





塑性铰的分类

◇ 力控制VS变形控制



摘自ASCE41-17





基于ASCE41的默认铰定义

◇ 前置条件

◇ 使用设计配筋

◇ 塑性铰指定 > 设计 > 保存 > 解锁 > 再分析

◇ 使用实配钢筋

程序截面的配筋数据

设计类型

柱 (P-M2-M3)

梁 (M3)

钢筋材料

纵筋 HRB400

箍筋 (排扎) HRB400

纵筋中心的保护层厚度

顶部钢筋 65 mm

底部钢筋 65 mm

塑性铰的钢筋覆盖项

I端顶部钢筋 2500 mm²

II端顶部钢筋 2500 mm²

I端底部钢筋 2000 mm²

II端底部钢筋 2000 mm²

确定 取消

程序截面的配筋数据

设计类型

柱 (P-M2-M3)

梁 (M3)

钢筋材料

纵筋 HRB400

箍筋 (排扎) HRB400

布置方式

矩形

环形

箍筋

排扎式

螺旋式

铰接设计

铰接

设计

实配钢筋

箍筋保护层 35 mm

沿3轴的纵筋数量 5

沿2轴的纵筋数量 5

纵筋直径和面积 25 314 mm²

角筋直径和面积 25 314 mm²

加密区箍筋

箍筋直径和面积 10 70 mm²

加密区1轴的纵向间距 100 mm

沿3轴的箍筋数量 4

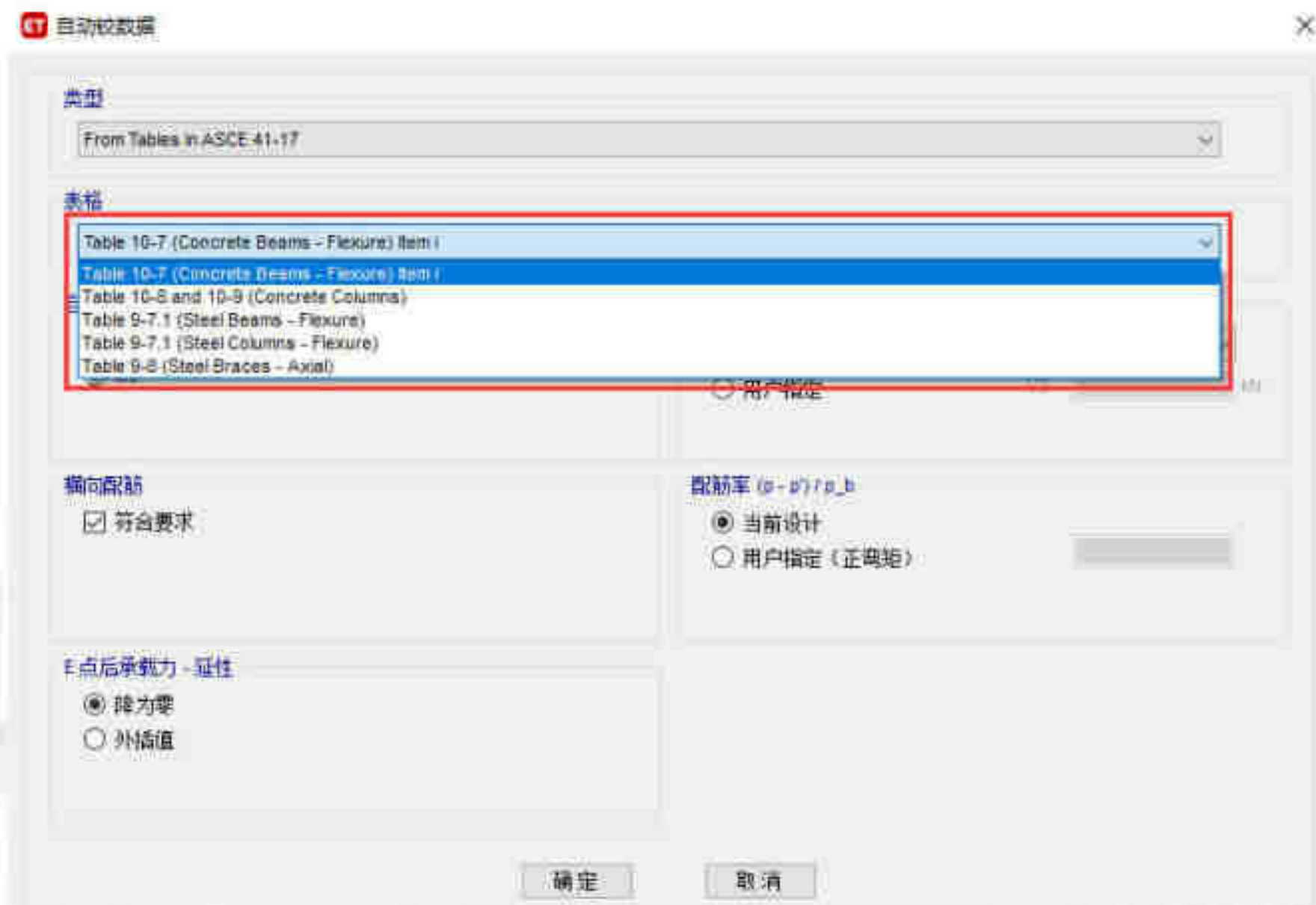
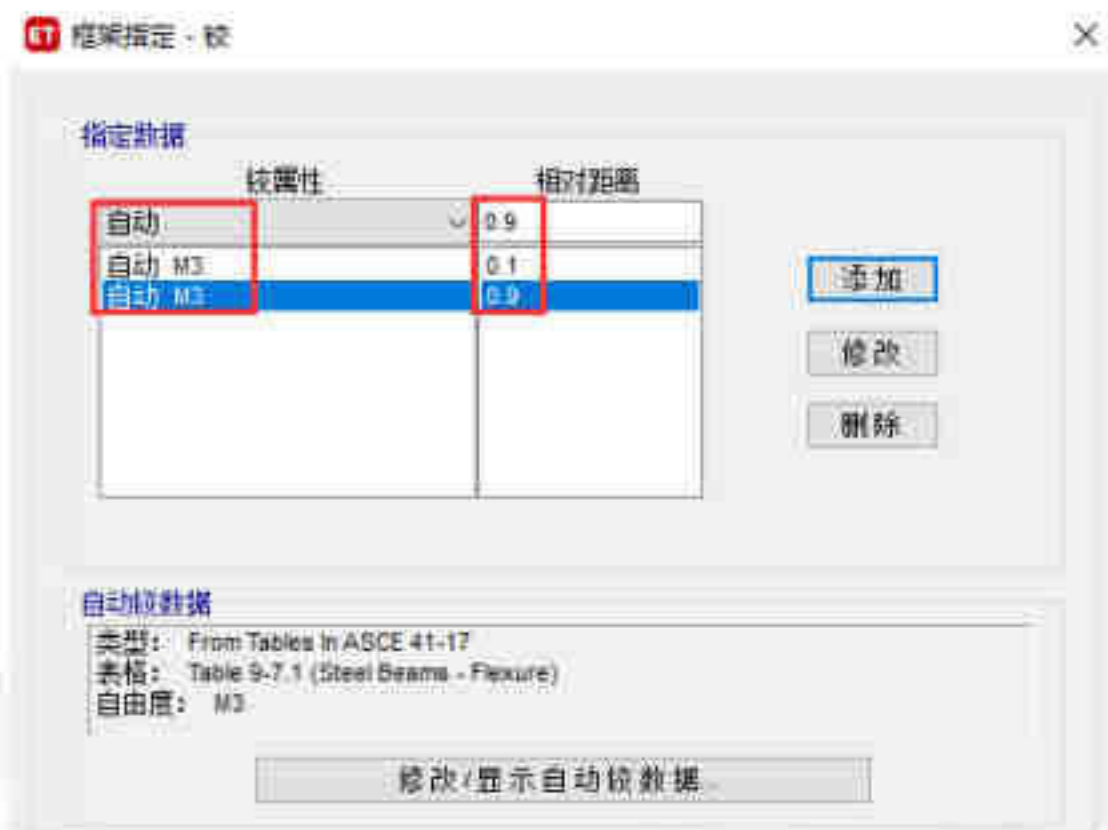
沿2轴的箍筋数量 4

确定 取消



基于ASCE41的默认铰定义

◇ 默认铰的指定





基于ASCE41-17 的默认铰定义

◇ 钢框架

Table 9-7.1. Modeling Parameters and Acceptance Criteria for Nonlinear Procedures—Structural Steel Beams and Columns—Flexural Actions

Modeling Parameters	Acceptance Criteria		
	Plastic rotation angle (radians) Performance Level		
	ID	LS	CP
Plastic rotation angle a and b (radians) Residual strength ratio c			
Beams			
1. Where: $\frac{d_f}{2t_f} \leq 0.30 \sqrt{\frac{E}{F_{ye}}}$ and $\frac{h}{t_w} \leq 2.45 \sqrt{\frac{E}{F_{ye}}}$			*
$a = 0,$ $b = 11\theta_p$ $c = 0.6$	0.25*	*	*
2. Where: $\frac{d_f}{2t_f} \geq 0.38 \sqrt{\frac{E}{F_{ye}}}$ or $\frac{h}{t_w} \geq 3.76 \sqrt{\frac{E}{F_{ye}}}$		0.75*	*
$a = 4\theta_p$ $b = 6\theta_p$ $c = 0.2$	0.25*	0.75*	*
3. Other: Linear interpolation between the values on lines 1 and 2 for both flange slenderness (first term) and web slenderness (second term) shall be performed, and the lower resulting value shall be used.			
Columns in Compression**			
1. Where: $\frac{d_f}{2t_f} \leq 0.30 \sqrt{\frac{E}{F_{ye}}}$ and For $\frac{P_u}{P_{ne}} < 0.2$ $\frac{h}{t_w} \leq 2.45 \sqrt{\frac{E}{F_{ye}}} \left(1 - 0.71 \frac{P_u}{P_{ne}}\right)$ For $\frac{P_u}{P_{ne}} \geq 0.2$ $\frac{h}{t_w} \leq 0.77 \sqrt{\frac{E}{F_{ye}}} \left(2.93 - \frac{P_u}{P_{ne}}\right) \leq 1.49 \sqrt{\frac{E}{F_{ye}}}$	0.5*	0.75*	*
$a = 0.8 \left(1 - \frac{P_u}{P_{ne}}\right)^{1.2} \left(0.1 \frac{L}{r_f} + 0.8 \frac{h}{t_w}\right)^{-1} - 0.0035 \geq 0$ $b = 7.4 \left(1 - \frac{P_u}{P_{ne}}\right)^{1.2} \left(0.5 \frac{L}{r_f} + 2.9 \frac{h}{t_w}\right)^{-1} - 0.006 \geq 0$ $c = 0.9 - 0.9 \frac{P_u}{P_{ne}}$	0.5*	0.75*	*
2. Where: $\frac{d_f}{2t_f} \geq 0.38 \sqrt{\frac{E}{F_{ye}}}$ or For $\frac{P_u}{P_{ne}} < 0.2$ $\frac{h}{t_w} \geq 3.76 \sqrt{\frac{E}{F_{ye}}} \left(1 - 1.83 \frac{P_u}{P_{ne}}\right)$ For $\frac{P_u}{P_{ne}} \geq 0.2$ $\frac{h}{t_w} \geq 1.12 \sqrt{\frac{E}{F_{ye}}} \left(2.33 - \frac{P_u}{P_{ne}}\right) \geq 1.49 \sqrt{\frac{E}{F_{ye}}}$			*
$a = 1.2 \left(1 - \frac{P_u}{P_{ne}}\right)^{1.2} \left(1.4 \frac{L}{r_f} + 0.1 \frac{h}{t_w} + 0.8 \frac{d_f}{2t_f}\right)^{-1} - 0.0023 \geq 0$ $b = 2.5 \left(1 - \frac{P_u}{P_{ne}}\right)^{1.2} \left(0.1 \frac{L}{r_f} + 0.2 \frac{h}{t_w} + 2.7 \frac{d_f}{2t_f}\right)^{-1} - 0.0097 \geq 0$ $c = 0.5 - 0.5 \frac{P_u}{P_{ne}}$	0.5*	0.75*	*
3. Other: Linear interpolation between the values on lines 1 and 2 for both flange slenderness (first term) and web slenderness (second term) shall be performed, and the lower resulting value shall be used.			

Table 9-8. Modeling Parameters and Acceptance Criteria for Nonlinear Procedures—Structural Steel Components—Axial Actions

Component/Action	Modeling Parameters			Acceptance Criteria		
	Plastic Deformation	Residual Strength Ratio		Plastic Deformation		
	a	B	c	ID	LS	CP
Braces in Compression (except EBF braces)**						
a. Slender $\frac{Kl}{r} \geq 4.2 \sqrt{E/F_y}$						
1. W, I, 2L in-plane*, 2C in-plane*	0.5 Δ_c	10 Δ_c	0.3	0.5 Δ_c	8 Δ_c	10 Δ_c
2. 2L out-of-plane*, 2C out-of-plane*	0.5 Δ_c	9 Δ_c	0.3	0.5 Δ_c	7 Δ_c	9 Δ_c
3. HSS, pipes, tubes	0.5 Δ_c	9 Δ_c	0.3	0.5 Δ_c	7 Δ_c	9 Δ_c
4. Single angle	0.5 Δ_c	12 Δ_c	0.3	0.5 Δ_c	9 Δ_c	12 Δ_c
b. Stocky $\frac{Kl}{r} \leq 2.1 \sqrt{E/F_y}$						
1. W, I, 2L in-plane*, 2C in-plane*	1 Δ_c	8 Δ_c	0.5	0.5 Δ_c	7 Δ_c	8 Δ_c
2. 2L out-of-plane*, 2C out-of-plane*	1 Δ_c	7 Δ_c	0.5	0.5 Δ_c	6 Δ_c	7 Δ_c
3. HSS, pipes, tubes	1 Δ_c	7 Δ_c	0.5	0.5 Δ_c	6 Δ_c	7 Δ_c
c. Intermediate	Linear interpolation between the values for slender and stocky braces (after application of all applicable modifiers) shall be used.					
Braces in Tension (except EBF braces)**						
1. W	10 Δ_t	13 Δ_t	0.6	0.5 Δ_t	10 Δ_t	13 Δ_t
2. 2L	9 Δ_t	12 Δ_t	0.6	0.5 Δ_t	9 Δ_t	12 Δ_t
3. HSS	9 Δ_t	11 Δ_t	0.6	0.5 Δ_t	8 Δ_t	11 Δ_t
4. Pipe	8 Δ_t	9 Δ_t	0.6	0.5 Δ_t	7 Δ_t	9 Δ_t
5. Single angle	10 Δ_t	11 Δ_t	0.6	0.5 Δ_t	8 Δ_t	10 Δ_t
Columns in tension (except EBF Columns)*	5 Δ_t	7 Δ_t	1.0	0.5 Δ_t	6 Δ_t	7 Δ_t
Buckling-Restrained Braces**	13.3 Δ_c	13.3 Δ_c	1.0	3.0 Δ_c	10 Δ_c	13.3 Δ_c



基于ASCE41-17 的默认铰定义

◇ 钢框架柱



轴力值P的工况取重力荷载代表值

P_G is the axial force component of the gravity load as determined by Eq. (7-3).

$$Q_G = Q_D + Q_L + Q_S \quad (7-3)$$

Q_D = Action caused by dead loads;

Q_L = Action caused by live load, equal to 25% of the unreduced live load obtained in accordance with ASCE 7 but not less than the actual live load; and

Q_S = Action caused by effective snow load.

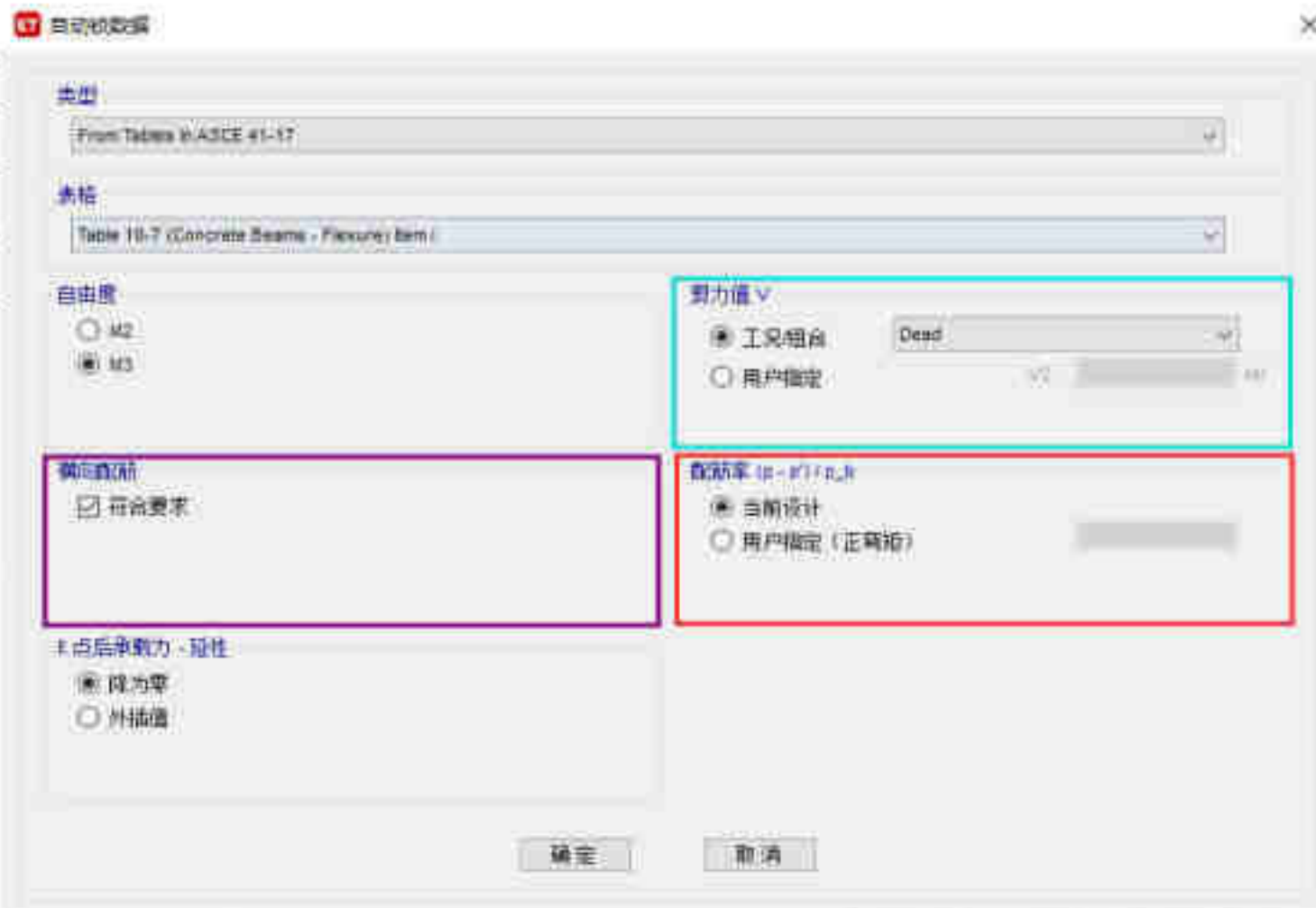


基于ASCE41-17 的默认铰定义

◇ 混凝土框架梁

Table 10-7. Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures—Reinforced Concrete Beams

Conditions	Modeling Parameters ^a			Acceptance Criteria ^a				
	Plastic Rotation Angle (radians)		Residual Strength Ratio	Plastic Rotation Angle (radians)				
	a	b		Performance Level				
			c	IO	LS	CP		
Condition i. Beams controlled by flexure ^b								
$\frac{L}{d} \leq 0$	Transverse reinforcement ^c C	$\frac{V_u}{A_s f_y d} \leq 3 (0.25)$	0.025	0.05	0.2	0.010	0.025	0.05
≤ 0	C	$\geq 6 (0.5)$	0.02	0.04	0.2	0.005	0.02	0.04
≥ 0.5	C	$\leq 3 (0.25)$	0.02	0.03	0.2	0.005	0.02	0.03
≥ 0.5	C	$\geq 6 (0.5)$	0.015	0.02	0.2	0.005	0.015	0.02
≤ 0	NC	$\leq 3 (0.25)$	0.02	0.03	0.2	0.005	0.02	0.03
≤ 0	NC	$\geq 6 (0.5)$	0.01	0.015	0.2	0.0015	0.01	0.015
≥ 0.5	NC	$\leq 3 (0.25)$	0.01	0.015	0.2	0.005	0.01	0.015
≥ 0.5	NC	$\geq 6 (0.5)$	0.005	0.01	0.2	0.0015	0.005	0.01
Condition ii. Beams controlled by shear ^b								
Stirrup spacing $\leq d/2$			0.0030	0.02	0.2	0.0015	0.01	0.02
Stirrup spacing $> d/2$			0.0030	0.01	0.2	0.0015	0.005	0.01
Condition iii. Beams controlled by inadequate development or splicing along the span ^b								
Stirrup spacing $\leq d/2$			0.0030	0.02	0.0	0.0015	0.01	0.02
Stirrup spacing $> d/2$			0.0030	0.01	0.0	0.0015	0.005	0.01
Condition iv. Beams controlled by inadequate embedment into beam-column joint ^b								
			0.015	0.03	0.2	0.01	0.02	0.03





基于ASCE41-17 的默认铰定义

◇ 混凝土框架柱

Table 10-9. Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures—Reinforced Concrete Circular Columns with Spiral Reinforcement or Seismic Hoops as Defined in ACI 318

Modeling Parameters	Acceptance Criteria		
	Plastic Rotation Angle (radians)		
	Performance Level		
Plastic Rotation Angles, a and b (radians) Residual Strength Ratio, c	IO	LS	CP
Columns not controlled by inadequate development or splicing along the clear height ^a			
$a = (0.05 - 0.06 \frac{N_{UD}}{A_g f_{c,c}} + 1.0 \rho_l - 0.007 \frac{V_{c,c}}{V_{c,code}}) \geq 0.0$ For $\frac{N_{UD}}{A_g f_{c,c}} \leq 0.5$ $b = \frac{0.85}{5 + \frac{N_{UD}}{0.8 A_g f_{c,c}} + \frac{1}{\rho_l} \frac{f_{c,c}}{f_{yt}}}$ $- 0.01 \geq a$ $c = 0.24 - 0.4 \frac{N_{UD}}{A_g f_{c,c}} \geq 0.0$	$0.15 a$ ≤ 0.005	$0.5 b^c$	$0.7 b^c$
Columns controlled by inadequate development or splicing along the clear height ^b			
$a = \begin{cases} \frac{1 \rho_l f_{yt}}{8 \rho_l f_{yt}} \geq 0.0 \\ \leq 0.025^d \end{cases}$ $b = (0.012 - 0.065 \frac{N_{UD}}{A_g f_{c,c}} + 12 \rho_l^e) \geq a$ $c = 0.15 + 36 \rho_l \leq 0.4$	0.0	$0.5 b$	$0.7 b$

P值来源

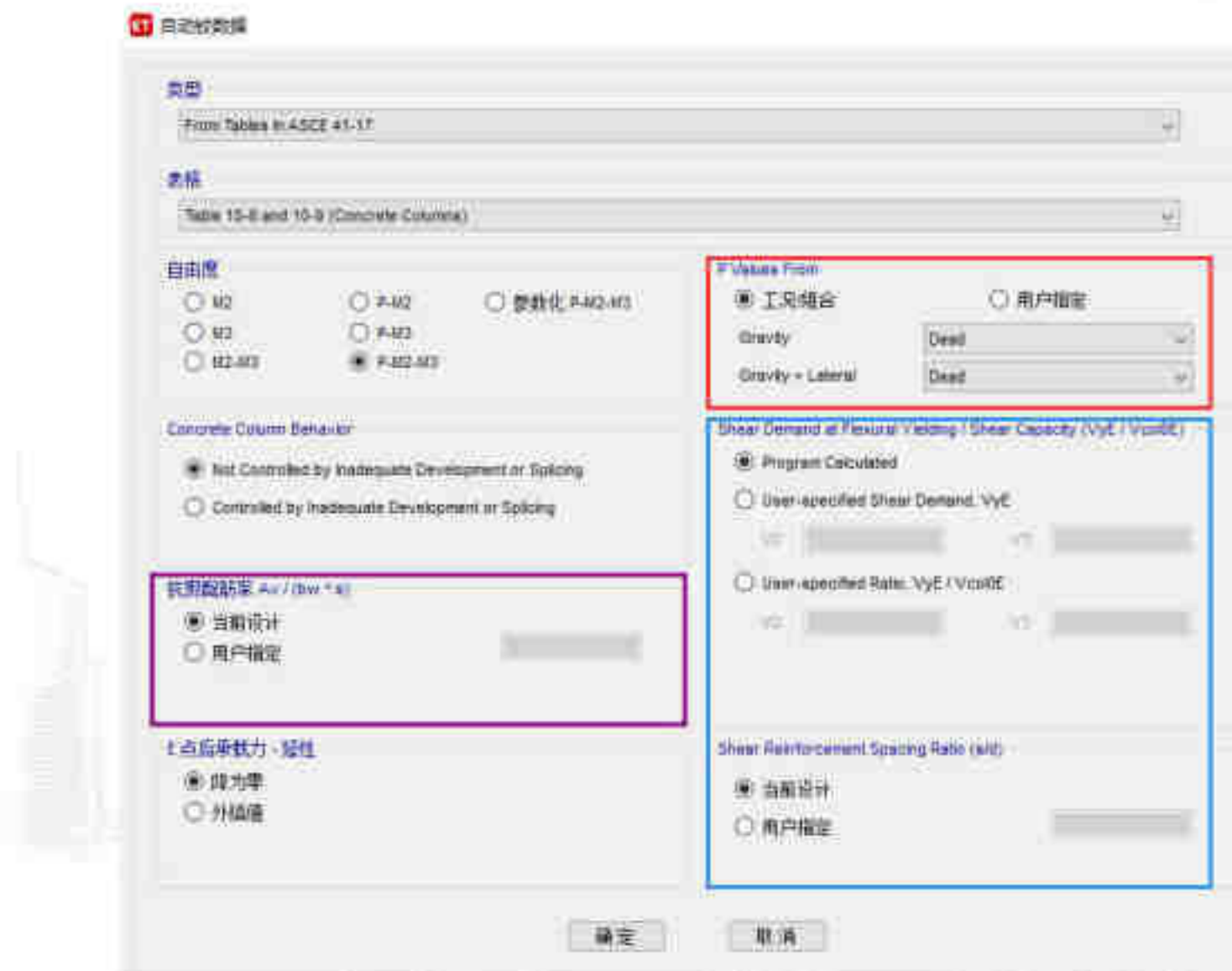
$$Q_{UD} = Q_G + Q_E \quad (7-34)$$

where

Q_{UD} = Deformation-controlled action caused by gravity loads and earthquake forces.

Q_G = Action caused by gravity loads as defined in Section 7.2.2; and

Q_E = Action caused by the response to the selected Seismic Hazard Level calculated using either Section 7.4.1 or Section 7.4.2;



V值计算

$$V_{Ccd} = k_{at} V_{Ccd0} = k_{at} \left[\alpha_{Ccd} \left(\frac{A_v f_{ytLJE} d}{s} \right) + \lambda \left(\frac{0.5 \sqrt{f'_{cLJE}}}{M_{UD}/V_{UD} d} \sqrt{1 + \frac{N_{UG}}{0.5 A_g \sqrt{f'_{cLJE}}}} \right) 0.8 A_g \right] \text{ (MPa units)} \quad (10-3.si)$$



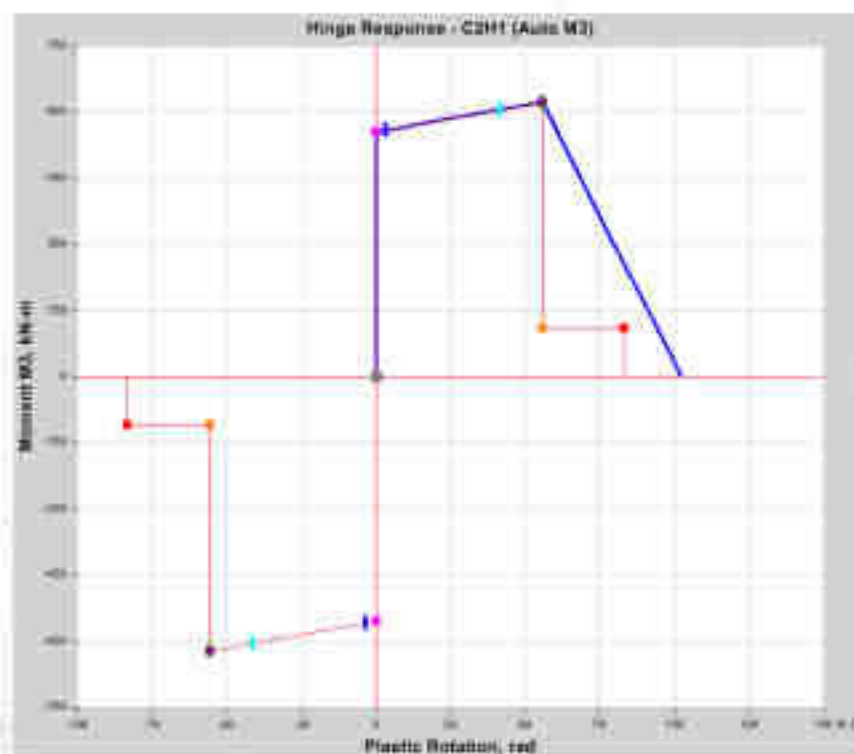
铰覆盖项

◇ 控制下降段斜率

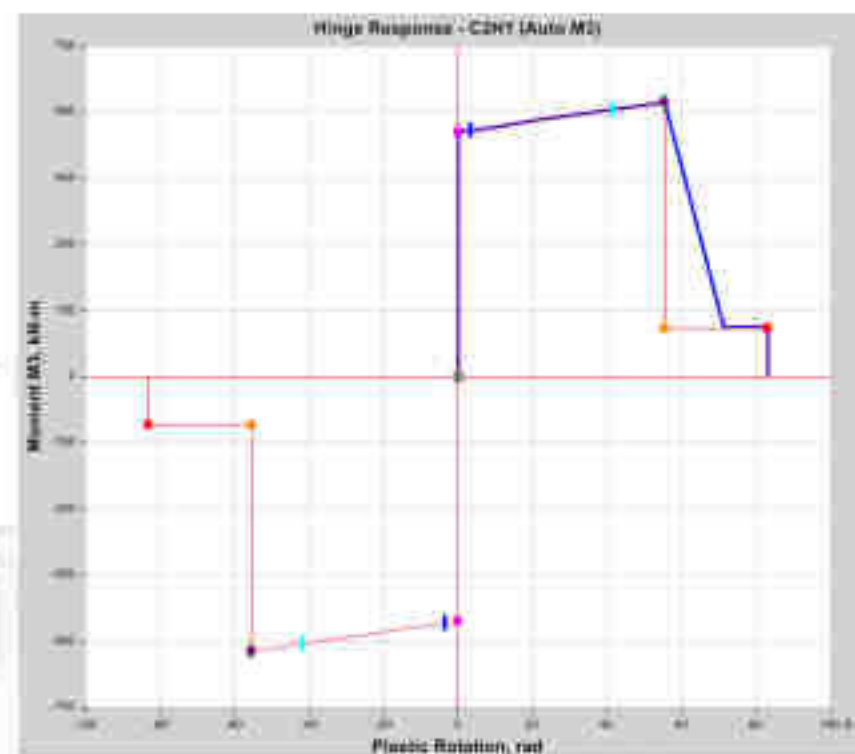
下降段斜率=细分框架的线刚度X卸载刚度比例



推荐设置



细分0.2, 卸载
刚度比例0.1



细分0.02, 卸载
刚度比例0.1



塑性铰的优缺点

◇ 优点

◇ 计算效率高

◇ 有实验数据和规范支撑

◇ 可接受准则表达清晰

◇ 缺点

◇ 对柱压弯耦合以及变轴力作用下的构件行为描述不好

◇ 部分材料和截面无法指定默认铰

02

纤维铰的定义与应用

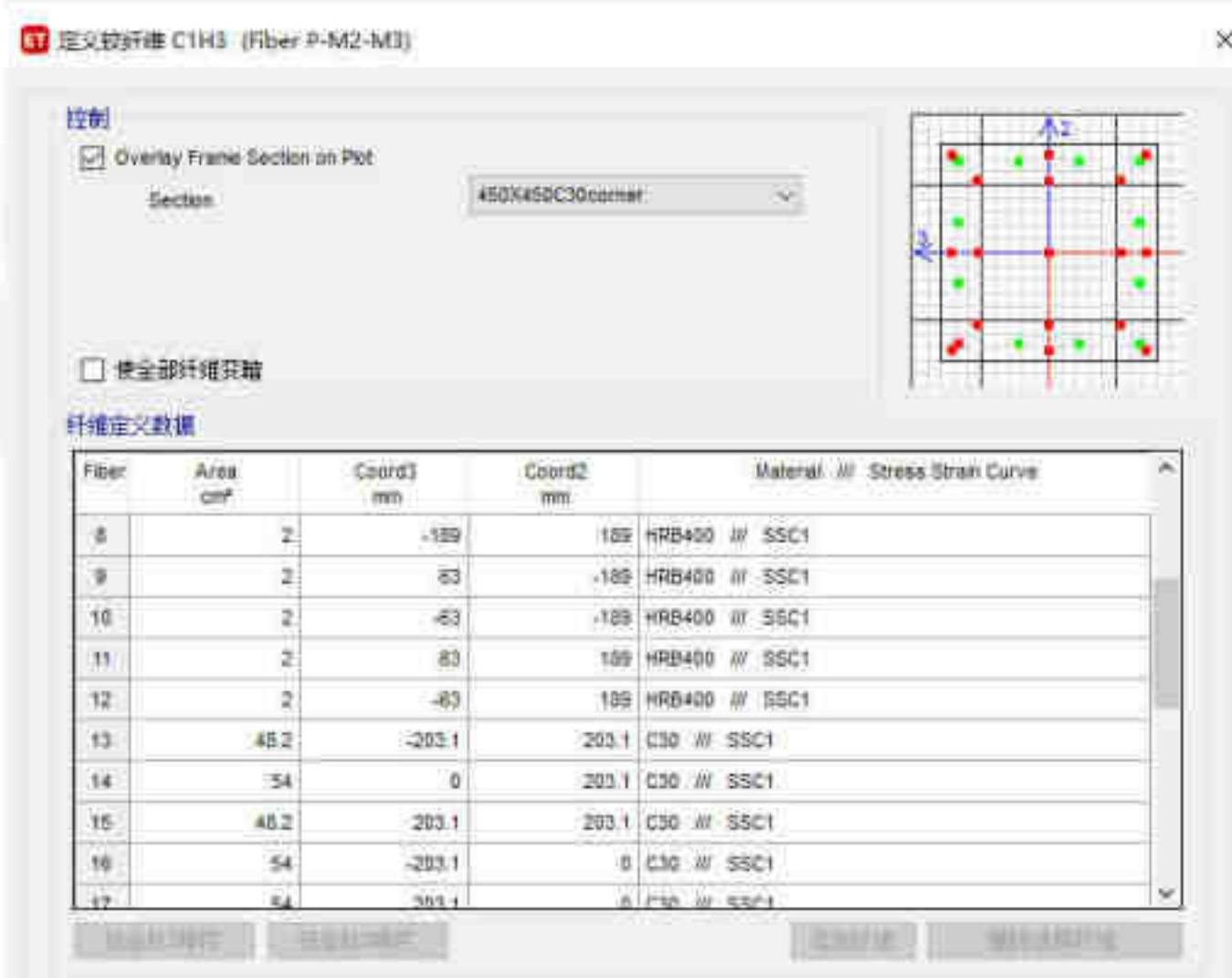
- ◆ 纤维铰的分类
- ◆ 纤维铰的定义
- ◆ 应用纤维铰的注意事项



纤维铰的定义

◇ 截面离散为纤维

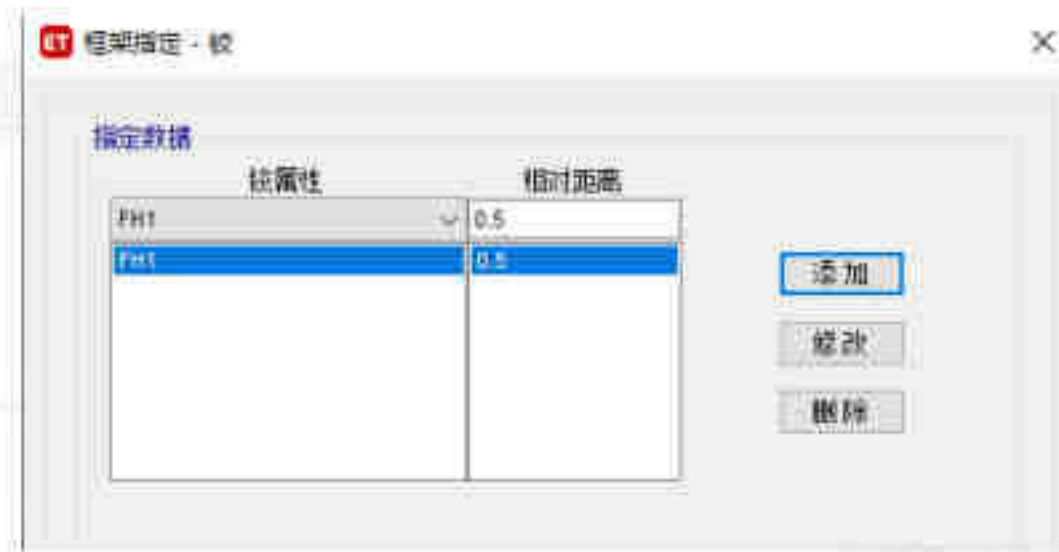
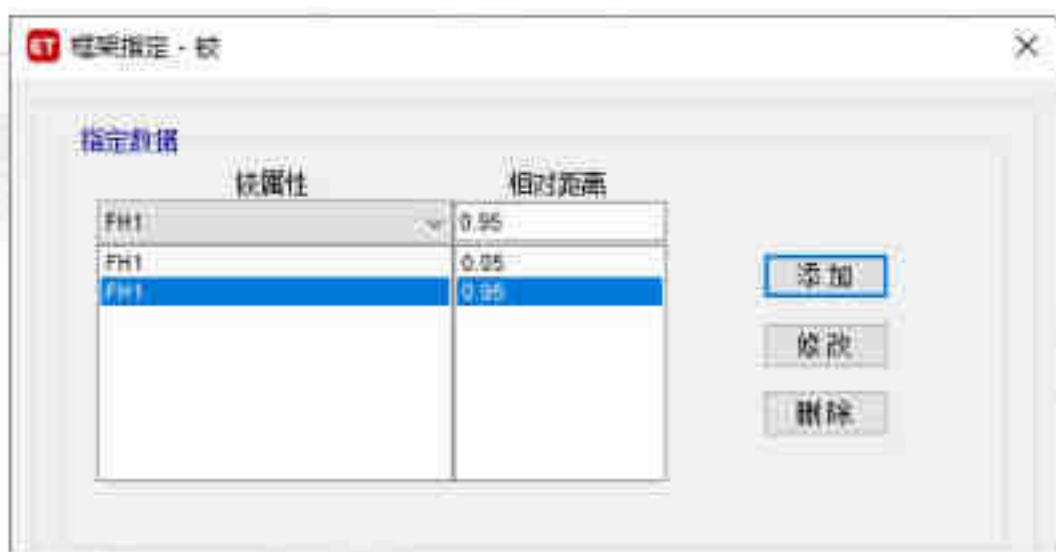
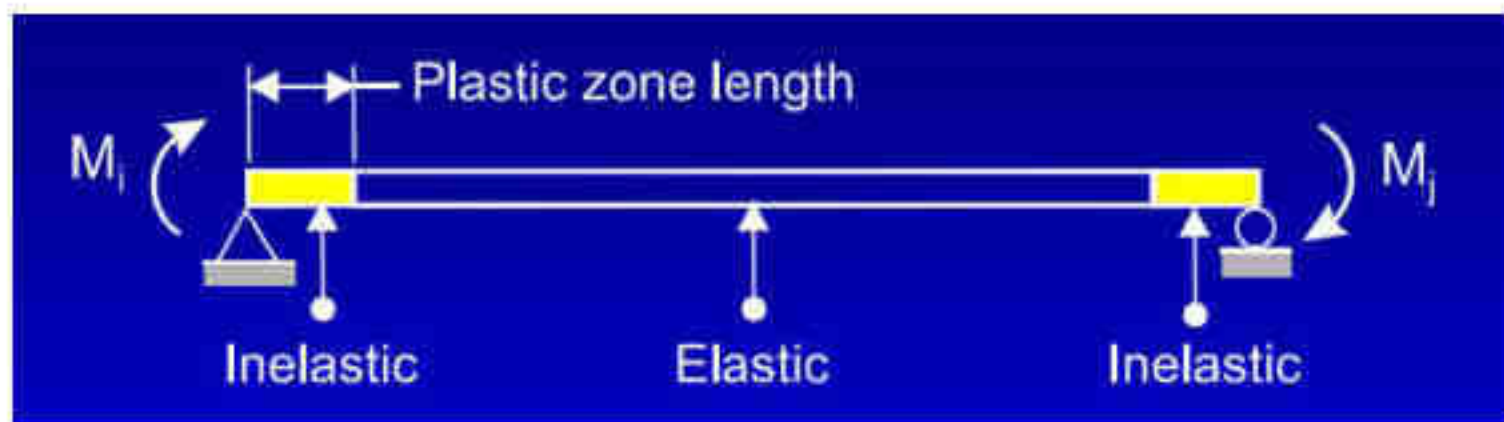
◇ 纤维铰长度





纤维铰的指定

◇ 纤维铰的位置





纤维铰的定义

◇ 自定义纤维

定义纤维 FH2side (Fiber P-M2-M3)

控制

Overlay Frame Section on Plot

Section: B300X800inside

使全部纤维只输



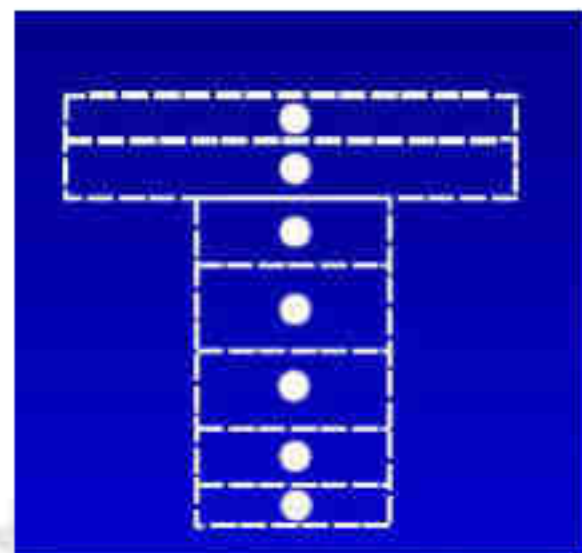
纤维定义数据

Fiber	Area cm ²	Coord3 mm	Coord2 mm	Material // Stress Strain Curve
1	180	0	-270	C30 // SSC1
2	9.3	0	-240	HRB400 // SSC1
3	360	0	-180	C30Mander // SSC1
4	360	0	-90	C30Mander // SSC1
5	720	0	0	C30Mander // SSC1
6	360	0	90	C30Mander // SSC1
7	360	0	180	C30Mander // SSC1
8	11.3	0	240	HRB400 // SSC1
9	180	0	270	C30 // SSC1

按坐标3排序 按坐标2排序 添加纤维 删除选择纤维

显示属性

确定 取消





纤维铰的定义

◇ 材料定义与可接受准则

非线性属性

常规数据

材料名称: C30

材料类型: Concrete, 各向同性

其它参数

带回类型: 混凝土

修改/显示带回参数

Drucker-Prager 参数

摩擦角: 0 deg

膨胀角: 0 deg

应力-应变曲线

参数化定义 Mander

用户自定义

转换为自定义

可接受准则

	拉应变	压应变	
IO	0.01	-0.003	mm/mm
LS	0.02	-0.006	mm/mm
CP	0.05	-0.015	mm/mm

忽略拉应变

参数化应变

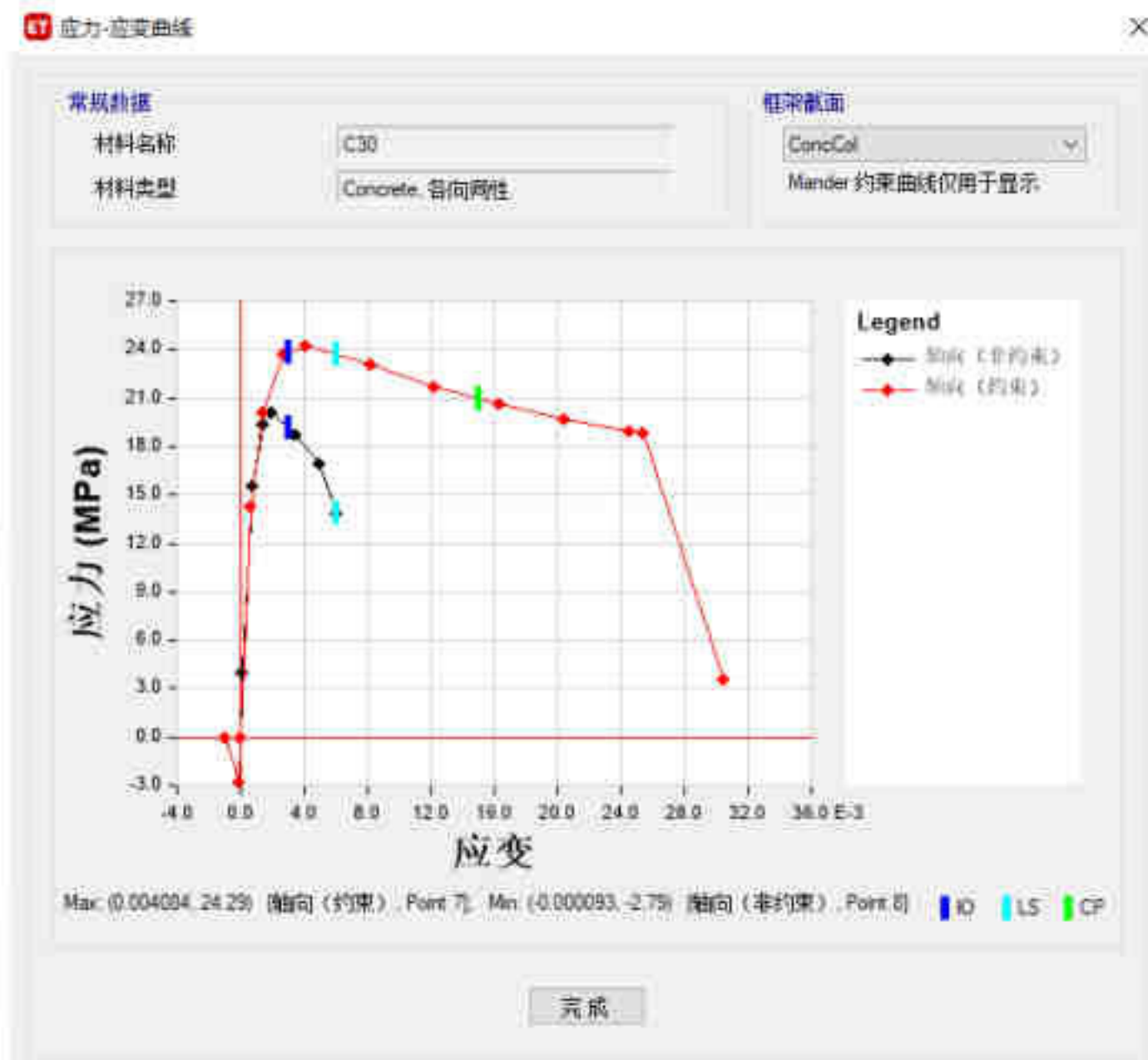
非约束混凝土的抗压强度应变 f_c : 0.002

非约束混凝土的极限应变: 0.005

终止受压斜率 (弹性模量 E 的比值): -0.1

显示应力-应变曲线

确定 取消





纤维胶使用的注意事项

◇ 纤维胶的适用范围

◇ 遵循平截面假定

◇ 无法考虑显著的剪切非线性行为

◇ 无法考虑剪切滑移以及锚固失效等问题

◇ 构件变形应满足假定的形函数

◇ 无法考虑钢构件局部屈曲或整体屈曲行为

03

墙铰定义与分层壳定义

- ◆ 墙铰定义
- ◆ 分层壳定义
- ◆ 墙肢可接受准则



墙铰定义

◇ 墙铰配筋

GT 墙铰配筋

钢筋材料

抗弯钢筋: HRB335

抗剪钢筋: HPB300

净保护层厚度: 10 mm

示意图



几何信息

起点 X (mm)	起点 Y (mm)	终点 X (mm)	终点 Y (mm)	长度 (mm)	厚度 (mm)	Start Zone Size (mm)	End Zone Size (mm)
1000	0	2000	0	1000	125	200	200

配筋信息

Flexural Detail - Each Face

位置	直径	间距 (mm)	数量
起点	10		3
中心	6.5	125	4
终点	10		3

Flexural Detail (Additional Individual Bars)

材料	距离 (mm)	配筋面积 (mm ²)

剪切/箍筋细节

位置	直径	间距 (mm)	箍筋
起点	6.5	80	Yes
中心	6.5	200	No
终点	6.5	80	Yes

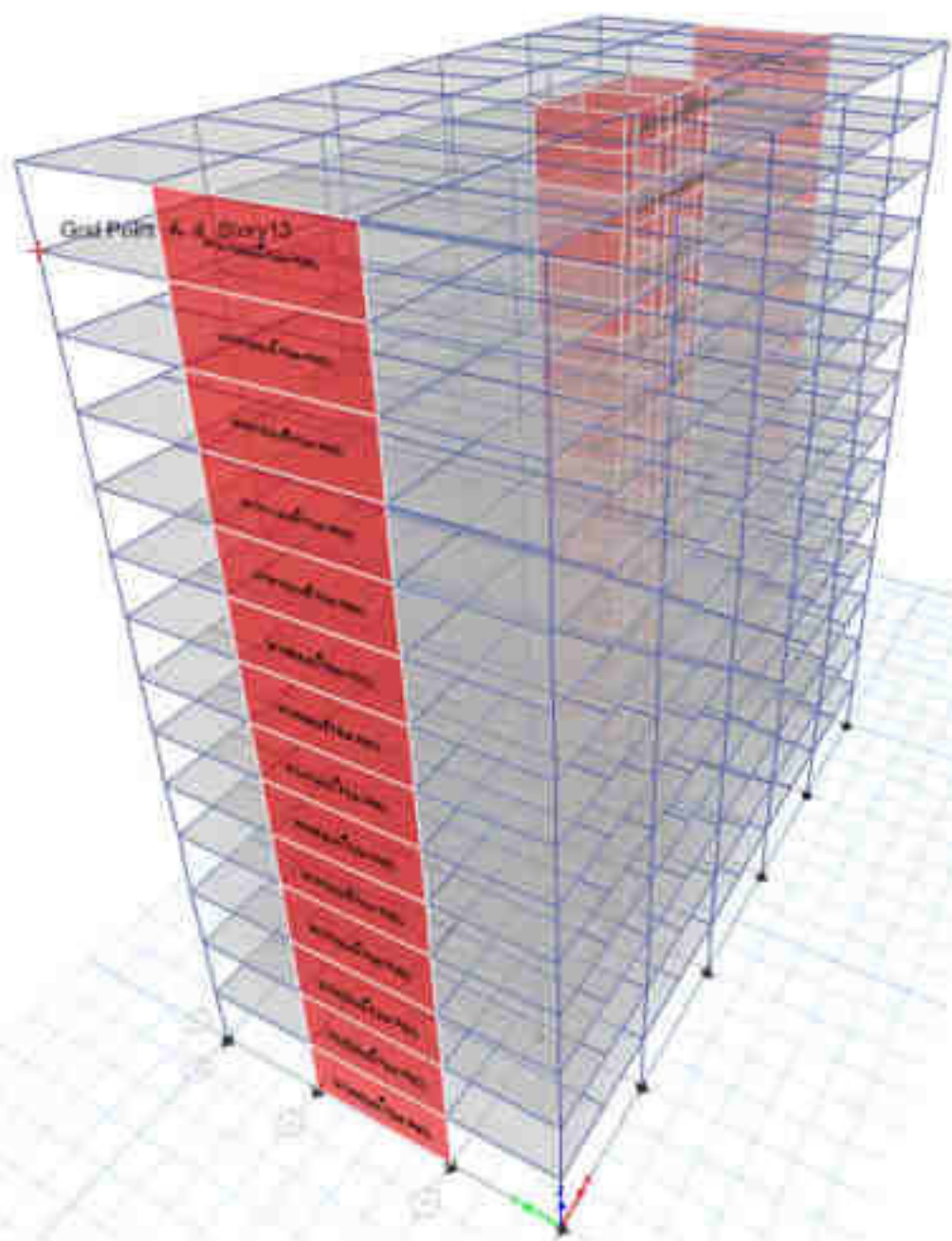
确定

取消



墙铰定义

◇ 墙铰指定



Fibers for Generated Wall Hinge W8186 (Story5 - WB)

Fiber Color
 Same as Material Property Color
 Make All Fibers Gray

Graphic Wall Width Factor
Scale Factor 1

Properties
[Show Properties...](#)

Fiber Definition Data

Fiber	Area cm ²	Coord2 mm	Material	Color
1	267.3	-850	C40	Blue
2	554.8	-800	C40	Blue
3	267.3	-650	C40	Blue
4	66.4	-900	HRB400	Green
5	66.4	-700	HRB400	Green
6	466.7	-520	C40	Blue
7	931.4	-300	C40	Blue
8	931.4	40	C40	Blue
9	931.4	360	C40	Blue

Back Currently Selected Fiber

[Done](#)



分层壳截面定义

◇ 约束边缘构件区域

定义参数

常规数据

名称: layer-boundary

类型: Specified

材料: 不适用

定义尺寸: 修改/显示

单元类型: Layered

属性修正 (默认值): 修改/显示

颜色: 黄色 修改

注释: 修改/显示

属性数据

修改/显示分层壳属性

当前分层数量: 3

Include Automatic Rigid Zone Area Over Wall

属性修正定义 - layer-boundary

分层数据

层名	位置	厚度	类型	积分点	材料	材料角	Material Behavior	S11	S22	S12
CONM	0	125	Membrane	1	C30-mander	0	Directional	Nonlinear	Nonlinear	Linear
CONP	0	125	Plate	3	C30-mander	0	Directional	Linear	Linear	Linear
REBAR	0	2.235	Membrane	1	HRB335	90	Directional	Nonlinear	Inactive	Inactive

设计信息

分层数量: 3

截面厚度: 125 mm

重叠厚度: 129.47 mm

层间间隙: 0 mm

截面

高亮显示

透明度

等比例缩放

最小 最大

排序

升序排列

降序排列

快速开始

参数化定义

添加

复制

删除

↑

↓



分层壳截面定义

◇ 分布钢筋区域

ET 墙体截面定义 - layer

分层数据

层名	位置	厚度	类型	积分点	材料	材料角	Material Behavior	S11	S22	S12
CONM	0	125	Membrane	1	C30	0	Directional	Nonlinear	Nonlinear	Linear
CONP	0	125	Plate	3	C30	0	Directional	Linear	Linear	Linear
REBAR	0	0.25	Membrane	1	HRB335	90	Directional	Nonlinear	Inactive	Inactive

添加
复制
删除



统计信息

分层数量: 3
截面厚度: 125 mm
重叠厚度: 125.5 mm
层间间隙: 0 mm

横截面



高亮显示

透明度

等比例缩放

最小 最大

排序

升序排列

降序排列

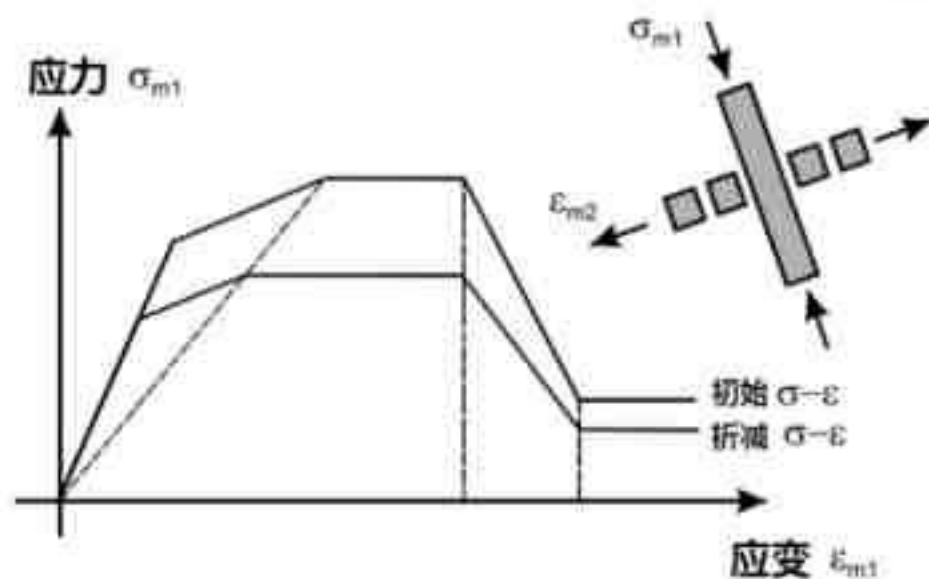
快速开始

参数化定义



分层壳截面定义

◇ 修正的Darwin-Pecknold 2D混凝土模型



Wall Property Layer Definition Data - Wall1

Layer Definition Data:

Layer Name	Distance	Thickness	Modeling Type	Number Integration Points	Material	Material Angle	Material Behavior	Material S11	Material S22	Material S12
ConcM	0	200	Membr...	1	C40	0	Coupled	Nonlinear	Nonlinear	Nonlinear
Pos3Bar1M	62	0.7	Membr...	1	HRB400	0	Directional	Nonlinear	Inactive	Nonlinear
Pos3Bar2M	62	0.7	Membr...	1	HRB400	90	Directional	Nonlinear	Inactive	Nonlinear
Neg3Bar1M	-62	0.7	Membr...	1	HRB400	0	Directional	Nonlinear	Inactive	Nonlinear
Neg3Bar2M	-62	0.7	Membr...	1	HRB400	90	Directional	Nonlinear	Inactive	Nonlinear
ConcP	0	200	Plate	2	C40	0	Directional	Linear	Linear	Linear

Calculated Layer Information:

- Number of Layers: 10
- Total Section Thickness: 200 mm
- Sum of Layer Overlaps: 218.8 mm
- Sum of Gaps Between Layer: 0 mm

Cross Section:

Order Layers:

- Order Ascending by Distance
- Order Descending by Distance

Quick Start:

- Parametric Quick Start...

Buttons: Add, Add Copy, Delete, OK, Cancel



墙肢可接受准则

◇ 四点位移计

ET Quad Gauge Property Data

General Data

Property Name: C Flange

Gauge Type: Rotation *选择剪应变或转角*

Direction: Pier *选择是墙肢还是连梁*

Display Color: Change...

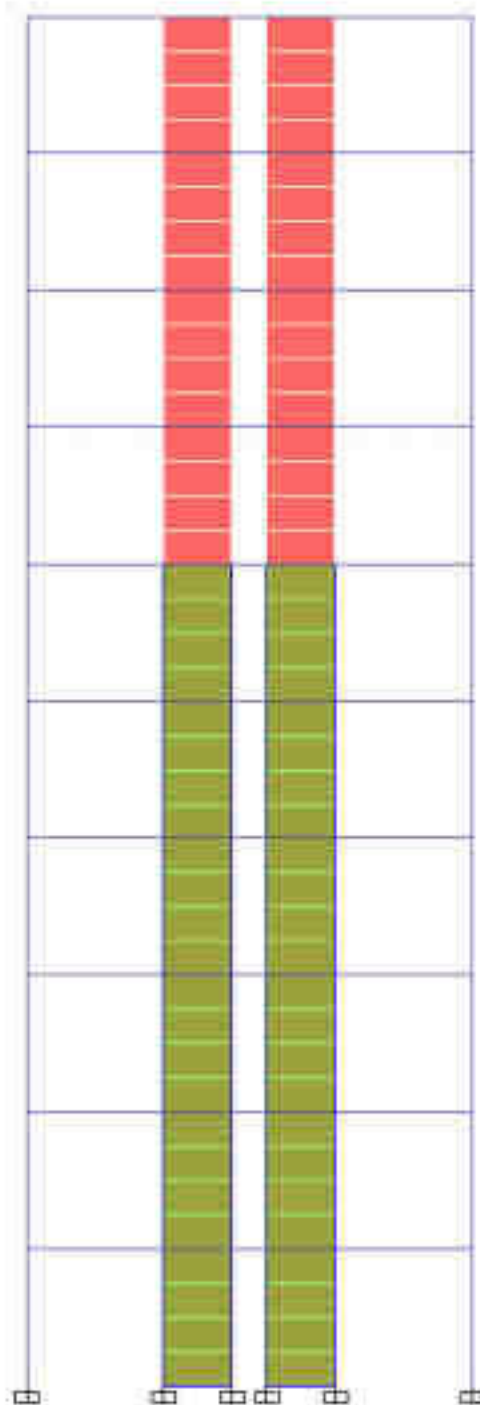
Property Notes: Modify/Show Notes...

Acceptance Criteria Rotations

Enable Acceptance Criteria *输入四点应变计的可接受准则*

	Positive	Negative	
Immediate Occupancy, IO	0.009	0.015	rad
Life Safety, LS	0.02	0.02	rad
Collapse Prevention, CP	0.04	0.04	rad

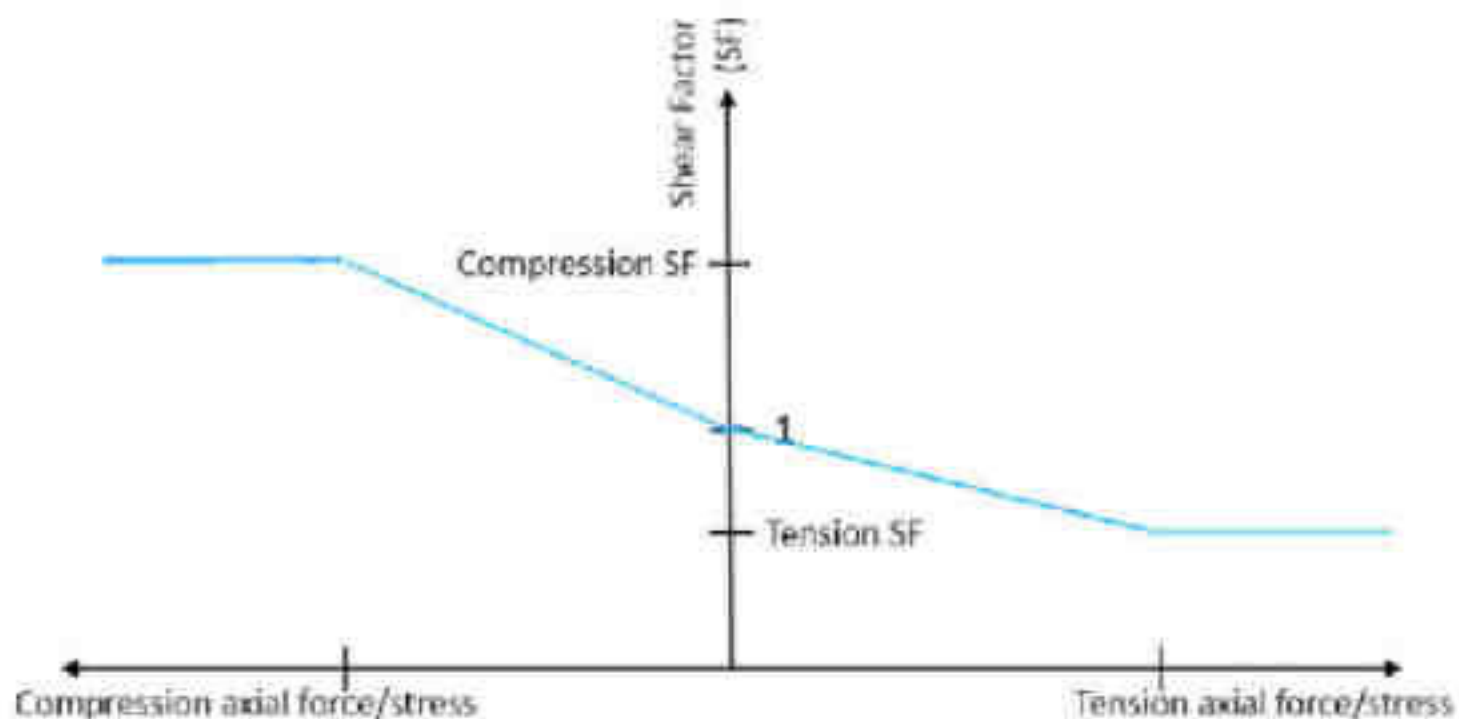
OK Cancel





墙肢可接受准则

◇ 剪力校核



Assign Pier Force Acceptance Criteria

Pier Selection Information

Selected Pier Label: PW3

Selected Story: Story12

Get Values from Currently Selected Pier Object
Note: Button is enabled when a single pier object is selected

General Data

Acceptance Criteria Type: Force

Acceptance Criteria Data 墙肢剪力可接受准则

Immediate Occupancy, IO	<input checked="" type="checkbox"/> Shear V2	<input checked="" type="checkbox"/> Shear V3
Life Safety, LS	1	1 kip
Collapse Prevention, CP	1	1 kip

Depends on Axial Force 定义轴力对剪力限值的影响

Tension:	Shear Factor	0.5
	Axial Force	1 kip
Compression:	Shear Factor	2
	Axial Force	1 kip

Note: Shear Factor = 1 will be used at Axial Force = 0

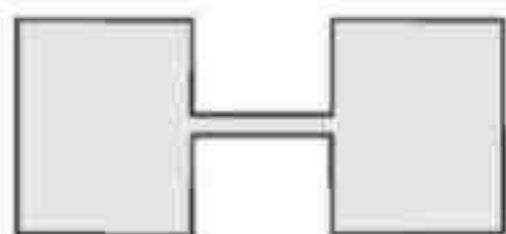
Reset Form to Default Values

OK Close Apply

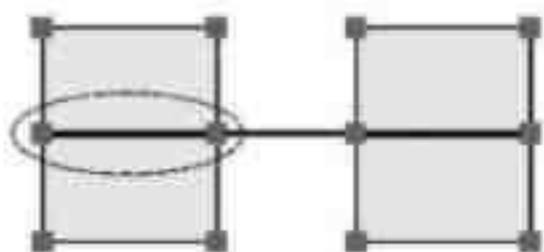


注意事项

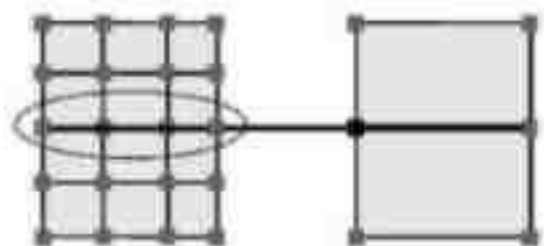
◇ 连梁或框架梁与墙的连接



(a) Slender Beam



(b) Wall Modeled With Large Elements



(c) Wall Modeled With Smaller Elements



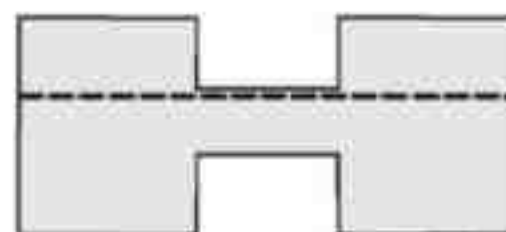
Elastic beam, EI/L = about 20 times EI/L for coupling beam, EA = small.

(d) Simple Element for Imbedded Beam

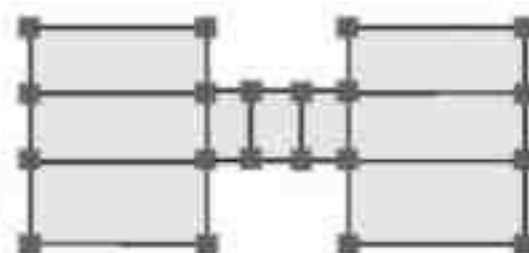


Elastic beam, EI/L = about 100 times EI/L for coupling beam, EA = small. Elastic connection with moment stiffness to model local deformation of wall.

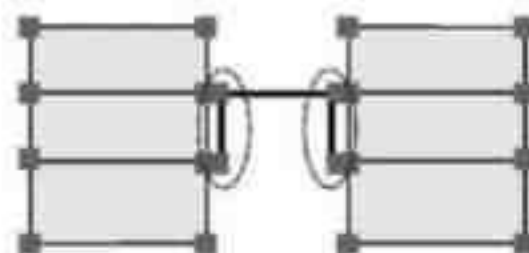
(e) Alternative Element for Imbedded Beam



(a) Case With Floor Slab at Top



(b) Model Using Wall Elements



(c) Model Using Frame Elements

If a rigid diaphragm is assumed, the neutral axis for the beam cross section is at the top (there is zero strain at the diaphragm level.) If the floor slab is modeled explicitly, it acts compositely with the wall elements. The neutral axis is likely to be close to the slab level. In both cases, axial extension of the beam wants to occur as it cracks, but this axial extension is restrained.



Elastic beam, EI/L = about 50 times larger than EI/L for coupling beam. EA = small, to avoid stiffening the piers in bending.



其他非线性单元

◇ 连接单元

ET Link Acceptance Criteria Definition

Link/Support Property Name: BRB400

Acceptance Criteria Type: Force Displacement

Direction Controls:

- F1
- F2
- F3
- M1
- M2
- M3
- Symmetric

Acceptance Criteria:

	F1 mm	F2 mm	F3 mm	M1 rad	M2 rad	M3 rad
Positive:						
IO	11					
LS	7.5					
CP	10					
Negative:						
IO						
LS						
CP						

Buttons: 确定, 取消



其他非线性单元

◇ 节点区的非线性行为 (仅用于钢节点)

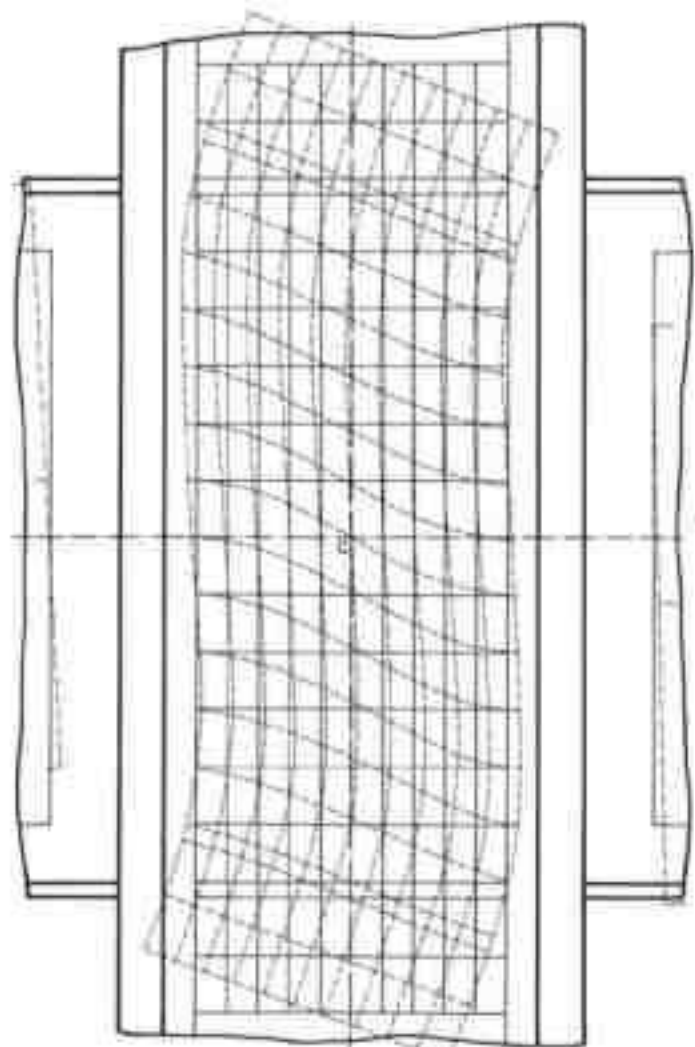


Table 9-7.2. Modeling Parameters and Acceptance Criteria for Nonlinear Procedures—Structural Steel Components Other Than Beams and Columns—Flexural and Shear Actions

Component or Action	Modeling Parameters			Acceptance Criteria		
	Plastic Rotation Angle, Radians		Residual Strength Ratio	Plastic Rotation Angle, Radians		
	a	b	c	IO	LS	CP
Column Panel Zones—Shear For $ P /P_{ye} < 0.4$ For $ P /P_{ye} \geq 0.4$	$12\gamma_y$	$12\gamma_y$	1.0	$1\gamma_y$	$12\gamma_y$	$12\gamma_y$
	$20(1 - P /P_{ye})\gamma_y$	$20(1 - P /P_{ye})\gamma_y$	$5/3(1 - P /P_{ye})$	$5/3(1 - P /P_{ye})\gamma_y$	$20(1 - P /P_{ye})\gamma_y$	$20(1 - P /P_{ye})\gamma_y$

$$\text{Panel Zones: } \theta_y \equiv \gamma_y = \frac{F_{ye}}{G\sqrt{3}} \sqrt{1 - \left(\frac{|P|}{P_{ye}}\right)^2} \quad (9-3)$$

$$\text{Panel Zones: } V_{CE} = V_{ye} = \begin{cases} \text{for } \frac{|P|}{P_{ye}} \leq 0.4 & 0.55F_{ye}d_c t_p \\ \text{for } \frac{|P|}{P_{ye}} > 0.4 & 0.55F_{ye}d_c t_p \left(1.4 - \frac{|P|}{P_{ye}}\right) \end{cases} \quad (9-8)$$



其他非线性单元

◇ 节点区的非线性行为 (ASCE41-17)

定义节点区

名称: PZone1

注释: 修改/显示

属性

- Auto Elastic Properties (Steel Only)
- 弹筒刚度
 - 主刚度: []
 - 次刚度: []
- Auto Nonlinear Properties based on ASCE 41-17 Table 9-7.2 (Steel Only)
- User-defined Nonlinear Properties [修改/显示]

连接属性: []

Auto Properties

- Doubler Plate Thickness, Major Direction: 0 mm
- Axial Load Ratio, P / P_y for Column: 0.2

连接方式

- 梁-柱
- 梁-梁柱
- 梁-柱
- Set Adjacent End Offsets to Rigid

与柱相联

- 与柱相联
- User Defined
 - Axis 2 Angle: []
 - Axis 3 Offset: []

Active Directions

- Major Moment / Rotation Only
- Minor Moment / Rotation Only
- Both Major and Minor Moment / Rotation

Acceptance Criteria

- None
- User Defined [修改/显示]
- Auto Based on ASCE 41-17 Table 9-7.2 (Steel Only)

确定 取消

User Nonlinear Panel Zone Data - 2PZ1

Moment-Rotation Relation

点	弯矩 (kF)	旋转 (rF)
C	0	-30.2
D	-1	-20.2
E	-1.72	-13
F	-1	-1
A	0	0
B	1	1
G	1.72	13
H	1	20.2
I	0	30.2

Additional Backbone Curve Points

- BC - Between Points B and C
- CD - Between Points C and D

弯矩和旋转的比例调整

- Use Yield Moment from ASCE 41-17 (Steel Only): 218.087 kF-m
- Use Yield Rotation from ASCE 41-17 (Steel Only): 0.00234

User Nonlinear Panel Zone Data - 2PZ1

Moment-Rotation Relation

点	弯矩 (kF)	旋转 (rF)
C	0	-30.2
D	-1	-20.2
E	-1.72	-13
F	-1	-1
A	0	0
B	1	1
G	1.72	13
H	1	20.2
I	0	30.2

Additional Backbone Curve Points

- BC - Between Points B and C
- CD - Between Points C and D

弯矩和旋转的比例调整

- Use Yield Moment from ASCE 41-17 (Steel Only): 545.2174 kF-m
- Use Yield Rotation from ASCE 41-17 (Steel Only): 0.00234



其他非线性单元

◇ 单压弹簧



◇ 单拉杆



04

非线性时程工况定义

- ◆ 地震波导入
- ◆ 非线性直接积分法
- ◆ 非线性参数
- ◆ 计算效率



地震波导入

◇ 时程函数

24402-S0758-91179.01 ALTADENA - EATON CANYON PARK AT 0 DEG
 2000 POINTS OF ACCEL DATA EQUALLY SPACED AT .020 SEC. (UNITS: CM/SEC/SEC)

-3.035	-1.032	-1.224	-3.023	-5.213	1.536	7.311	5.159
.633	-2.967	1.503	4.451	4.875	-4.440	-4.622	3.770
2.357	6.897	4.506	4.057	3.296	-4.530	-25.395	-2.102
6.669	3.584	10.629	1.284	-5.357	-12.719	28.410	26.954
-15.361	-8.254	19.363	-5.215	-27.125	5.048	2.821	-5.591
-13.301	-14.433	-8.746	-14.579	12.576	-10.467	-4.110	11.164
-3.752	20.732	9.316	1.457	-11.265	-17.571	-6.691	5.676
10.472	-4.210	7.080	23.193	5.719	-59.833	-24.416	20.104
-42.895	-39.473	-3.032	61.851	49.244	9.141	-6.692	-28.013
-1.693	3.902	-11.334	-22.757	6.909	1.652	-50.428	-36.798
28.779	27.511	-13.705	-37.085	-7.744	14.346	27.502	2.356
-31.200	-10.449	15.187	-1.724	-13.103	11.922	24.454	-8.426
-21.484	10.634	52.391	50.752	21.429	-.113	-5.354	16.961
11.976	-2.801	9.216	29.412	15.544	41.880	38.865	58.152
87.590	98.282	134.790	130.607	137.019	167.359	159.135	149.901
70.216	-74.770	-204.089	-320.932	-376.749	-408.030	-430.039	-378.326
-149.686	126.460	240.701	243.609	244.926	262.295	235.445	201.496
207.462	138.392	-25.269	-189.968	-324.722	-409.348	-438.913	-330.229
-184.177	-134.063	-114.647	-83.463	-42.336	20.328	105.140	209.734
271.112	226.006	207.925	246.054	297.601	334.041	311.964	92.021
-169.480	-289.698	-301.895	-217.805	-31.967	171.981	191.121	120.627
-46.936	-250.885	-317.958	-260.925	-97.220	108.978	179.281	92.503
-53.121	-80.848	98.998	214.080	202.406	48.902	-23.760	37.417
43.092	-9.019	-27.170	-34.122	-90.674	-68.175	-20.960	-.026
-55.236	-84.991	-2.281	32.491	-6.468	.758	44.765	101.013
35.874	3.616	-22.559	-16.047	-18.929	-39.237	-43.304	-23.680
-19.061	-13.113	39.096	76.581	65.917	38.885	15.761	-23.354
-44.962	-14.322	8.077	-2.250	-16.745	-25.350	-37.995	-42.201
-28.427	-25.131	-32.851	-15.744	4.714	-2.457	-18.370	14.920
34.043	19.458	15.759	6.825	15.549	30.598	-.513	-46.159
-57.191	-11.246	9.635	-27.509	-43.978	-40.860	-43.442	-27.617
16.695	28.093	10.853	15.939	45.193	54.392	26.479	1.032
17.880	36.671	12.693	-20.772	-1.472	32.749	48.273	36.120
12.378	4.541	1.058	-8.601	-27.698	-45.509	-40.023	-11.642
-8.723	-10.945	6.095	24.460	20.422	18.566	25.582	18.444
4.059	-6.450	-2.563	-8.925	-19.170	-22.209	-24.681	-20.408

函数时称名: T+1

函数文件: 浏览

文件名: C:\Program Files\Computers and Structures\ETABS 201314\Time History Functions\ALTADENA-1.TH

跳过前几行: 2

每行跳过前缀字符: 0

每条线的点数: 8

转化为用户定义 显示文件

数值是:

时间与函数值

函数值等间距于: 0.02

格式类型:

自由格式

固定格式

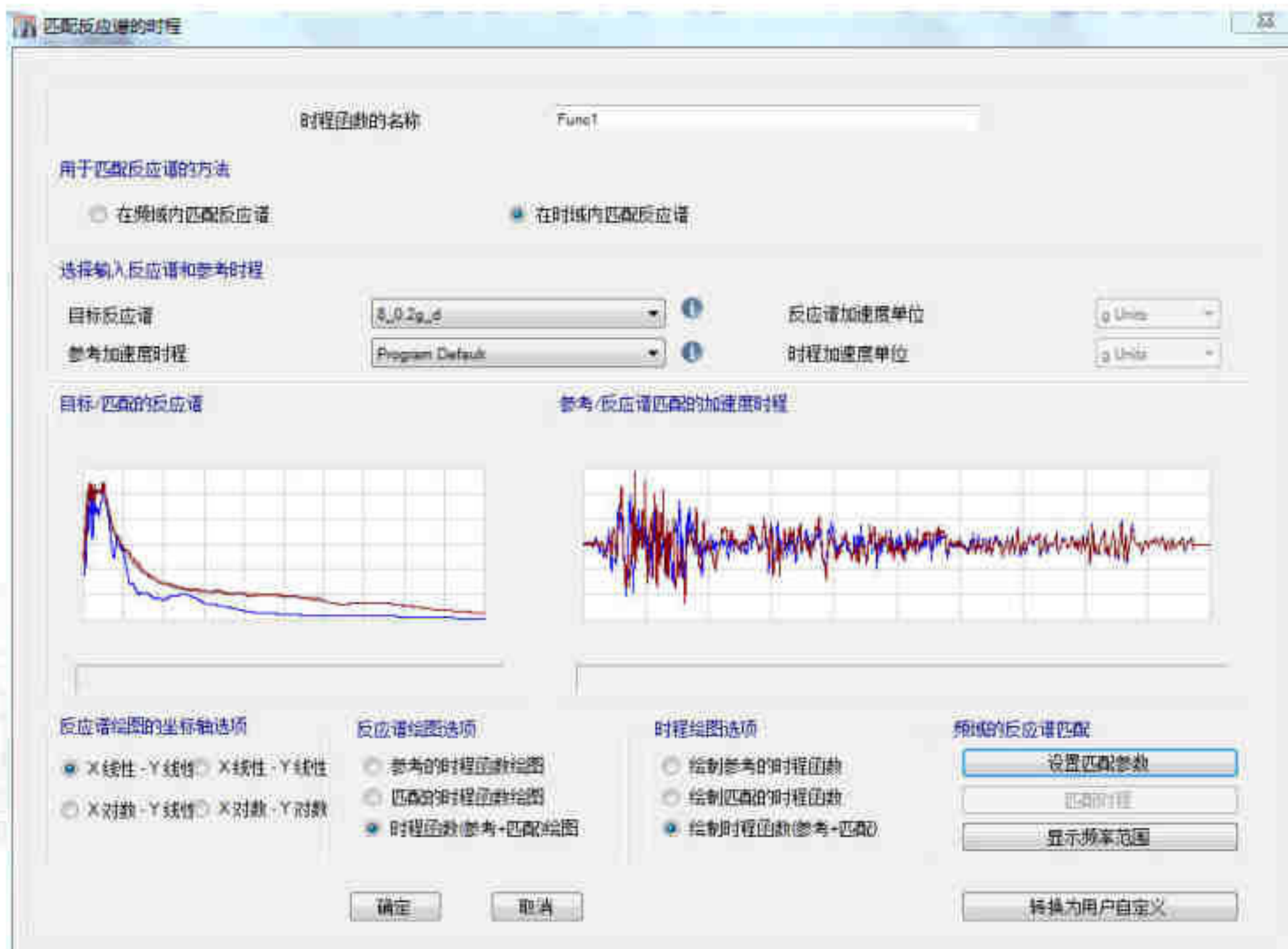
每项特征

函数图形



生成人工波

◇ 频域或时域方法





非线性直接积分法工况

- ◇ 初始重力工况
- ◇ 几何非线性
- ◇ 时间间隔与输出步数
- ◇ 阻尼设置
- ◇ 时间积分
- ◇ 非线性参数

荷载工况数据

常规

荷载工况名称: El-Centro

荷载工况类型/子类型: Time History / Nonlinear Direct Integration

在此组中去掉对象: 不适用

新组名: Previous

初始条件

零初始条件 (从未加应力状态开始)

从非线性工况终点继续加载 (阶段终点荷载包括在内)

非线性工况: PRE

施加的荷载

荷载类型	荷载名称	函数	比例系数
Acceleration	U1	Usaca01N-S	0.64
Acceleration	U2	Usaca01E-W	0.64

高级

其他数据

几何非线性属性: P-Delta

输出时间步: 2000

输出时间间隔: 0.02 sec

比例阻尼: 质量 0.453, 刚度 0.0041

时间积分: Hilber-Hughes-Taylor

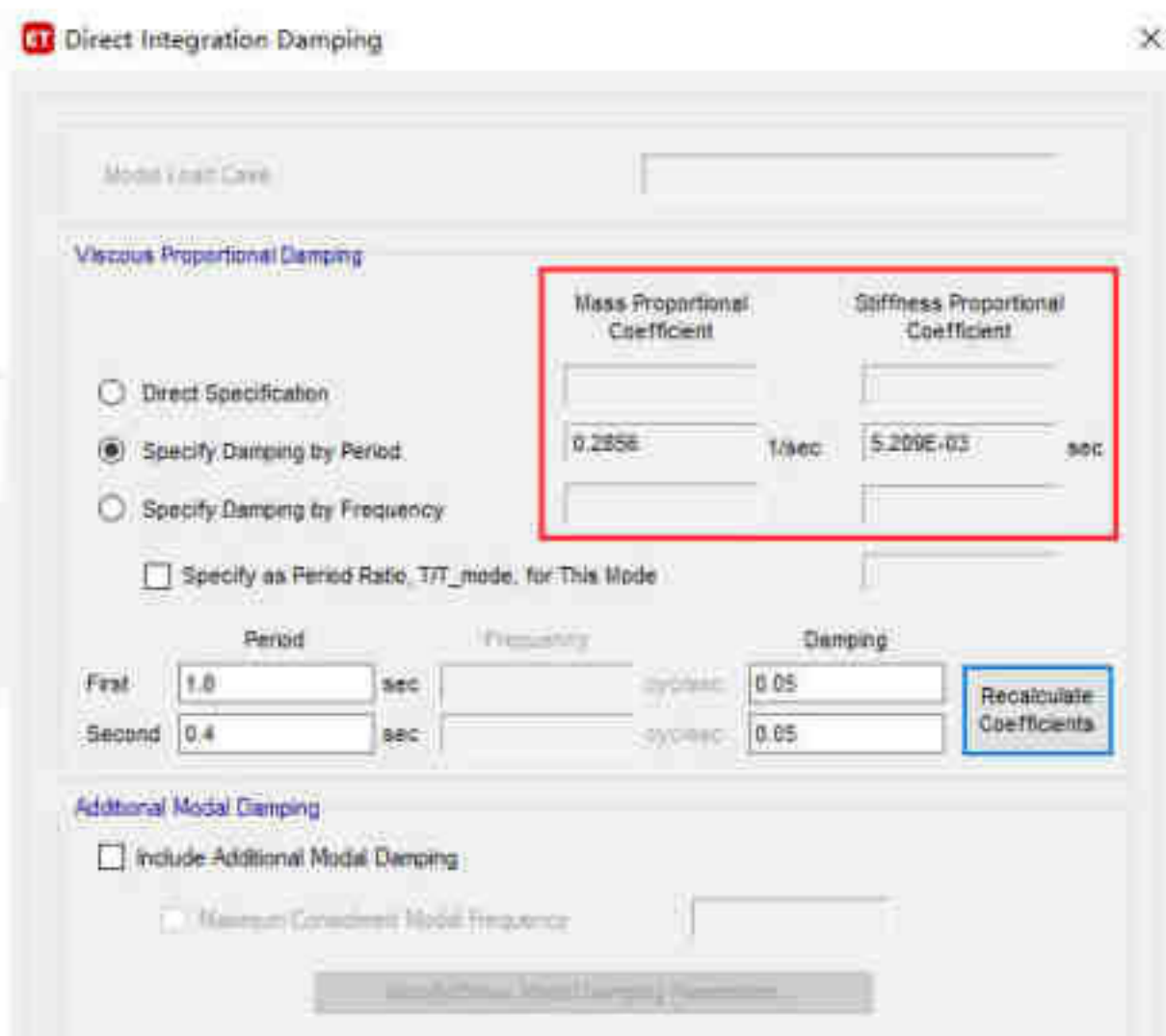
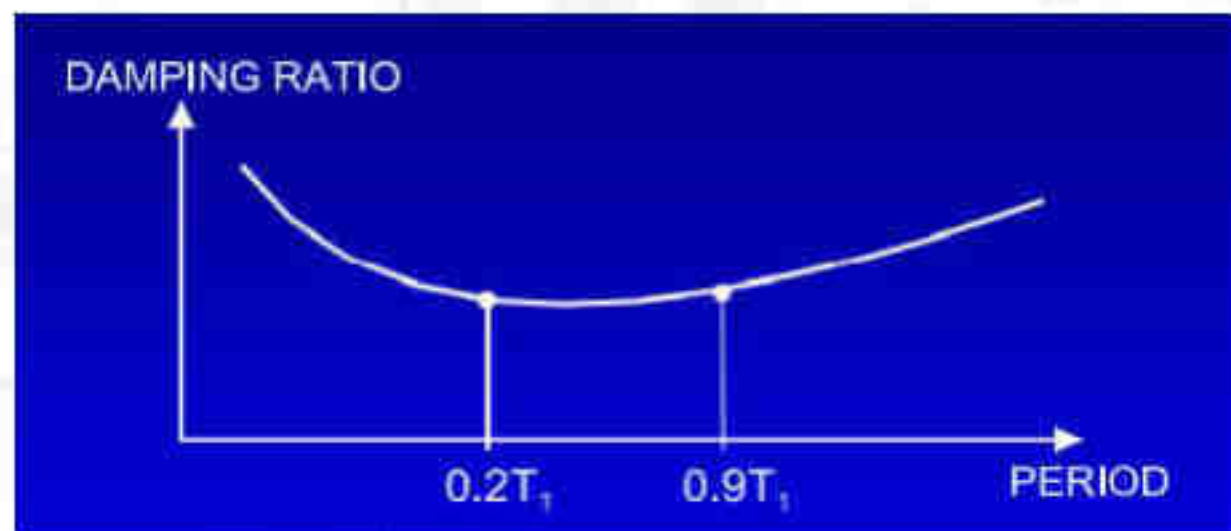
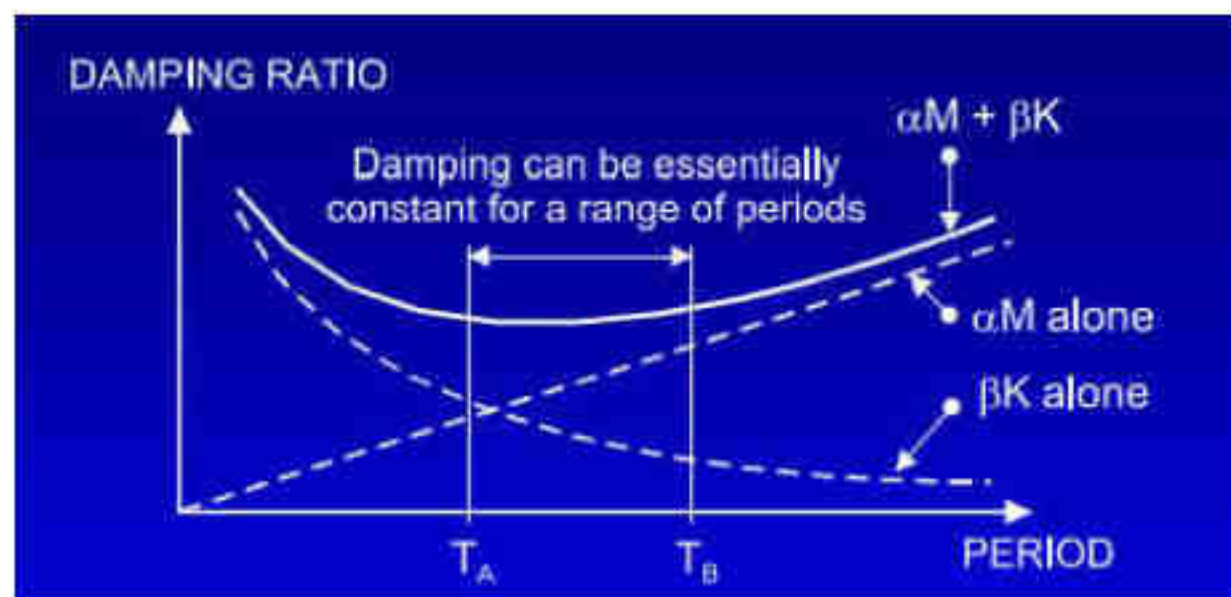
非线性参数: 默认

确定 取消



阻尼设置

◇ 瑞利阻尼





阻尼设置

◇ 模态阻尼

$$C_{modal} = \sum_{i=1}^N \frac{4\pi}{T_i} \xi_i (M\phi_i)(M\phi_i)^T$$

其中 T_i 、 ξ_i 和 ϕ_i 是模态 i 的周期、阻尼系数和振型； N 是模态总数。

例如，如果模态阻尼影响的最高阶模态频率为 f ，可以指定频率 f 的刚度比例阻尼为0.2%，指定频率 $10f$ 为2%，这样给不受模态阻尼衰减的高频提供阻尼。阻尼采用的实际值应当由结构本身和工程判断来确定。

参考克拉夫《结构动力学》第二版12章

Modal Load Case: Modal

Viscous Proportional Damping

Mass Proportional Coefficient: 0 1/sec

Stiffness Proportional Coefficient: 1.273E-05 sec

Specify as Frequency Ratio, Ω_{mode} , for This Mode:

	Period	Frequency	Damping
First	sec	50 cyc/sec	0.002
Second	sec	500 cyc/sec	0.02

Additional Modal Damping

Include Additional Modal Damping

Maximum Considered Modal Frequency: 50 1/sec

Modify/Show Modal Damping Parameters...

模态阻尼

阻尼类型

- 常数阻尼比
- 基于周期或频率的插值阻尼比
- 质量比例系数和刚度比例系数

常数阻尼比

阻尼比

0.05

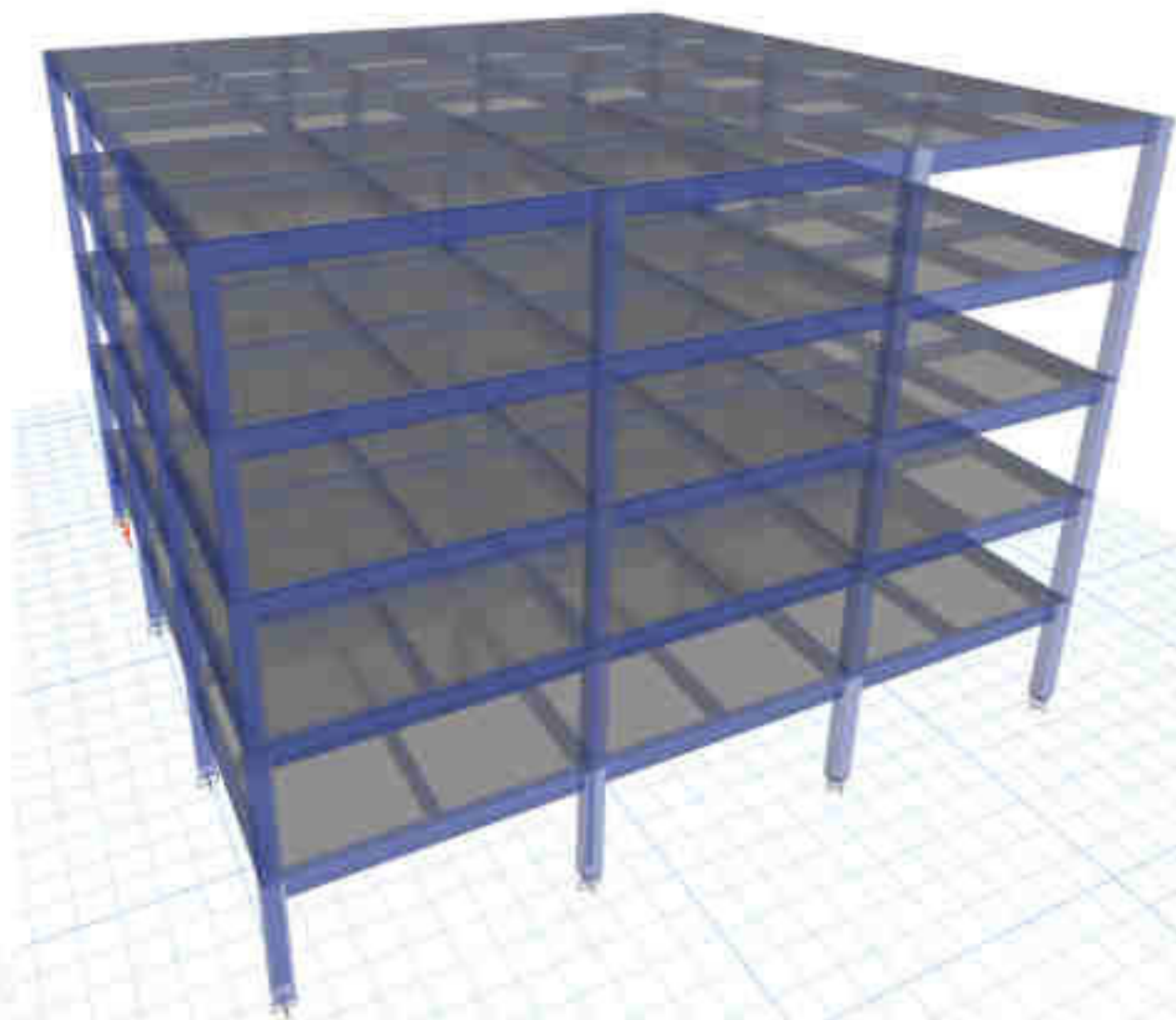
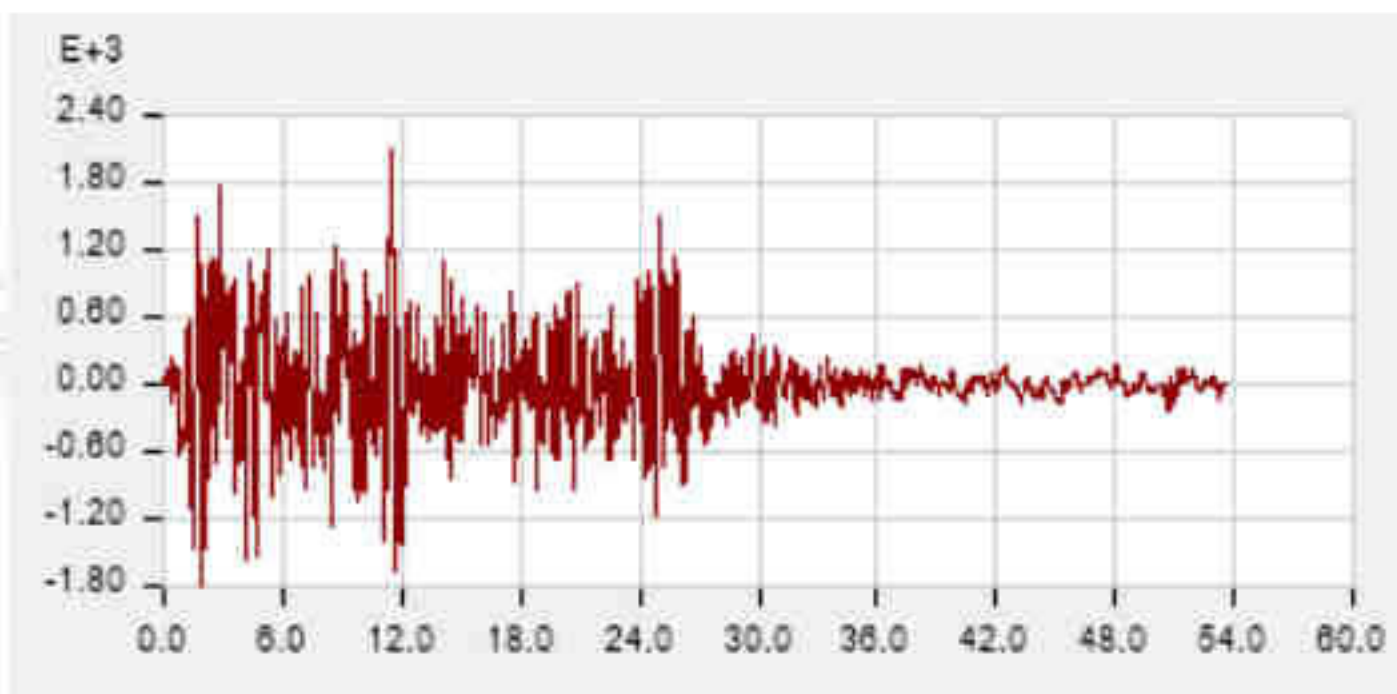


阻尼对比

◇ 基本模型

◇ 基本周期: 1.04s

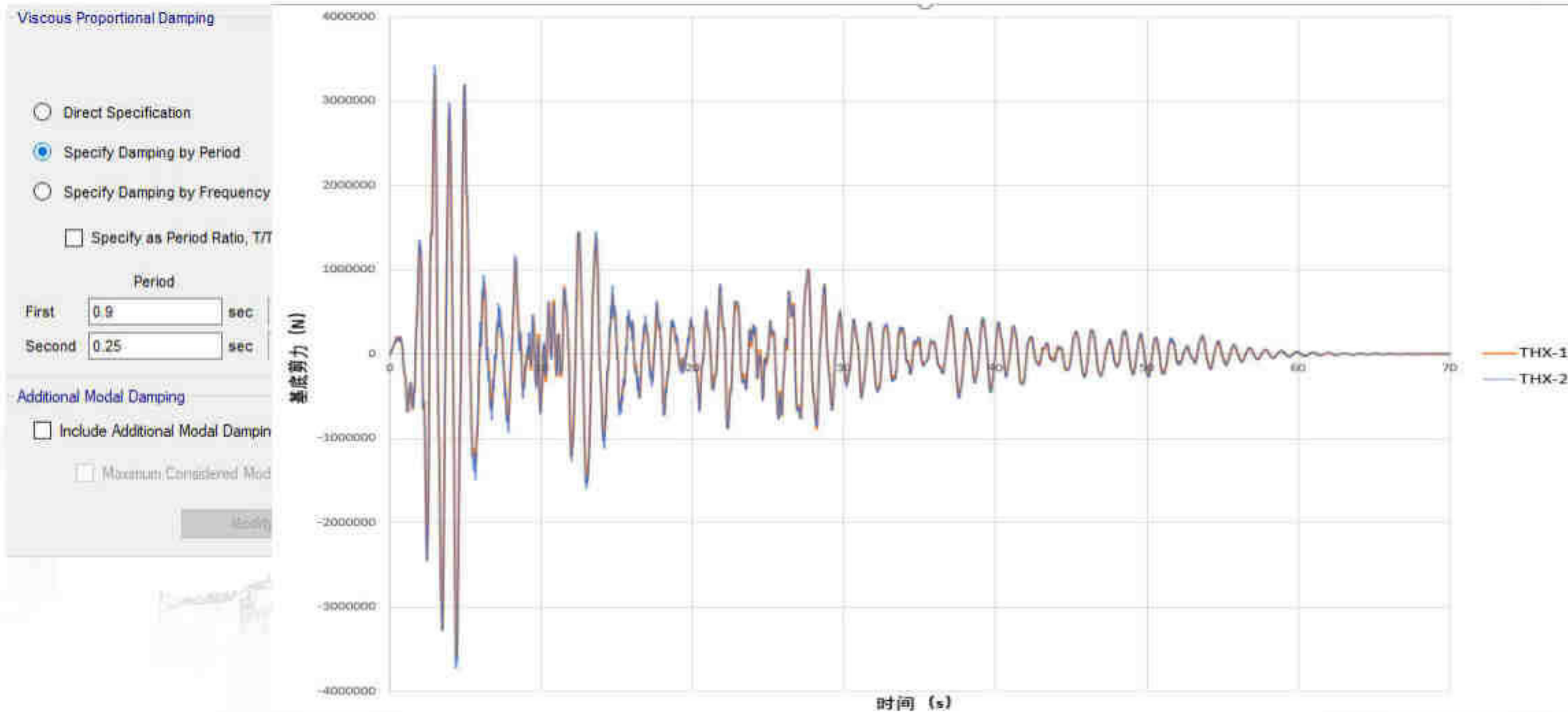
◇ 地震作用: EL-centro波, 54s





阻尼对比

◇ THX-1 VS THX-2





阻尼对比

◇ THX-1 VS THX-3

Viscous Proportional Damping

Direct Specification

Specify Damping by Period

Specify Damping by Frequency

Specify as Period Ratio, T₁

Period

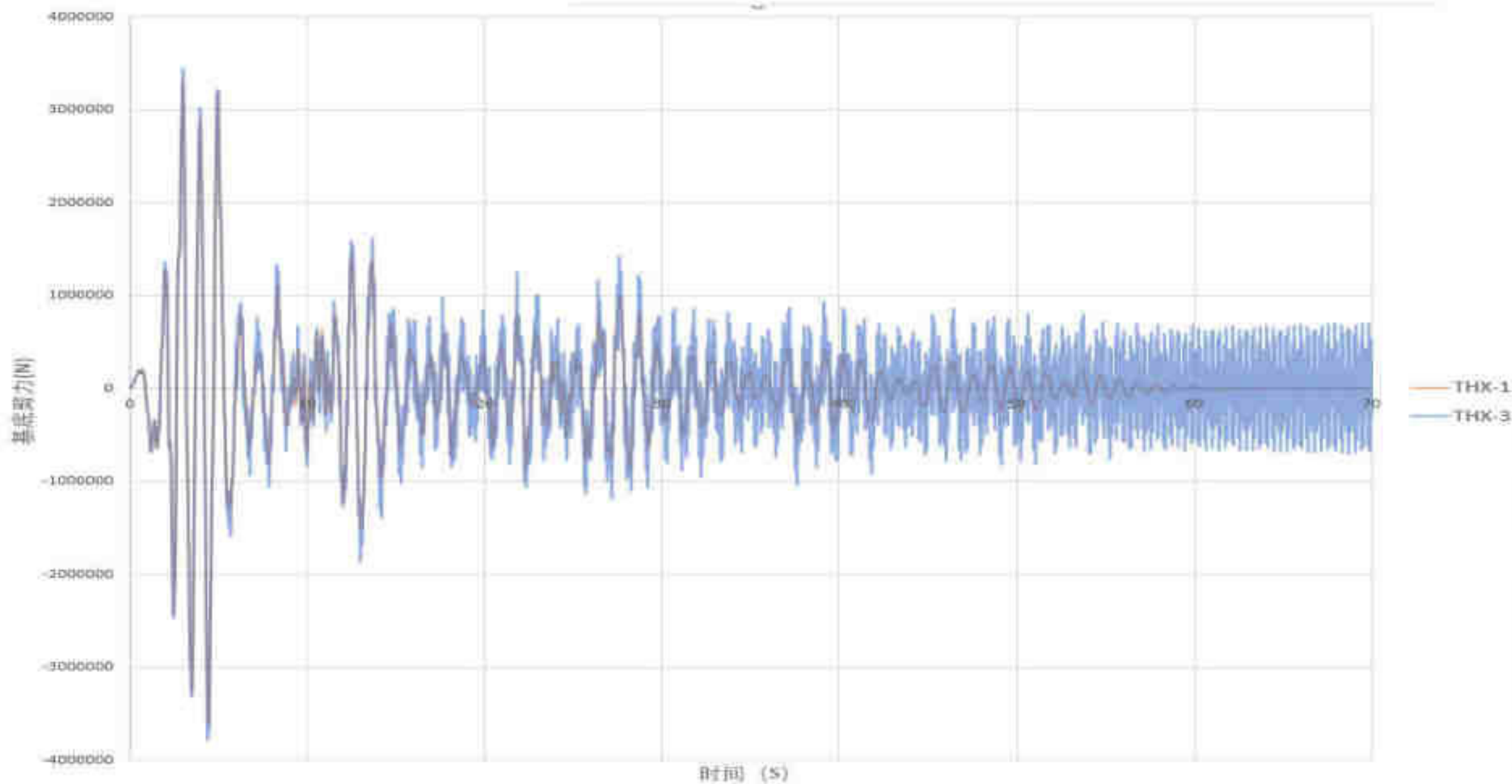
First sec

Second sec

Additional Modal Damping

Include Additional Modal Damp

Maximum Considered Mo





时间积分方法

◇ HHT法

α 为数值阻尼，取值范围 $[0, -1/3]$

建议取值 $-0.05 \sim -0.02$

时间积分参数

积分方法	Gamma	Beta	Theta	Alpha	Alpha-m
<input type="radio"/> Newmark					
<input type="radio"/> Wilson					
<input type="radio"/> Collocation					
<input checked="" type="radio"/> Hilber-Hughes-Taylor	0.5	0.25		-0.02	
<input type="radio"/> Chung and Hulbert					

确定 取消



非线性参数

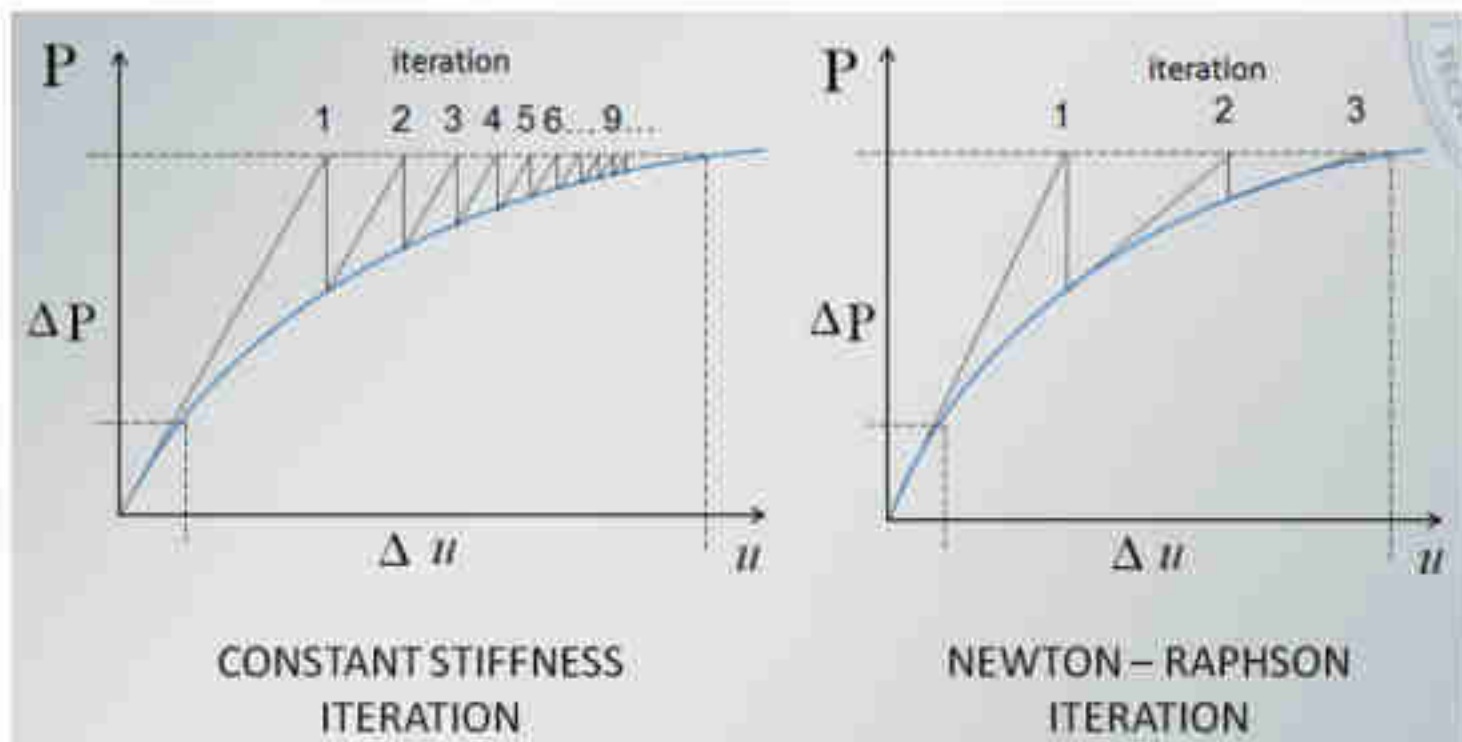
◇ 迭代方法

ET 非线性参数



求解控制

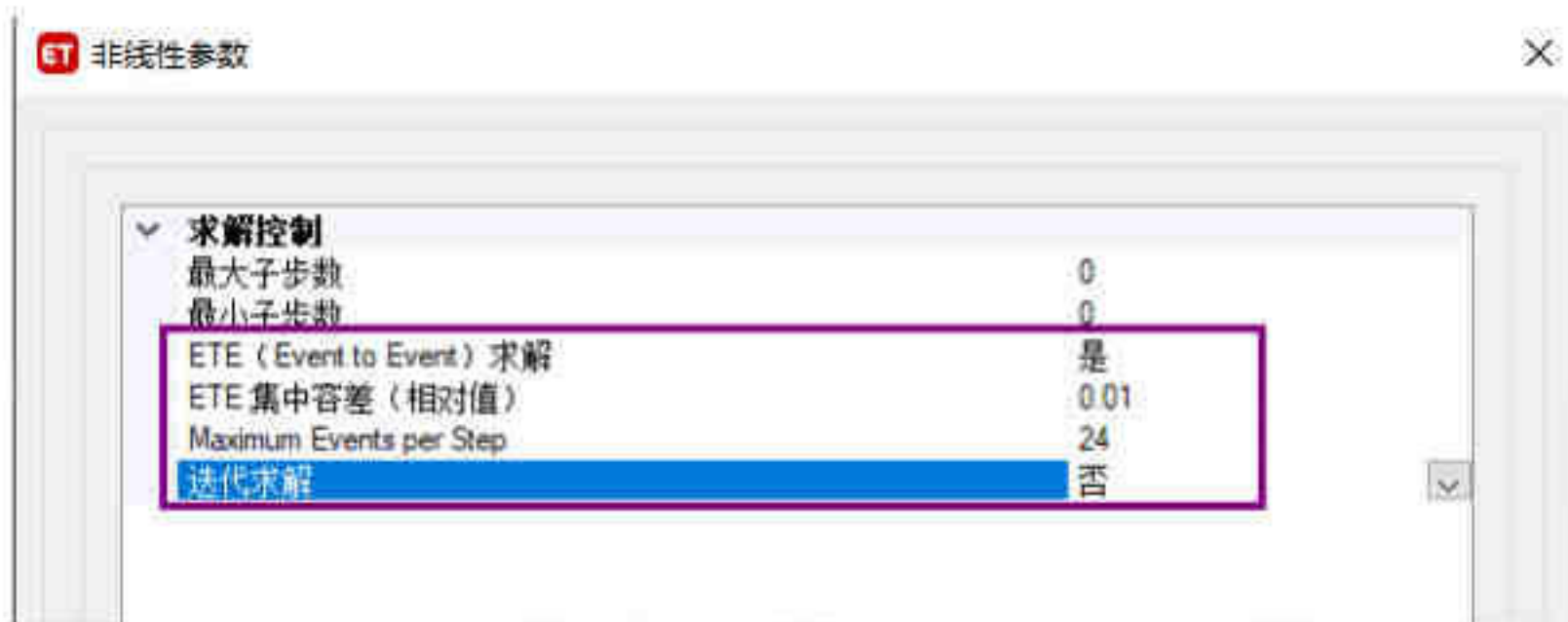
最大子步数	0
最小子步数	0
EFE (Event to Event) 求解	否
迭代求解	是
最大的常刚度迭代次数	10
最大的 NR 迭代次数	40
迭代收敛容差 (相对值)	0.0001
线性搜索	是
每次迭代的最大线性搜索次数	20
线性搜索·可接受容差 (相对值)	0.1
线性搜索·步长系数	1.618



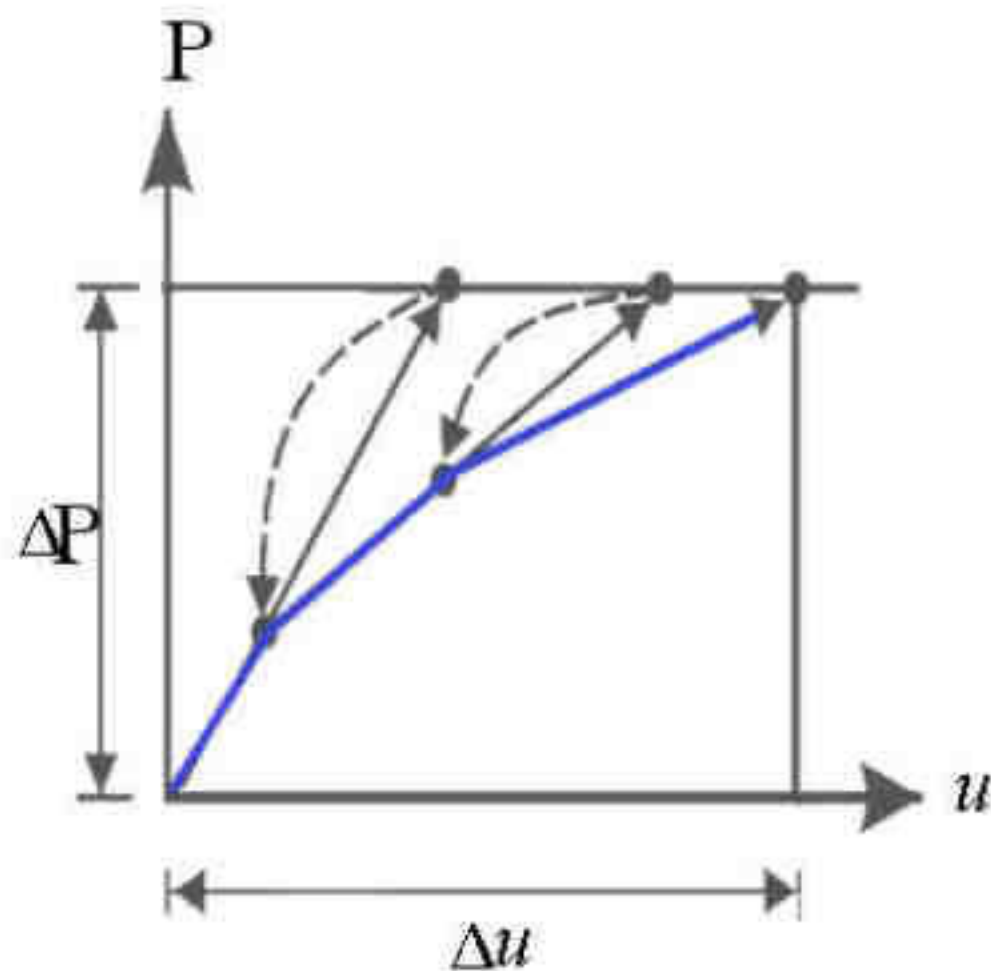


非线性参数

◇ 事件到事件方法



适用范围：所有的框架较、分层壳以及连接单元中的多段线性塑性、钩、缝以及摩擦摆单元。





求解器

◇ SAPFire求解器

◇ 标准求解器

◇ 适用于小模型，或检查模型，标准求解器会给出所有警告，计算速度最慢

◇ 高级求解器

◇ 默认求解器，适合各类模型，计算速度中等

◇ 多线程求解器

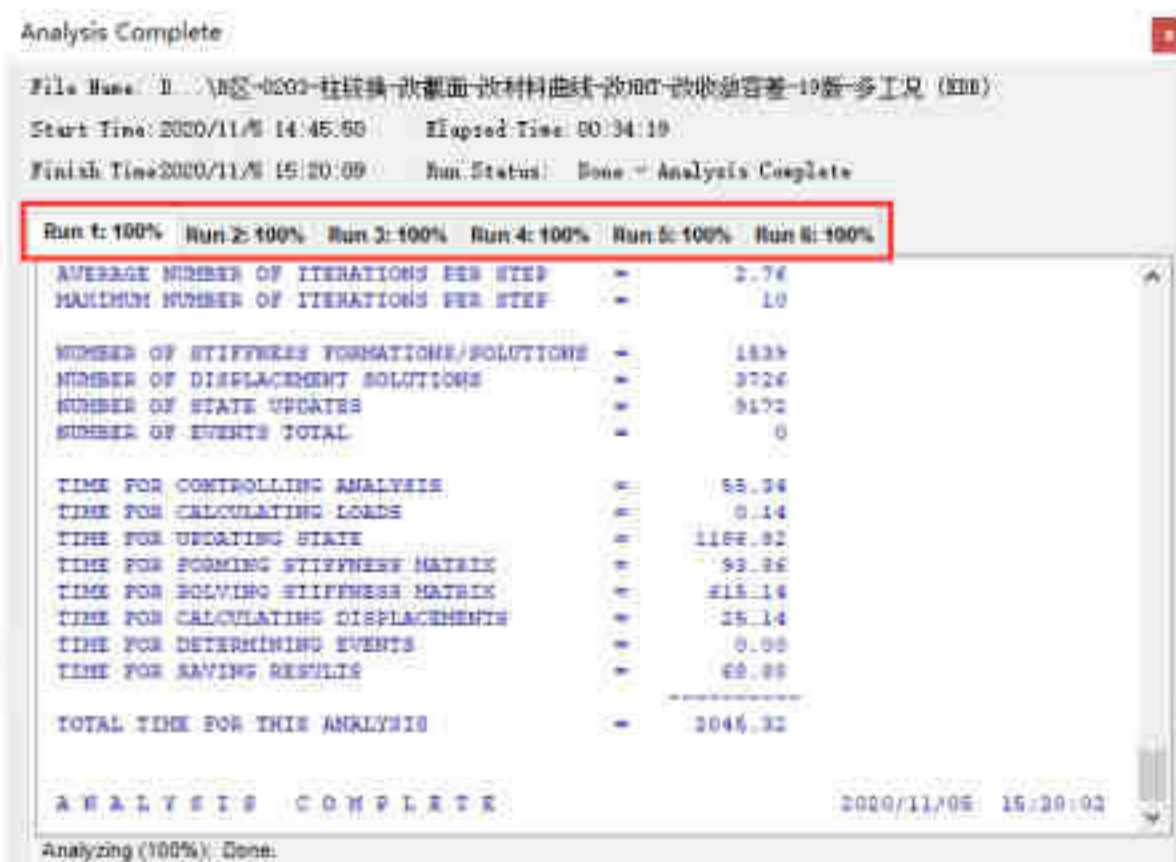
◇ 适用于中、大型模型，计算速度最快，但是内存使用量大





求解器的增强

◇ 并行计算



单个工况运行时间

17min40s

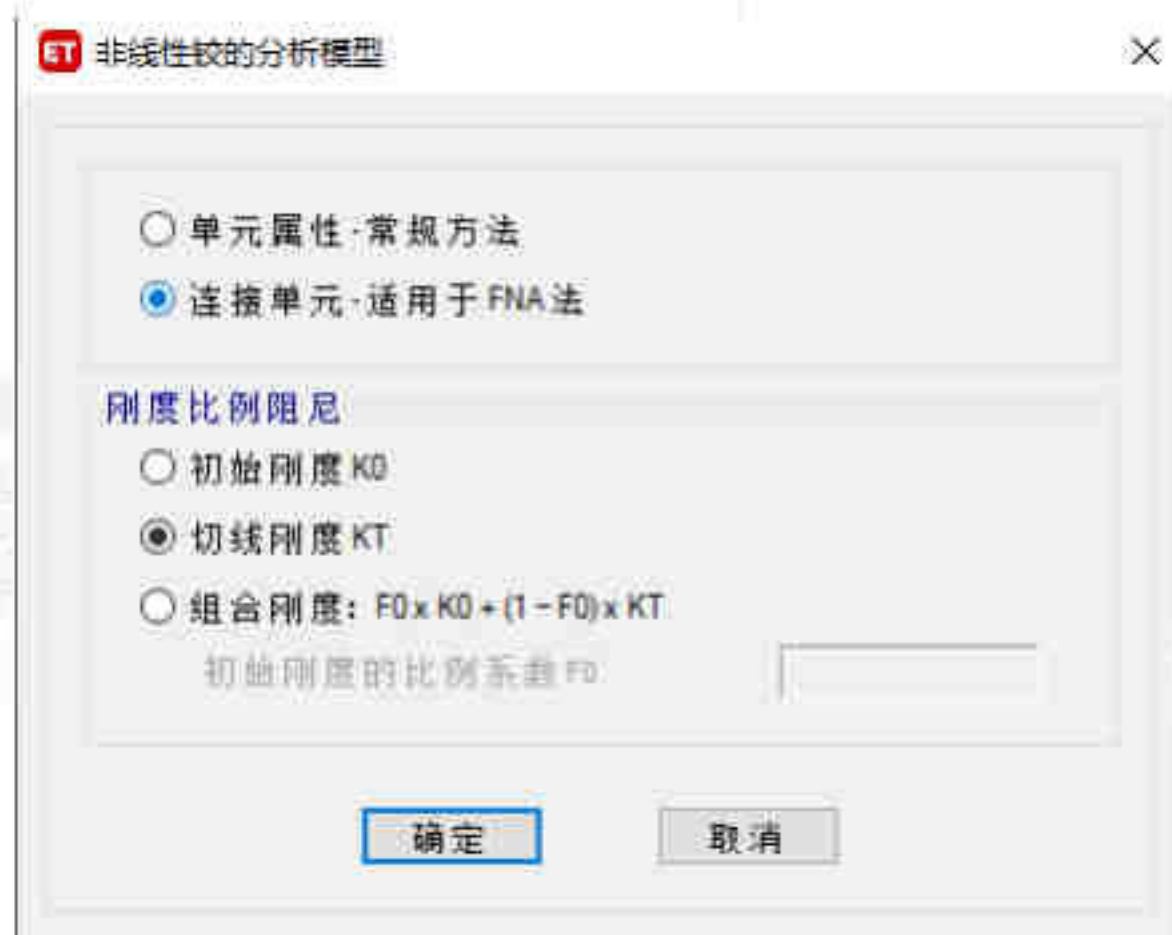
六个工况并行计算时间

34min19s



铰的模拟方式

- ◇ 单元属性（推荐使用）
- ◇ 连接单元-可用于FNA法



05

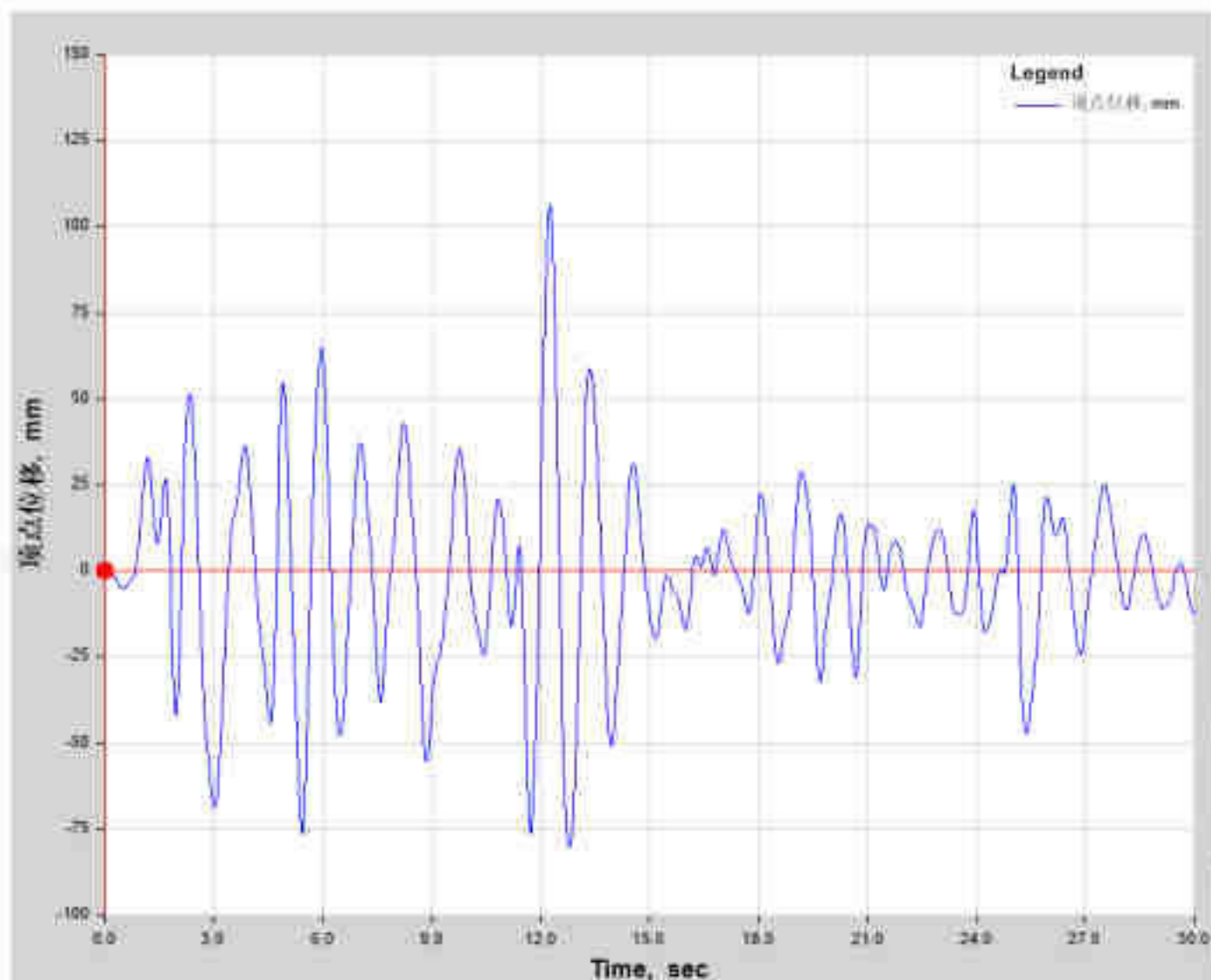
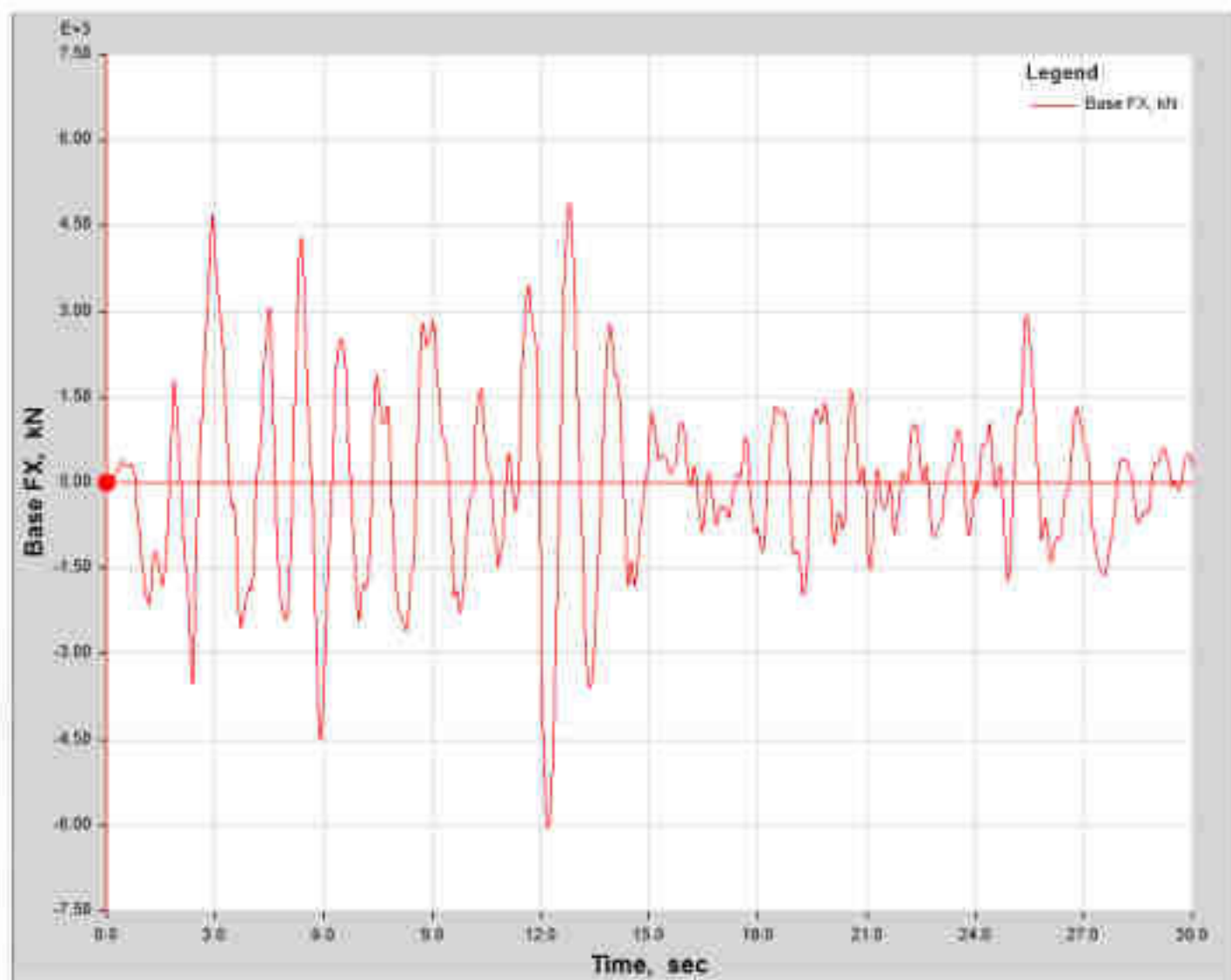
结果查看

- ◆ 时程曲线
- ◆ 铰结果
- ◆ 性能校核
- ◆ 能量图



时程曲线

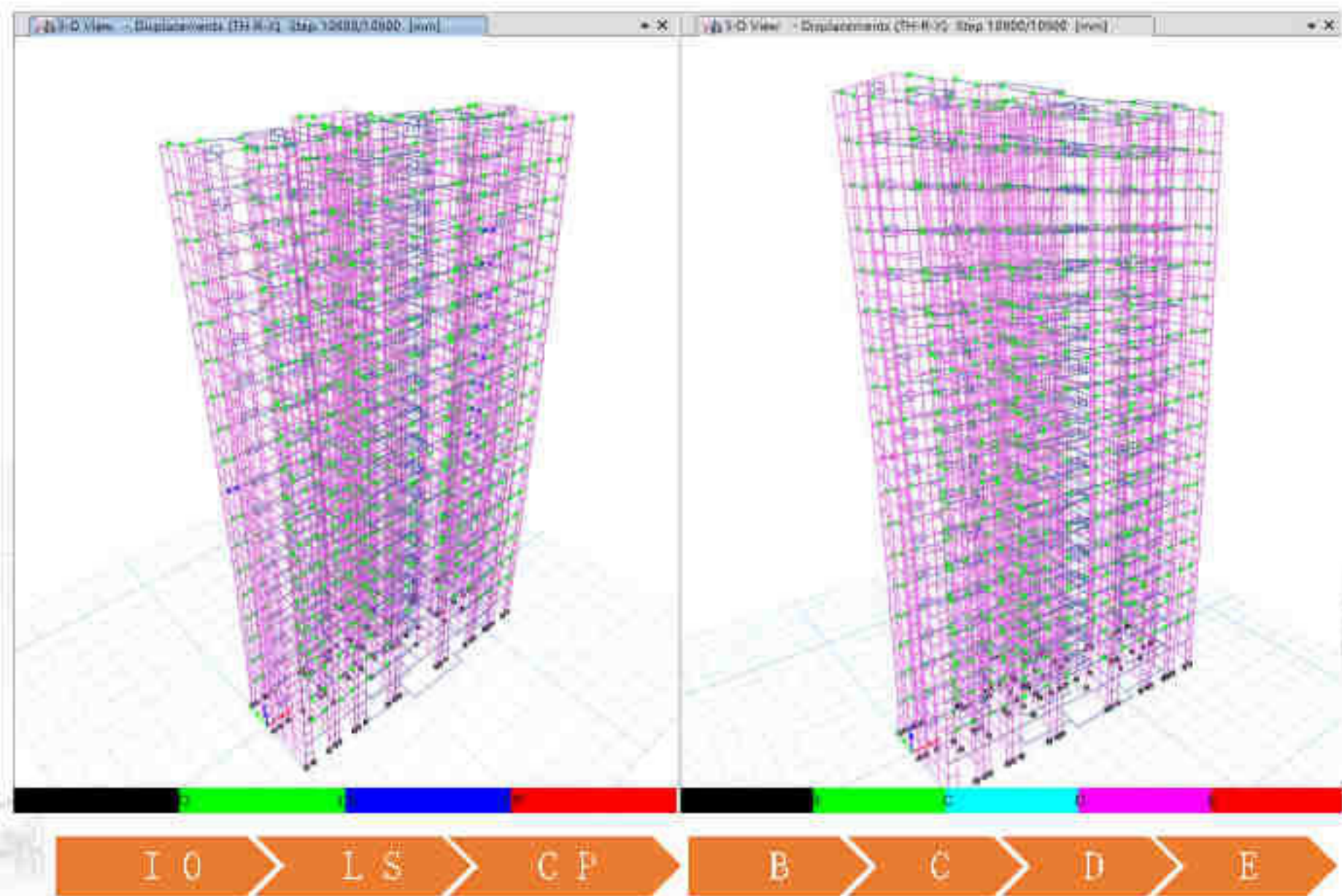
◇ 各类时程曲线





铰结果

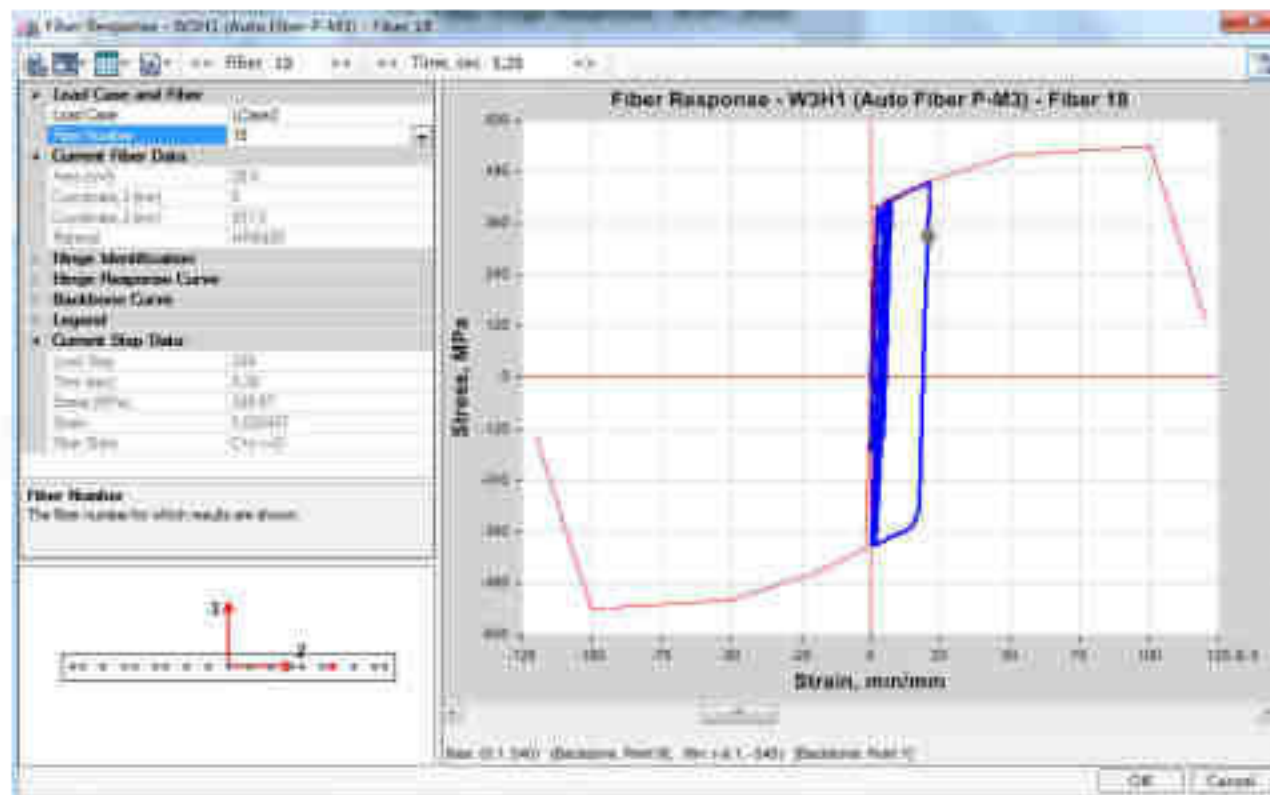
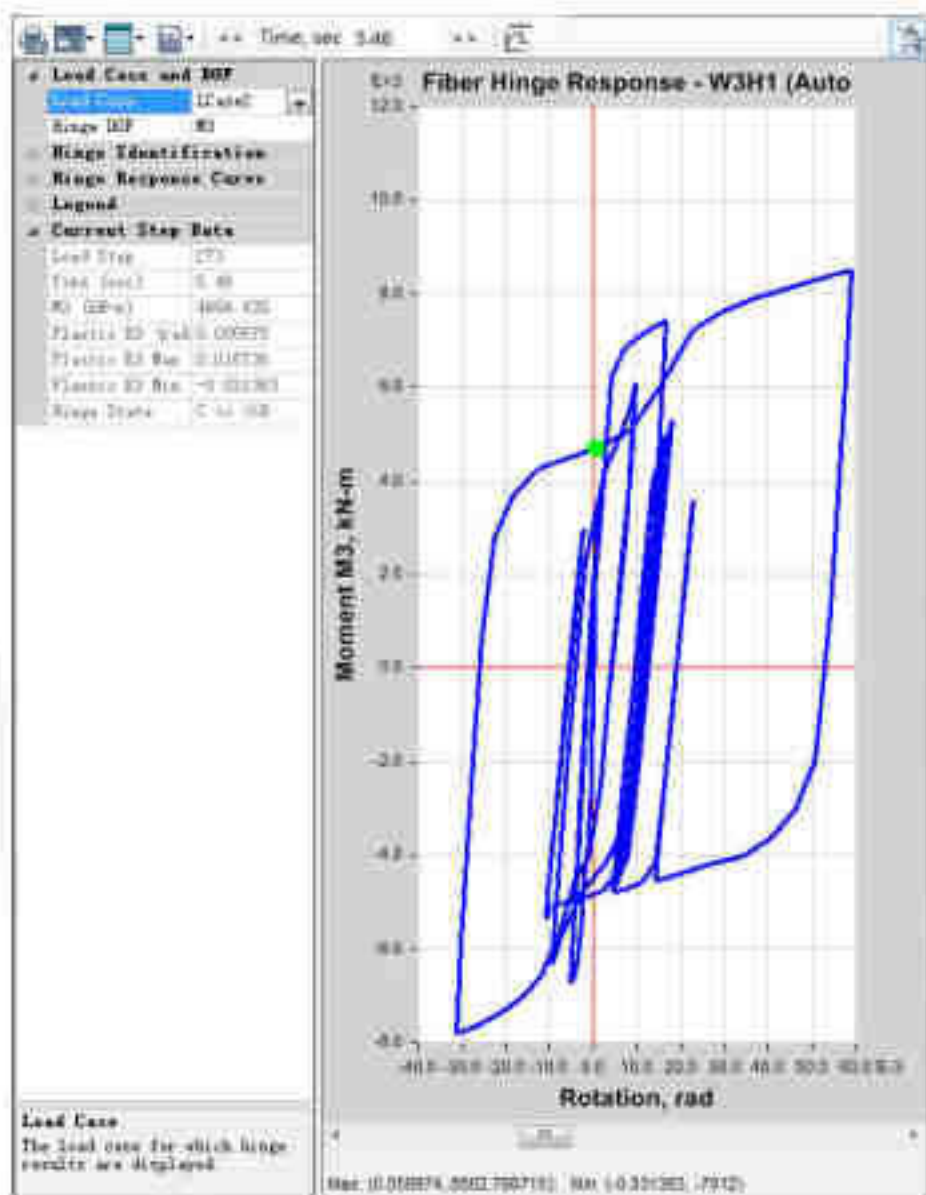
◇ 整体显示





铰结果

◇ 单个结果





性能校核

性能校核名称

Performance Check Name:

Group: All

需求集列表 (Demand Set List) 1

- Motion1
- Motion3
- Motion5

Buttons: Add, Delete

Combination Method for Demand Sets

Use Mean Plus Multiple Times Standard Deviation

Use Maximum Demand

Data for Demand Set (Data for Demand Set) 2

Demand Set Name: Motion1

Load Case	Step Number
Motion1H1 分析工况	

Buttons: Add, Delete

Load Case Combination Method: Maximum

性能评价指标 (Include) 3

- Frame Hinges
- Wall Hinges
- Link
- Strain Gauges
- Pier and Spandrel Forces
- Panel Zones

Buttons: OK, Cancel

11. 性能校核 - 1. Frame Hinge (2D) (mm) (10 mm)

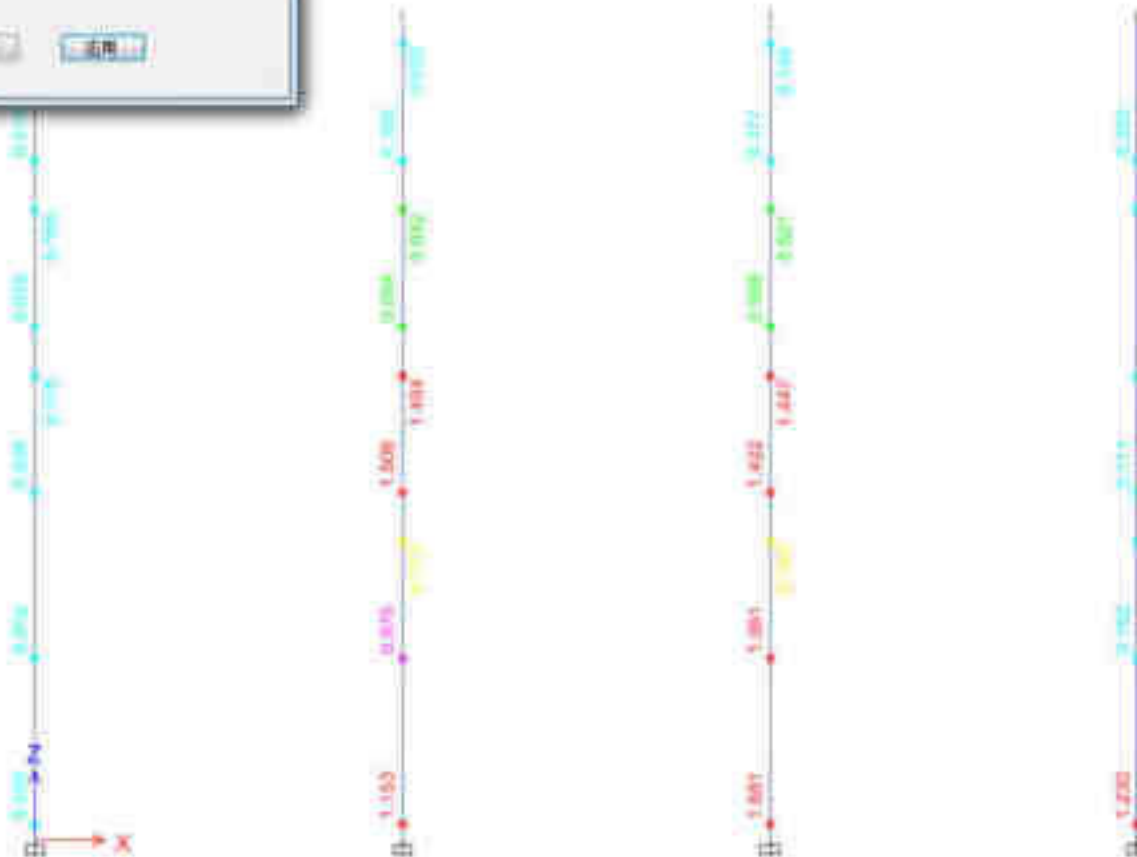
Performance Check

Performance Check Settings

Performance Check:

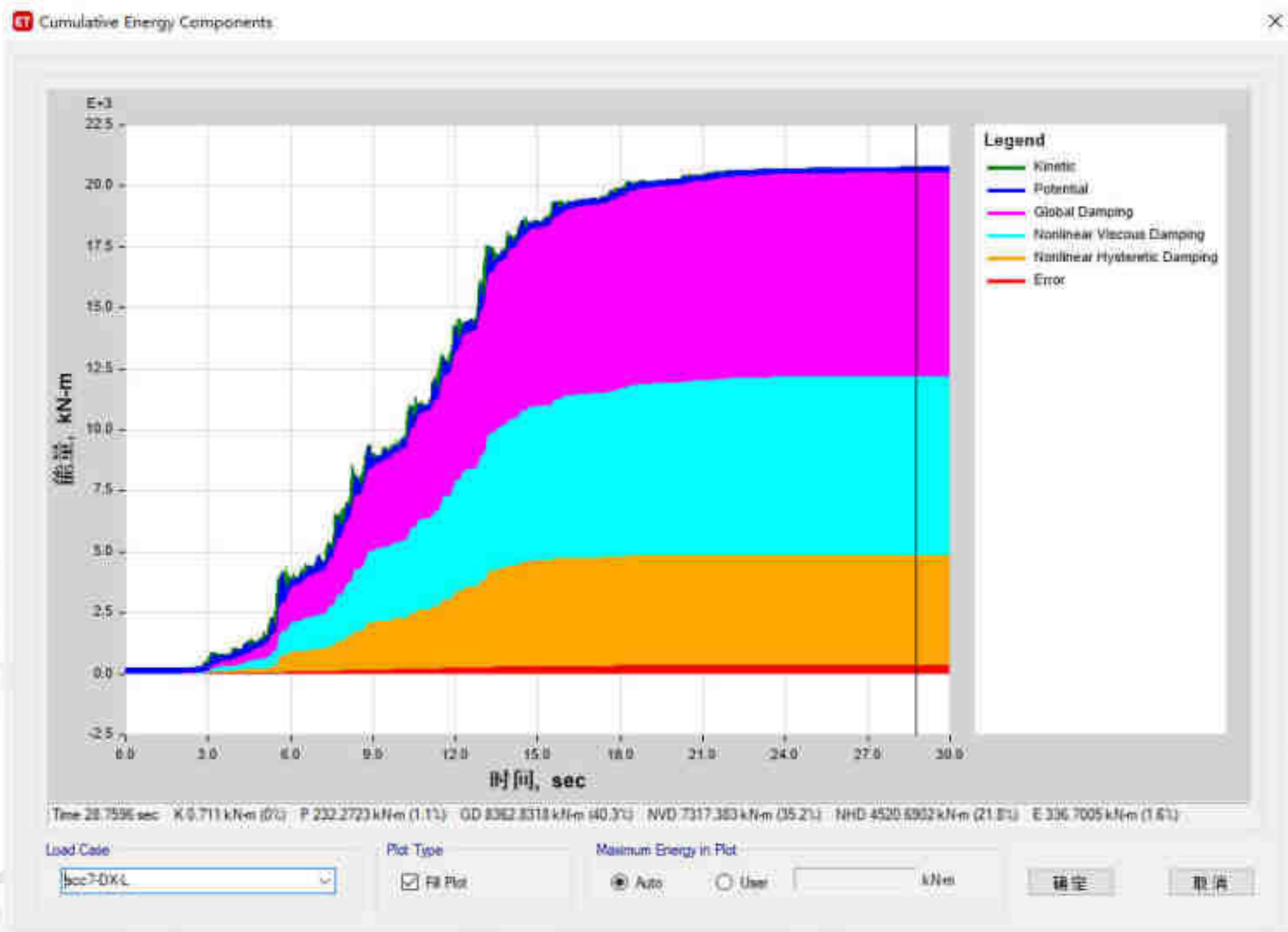
Display Check For:

Buttons: OK, Cancel, OK



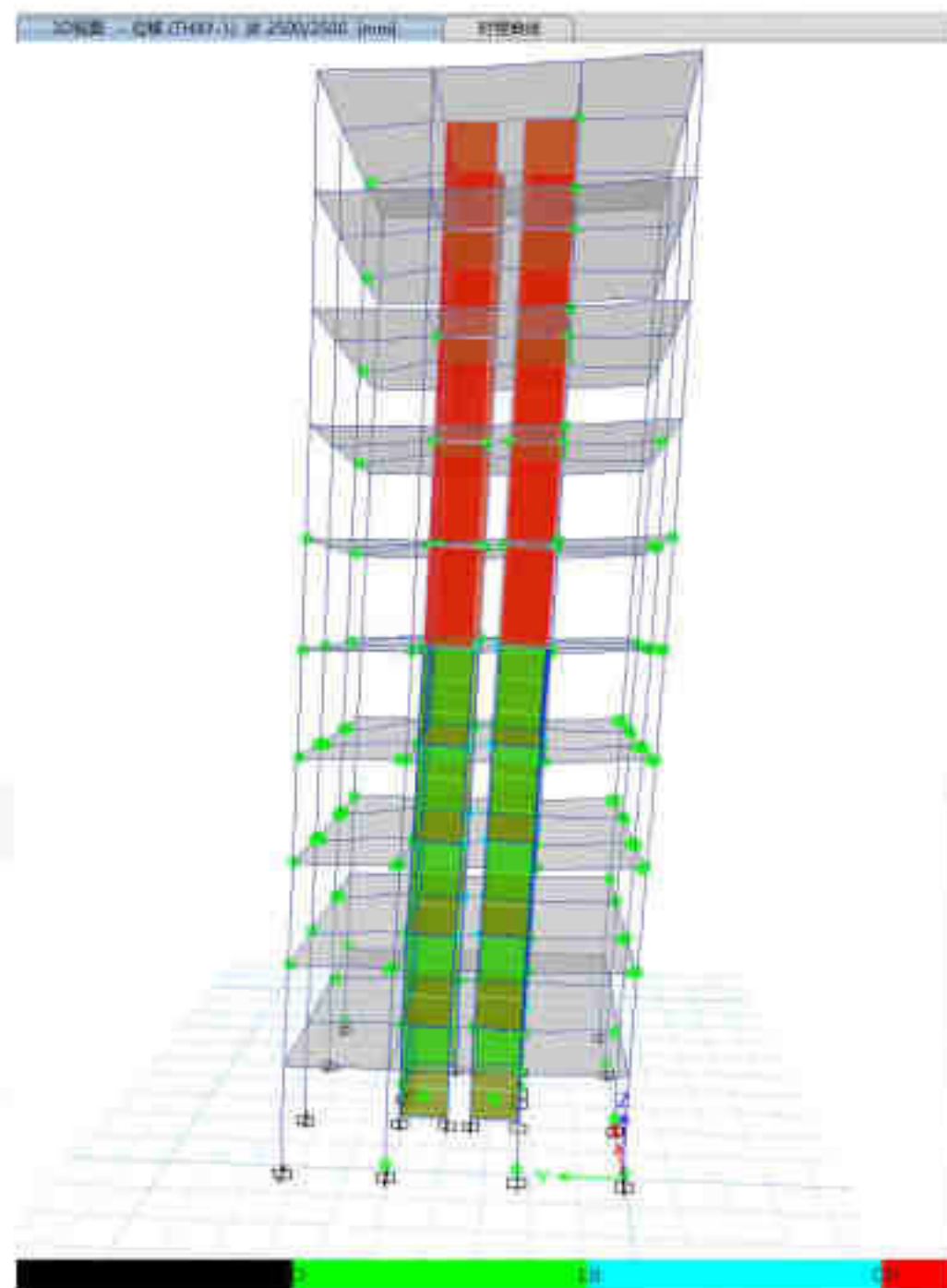
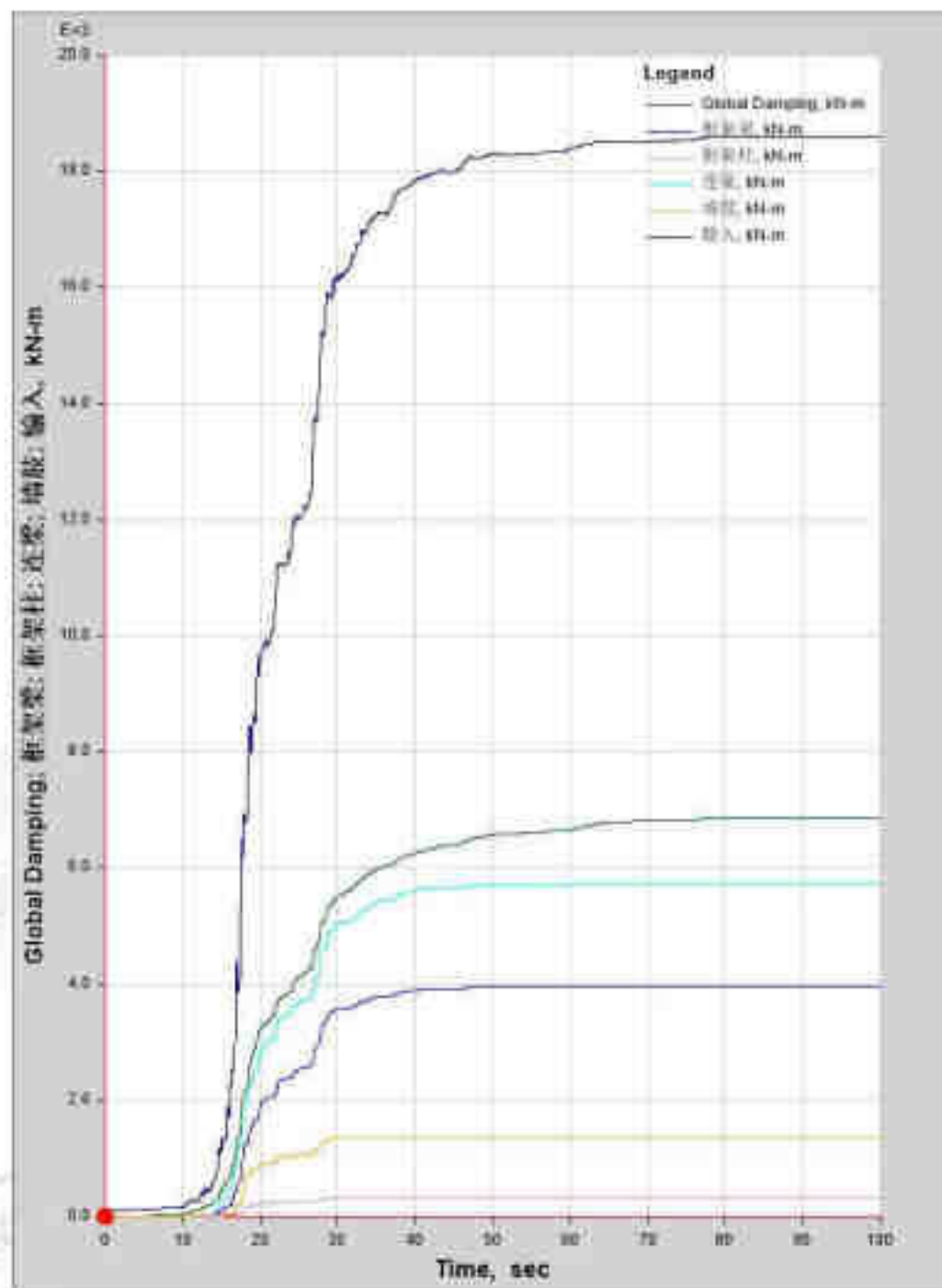


能量图





能量图



Thanks



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