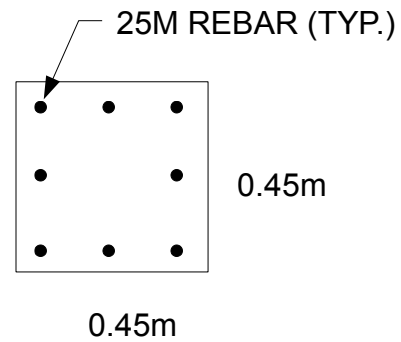
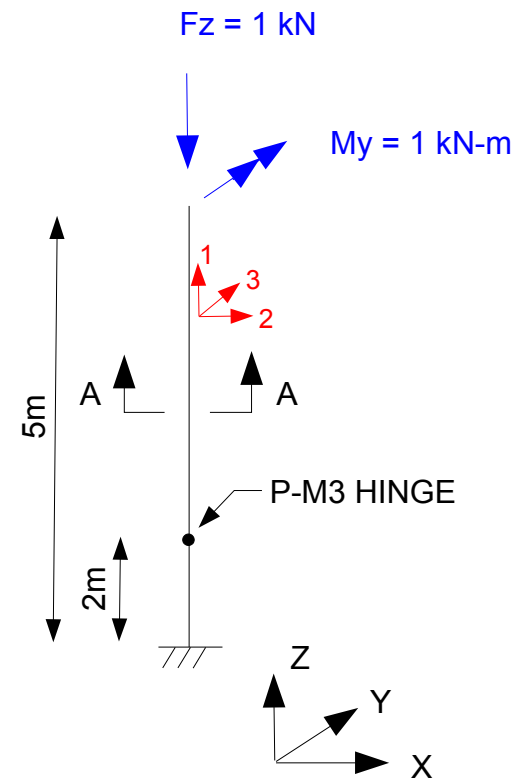


Hinge Response When Position of Yield Point on the Interaction Curve/Surface Changes

Purpose

- The purpose of this test problem is to demonstrate that the hinge response may not follow the backbone curve when the position of the yield point on the interaction diagram/surface changes.

Geometry



SECTION A-A
(NOT TO SCALE)

Hinge Properties

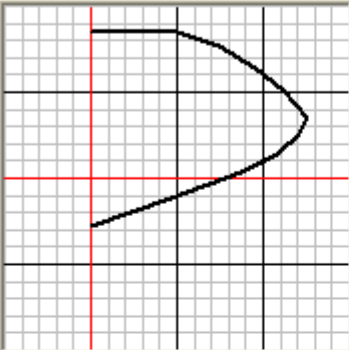
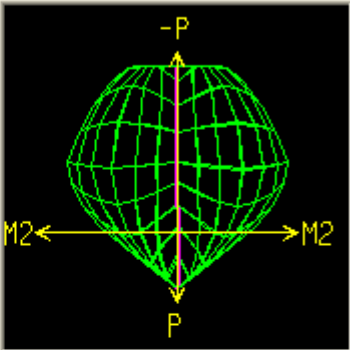
Section Interaction Curve Calculated By Section Designer

SAP2000 v14.2.0 Advanced - model B V14.2.0

Interaction Surface (ACI 318-05/IBC2003)

Edit

	P	M2	M3
1	-5046	0.078	-1.7951
2	-5046	0.078	188.134
3	-4559	0.078	279.8912
4	-3835	0.078	357.9703
5	-3033	0.078	419.9543
6	-2117	0.078	473.2757
7	-1550	0.1954	454.5277
8	-831.2084	3.4648	409.2503
9	-175.2433	5.1396	327.6039
10	718.367	10.1686	177.2407
11	1654.742	-0.0827	1.903
12			
13			
14			
15			
16			
17			
18			
19			
20			

Design-Code Curve
 Fiber-Model Curve

Design Options

phi
 no phi
 no phi with fy increase

3D View

Plan
 Elevation

3d MM PM3 PM2

Show Design-Code Results
 Show Fiber-Model Results

Curve 1
Angle 0.

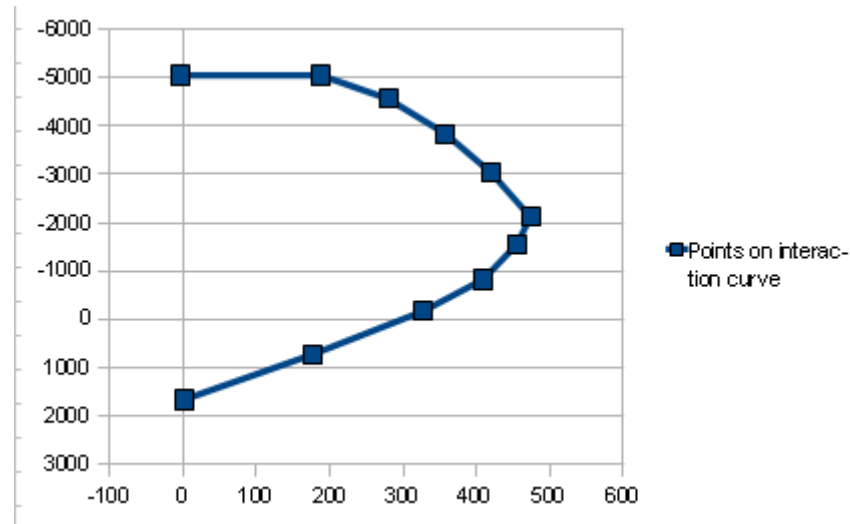
Done

Points on interaction curve

P	M3	
1	-5046	-1.7951
2	-5046	188.134
3	-4559	279.8912
4	-3835	357.9703
5	-3033	419.9543
6	-2117	473.2757
7	-1550	454.5277
8	-831.2084	409.2503
9	-175.2433	327.6039
10	718.367	177.2407
11	1654.742	1.903

Initial Yield Point for Case 2

Initial Yield Point for Case 1



Interaction curve specified in the hinge definition is based on the previously shown interaction curve calculated by section designer:

SAP2000 v14.2.0 Advanced - model B V14.2.0

P-M3 Interaction Curve Definition for P-M3

Edit

User Interaction Curve Options

Interaction Curve Is Symmetric

Number of Curves:

Number of Points on Each Curve:

Scale Factors (Same for All Curves)

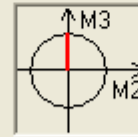
Unit: P: M3:

First and Last Points (Same for All Curves)

Point	P	M3
1	-5046.	0
11	1654.	0

Interaction Curve Requirements - With Symmetry

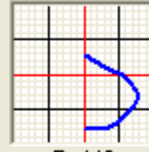
- Only one P-M3 curve is specified.
- P (tension positive) increases monotonically.
- M3 = 0 at the first and last points.
- All M3 > 0 (except at first and last points).
- The curve must be convex (no dimples in surface).



Interaction Curve Data

Current Curve:

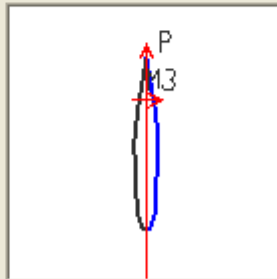
Point	P	M3
1	-5046.	0.
2	-5045.	188.
3	-4559.	279.
4	-3835.	357.
5	-3033.	419.
6	-2117.	473.
7	-1550.	454.
8	-831.	409.
9	-175.	327.
10	718.	177.
11	1654.	0.



P - M3

Plot of Full Interaction Curve

Highlight Current Curve



P:

M3:

Frame Hinge Property Data for P-M3 - Interacting P-M3

Hinge Specification Type

Moment - Rotation

Moment - Curvature

Hinge Length

Relative Length

Scale Factor for Rotation (SF)

SF is Yield Rotation per FEMA 356 Eqn. 5-2
(Steel Objects Only)

User SF

1.

Load Carrying Capacity Beyond Point E

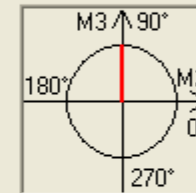
Drops To Zero

Is Extrapolated

Symmetry Condition

Moment Rotation Dependence is Symmetric

Moment Rotation Dependence is Not Symmetric



Requirements for Specified Symmetry Condition

1. Specify curve at angle of 90°.

Axial Forces for Moment Rotation Curves

Number of Axial Forces

6

Modify/Show Axial Force Values...

Curve Angles for Moment Rotation Curves

Number of Angles

1

Modify/Show Angles...

Modify/Show Moment Rotation Curve Data...

Modify/Show P-M3 Interaction Surface Data...

OK

Cancel

Definition of hinge moment rotation curve (the curve is the same for all levels of axial force):

SAP2000 v14.2.0 Advanced - model B V14.2.0

Moment Rotation Data for P-M3 - Interacting P-M3

Edit

Select Curve
 Axial Force: -4000. Angle: 90. Curve #1: [Navigation Buttons]
 Units: KN, m, C

Point	Moment	Rotation/SF
A	0.	0.
B	1000.	0.
C	1.	0.01
D	1.	0.02
E	1.	0.03

Note: Yield moment is defined by interaction curve

Copy Curve Data Paste Curve Data

Acceptance Criteria (Plastic Deformation / SF)

- Immediate Occupancy: 3.000E-03
- Life Safety: 0.012
- Collapse Prevention: 0.015
- Show Acceptance Points on Current Curve

3D View
 Plan: 0 Elevation: 0 Aperture: 0
 Axial Force: -4000
 Hide Backbone Lines
 Show Acceptance Criteria
 Show Thickened Lines
 Highlight Current Curve

Moment Rotation Information
 Symmetry Condition: Symmetric
 Number of Axial Force Values: 6
 Number of Angles: 1
 Total Number of Curves: 6

Angle Is Moment About
 0 degrees = About Positive M2 Axis
 90 degrees = About Positive M3 Axis
 180 degrees = About Negative M2 Axis
 270 degrees = About Negative M3 Axis

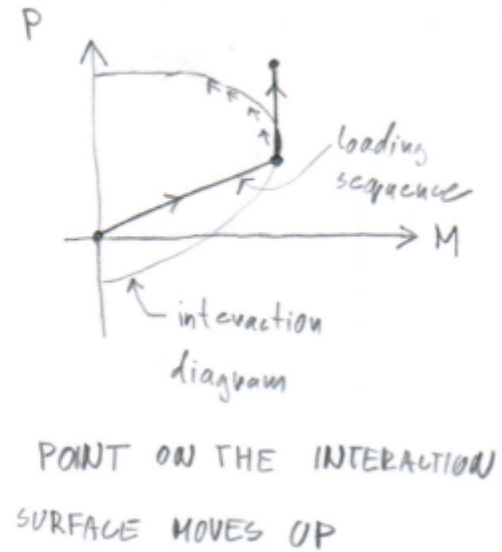
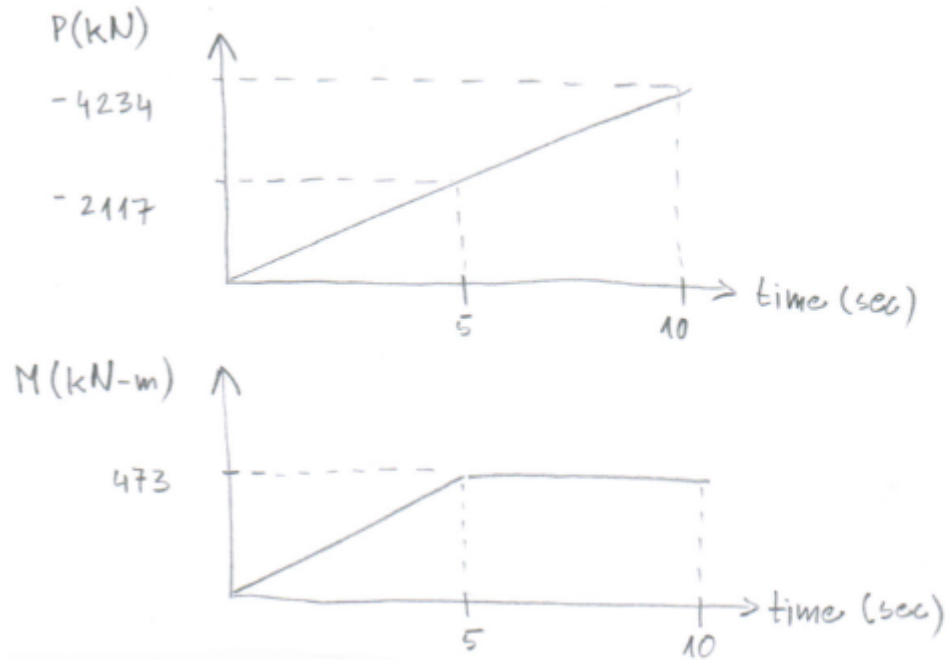
OK Cancel

Loading

- The loading is applied a nonlinear direct-integration time-history load cases. See the following pages for the variation of loading in time.

Case 1

Loading sequence and response for Case 1:



Hinge Results

File Select

Select Hinge

1H1 (P-M3)

Show Hinges on Selected Frames Only

Show Hinge Property Definition...

Hinge Location And Behavior

Frame Object 1

Relative Distance 0.2

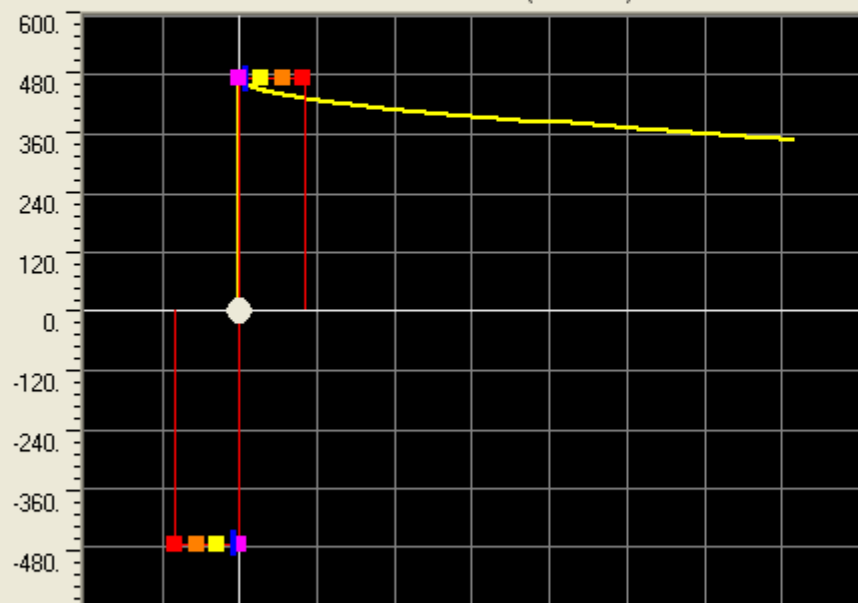
Hinge Behavior Deformation Controlled

Units

KN, m, C

Hinge Results

Plastic Rotation (radians)



Moment M3 (kn-m)

Select Load Case

TH_case1

Time 0

Current Hinge Data

Hinge DOF M3

M3 0.

Plastic R3 0.

Plastic R3 Max 0.

Plastic R3 Min 0.

Hinge State A to <=B

Hinge Status A to <=I0

Plot Control Parameters

- Show Hinge Backbone
- Scale for Full Backbone
- Add Left and Right Borders
- Add Top and Bottom Borders

Mouse Pointer Location Horiz Vert

Done

Hinge Results

File Select

Select Hinge

1H1 (P-M3)

Show Hinges on Selected Frames Only

Show Hinge Property Definition...

Hinge Location And Behavior

Frame Object 1

Relative Distance 0.2

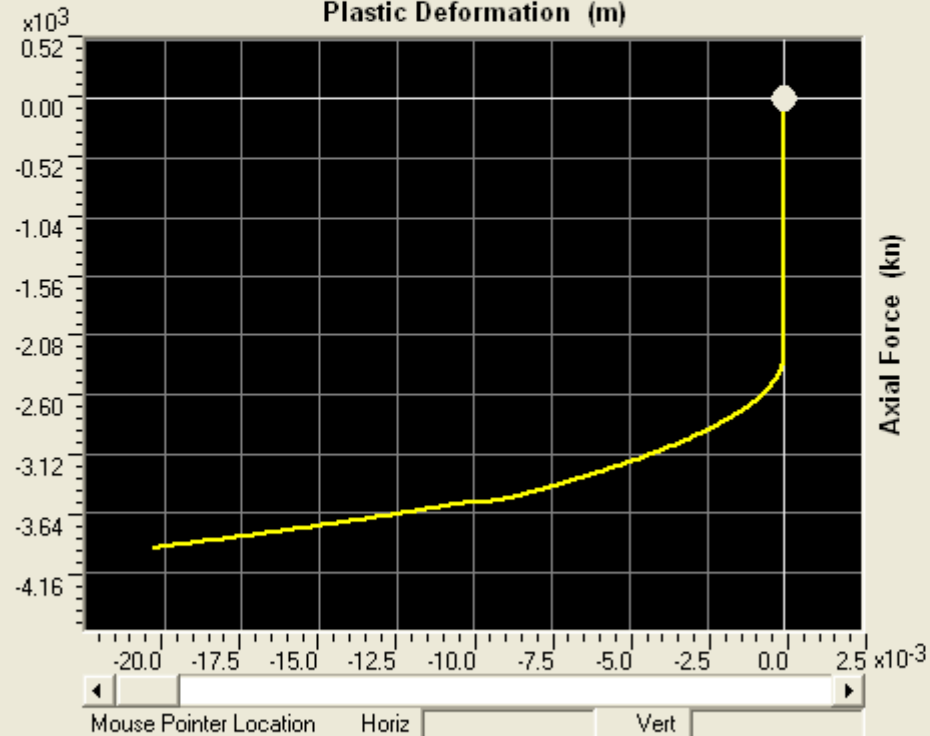
Hinge Behavior Deformation Controlled

Units

KN, m, C

Hinge Results

Plastic Deformation (m)



Select Load Case

TH_case1

Time 0

Current Hinge Data

Hinge DOF P

P 0.

Plastic U1 0.

Plastic U1 Max 0.

Plastic U1 Min 0.

Hinge State A to <=B

Hinge Status A to <=I0

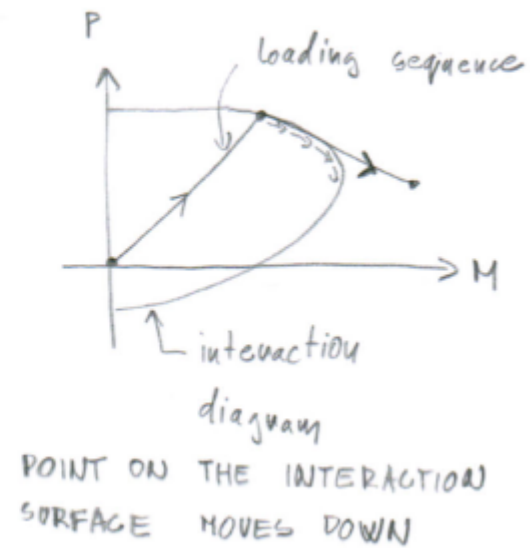
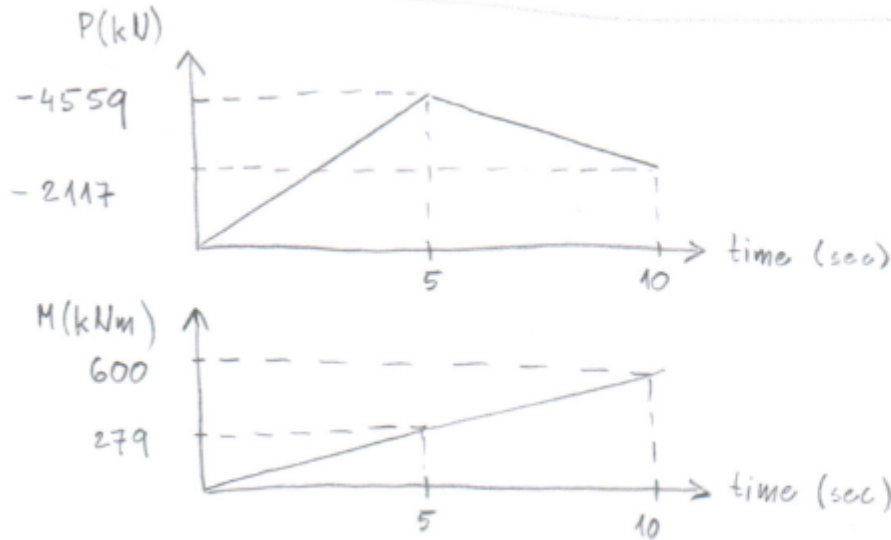
Plot Control Parameters

- Show Hinge Backbone
- Scale for Full Backbone
- Add Left and Right Borders
- Add Top and Bottom Borders

Done

Case 2

Loading sequence and response for Case 2:



Hinge Results

File Select

Select Hinge

1H1 (P-M3)

Show Hinges on Selected Frames Only

Show Hinge Property Definition...

Hinge Location And Behavior

Frame Object 1

Relative Distance 0.2

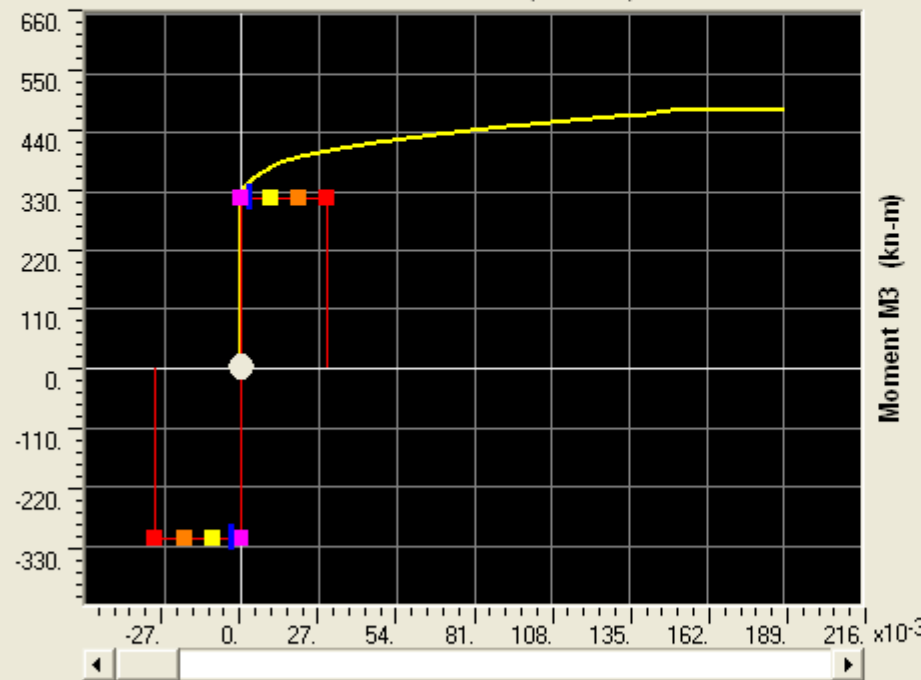
Hinge Behavior Deformation Controlled

Units

KN, m, C

Hinge Results

Plastic Rotation (radians)



Moment M3 (kn-m)

Select Load Case

TH_case2

Time 0.

Current Hinge Data

Hinge DOF M3

M3 0.

Plastic R3 0.

Plastic R3 Max 0.

Plastic R3 Min 0.

Hinge State A to <=B

Hinge Status A to <=I0

Plot Control Parameters

- Show Hinge Backbone
- Scale for Full Backbone
- Add Left and Right Borders
- Add Top and Bottom Borders

Mouse Pointer Location

Horiz

Vert

Done

Hinge Results

File Select

Select Hinge

1H1 (P-M3)

Show Hinges on Selected Frames Only

Show Hinge Property Definition...

Hinge Location And Behavior

Frame Object 1

Relative Distance 0.2

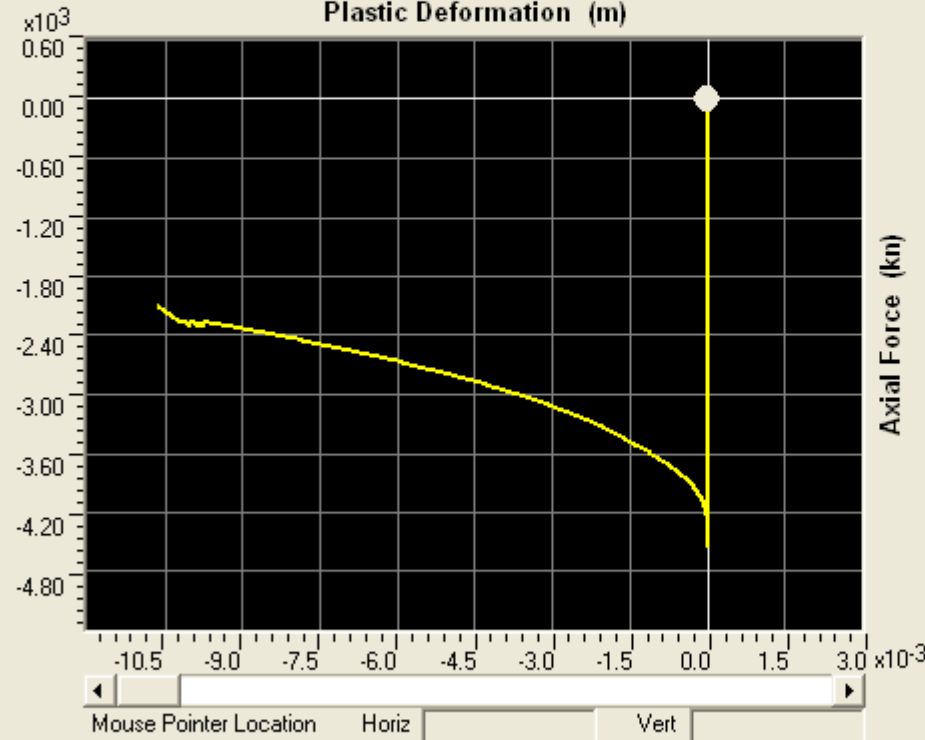
Hinge Behavior Deformation Controlled

Units

KN, m, C

Hinge Results

Plastic Deformation (m)



Select Load Case

1H_case2

Time 0.

Current Hinge Data

Hinge DOF P

P 0.

Plastic U1 0.

Plastic U1 Max 0.

Plastic U1 Min 0.

Hinge State A to <=B

Hinge Status A to <=I0

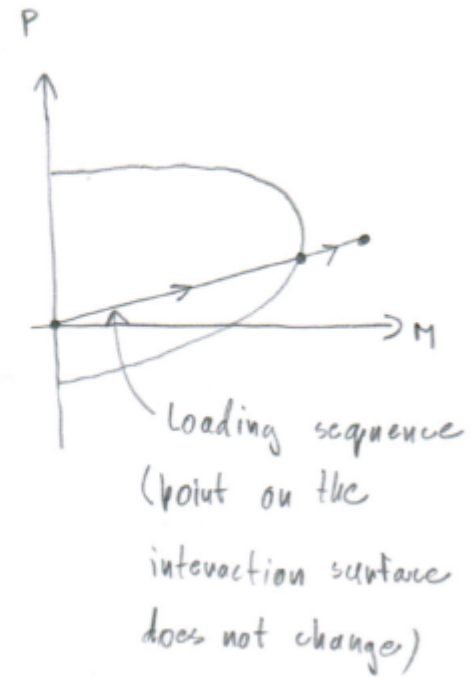
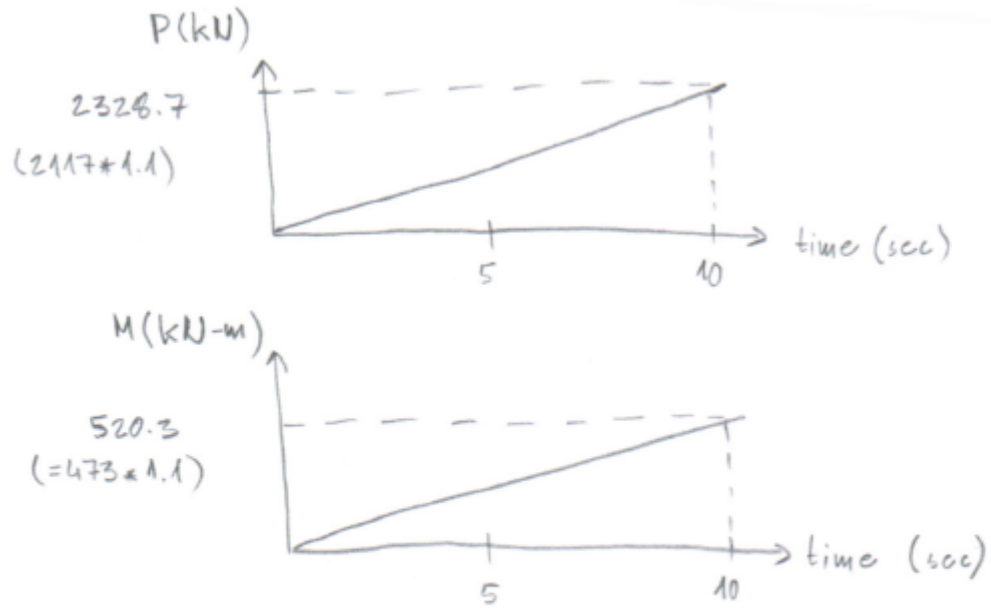
Plot Control Parameters

- Show Hinge Backbone
- Scale for Full Backbone
- Add Left and Right Borders
- Add Top and Bottom Borders

Done

Case 3

Loading sequence and response for Case 3:



Hinge Results

File Select

Select Hinge

1H1 (P-M3)

Show Hinges on Selected Frames Only

Show Hinge Property Definition...

Hinge Location And Behavior

Frame Object 1

Relative Distance 0.2

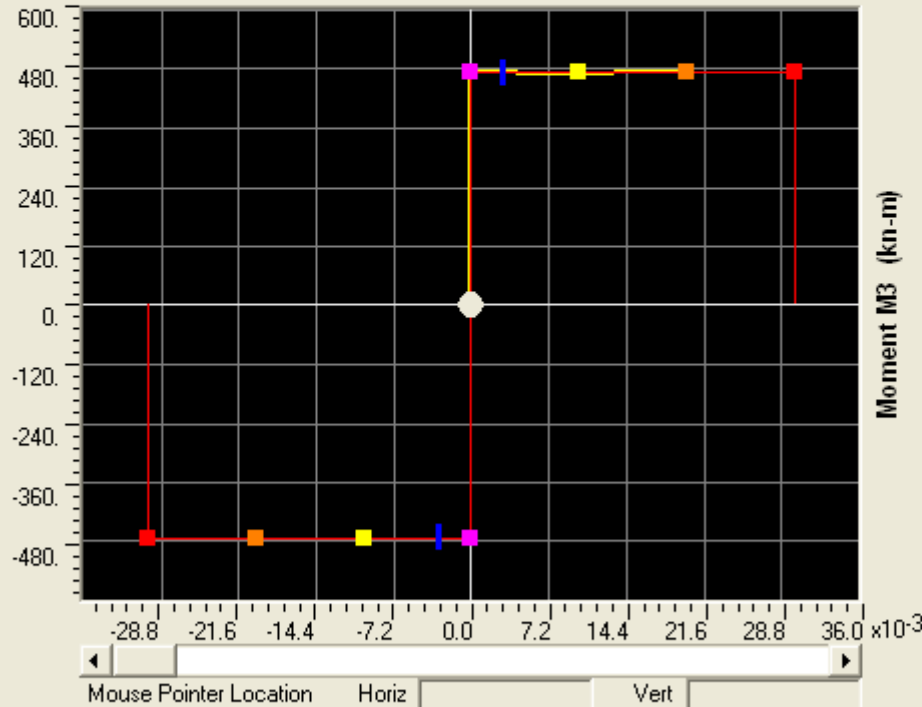
Hinge Behavior Deformation Controlled

Units

KN, m, C

Hinge Results

Plastic Rotation (radians)



Select Load Case

TH_case3

Time 0.

Current Hinge Data

Hinge DOF M3

M3 0.

Plastic R3 0.

Plastic R3 Max 0.

Plastic R3 Min 0.

Hinge State A to \leq B

Hinge Status A to \leq IO

Plot Control Parameters

- Show Hinge Backbone
- Scale for Full Backbone
- Add Left and Right Borders
- Add Top and Bottom Borders

Done

Hinge Results

File Select

Select Hinge

1H1 (P-M3)

Show Hinges on Selected Frames Only

Show Hinge Property Definition...

Hinge Location And Behavior

Frame Object 1

Relative Distance 0.2

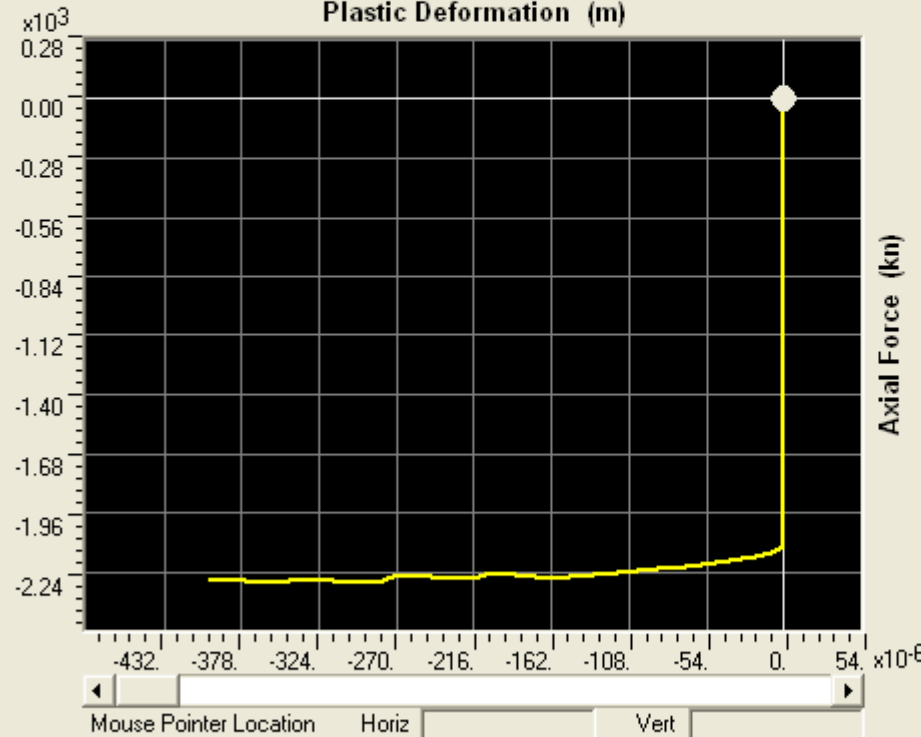
Hinge Behavior Deformation Controlled

Units

KN, m, C

Hinge Results

Plastic Deformation (m)



Select Load Case

TH_case3

Time 0.

Current Hinge Data

Hinge DOF P

P 0.

Plastic U1 0.

Plastic U1 Max 0.

Plastic U1 Min 0.

Hinge State A to <=B

Hinge Status A to <=I0

Plot Control Parameters

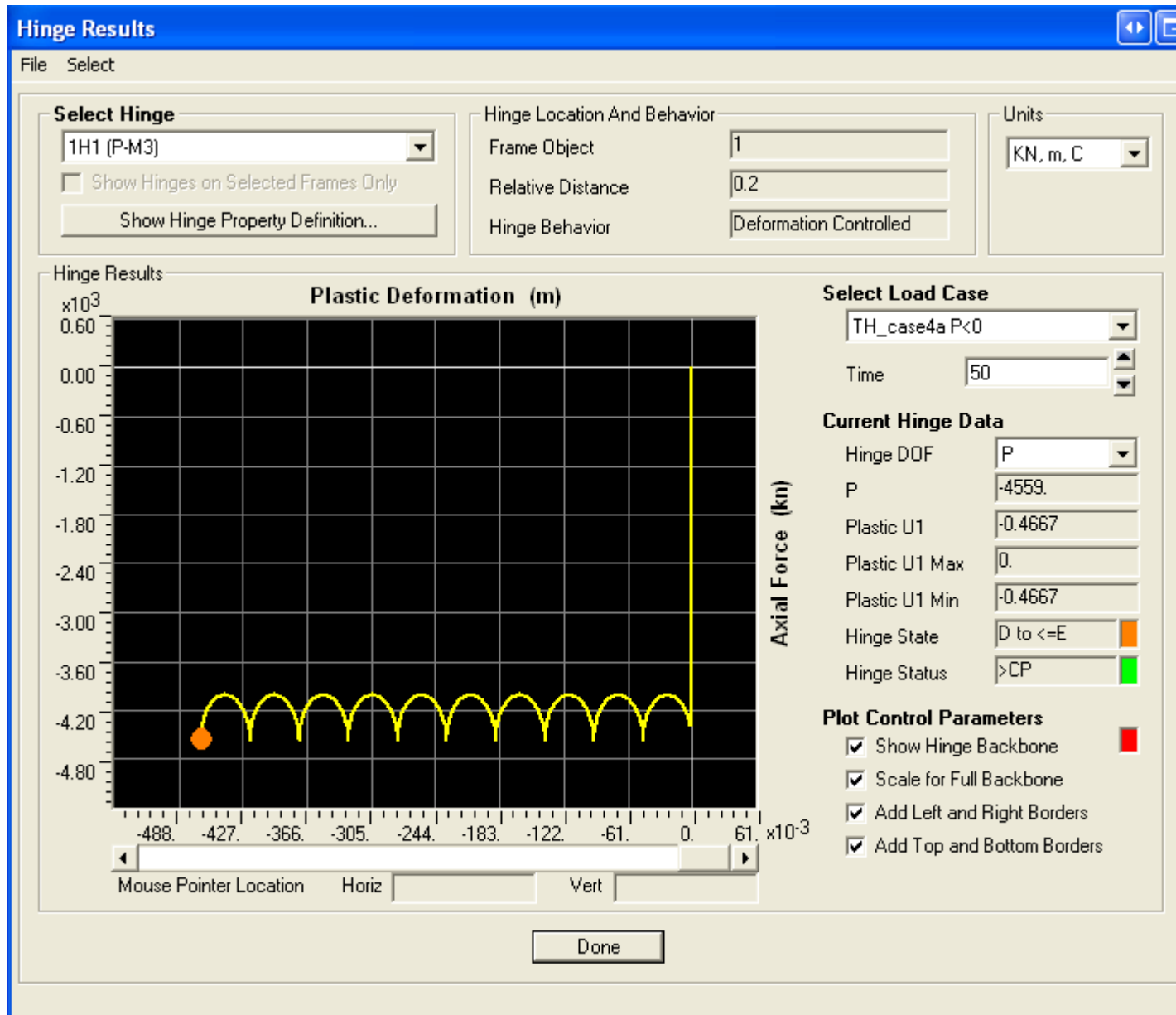
- Show Hinge Backbone
- Scale for Full Backbone
- Add Left and Right Borders
- Add Top and Bottom Borders

Done

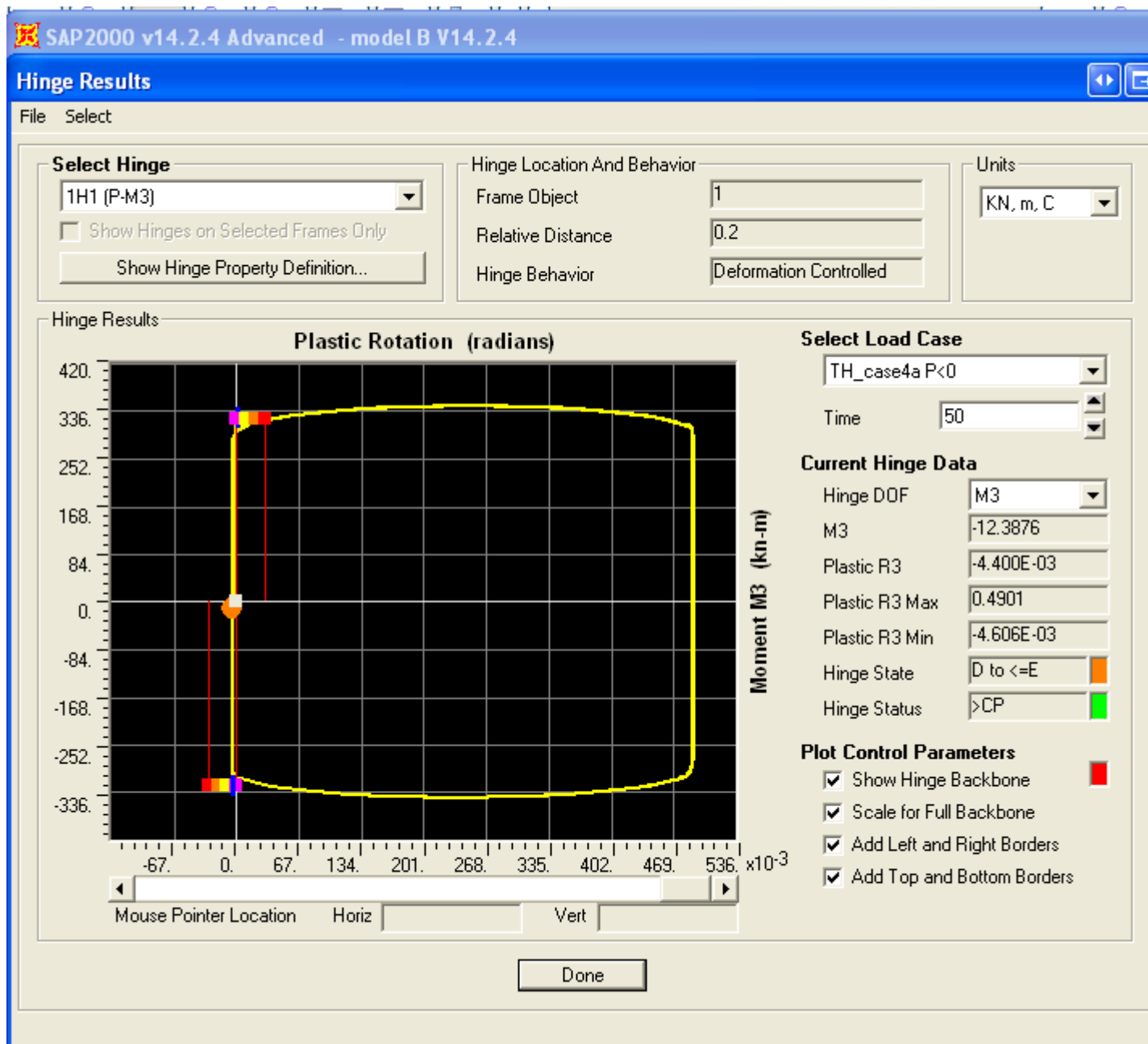
Case 4

- Ratcheting behavior.
- Loading is similar to Case 2, but the axial force is ramped to full value during 1 sec and then is kept constant.
- Moment loading is applied using sine time function with 5 cycles, with a duration of each cycle equal to 10 seconds.
- The total duration of the loading is 50 seconds.

Response for P=-4559kN ... compression
(Note the ratcheting behavior, ie. accumulation of plastic deformation, in axial direction.)

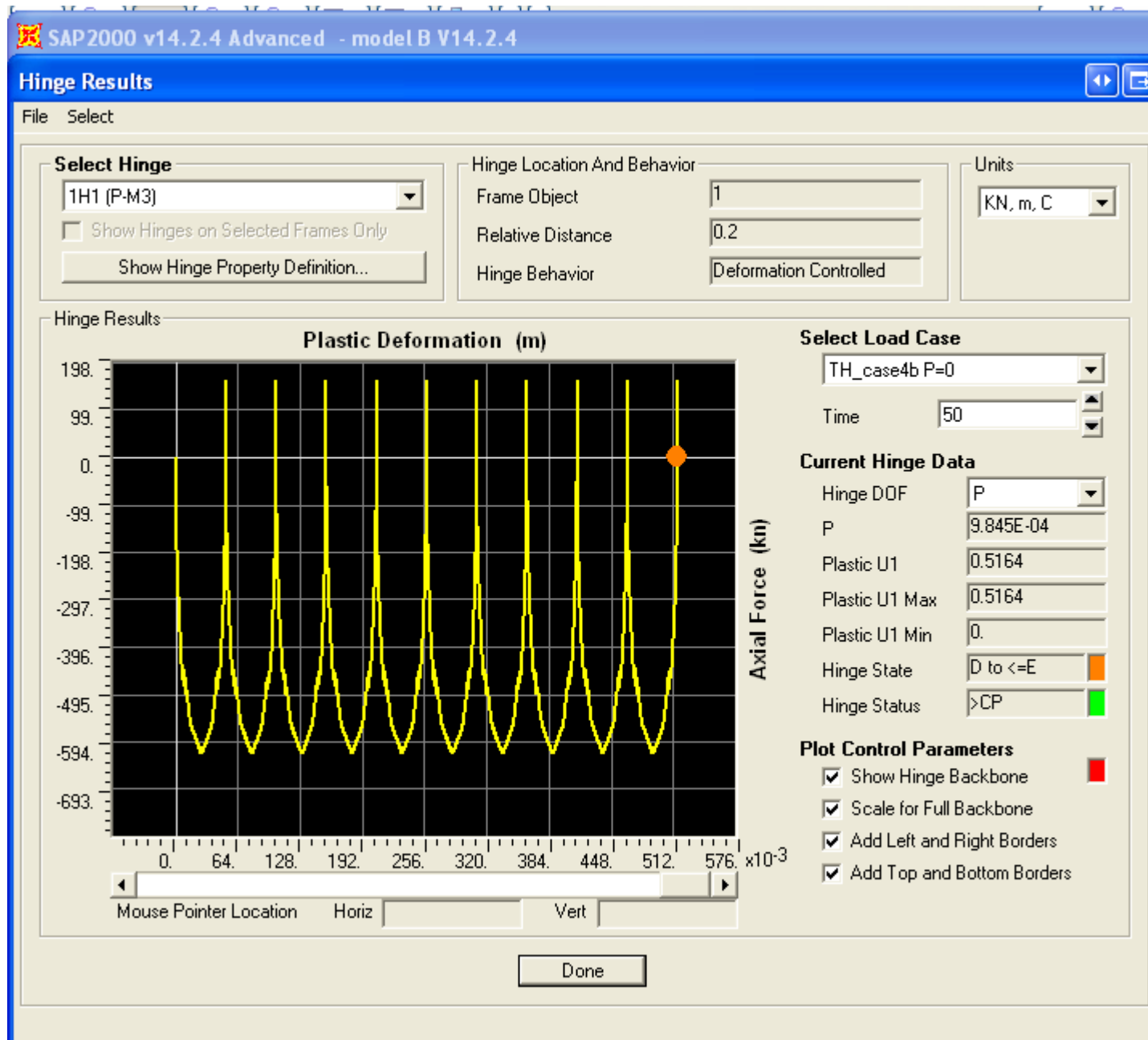


Response for P=-4559kN ... compression
(Note that the hinge response beyond point E is extrapolated.)



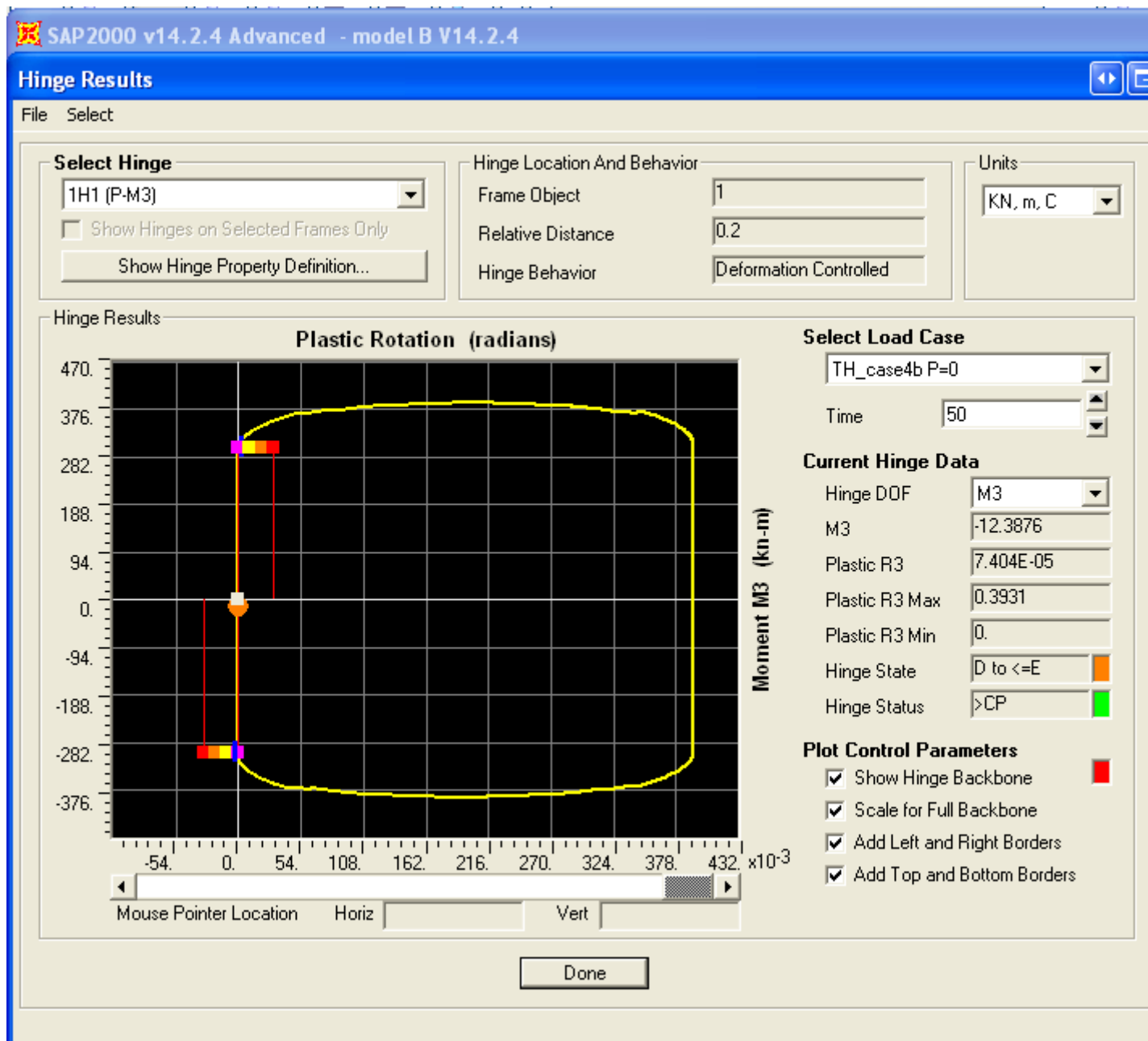
Response for P=0kN

(Note the ratcheting behavior, ie. accumulation of plastic deformation, in axial direction.)

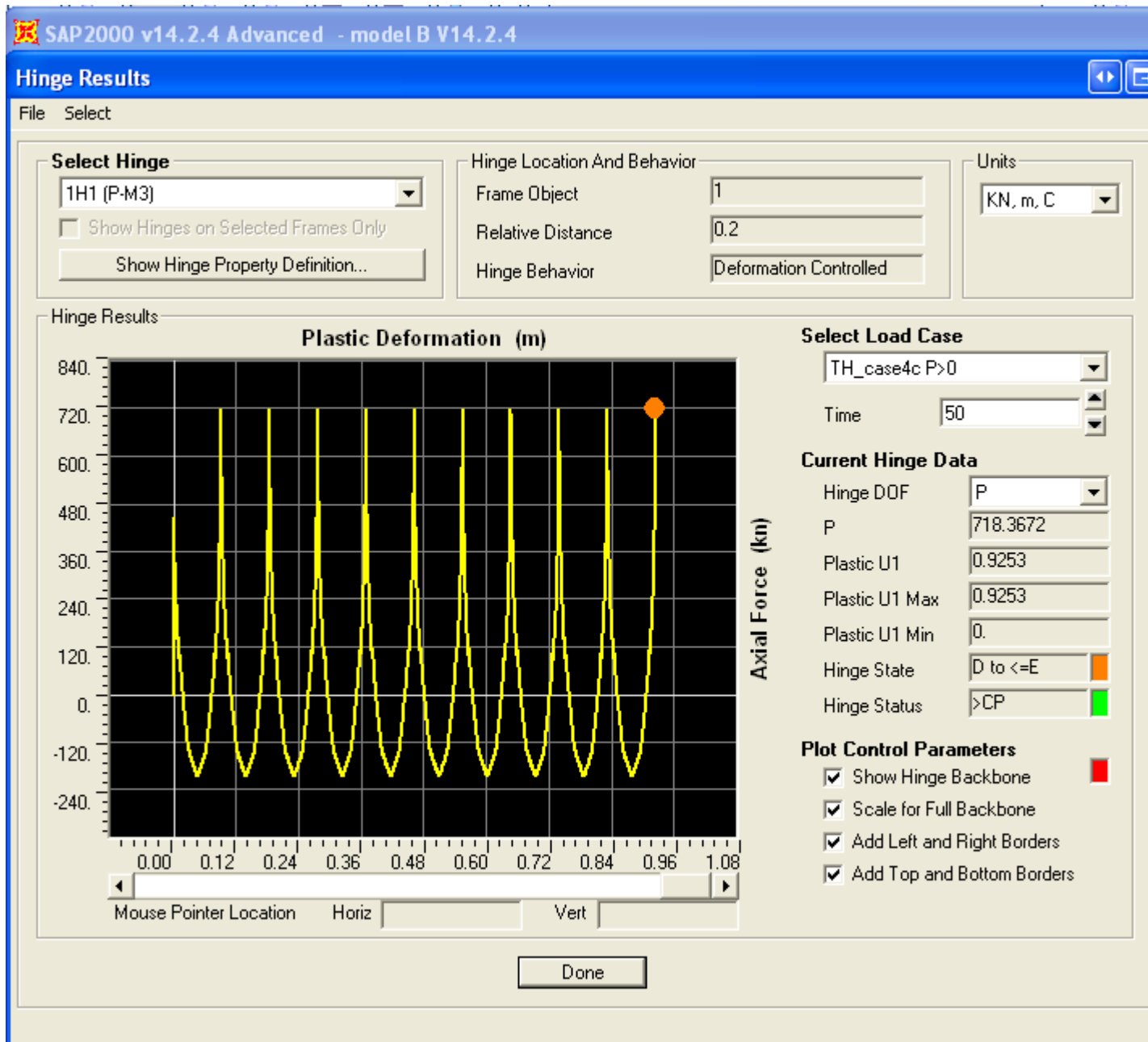


Response for P=0kN

(Note that the hinge response beyond point E is extrapolated.)



Response for P=718kN ... tension
(Note the ratcheting behavior, ie. accumulation of plastic deformation, in axial direction.)



Response for P=718kN ... tension
(Note that the hinge response beyond point E is extrapolated.)

