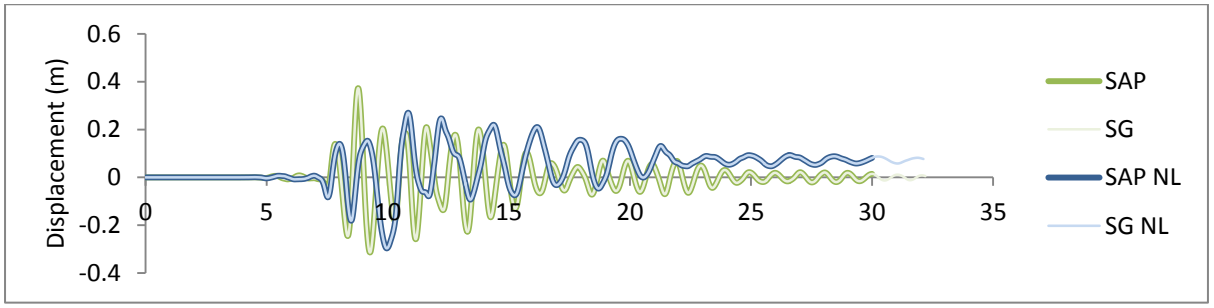
SEISMOGRAPH

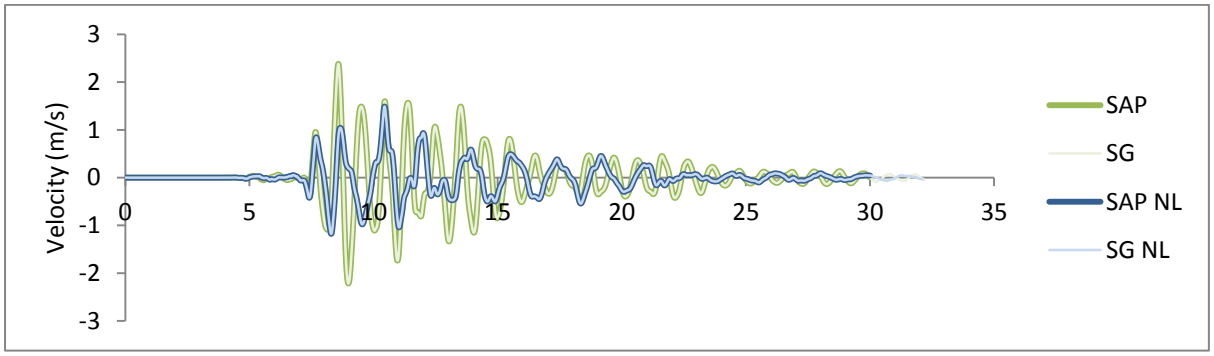
Verification Examples (B3)

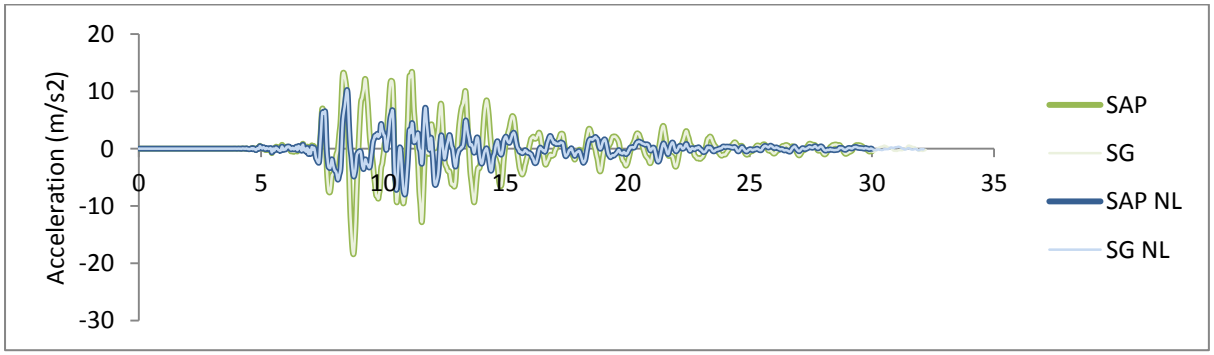
SMDA: SDF Tool

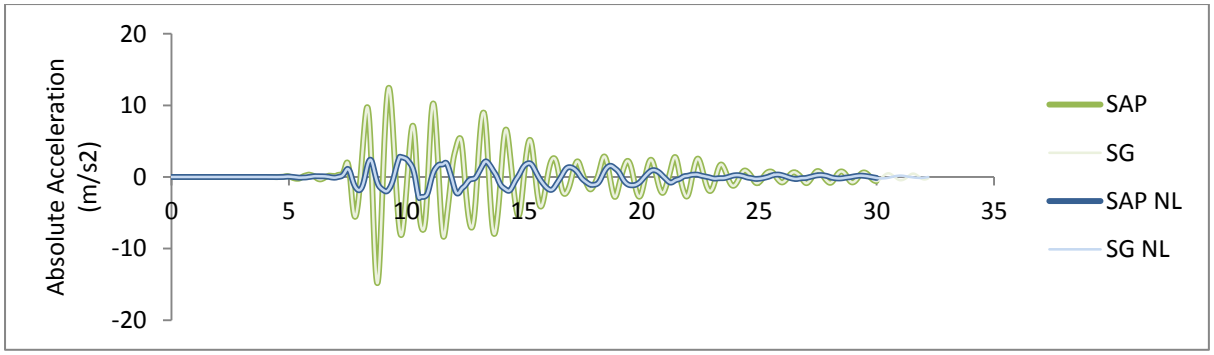
Example 1 – Seismic Excitation

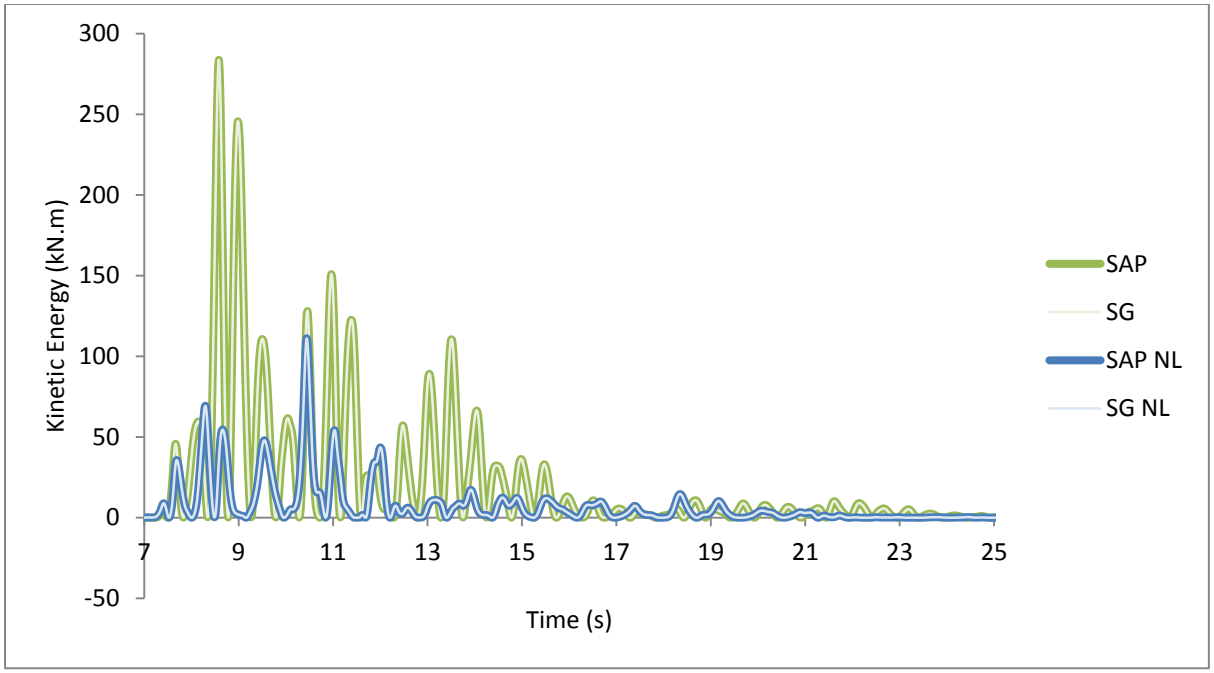
A comparison between the SAP2000 results and SG results.

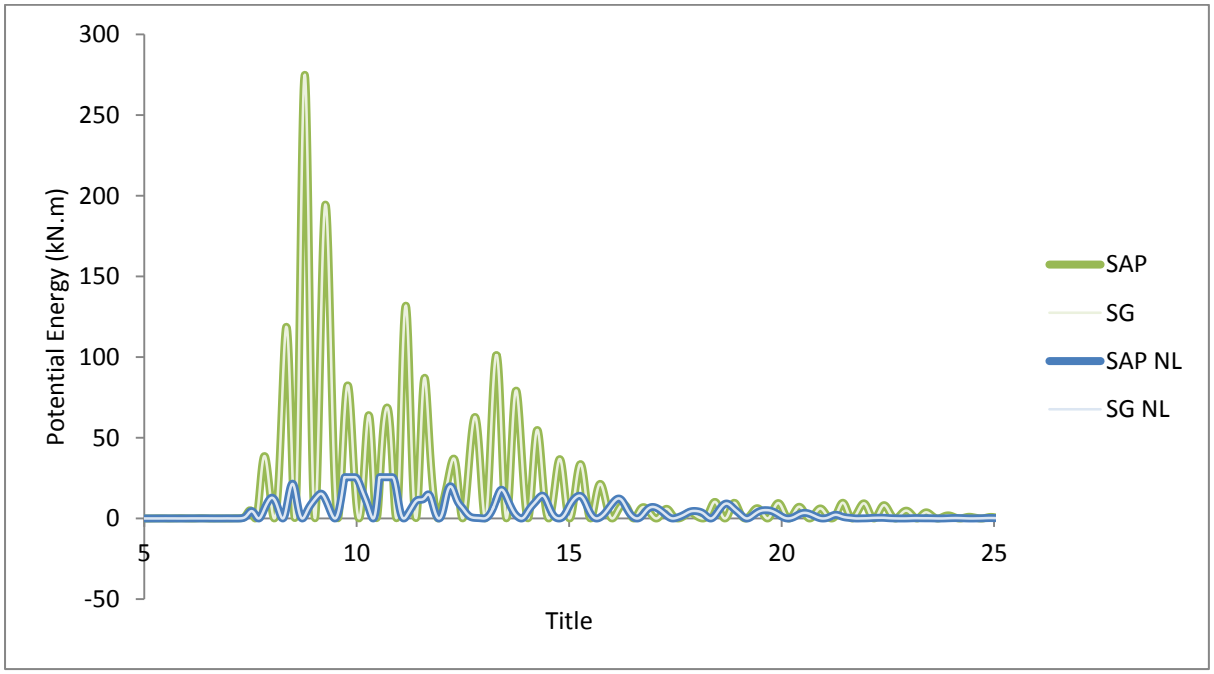


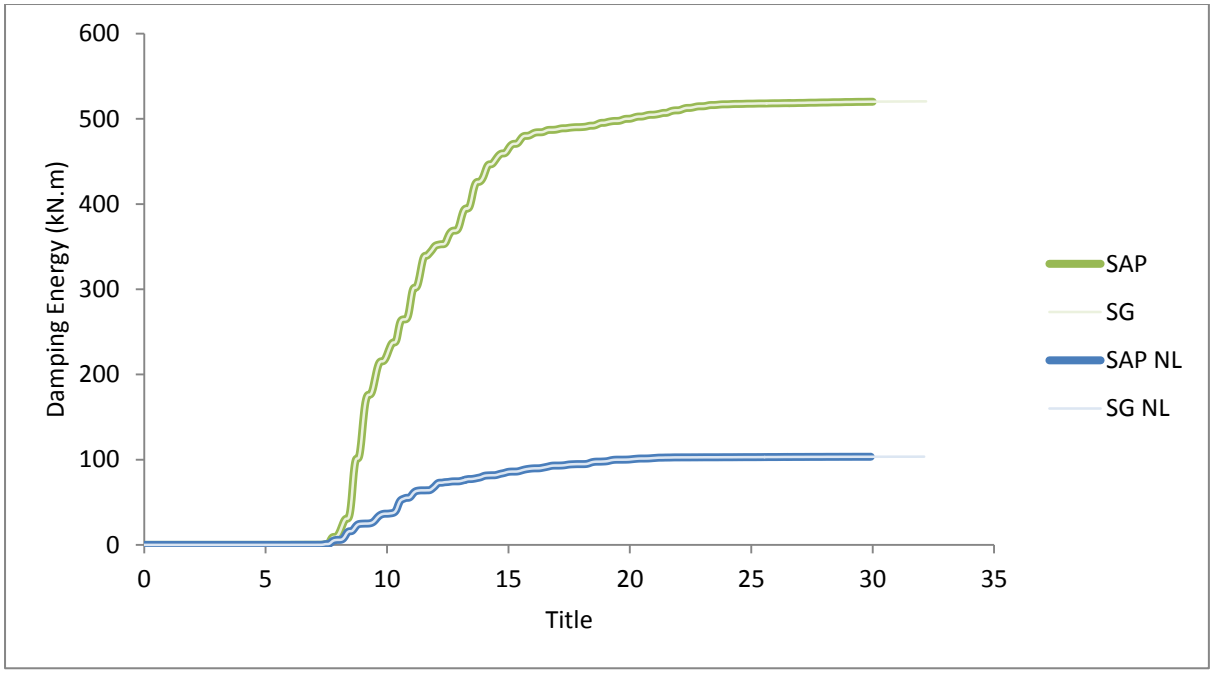


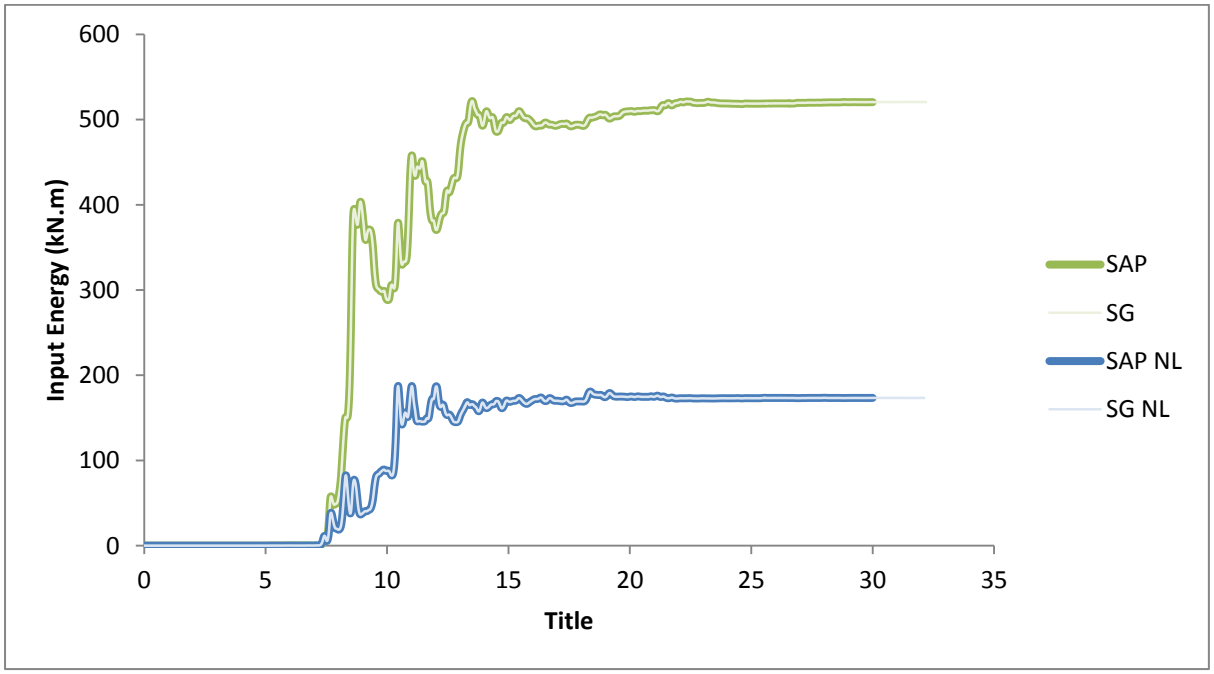


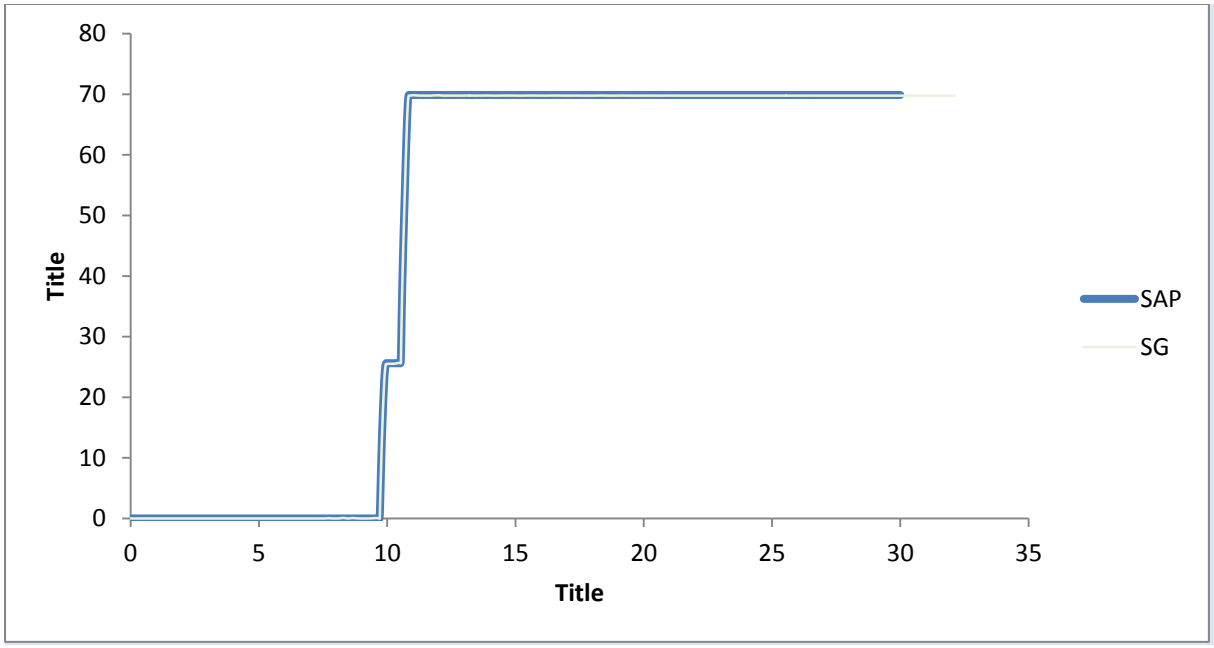


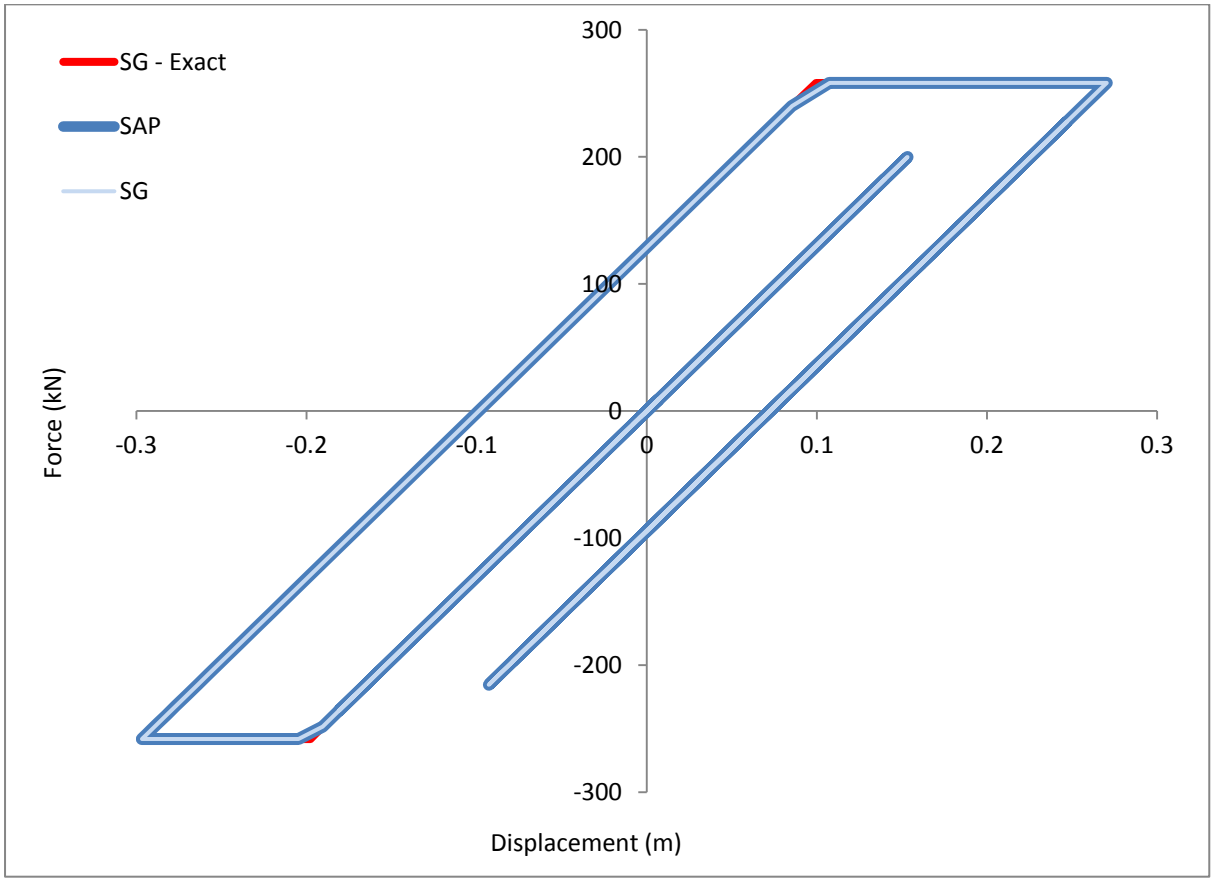

Kinetic Energy (kN.m)
300
250
200
150
100
50
0
-50
7
9
11
13
15
17
19
21
23
25
Time (s)
SAP
SG
SAP NL
SG NL


Potential Energy (kN.m)
300
250
200
150
100
50
0
-50
5
10
15
20
25
Title
SAP
SG
SAP NL
SG NL


Damping Energy (kN.m)
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
Title
SAP
SG
SAP NL
SG NL

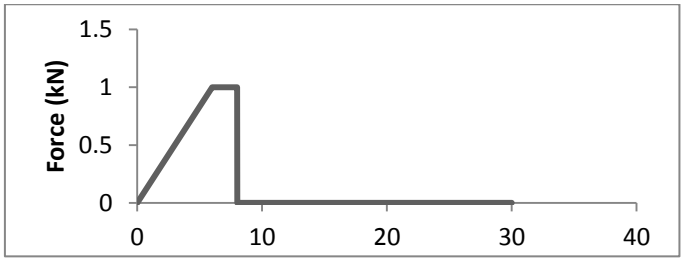

Input Energy (kN.m)
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
Title
SAP
SG
SAP NL
SG NL

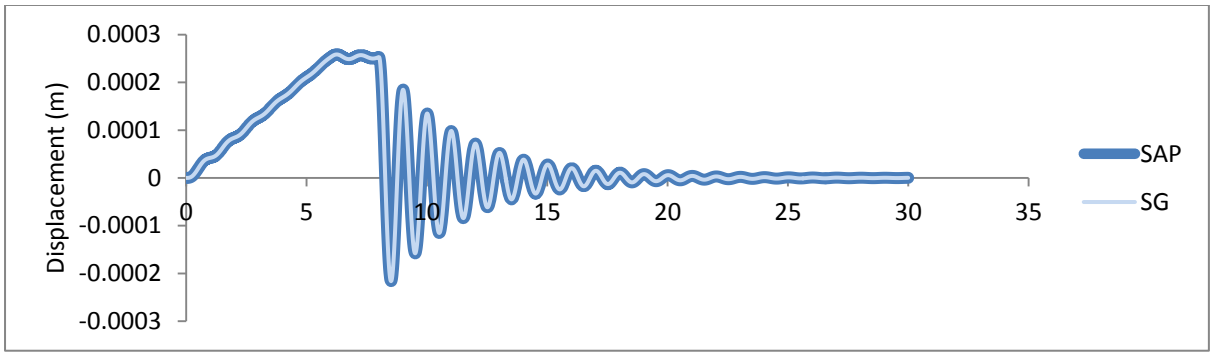

80
70
60
50
40
30
20
10
0
Title
0
5
10
15
20
25
30
35
Title
SAP
SG

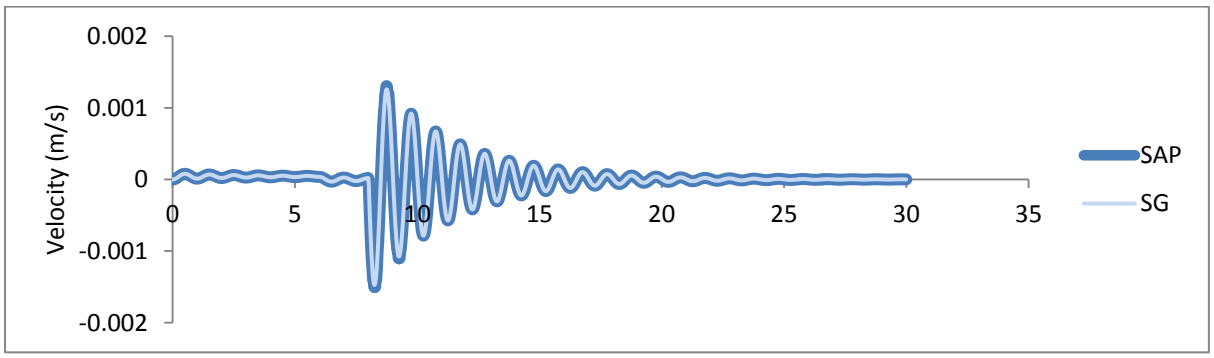

SG - Exact
SAP
SG
300
200
100
0
-100
-200
-300
Force (kN)
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
Displacement (m)

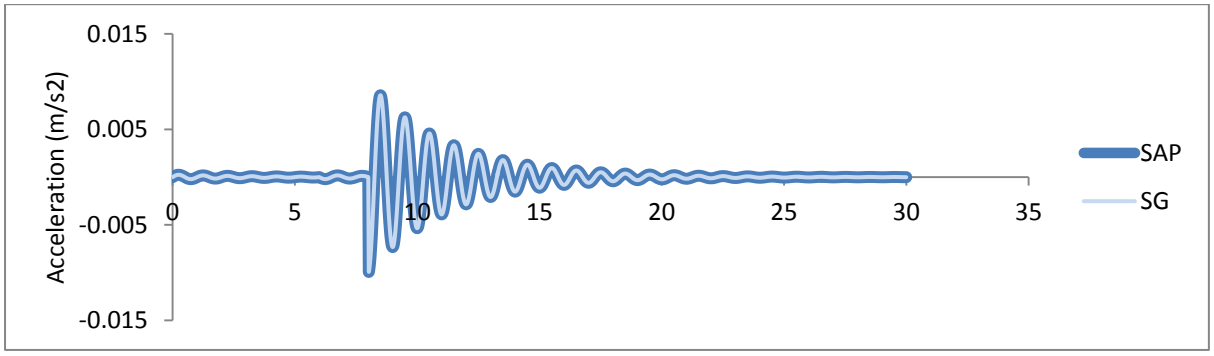
Example 2 – Direct Force (Linear Analysis)

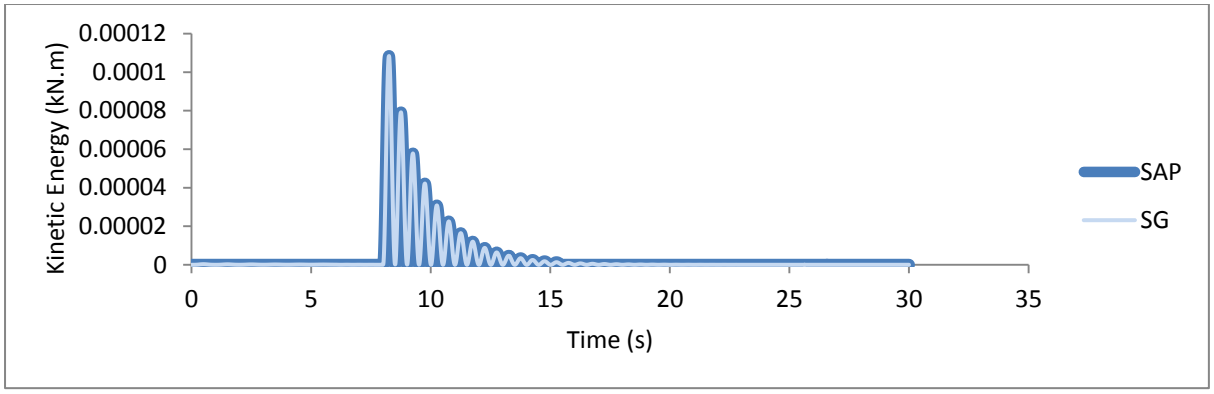
A comparison between the SAP2000 results and SG results.

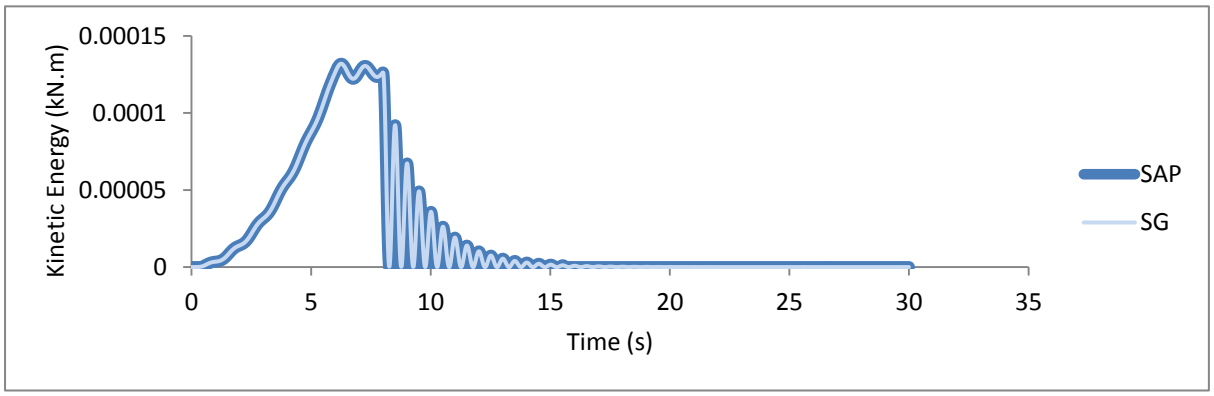


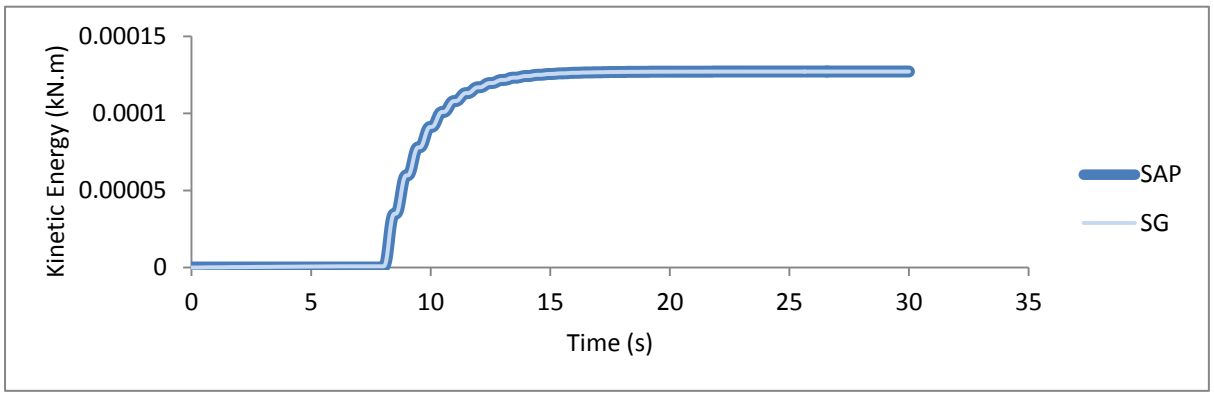


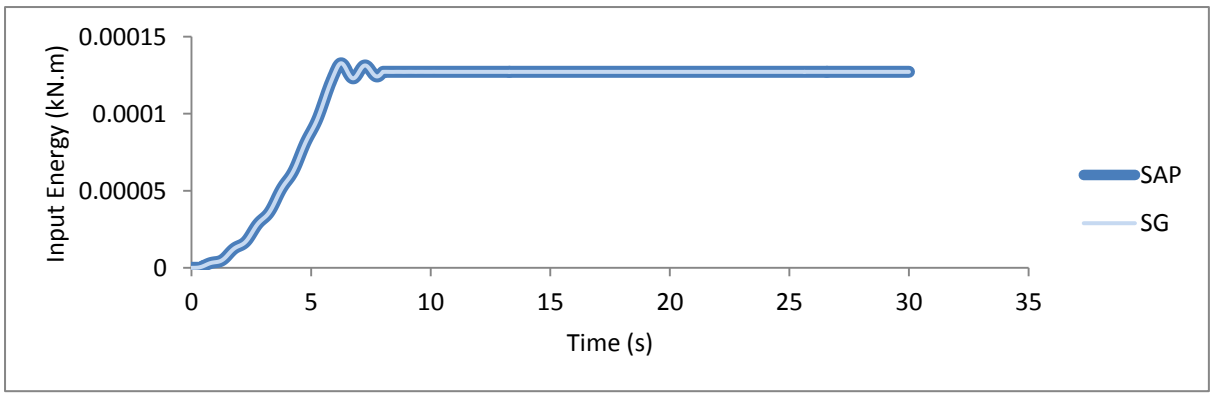





Kinetic Energy (kN.m)
0.00012
0.0001
0.00008
0.00006
0.00004
0.00002
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

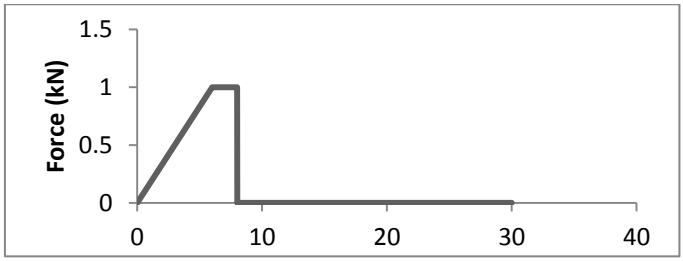

Kinetic Energy (kN.m)
0.00015
0.0001
0.00005
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

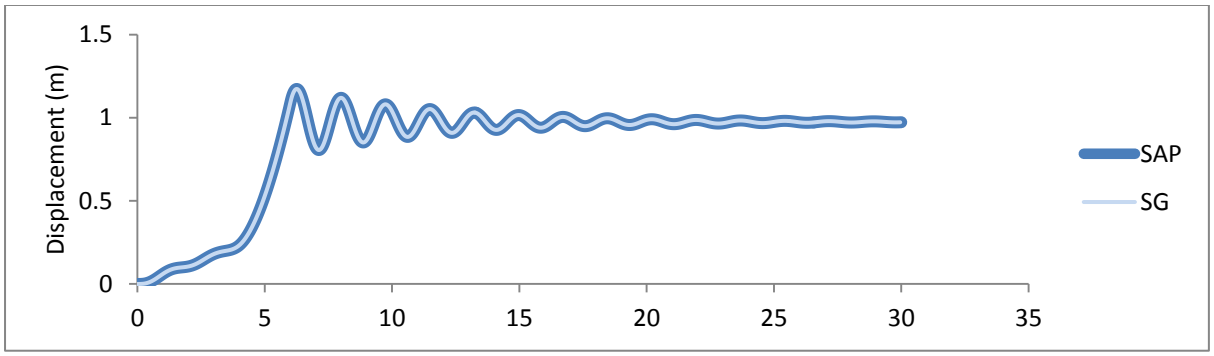

Kinetic Energy (kN.m)
0.00015
0.0001
0.00005
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

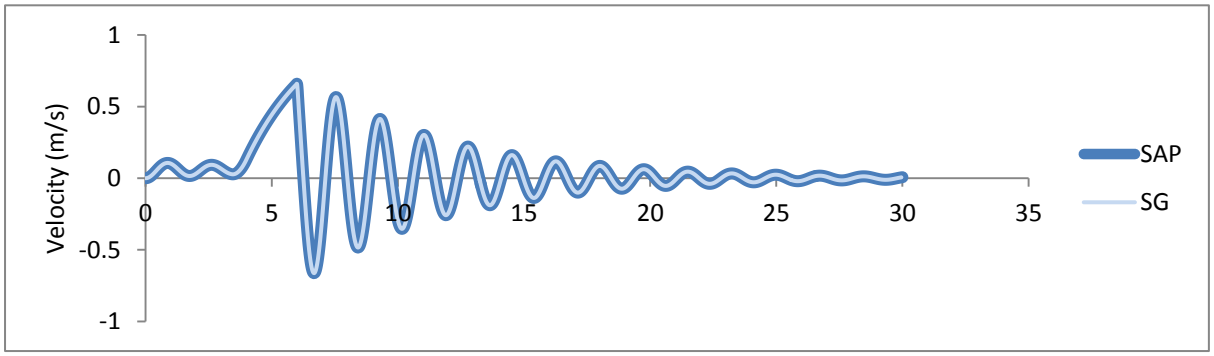

Input Energy (kN.m)
0.00015
0.0001
0.00005
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

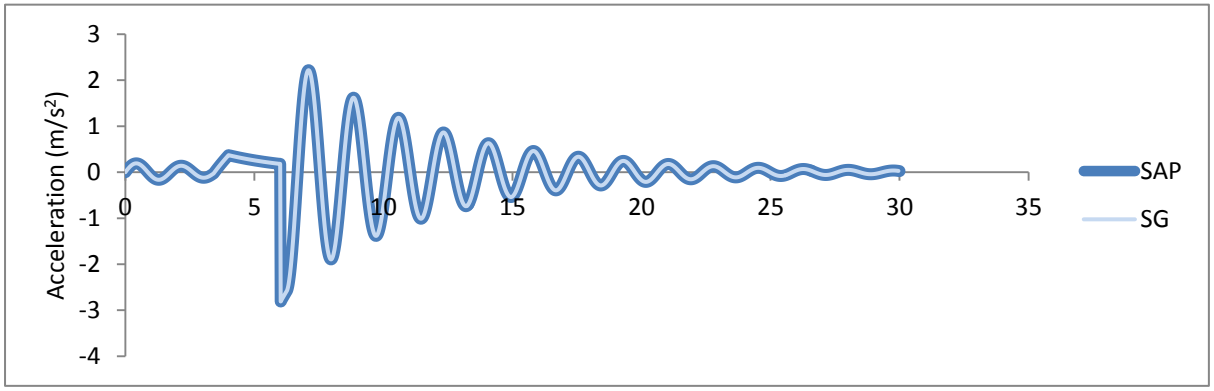
Example 3 – Direct Force (Nonlinear Analysis)

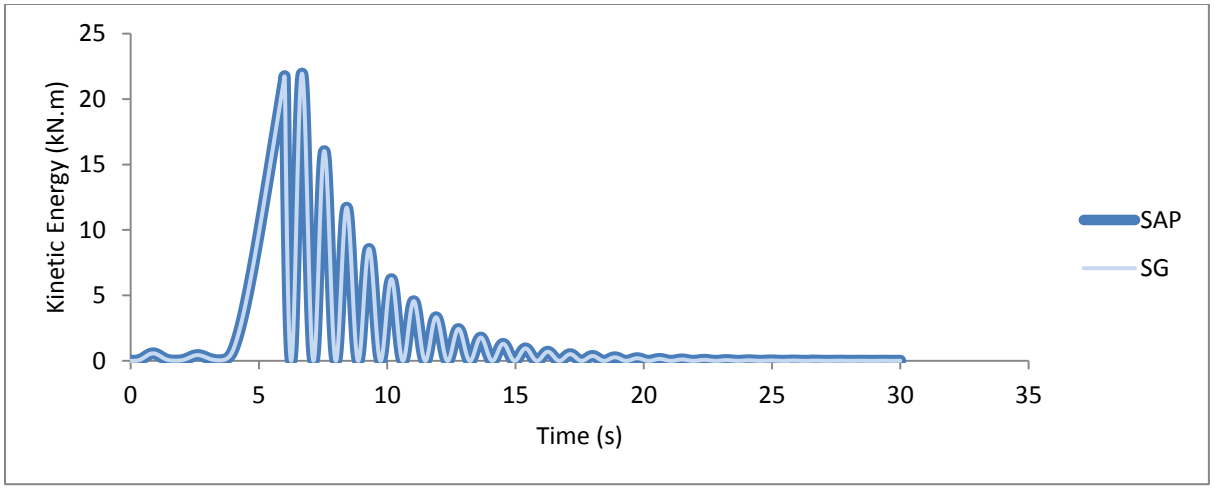
A comparison between the SAP2000 results and SG results.

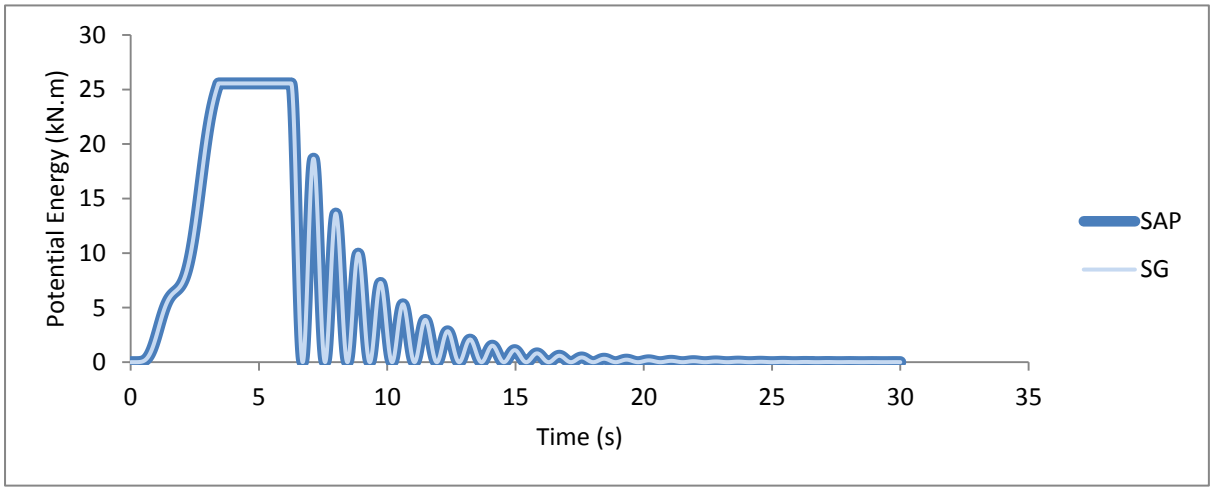


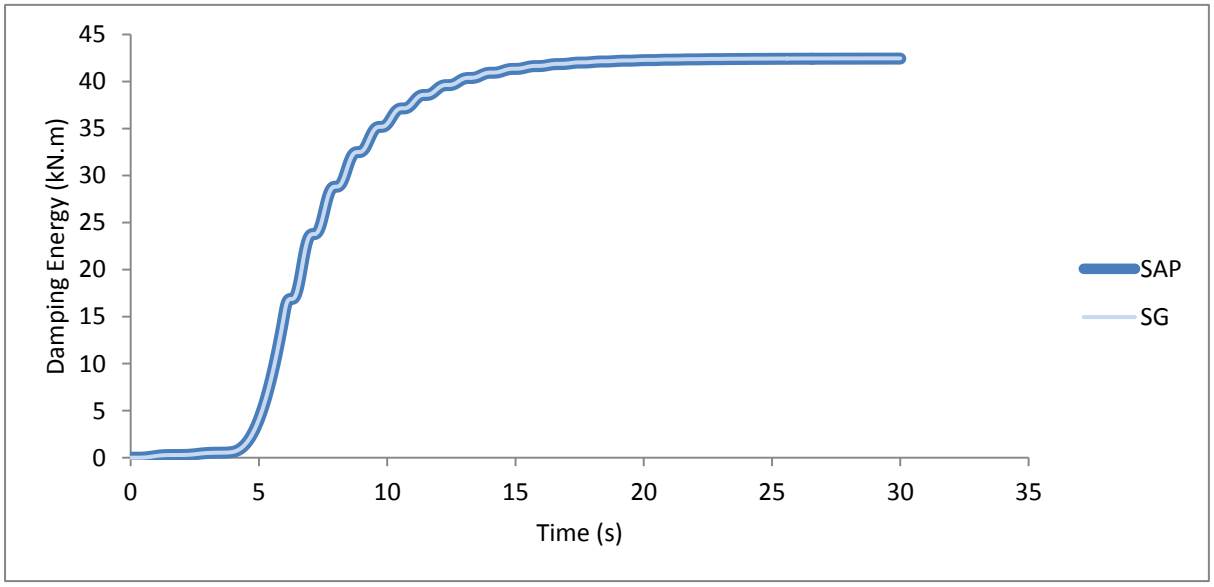


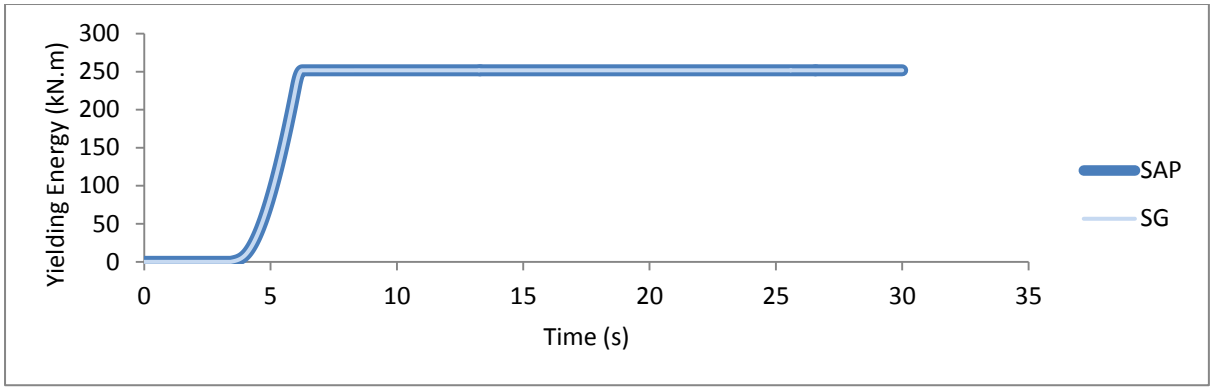


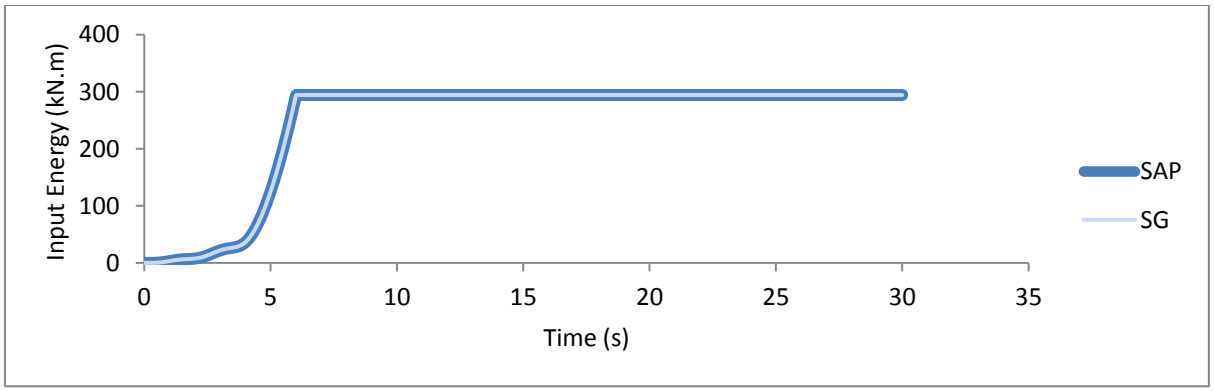



Kinetic Energy (kN.m)
25
20
15
10
5
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

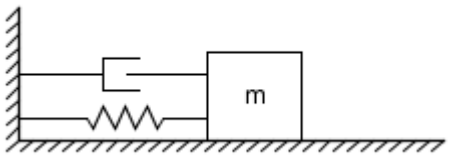

Potential Energy (kN.m)
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG


Damping Energy (kN.m)
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG


Yielding Energy (kN.m)
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

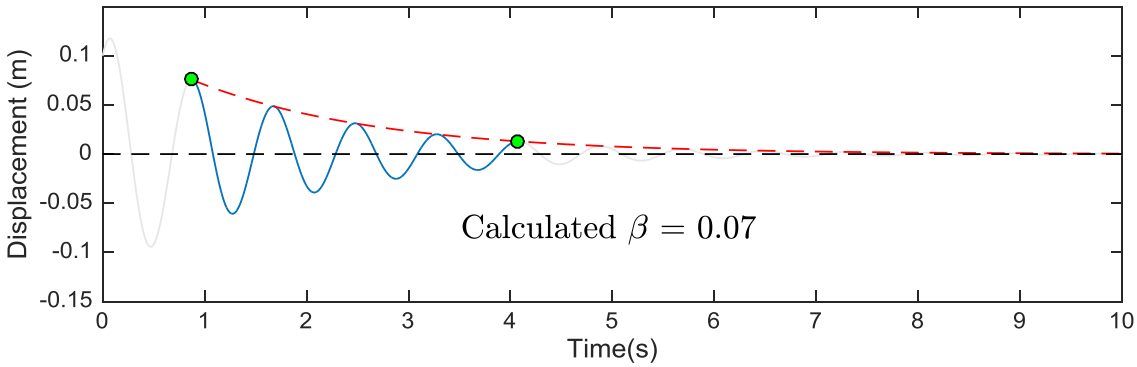

Input Energy (kN.m)
400
300
200
100
0
0
5
10
15
20
25
30
35
Time (s)
SAP
SG

Example 4 – Damping Tool



System Properties		
m	1	Ton
k	61.685	kN/m
c	1.0996	kN.s/m
Beta	0.07	
T	0.8	s

4.1. Free Vibration



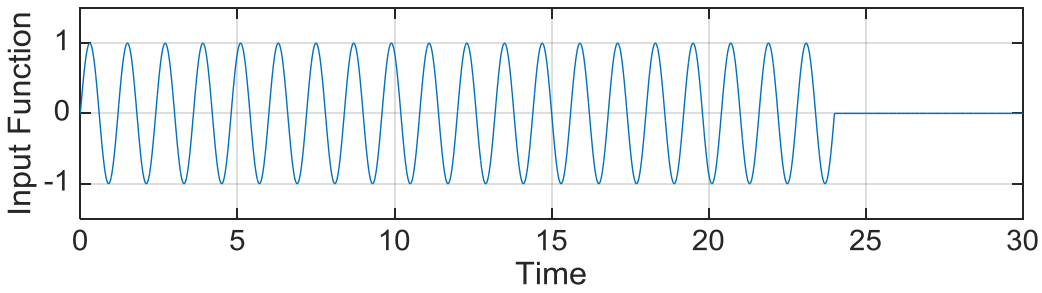
Initial Conditions	
U0	0.1 m
V0	0.5 m/s

$$\begin{cases} j = 4 \\ u_i = 0.0757\, m \\ u_{i+j} = 0.0130\ m \\ \omega_n = 7.854\ Rad/s \\ m = 1\ ton \end{cases}$$

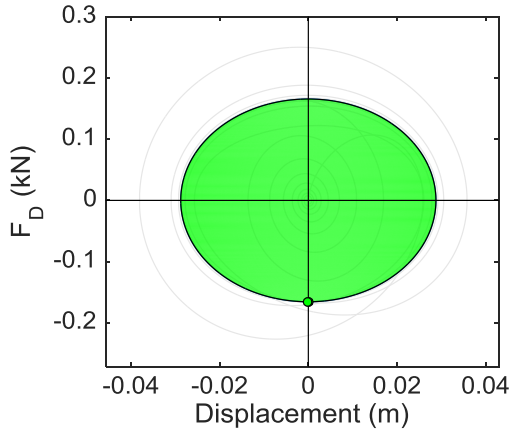
$$\beta = \frac{1}{2\pi \times 4} \ln\left(\frac{0.0757}{0.0130}\right) = 0.0701$$

$$C = 2 \times 1 \times 7.854 \times 0.0701 = 1.1011\ kN.s/m$$

4.2. Forced Vibration



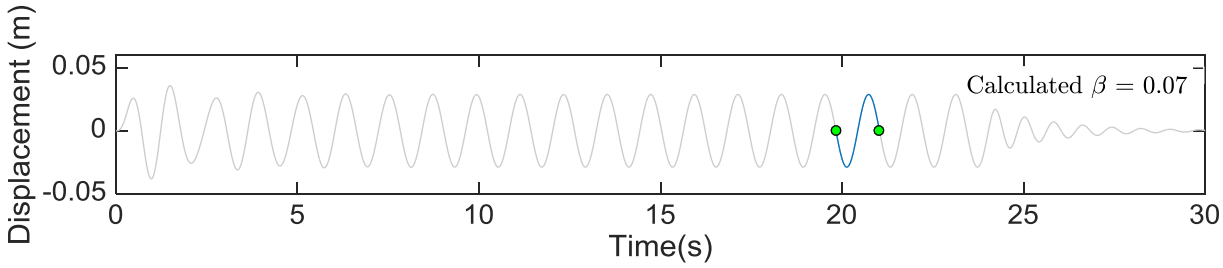
Input Force (T = 1.2 s)



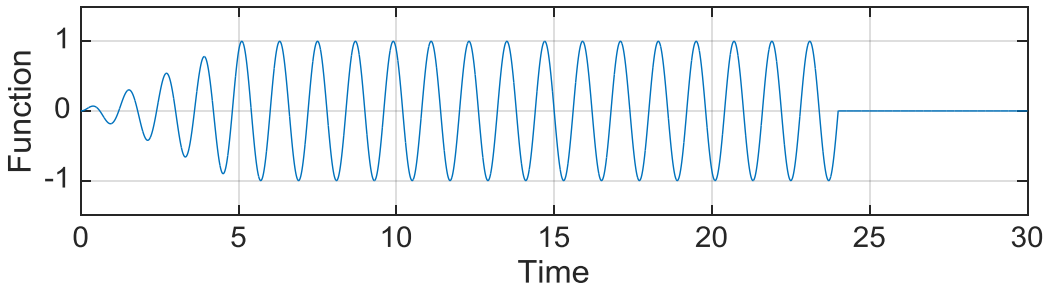
$$\begin{cases} E_D = 0.014978\ kN.m \\ u_0 = 0.02878\ m \\ \omega_n = 7.854\ Rad/s \\ \omega = 5.236\ Rad/s \\ m = 1\ ton \end{cases}$$

$$\beta = \frac{0.014978}{2\pi \times 1 \times 5.236 \times 7.854 \times 0.02878^2} = 0.07$$

$$C = 2 \times 1 \times 7.854 \times 0.07 = 1.0996\ kN.s/m$$



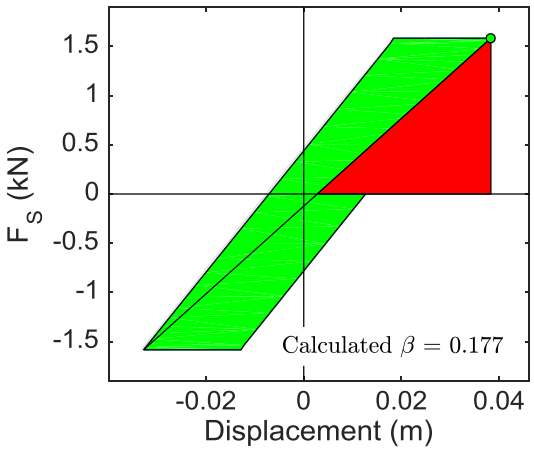
4.3. Equivalent Viscous Damping



Input Force (T = 0.8 s)

$\mu = 1.5$

$$\begin{cases} k_{eff} = 44.55\ kN/m \\ u_0 = 0.0356\ m \\ F_y = 1.5839\,kN/m \\ u_y = 0.01561\ m \end{cases}$$



$$E_{S0} = \frac{1}{2} \times 44.55 \times 0.0356^2 = 0.0282\,kN.m$$

$$E_D = 2 \times 1.5839 \times (0.0356 - 0.01561) = 0.0633\,kN.m$$

$$\beta = \frac{0.0633}{4\pi \times 0.0282} = 0.178$$

SEISMOGRAPH

earthquake engineering software