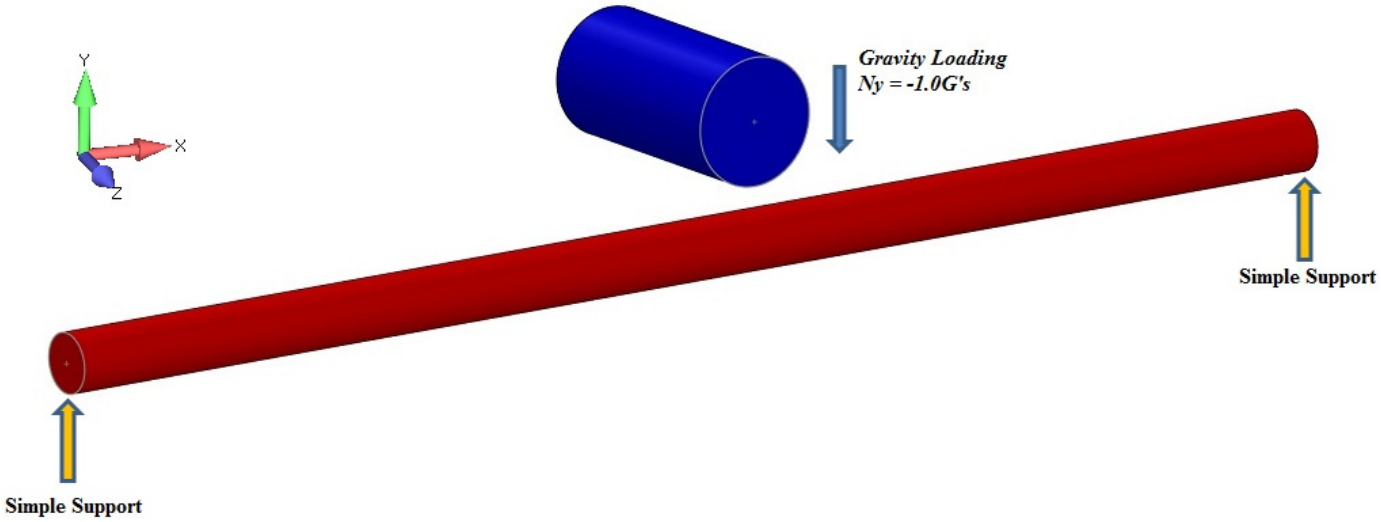
Transient Dynamic Impact Solutions – Episode II: Dropped Mass Impacting Beam Mid-Span

Run Notes & Keystroke Summary:
Transient Dynamic Impact Solutions – Episode III: Mass Striking Beam

23 September 2015



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1.0 Introduction

The input data files for the FEA model outlined in this document may be downloaded by contacting ***Applied Analysis & Technology*** at AppliedAT@aol.com.

The input data files and keystroke summaries are for use with **FeMap v11.1.2** and ***Patran 2014r1*** or later. User notes for ***Patran*** are contained in ***Appendix A***. ***Patran*** users may download "***Impact-SSBeam_v2014.db***".

2.0 Getting Started

"***Impact-SSBeam_v11.2.modfem***" contains the complete solution files for nonlinear transient response due to a concentrated mass, dropped from a known height, impacting the mid-span of a simply supported beam.

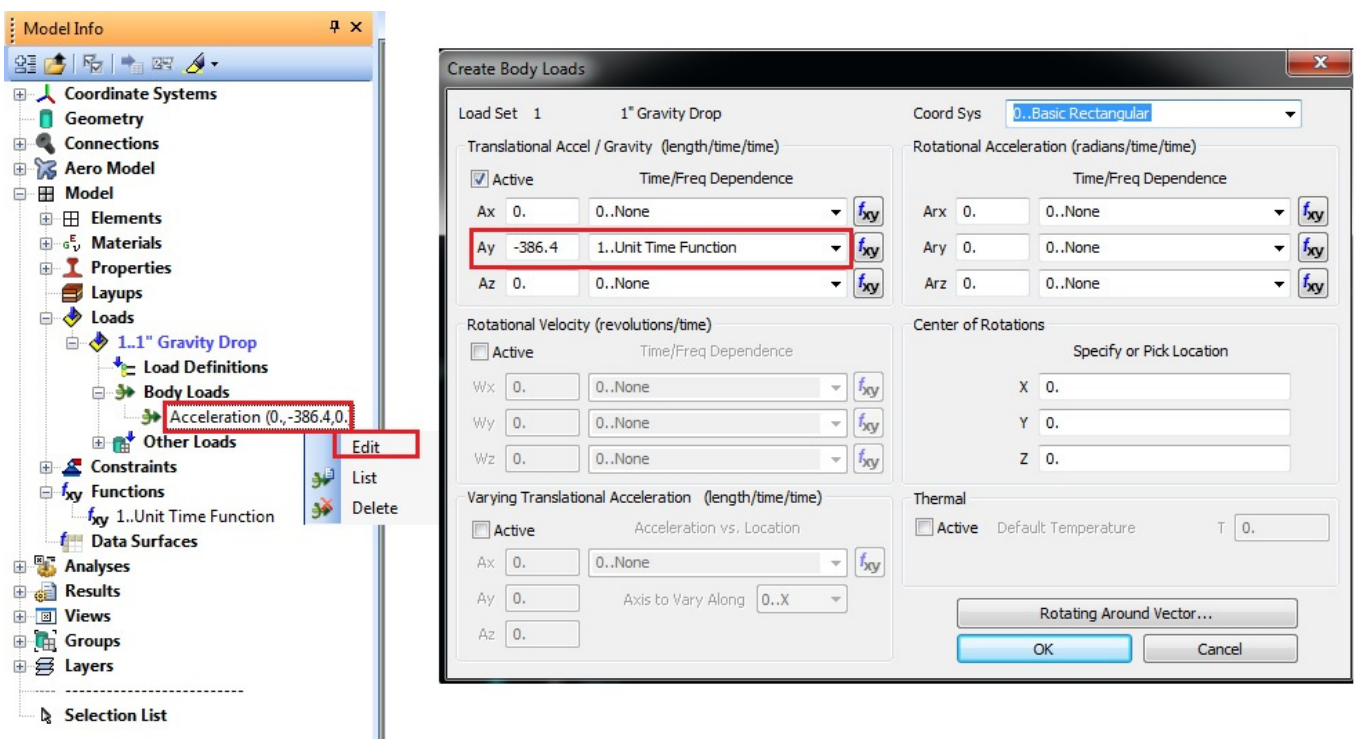
After first starting the program at the top menu bar: **File–Open** and locate the file "***Impact-SSBeam_v11.2.modfem***". Listed below are keystroke operations to lead one through this sample problem. One can either simply review the stored solution data and summary view screens or try re-processing some cases. The keystroke summaries are condensed operations to speed one through the sample problem.

Reviewing Input Parameters & Correct Units for Transient Dynamic Solution

- To check the bar material select **Modify–Edit–Material** **OK**. In the dialog boxes are data for "**Generic Steel**", note $E = 30 \times 10^6$ ***lbs/in***^{2}, **ν = 0.3** and **ρ = 0.0007324 lbs-sec**^{2}**/in**^{4}. Select **Cancel** or **ESC** to exit.

- To check the bar section select **Modify–Edit–Property-Select All** **OK**. In the dialog boxes are data for "**Circular Beam 1/2" Dia**", note ***Izz=Iyy =0. 0.00306796 in***^{4}. Data for "**5 lb Weight**", note ***Mx =0. 0.01294 lb-sec***^{2}***/in*** (5 lbs weight). Data for the "**Gap Element**", ***Initial Gap = 1 inch***, ***Compression Stiffness = 1x10***^{6} ***lb/in***, ***Tension Stiffness = 1x10***$^{-4}$ ***lb/in***. Select **Cancel** or **ESC** to exit.

- To check the gravitational loading from the **Model Info** tree, Load Set **1.. 1" Gravity Drop**, right click on **Acceleration (0.,-386.4,0.)**, right click on **Edit** note a value of ***Ay = -386.4 in/sec***^{2} with **Time/Freq Dependence** = ***1..Unit Time Function*** included. Select **Cancel** or **ESC** to exit. The **1.. Unit Time Function** can be checked in a similar manor.



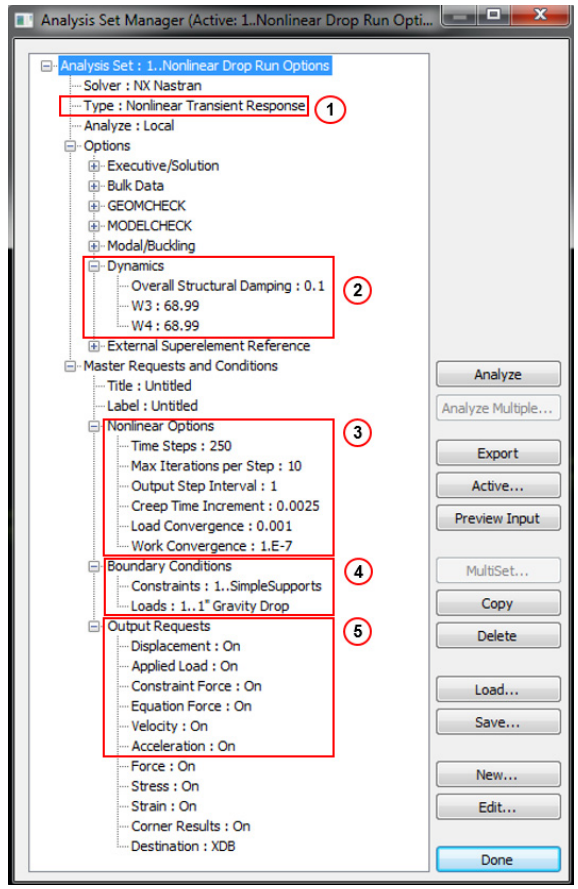
Processing and Viewing Transient Solution

Step 1: *Run Transient Thermal Solution.*

From the top menu bar: **Model – Load – Set** Select **1.. Nonlinear Drop Run Options**. Everything has been preprogrammed for the ***Nonlinear Transient Response***. Press **OK** to **ESC** and exit.

From the top menu bar select **Model – Analysis** and review the following key entries:

- Analysis Set: **1.. Nonlinear Drop Run Options**
  - ✓ Type: **Nonlinear Transient Response**
- Dynamics
  - ✓ Overall Structural Damping **0.1** ($\zeta = 2*c/c_o$)
  - ✓ Solution Frequencies **W3, W4 = 68.99 Hz** (Beam Only)
  - ✓ Number of Steps : **250**
  - ✓ Output Step Interval : **1**
  - ✓ Creep Time Interval : **0.0025**
  - ✓ Load Convergence : **0.001**
  - ✓ Work Convergence : **1.0E-7**
- Boundary Conditions
  - ✓ Constraints: **1.. Simple Supports**
  - ✓ Loads: **1.. Gravity Drop**
- Output Results
  - ✓ Displacement: **On**
  - ✓ Velocity: **On**
  - ✓ Acceleration: **On**
  - ✓ Constrain Force : **On**



Refer to the **Analysis Set Manager** shown at right. After verifying the entries in the dialog box show, **Select** Done **.**

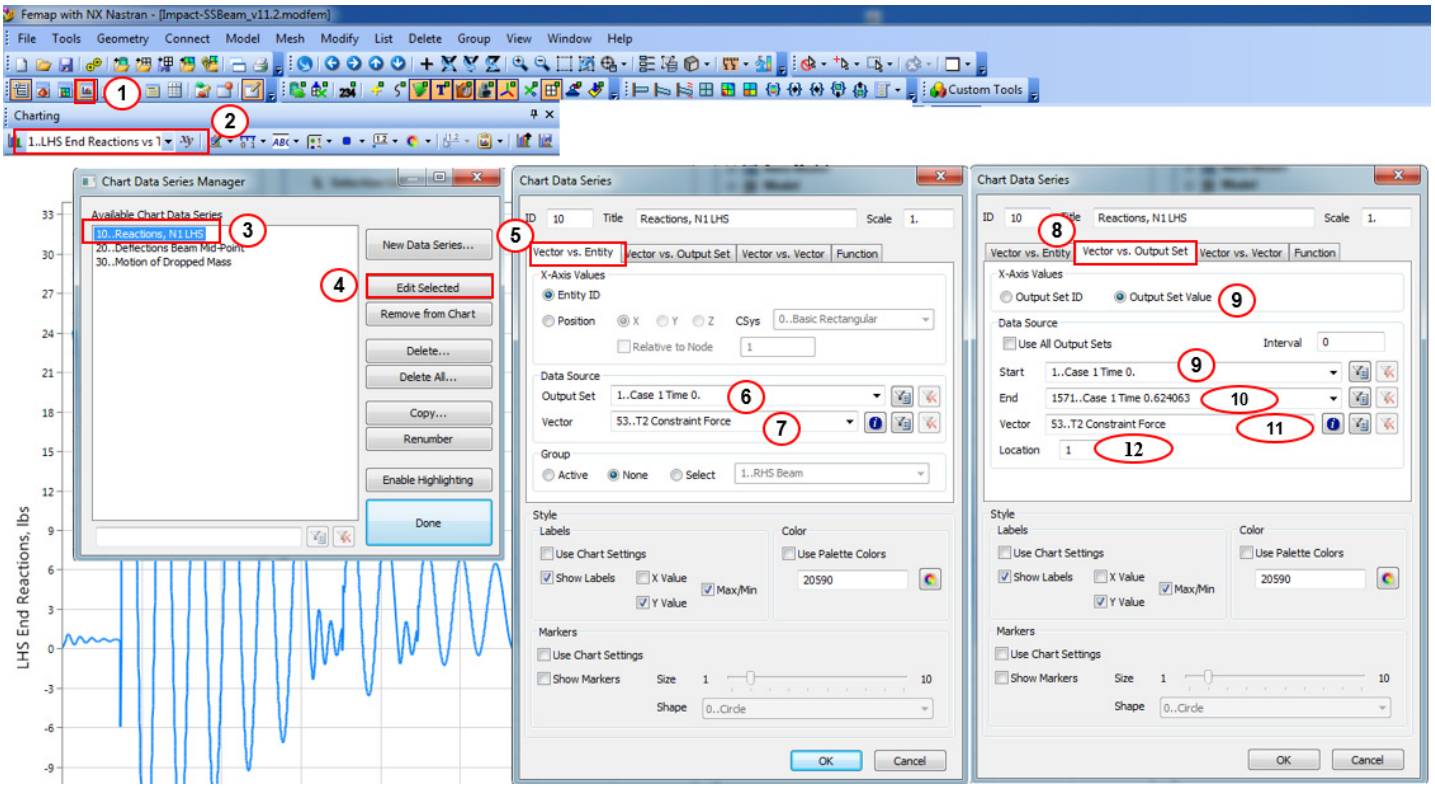
Next Select **File - Analyze**. Processing should begin to run and automatically read in results.

Step 2: *Post Processing Transient Graph of Axial Stress for End Element*

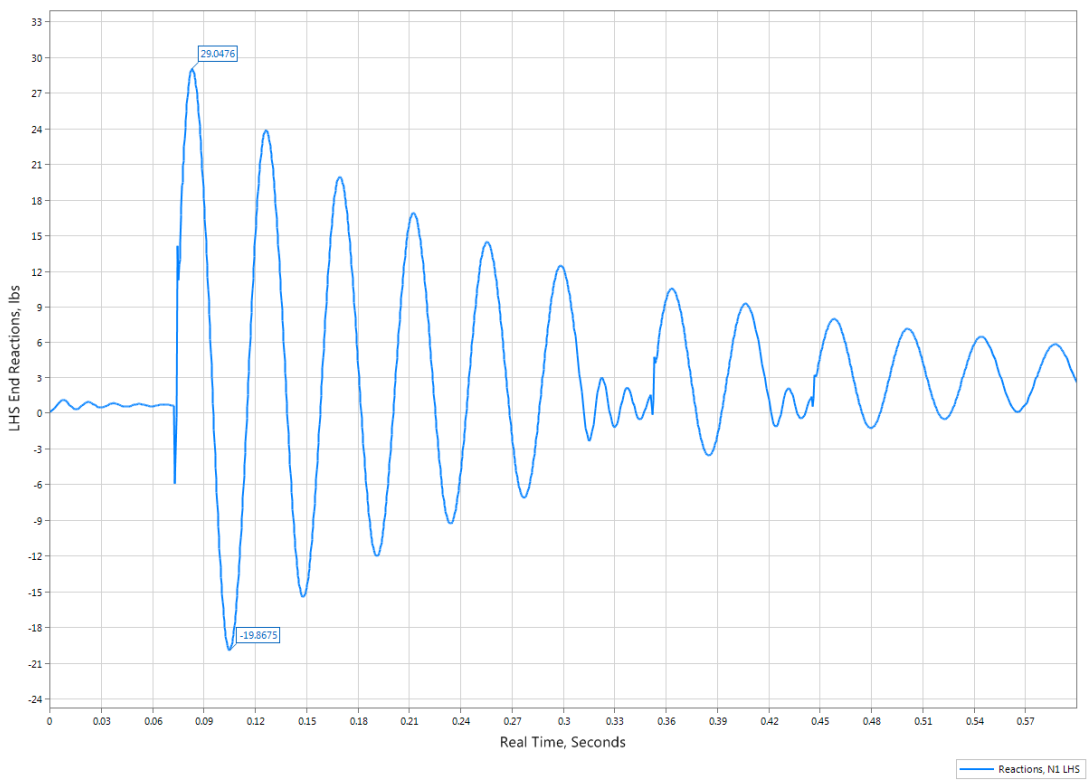
To open a Window for viewing graphical results select **Charting** from the LHS toolbar. I've stored all of the set-up parameters and pre-selected proper scaling for displaying axial stresses versus time in graphics form for the free end of the rod.

1.) Click on ***Chart Icon*** box.
2.) The next dialog box should be "***Select XY Data Series Manager***".
3.) Select "***LHS End Reactions vs Time***"
4.) Select "***Edit Selected***"
5.) Select "***Vector vs Entity***"
6.) For **Output Case**, select "***1..Case 1 Time 0***"
7.) For **Vector**, select "***53.. T2 Constraint Force***"
8.) Select "***Vector vs Output Set***"
9.) Select "***Output Set Value***"
10.) For **Start**, select "***1..Case 1 Time 0***"
11.) For **End**, select, "***1571..Case 1 Time 0.624063***"
12.) For **Location**, select element "***1***" (Node 1, LHS Ty Constrain Location)

A graph of reaction force (constraint force) as a function of time (seconds) Node 1 at the LHS end simple support of the circular beam model idealization should display similar to the one below. Similar graphical results are stored to show displacement at the mid-span of the beam and displacement time history of the dropped mass.



LHS End Reactions vs Time



For any questions you may have regarding this FAX/memorandum, please call at (714) 846-4235, E-Mail at **AppliedAT@aol.com**.

Regards,

David R. Dearth, P.E.

Appendix A

Run Notes for use with Patran

These run notes are highly condensed for use by experienced Patran users.

Patran users might find the following reference commands helpful.

The following files are needed to review results: "***Rod_Impact_v2013.db***","***Rod_Impact-Solution.xdb***".

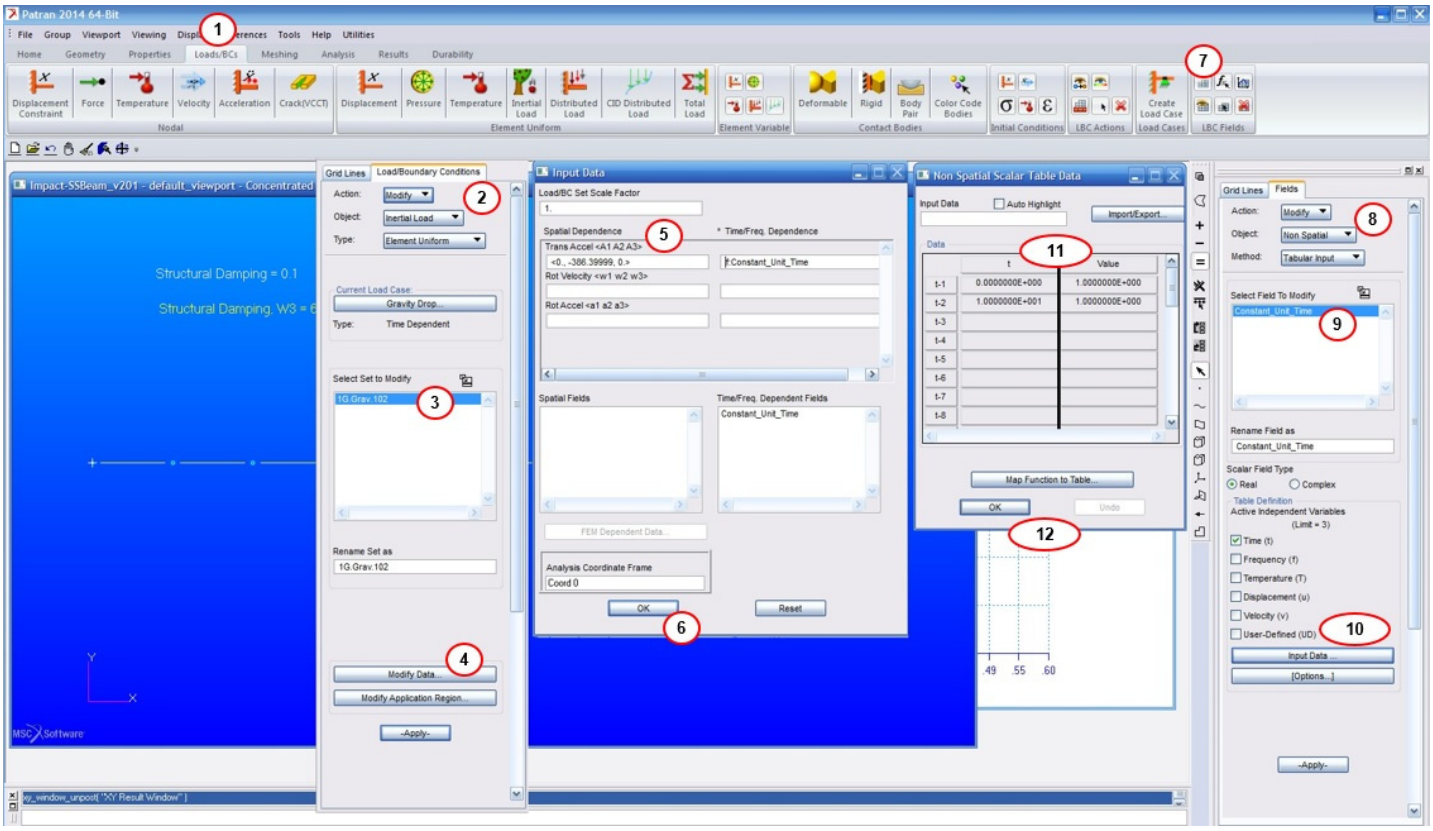
Review Impact Initial Conditions

To review load case options select:

✓ (1.) **Loads/BC**,(2.) **Modify** , **Inertial Load**, **Element Uniform** , (3.) **1G.Gravity** , (4.) **Modify Data**, (5.) ***Trans Accel <0., -386.4, 0.>*** {Ny = -386.4 in/sec^2}, ***Time/Freq Dependence*** "***f:Constant_Unit_Time***" (6.) **OK**

✓ (7.) **Fields** , (8.) **Modify** , **Non Spatial** , **Tabular Input** (9.) "***Constant_Unit_Time***", (10.) **Input Data** , (11.) Constant vs Time, (12.) **OK**

See screen print below.



To inquire on the concentrated mass select **Properties – Modify – 5_lb_Mass – Modify Properties** and note mass properties. **Mass** = 5/386.4 = **0.01294 lb-sec^2/in**.

To inquire on the beam **Properties – Modify – 1D – Beam "0.5in_Dia_Beam" – Modify Properties** and note **Area = 0.19635 in^2 & I1, I2 = 0.003068 in^4**.

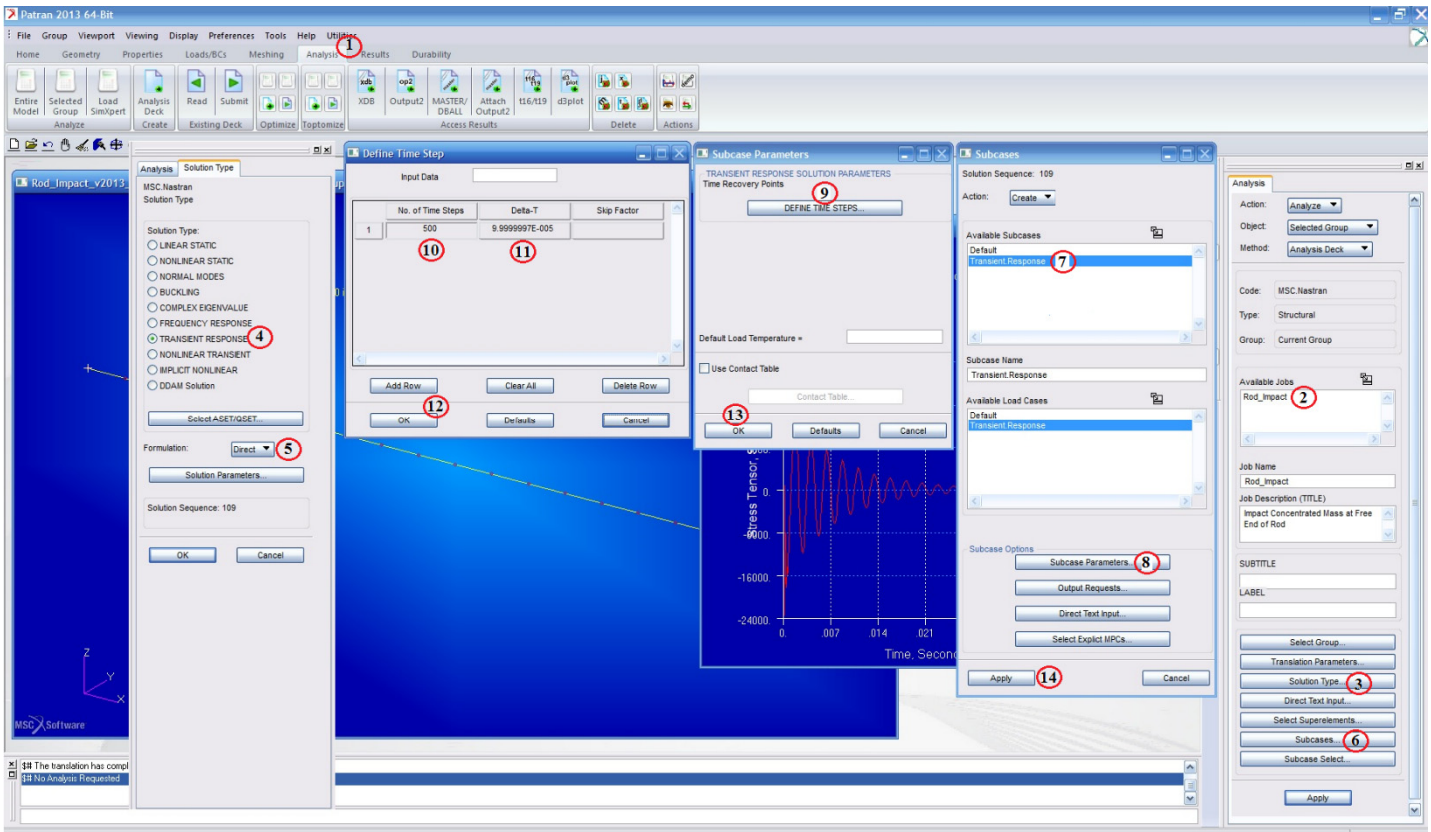
To inquire on the Gap **Properties – Modify – 1D – Gap – Modify Properties** and note **Initial Opening = 1.0 & Closed Stiffness = 1x10^6 lb/in**.

Review Analysis Run Options

To inquire on the analysis run options select:

- ✓ (1.) **Analysis**, (2.) "***FallingWeight***", (3.) **Solution Type**. Note the following:
- ✓ (4.) **Nonlinear Transient** (Solution Sequence 129) , (5.) **Direct**.
- ✓ (6.) **Subcases** , (7.) **Transient Response** , (8.) **Subcase Parameters** , (9.) **Define Time Steps**, Select (10.) No. of Time Steps **500** , (11.) Delta-T **0.0001** , (12.) **OK** , , (13.) **OK** , (14.) **Apply**

See screen print below.



Review Results

To display the time history analysis results:

- ✓ (1.) **Results**, (2.) **Graph** (3.) **Modify** , **Graph** , **Y v X** , (4.) **Existing Graph Plots** , Select **Plot Response** ,
- ✓ (5.) Select Result Cases, **… Time = 0.0 to … Time = 0.6248875**, (6.) **Constraint Forces, Translational** , (7.) **Y Component**
- ✓ (8.) Target Entity, **Nodes** , Select Node **Node 1**
- ✓ (9.) Display Attributes, (10.) X Axis Label **Real Times, Seconds** , (11.) Y Axis Label **Constraint Forces, Ty** , (12.) **Apply**

See screen print below.