

VPG/PrePost Tutorial

Drop Test Module

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VPG/PrePost Tutorial

This tutorial was created to familiarize eta/VPG users with the functions and techniques associated with the use of the automated drop test model preparation and the associated features within the VPG user environment. This tutorial will demonstrate the steps required to properly prepare a model for drop test simulation using VPG.

Background Information: Graphic User Interface

The graphic user interface consists of 6 areas within a single window: Main Menu, Drawing Window, View Options, Dialog Window and Display Options and the Top Menu Area.

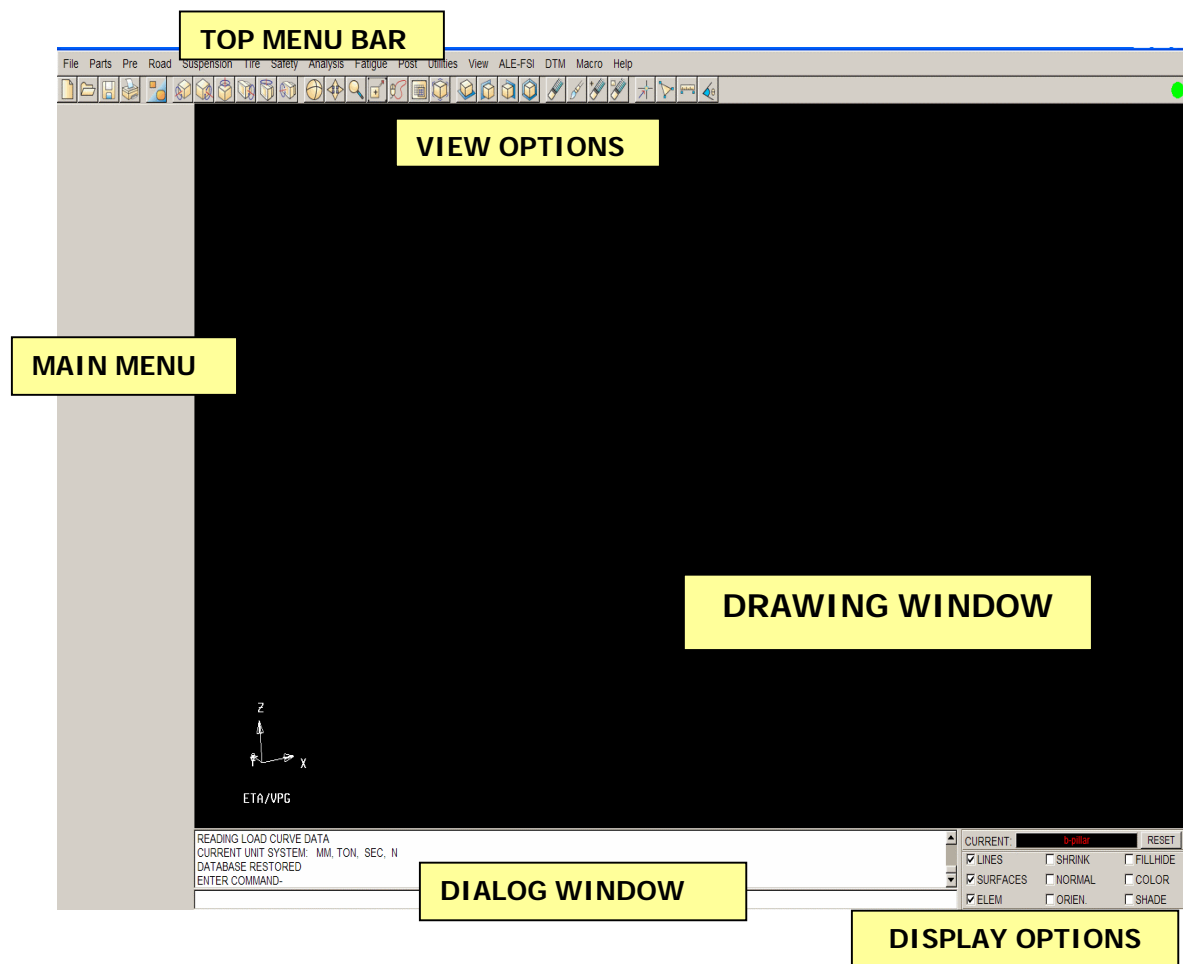


Figure 1: VPG User Interface

1. **MAIN MENU:** The Main menu options are displayed in this area after selections from the TOP MENU BAR
2. **DRAWING WINDOW**

Display graphic entities (CAD- points, lines, surfaces; FEA- nodes, elements).

3. VIEW OPTIONS

Part control, model positioning, program setup and utilities.

4. DIALOG AREA

Interface command prompt and scrollable command history.

5. DISPLAY OPTIONS

Toggle ON/OFF graphic entities to be displayed and controls display mode.

6. TOP MENU BAR

This menu lists all of the main menus as well as Utility menus and Help Menus

Function Keys

For quick access and to improve productivity, function keys are assigned for the most frequently used menus as follow:

F1	F2	F3	F4	F5	F6
Clear Menu	Element Options	Import File	Line Options	Model Checker	Node Options

F7	F8	F9
Surface Options	Pre-Processor	Online Help

NOTE: Please note that some images shown in this tutorial may make use of optional display features including background colors, shading, and element outlines. These may be controlled through the UTILITY Menu, and the SETUP options found there.

NOTE: Information for the Drop Test Module is designated using a ARIAL font, while the actual Tutorial actions are shown with the TIMES ROMAN font.

Introduction

Primary abuse loads that consumer products must withstand are due to transporting the product to the consumer, and user abuse such as dropping the product.

Engineers have developed testing procedures that allow them to study the durability of products to such drop tests. These tests are used to evaluate the design of a product and the packaging materials used to ship the product. The tests allow engineers to better design energy absorbing materials into their products and provide adequate strength to products so that they may withstand impacts.

In order to make more efficient use of the time available to design and test a consumer product, simulations using LS-DYNA have also been developed, which simulate the testing process.

Results of these simulations are in the form of deformations, stresses and acceleration histories. In the test, these are obtained by accelerometer measurements, strain gage measurements and high-speed video. The simulation data is obtained through results files specified in the simulation model(s).

Since there are many possible variations of a drop test, both the testing and simulation process can be time consuming. As simulations of drop events have become more and more reliable and predictive in nature, there has been a need to implement automation into the process of creating drop test simulation models.

In order to automate this process a Drop Test Module has been implemented in eta/VPG that allows the engineer to quickly define all necessary parameters used in a drop test, and by allowing the engineer to create a series of drop test simulations, representing multiple test configurations.

Drop Test Parameters

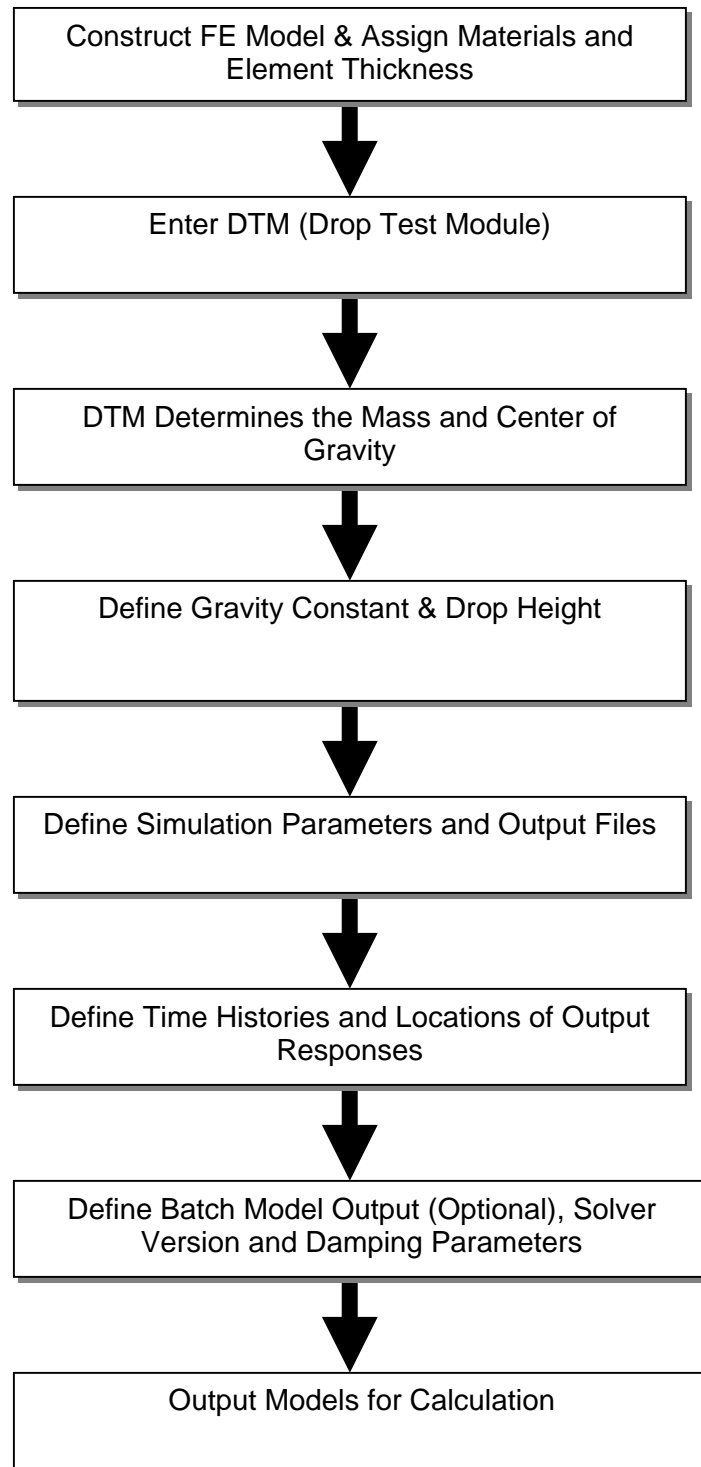
Testing is usually conducted by dropping the product from a specific height onto a rigid surface. The drop height may vary depending on the type of product and the desired severity of the impact. Another variable that is found in most drop tests is the angle at which the product is dropped. For instance a product may be dropped at a 0 degree angle with respect to the rigid surface, or it may be dropped at a 30 degree angle with respect to the surface. The impact may be performed at many different angles, to identify the critical angle at which the product may have a failure.

Another parameter that is necessary to define is the measurement points in the test specimen. This is usually where an accelerometer is placed on the specimen for the test to collect deceleration data.

In summary, the parameters that need to be identified for each individual drop test are:

- Drop Height
- Drop Angle
- Data Output Requirements

Procedural Flowchart



Using the Drop Test Module

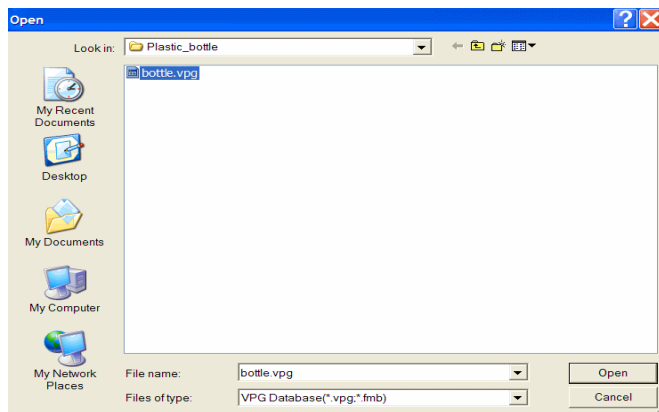
For our example we will import a model which meets all of the above requirements.

To start our example, select DTM from the Main Menu. This will open the Drop Test Module and allow you to begin to define all of the parameters necessary for a drop test simulation.

It is expected that prior to entering the DTM Menu, the user has:

- A completed FE Mesh
- Material properties and Thicknesses have been assigned to the model parts
- There are no current drop test boundary conditions or contacts defined on the model

Start VPG and create a new database. Enter *bottle.vpg* as the database name.



VPG will prompt “create a new database?” select **YES**.

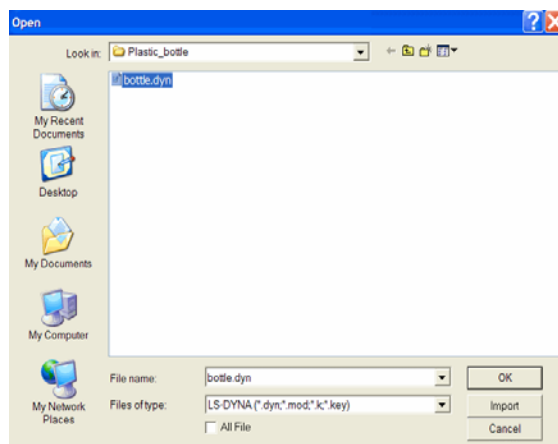
VPG will ask the user to select a database type, defining the solver which will be used in the simulation. The DTM is only supported in the LS-DYNA solver, therefore select **DYNA** from the **SELECT ANAYSIS PROGRAM** menu.

Into the empty database, we will import a model, ready for definition of drop test boundary conditions.

From the **FILE** menu, select **IMPORT**. Using the file selection window, select “bottle.dyn” from the file list.

The elements, nodes, material properties and definitions will be imported into the empty database. The model will be displayed in the drawing window, as shown in Figure 1.

This unit is made from a plastic material, and is composed of two components. The model was meshed in eta/VPG using the **DRAG MESH** option in the **ELEMENT** Menu. The model has no interior elements and is made up entirely of shell elements.



The appropriate materials were defined and applied to the components, using a *MAT_PLASTIC_KINEMATIC definition in LS-DYNA.

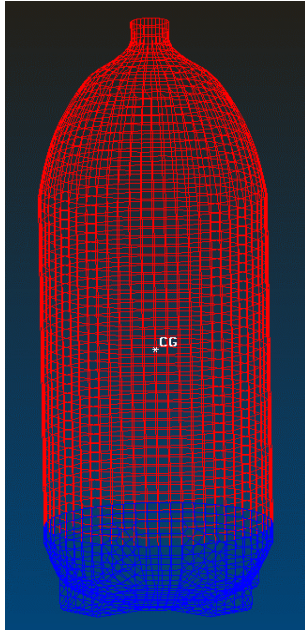


Figure 1: Drop Test Model Specimen

The Drop Test Module will now be used to complete the model and prepare it for drop testing simulation.

Select DTM from the MAIN menu as shown in Figure 2. Upon entering the Drop Test Module, VPG executes a command to calculate the center of gravity and the mass and inertias of the current model. The center of gravity will be shown, designated with a "CG" at the location.

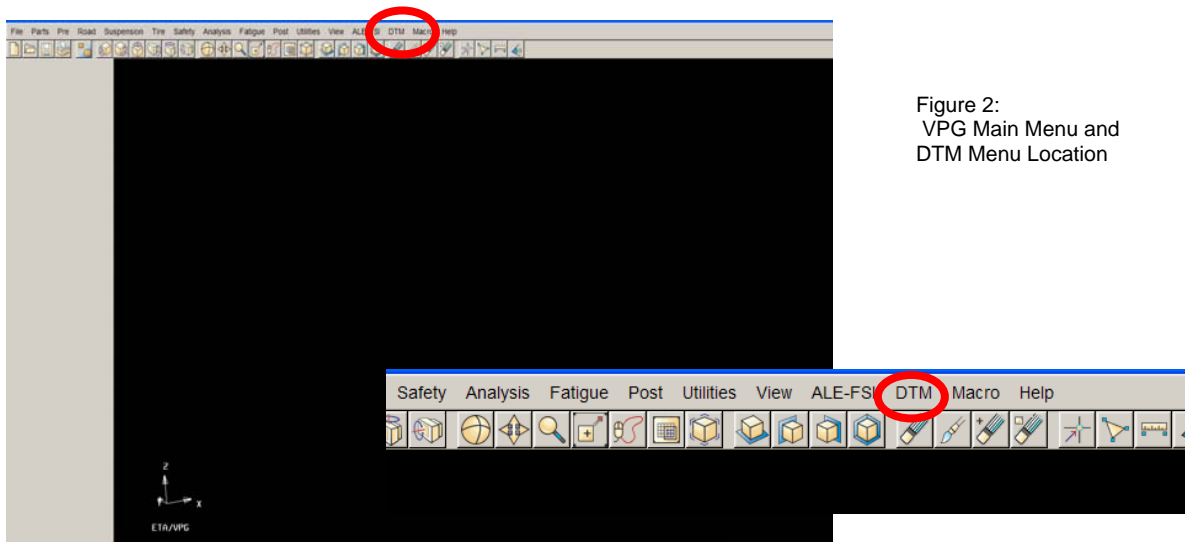


Figure 2:
VPG Main Menu and
DTM Menu Location

VPG Drop Test Module Menu

The menu provides additional sub-menus which allow the user to specify various parameters.

The DROP DIRECTION menu provides a means to define the direction of the drop. A local coordinate system can be defined from the calculated CG point to another specified node on the model. Another method of creating a local coordinate system is to define a direction between two nodes. VECTOR command allows the user to define a vector which will serve as the direction of the drop.

The user may make use of the global coordinate system of the model, to define the drop axis.

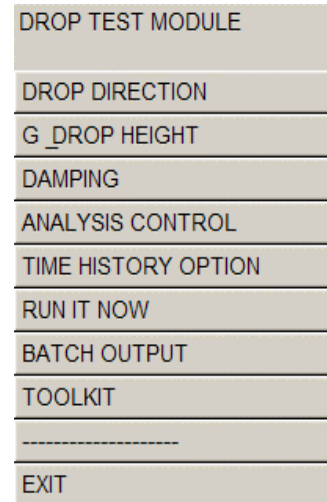


Figure 3: Drop Test Module Menu

For our case we would use the default value of a $-Z$ drop direction. All other parameters will be defined relative to this coordinate system.

The G and DROP HEIGHT command allows users to define the drop height parameter and the gravity constant used in the model. The sub-menu is shown in Figure 4.

The gravity constant can be adjusted to meet the users mass and distance units. A common default value is provided for the user. Definition of this parameter results in the creation of a *LOAD_BODY_Z in the LS-DYNA input file.

The Drop Height parameter specifies the distance above the surface the model should be drop from. VPG calculates an initial velocity based on the gravity constant and drop height, and applies this velocity to all nodes in the model through and *INITIAL_VELOCITY definition.

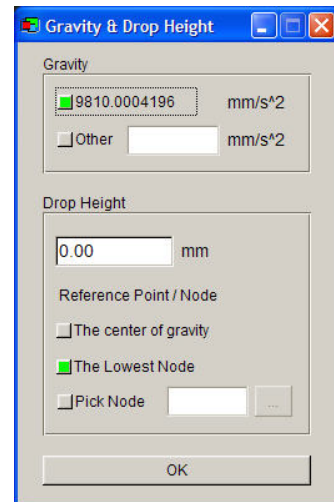


Figure 4: Drop Height and Gravity Definition Menu

For our drop test simulation, we will use the default gravity constant, by selecting the button next to the 9810.0004196 mm/sec²

The desired drop height for our case is 1 meter. Since our model units are in mm, we enter 1000 in the field. We will allow VPG to calculate the drop height from the lowest node in the model.

Definition of the model DAMPING parameter is necessary to provide an accurate response of the drop model. The damping is defined by creating a *DAMPING_GLOBAL definition in the model. If necessary, a nonlinear damping may be defined by means of a Load Curve.

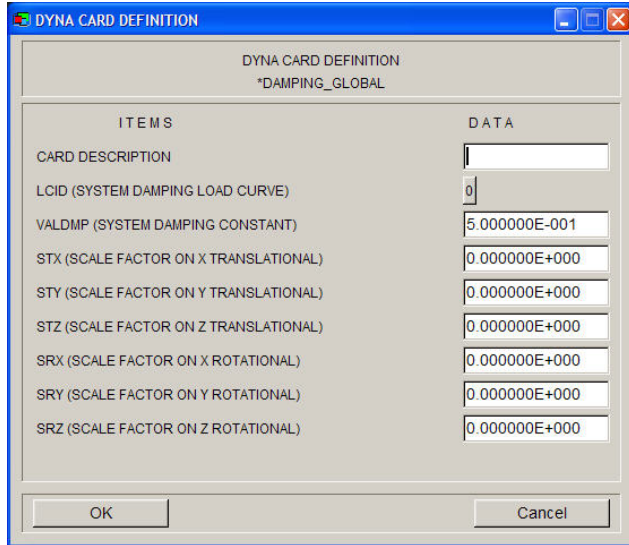


Figure 5: Damping Parameter Definition

The ANALYSIS CONTROL sub-menu allows the user to control the simulation height at which the model will be defined. This definition places the rigid impact surface the specified distance from the model. Since in the physical test, the specimen must be dropped from the actual height, definition of the parameter at a distance close to the model (lower number), reduces the required simulation time. By default, the drop height is used as the start height for the simulation.

The ANALYSIS CONTROL sub-menu also allows the user to define the simulation duration and the number of output steps that the analysis will create.

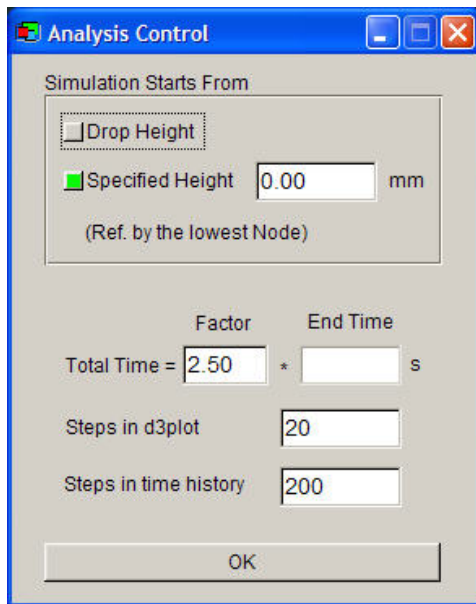


Figure 6: Analysis Parameter Definition

 For the bottle model, we will define a height of 20 mm at which the model will be dropped in the simulation. This will allow VPG to calculate the appropriate boundary conditions, and place the contact surface 20.00 mm from the lowest point in the model.

We will also define a total simulation time of 2.5 seconds for the simulation. These are default values for the DTM.

Output steps for the model results will be made at intervals specified in the Steps in D3PLOT field. Enter 20 in this field to allow 20 time steps to

be created.

Similarly, we will define 200 time history data points to be created for each of the time history parameters (NODOUT, GLSTAT, MATSUM, etc.), as specified in the TIME HISTORY MENU.

Additional output data can be obtained from the analysis. This data, such as material energies, contact energies, global response data, and node response data can be obtained by selecting the options from the TIME HISTORY sub-menu. Since these results are provided via the SET definition in LS-DYNA, VPG allows the users to define nodes and elements to be added to sets for the output of this data.

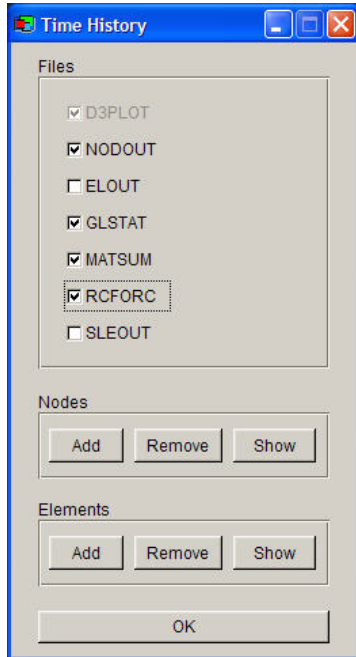


Figure 7: Time History Parameter Definition

For our current exercise, no additional output will be selected.

The BATCH MENU allows users to create many simulation models at one time. A typical series of tests used to evaluate a design may consists of many different drop angles and heights. VPG Drop Test Module allows the user to define a series of angles and drop heights which are to be simulated. By defining the range of angles and drop heights, and the increment between each configuration, the user can automatically generate a series of models which can be evaluated.

The result of this definition is the creation of models named DTMdeck001.dyn, DTMdeck002.dyn, etc. Up to 999 input files may be created in this manner.

For our current exercise, we will not define any Batch Output parameters

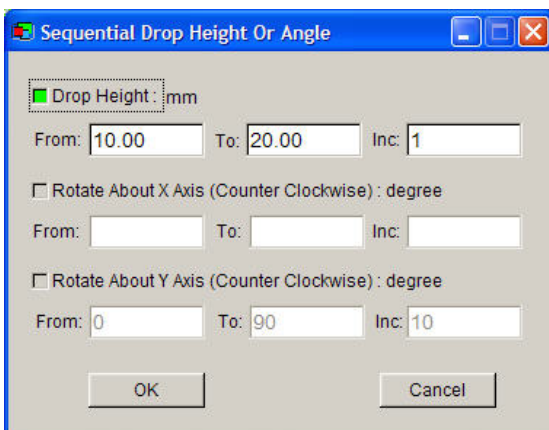


Figure 8: Batch Model Creation Options

Additional tools for set up of the model are found in the TOOLKIT menu. This provides tools such as a recalculation of the model center of gravity, in the event that the model was modified. It also allows the user to remove the damping definition and control which version of LS-DYNA is executed and the amount of memory requested for each simulation.

These additional options are not covered in this tutorial.

Summary

Drop Testing Simulation can be made more efficient by using VPG to set up individual or multiple drop conditions, providing a streamlined process to creating drop test models.