

Performing Vertical Pedestrian Loading with Restart Analyses in LUSAS

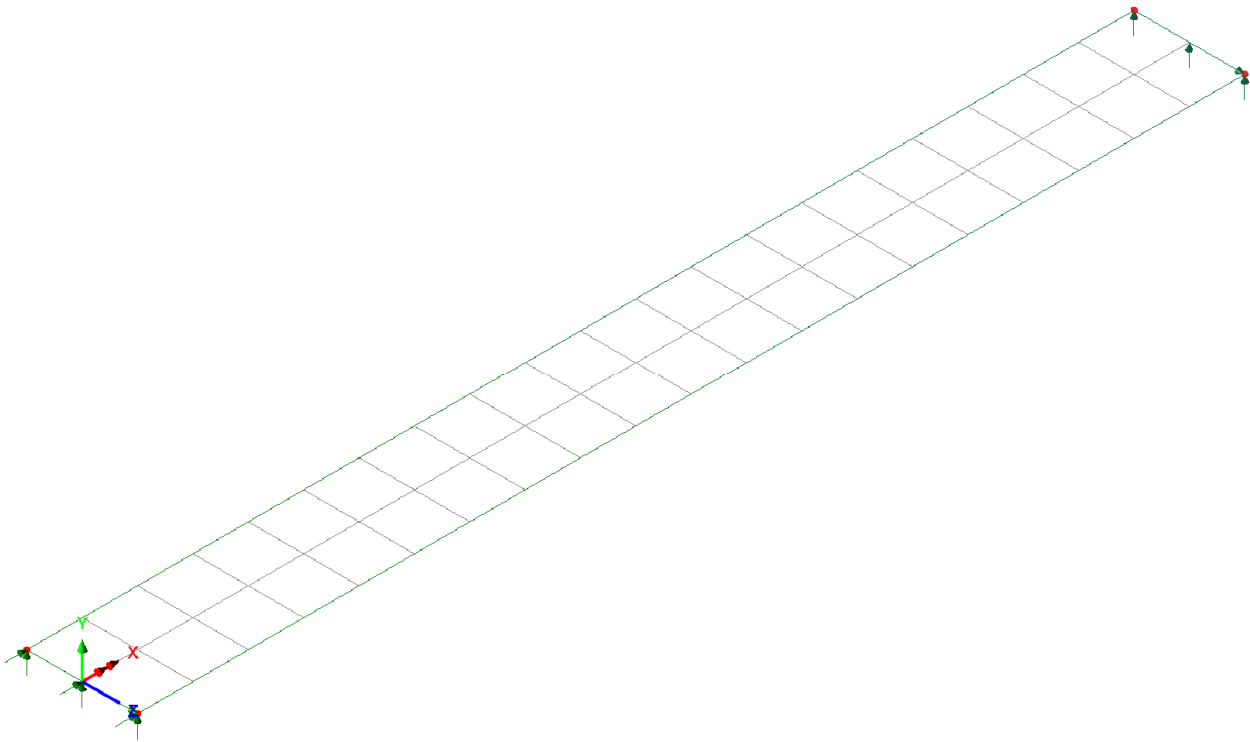
Moving pedestrian loading analyses using either the BD37/01 or BS EN 1991-2 2003 wizards can be performed in LUSAS. For all but the shortest structures these analyses will usually require a significant number of time steps to analyse the passage of the pedestrian / pedestrian group across the whole structure. It is recommended therefore that the analysis is broken up into a number of restart analyses each with a maximum of 1000 time steps.

Restart analyses are relatively simple to set up and break the complete solution into smaller chunks that can be run sequentially. This method also has the advantage that, should anything go wrong during a long analysis such as insufficient disk space or power failure, only the solution from the start of the last restart will be lost and not the whole analysis.

NOTE: For complex models it may be necessary to have smaller numbers of time steps than 1000 in each restart analysis due to the size of the results files (*.mys).

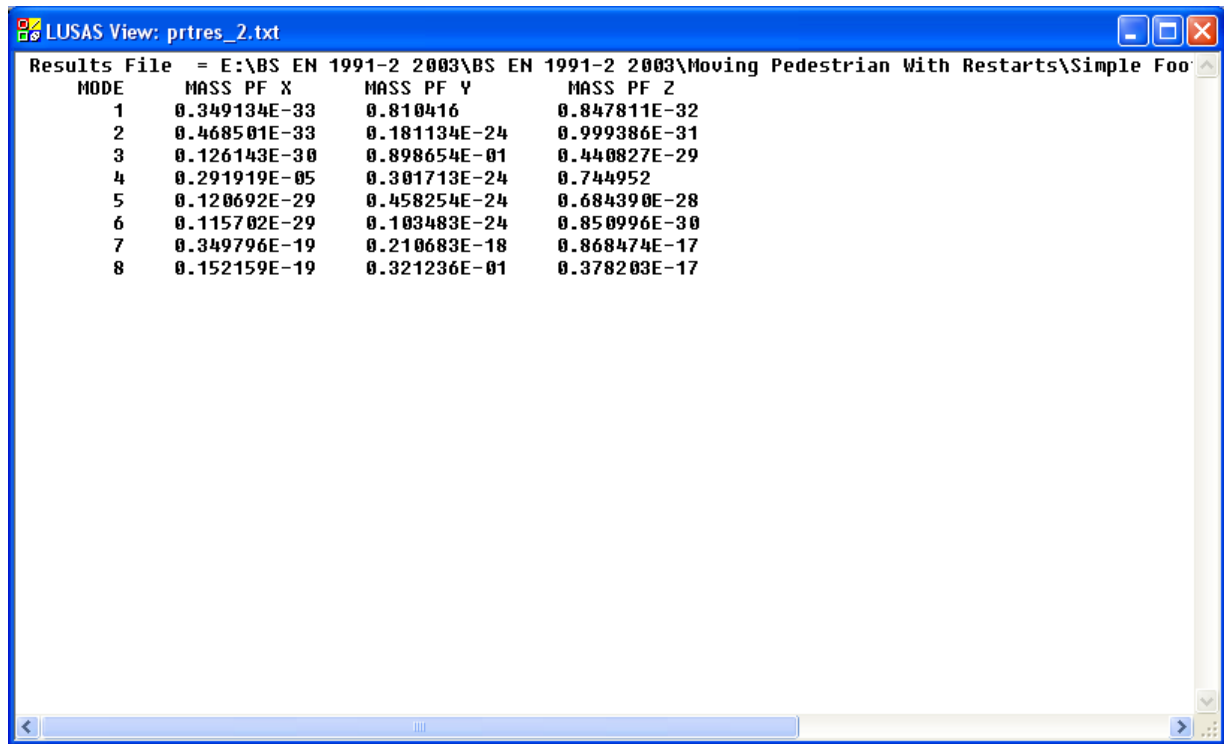
To demonstrate the procedure for conducting a restart analysis we will perform a pedestrian moving load analysis using the wizard for the NA to BS EN 1991-2 2003 on a very simple footbridge.

The structure used is simply a steel deck of 300mm thickness with a width of 2m and a span of 20m with simple supports as shown in the following figure.



If we perform an eigenvalue analysis over the frequency range of 0 to 50Hz of this structure we find the following frequency and mass participation behaviour:

MODE	EIGENVALUE	FREQUENCY	ERROR NORM
1	123.137	1.76609	0.413630E-10
2	2008.47	7.13268	0.328768E-11
3	10497.3	16.3064	0.911920E-12
4	13876.7	18.7483	0.166735E-11
5	21822.1	23.5109	0.141219E-11
6	34679.2	29.6384	0.488585E-12
7	89213.8	47.5375	0.738871E-07
8	89584.3	47.6361	0.336236E-07



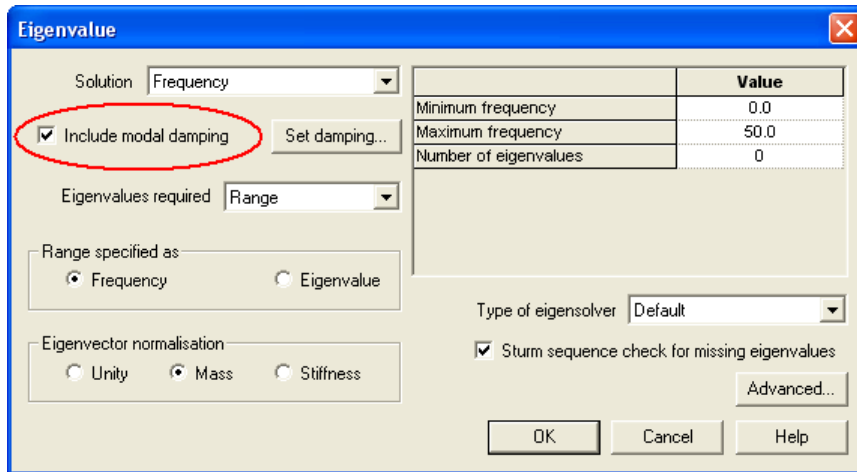
From these we can see that there are two key modes of the structure that have approximately 80% of the structure mass participating in them for the mode 1 vertical (Y) and mode 4 lateral (Z) directions. These will therefore be used to define the frequency range for the Rayleigh damping parameters.

Using the Microsoft Excel spreadsheet downloadable from the User Area on the LUSAS Support Website and assuming 3% damping we can calculate the Rayleigh damping parameters as indicated below which can be added to the material properties of the model:

A	B	C	D	E	F	G
1		Rayleigh Damping Coefficients				
2	Usage:					
3	a) Input the start and end frequencies of interest					
4	b) Input the damping ratios required at these frequencies					
5	c) Extract the Rayleigh damping coefficients and specify in the material properties of the material					
6						
7		Frequency (Hz)*	Damping Ratio*	Damping (%)	Circular Frequency (/s)	Eigenvalue
8	1st	1.7661	0.03	3	11.10	123.14
9	2nd	18.7483	0.03	3	117.80	13,876.61
10						
11						
12		Rayleigh Damping Parameters:				
13			Alpha:	0.608481301		
14			Beta:	0.000465493		

To check that we have achieved the damping levels that we require we can reanalyse the eigenvalue analysis using this modified material property and enable the **Include modal**

damping as indicated in the figure below (we are using the default settings to calculate all modes so we do not need to click on the **Set damping...** button).



If we now look at the analysis output file *.out we will see underneath the frequency and mass participation information a section called **Modal Damping Factors** which will tell us the distributed damping factors attained using the material Rayleigh damping parameters. Looking at modes 1 and 4 which were the limits of our range for tuning the damping parameters we see that we have successfully obtained 3% or (0.3E-1) at these target frequencies with the remaining modal damping values following the Rayleigh proportional damping behaviour (refer to the LUSAS Theory Manual for more information on Rayleigh damping).

M O D A L D A M P I N G C O N T R O L V I S C O U S

DEFAULT DAMPING FACTOR = 0.500000E-01

RAYLEIGH PARAMETERS WILL BE EXTRACTED FROM MATERIAL PROPERTIES INPUT

DISTRIBUTED DAMPING FACTORS WILL BE COMPUTED FOR ALL MODES

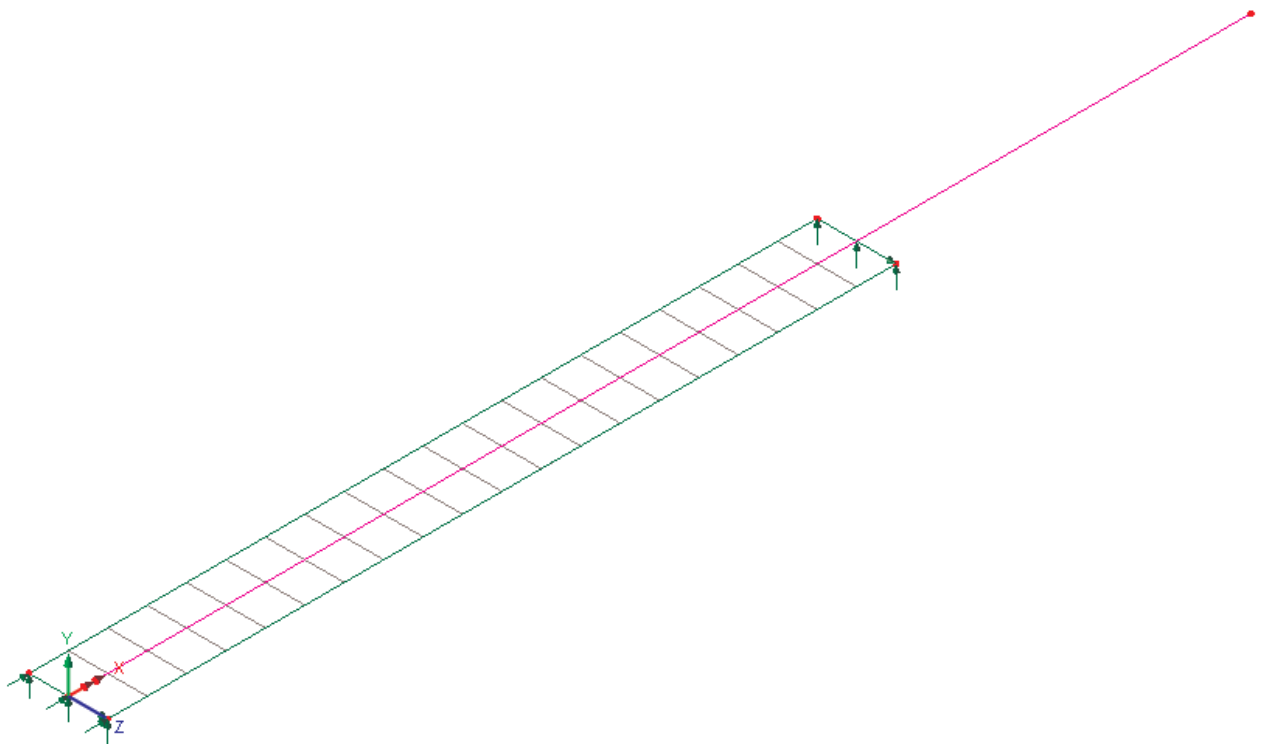
M O D A L D A M P I N G F A C T O R S

MODE	EIGENVALUE	FREQUENCY	VISCOUS DAMPING
1	123.137	1.76609	0.300000E-01
2	2008.47	7.13268	0.172194E-01
3	10497.3	16.3064	0.268158E-01
4	13876.7	18.7483	0.300001E-01
5	21822.1	23.5109	0.364416E-01
6	34679.2	29.6384	0.449766E-01
7	89213.8	47.5375	0.705369E-01
8	89584.3	47.6361	0.706790E-01

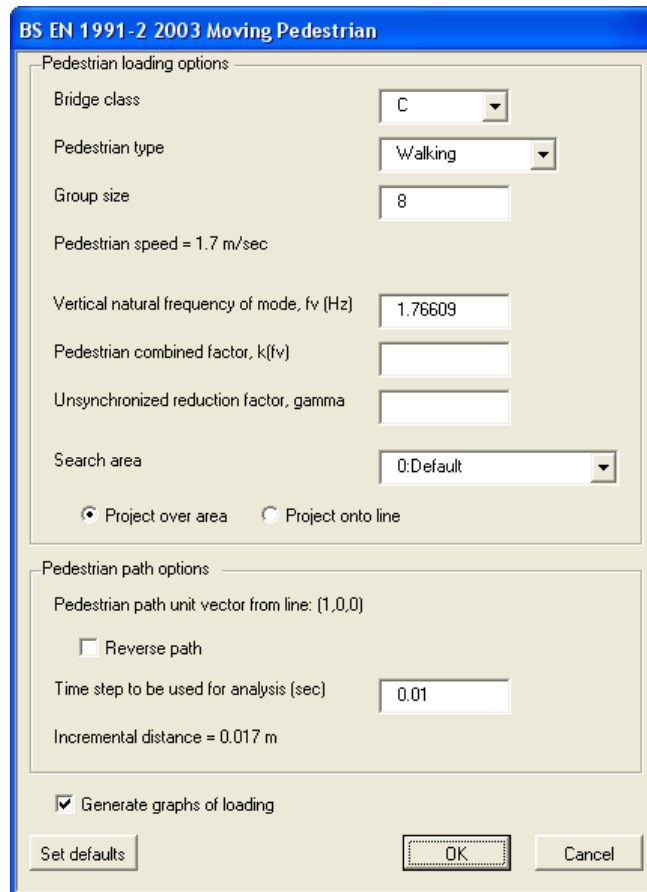
TIME FOR COMPUTATION OF DAMPING FACTORS = 0.10938 SEC.

We now have our damping requirements for the structure. Our last modelling task before using the pedestrian moving load wizard is to define the path along which the pedestrian / pedestrian group will move. For the example this will be along the centreline of the structure as indicated below.

NOTE: The path has been extended 10m beyond the 20m long bridge structure to allow the analysis to also include the free vibration response after the pedestrian / pedestrian group has left the structure (also to create > 1000 time steps to demonstrate restarts). As an alternative to this approach which will generate load cases with no effective loading the model could be edited after creation of the pedestrian loading to add a new load case with a dynamic control to perform additional time steps after the pedestrian / pedestrian group has left the structure. This could also be done by manually editing the datafile prior to running the analysis. Either of these should still take account of restart requirements.



We can now select this straight line defining the pedestrian path and run the loading wizard. For this example we will treat the structure as a class C bridge for urban routes with pedestrians walking across it with a frequency tuned to the fundamental vertical natural frequency of 1.76609Hz obtained in the eigenvalue analysis. This means that the default group size from table NA.7 will be 8 with a reference load of 280N and walking speed of 1.7m/s (dealt with internally in the wizard). Our initial information for the wizard is indicated in the following figure:



We are left with the Pedestrian combined factor, $k(f_v)$, and the Unsynchronized reduction factor, γ , to calculate from the clauses of the code of practice. Based on the natural frequency being analysed of 1.76609Hz and the walking pedestrian, Figure NA.8 gives us a $k(f_v)$ value of 1.0. The unsynchronized reduction factor is dependent upon both the damping of the structure and effective span for the mode shape corresponding to our vertical natural frequency. The effective span will be taken as the total span length of 20m as this is considered conservative by the code of practice but can also be calculated in accordance with Figure NA.7. Based on this and a logarithmic decrement δ of 0.18858 (equivalent to a damping ratio of 3% and calculated from $\delta = 2\pi\xi / \sqrt{1 - \xi^2}$), Figure NA.9 gives a γ value of 0.545.

The search area and projection will be left as the default values and the direction will be in the orientation of the line (from left to right in the figures).

For the time step, the default value of 0.01sec will create a total of 1766 time steps for the 30m pedestrian path with a walking speed of 1.7m/s which would probably be suitable for the analysis of this structure. For the example we will use a reduced time step to allow us to create an analysis that will require multiple restart analysis of 1000 time steps each to fully demonstrate the procedure for setting up the analysis. The time step will therefore be set to 0.0075sec which will equate to an equivalent incremental movement distance of 0.01275m per time step resulting in approximately 2350 time steps necessary for the pedestrian to move the 30m.

The final information required for the wizard is shown in the following figure. We can now click the **OK** button to create the complete model for the moving pedestrian analysis.

BS EN 1991-2 2003 Moving Pedestrian

Pedestrian loading options

Bridge class: C

Pedestrian type: Walking

Group size: 8

Pedestrian speed = 1.7 m/sec

Vertical natural frequency of mode, f_v (Hz): 1.76609

Pedestrian combined factor, $k(f_v)$: 1.0

Unsynchronized reduction factor, γ : 0.545

Search area: 0:Default

Project over area Project onto line

Pedestrian path options

Pedestrian path unit vector from line: (1.0,0)

Reverse path

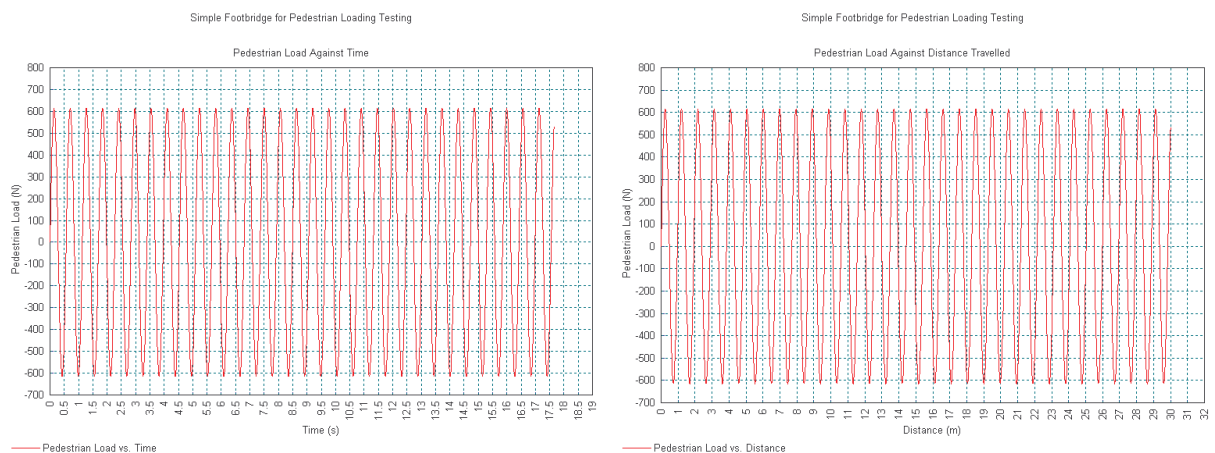
Time step to be used for analysis (sec): 0.0075

Incremental distance = 0.01275 m

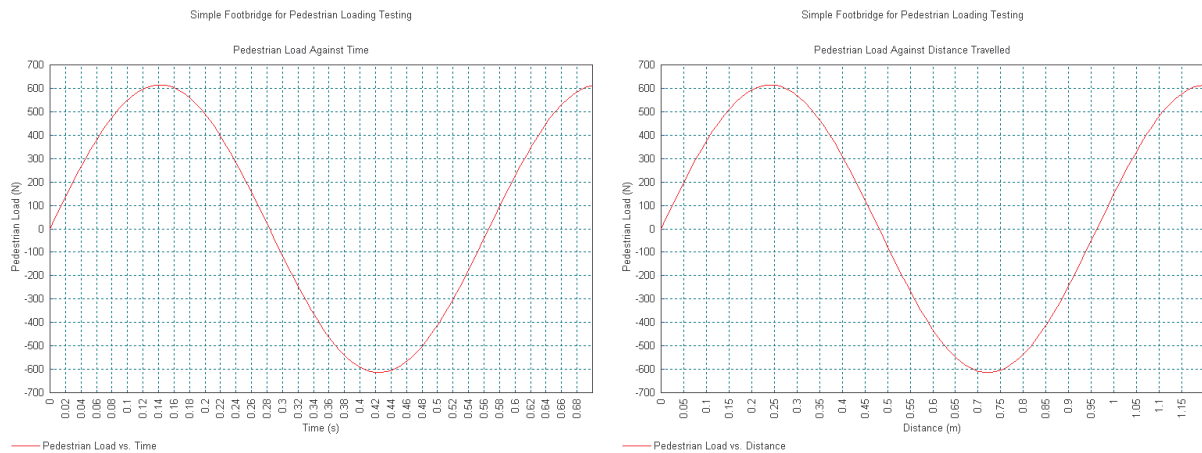
Generate graphs of loading

Set defaults OK Cancel

This will create two graphs illustrating the loading defined in the model for the pedestrian / pedestrian group versus time and distance as indicated below.



These graphs can be inspected to ensure that the sinusoidal variation of the magnitude of the loading has been suitably captured using the time step selected by visual inspection that all of the peaks are identical for the overall curves and also by zooming into the first cycle using the zoom feature in the LUSAS graphing as illustrated below.




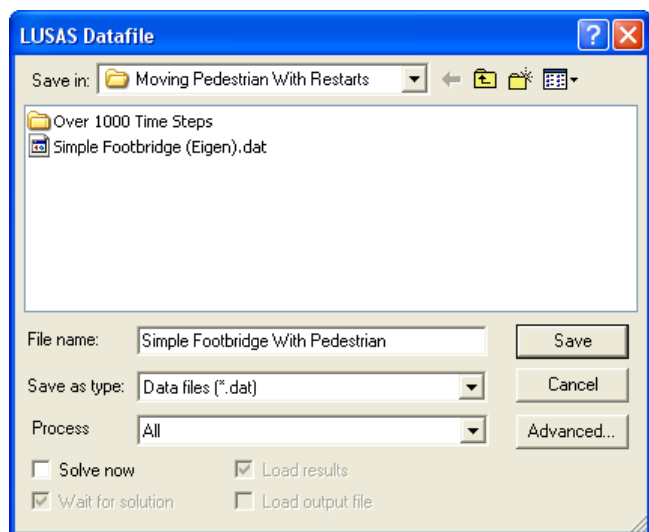
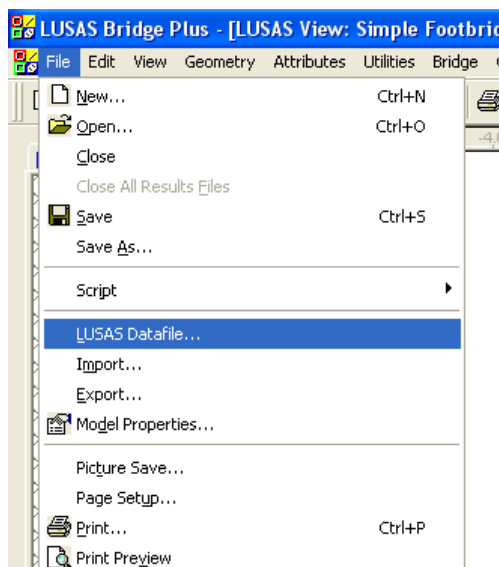
E:\BS EN 1991-2 2003\BS EN 1991-2 2003\Moving Pedestrian With Restarts\Simple Footbridge.mdl

Units: N,m,kg,s,CE\BS EN 1991-2 2003\BS EN 1991-2 2003\Moving Pedestrian With Restarts\Simple Footbridge.mdl

Units: N,m,kg,s,C

If we do not achieve smooth curves with the correct peaks then the time step of an analysis will probably need to be reduced.

We can now save the model (usually best to save it under a new file name to avoid accidentally overwriting the original model that was used as the starting point for the pedestrian loading analysis) and tabulate the analysis. Rather than clicking the  button which would tabulate and solve the analysis we wish to only write the datafile to disk so we can perform the edits required for the restart analysis. To do this select the **LUSAS Datafile...** option from the **File** menu, deselect the **Solve now** option and click **Save** to write the datafile to the working directory.

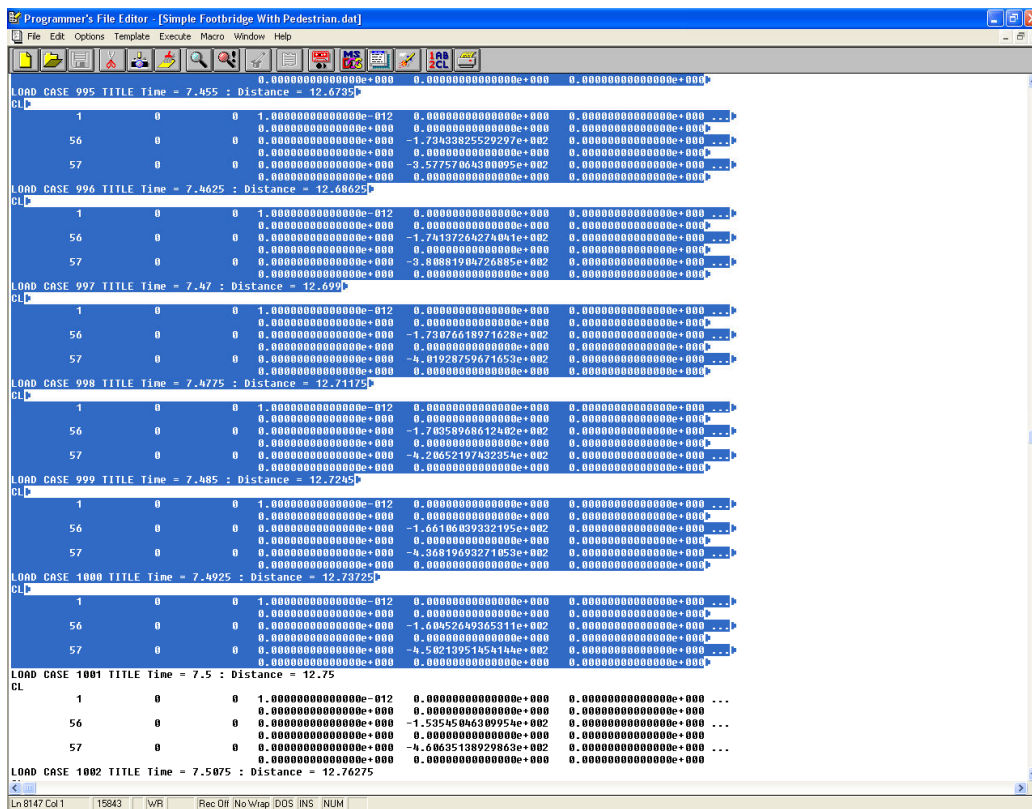


If we look at this datafile we will find that it has all 2354 time steps defined as individual load cases in the analysis with a single dynamic control that performs a single time step at the start of the analysis that is inherited by all of these load cases. We now need to break this single datafile into multiple 1000 time step / load case chunks. It is usually best to keep this 'base' datafile as it is and create new datafiles for the restart analysis. These will usually have the same basename as the original datafile but with a suffix similar to *_a.dat, *_b.dat, *_c.dat or *_1.dat, *_2.dat, *_3.dat to indicate the order that the datafiles need to be analysed in LUSAS Solver.

Create three text files with a *.dat extension as follows (**NOTE:** The name of the file will be different for your analysis):

```
Simple Footbridge With Pedestrian_1.dat
Simple Footbridge With Pedestrian_2.dat
Simple Footbridge With Pedestrian_3.dat
```

For the first datafile, copy the information from the original datafile created using the wizard down to the end of LOAD CASE 1000 and paste it into the new datafile as indicated below:



```

Programmer's File Editor - [Simple Footbridge With Pedestrian_1.dat *]
File Edit Options Template Execute Macro Window Help
56 0 0 0.000000000000e+000 -1.73076618971628e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 0.000000000000e+000 0.000000000000e+000 ...
LOAD CASE 998 TITLE Time = 7.4775 : Distance = 12.71175
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
56 0 0 0.000000000000e+000 -1.78358968612482e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 -4.28652197432354e+002 0.000000000000e+000 ...
LOAD CASE 999 TITLE Time = 7.485 : Distance = 12.7245
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
56 0 0 0.000000000000e+000 -1.66186839332195e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 -4.36819693271853e+002 0.000000000000e+000 ...
LOAD CASE 1000 TITLE Time = 7.4925 : Distance = 12.73725
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
56 0 0 0.000000000000e+000 -1.69452649365311e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 -4.58213951454144e+002 0.000000000000e+000 ...
Ln8147 Col1 8147 # |WR| Rec Off NoWrap DOS INS NUM

```

Add the following two lines to the end of the datafile as indicated below and save it:

```

RESTART WRITE
END

```

```

Programmer's File Editor - [Simple Footbridge With Pedestrian_1.dat]
File Edit Options Template Execute Macro Window Help
56 0 0 0.000000000000e+000 -1.73076618971628e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 0.000000000000e+000 0.000000000000e+000 ...
LOAD CASE 998 TITLE Time = 7.4775 : Distance = 12.71175
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
56 0 0 0.000000000000e+000 -1.78358968612482e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 -4.28652197432354e+002 0.000000000000e+000 ...
LOAD CASE 999 TITLE Time = 7.485 : Distance = 12.7245
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
56 0 0 0.000000000000e+000 -1.66186839332195e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 -4.36819693271853e+002 0.000000000000e+000 ...
LOAD CASE 1000 TITLE Time = 7.4925 : Distance = 12.73725
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
56 0 0 0.000000000000e+000 -1.69452649365311e+002 0.000000000000e+000 ...
57 0 0 0.000000000000e+000 -4.58213951454144e+002 0.000000000000e+000 ...
RESTART WRITE
END
Ln8149 Col1 8149 |WR| Rec Off NoWrap DOS INS NUM

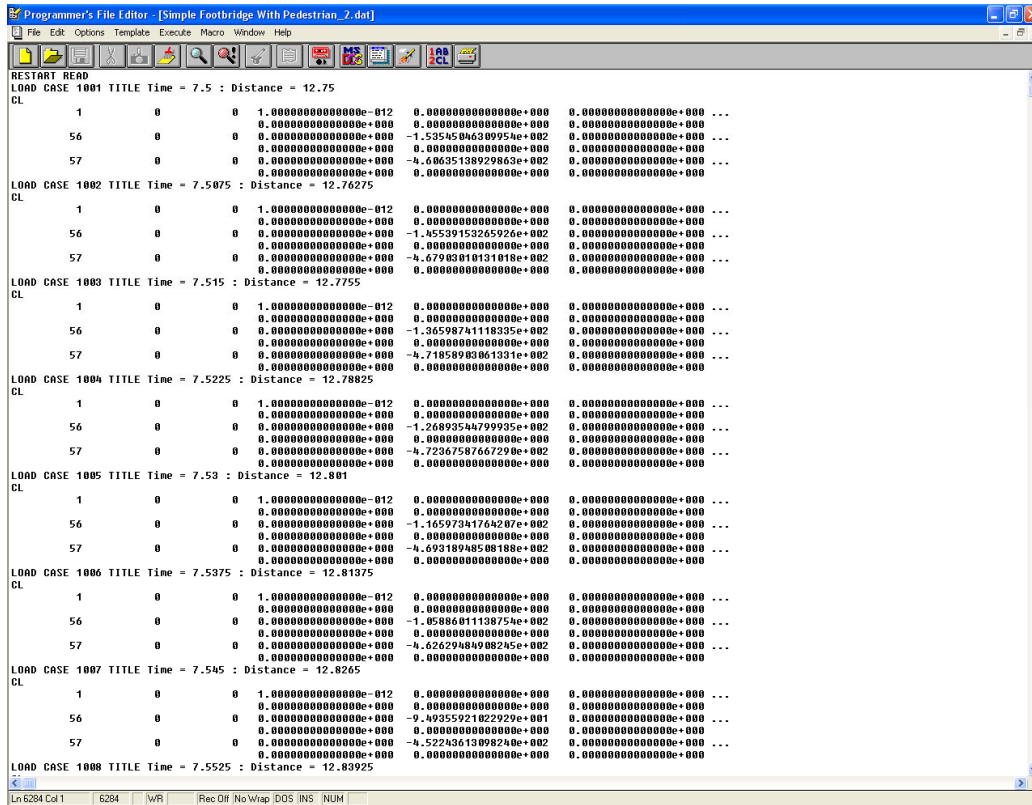
```

This completes the first datafile of the restart analysis. We now need to create the second datafile in the sequence. In the second datafile enter the first line as

```
RESTART READ
```

Now copy load cases 1001 through to 2000 from the original base file and paste them after this line. Finally add the following two lines to the end of this second datafile so it looks like the following figures:

```
RESTART WRITE  
END
```



```

Programmer's File Editor - [Simple Footbridge With Pedestrian_2.dat]
File Edit Options Template Execute Macro Window Help
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1988 TITLE Time = 14.9825 : Distance = 25.33425
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1989 TITLE Time = 14.91 : Distance = 25.347
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1990 TITLE Time = 14.9175 : Distance = 25.35975
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1991 TITLE Time = 14.925 : Distance = 25.3725
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1992 TITLE Time = 14.9325 : Distance = 25.38525
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1993 TITLE Time = 14.94 : Distance = 25.398
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1994 TITLE Time = 14.9475 : Distance = 25.41075
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1995 TITLE Time = 14.955 : Distance = 25.4235
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1996 TITLE Time = 14.9625 : Distance = 25.43625
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1997 TITLE Time = 14.97 : Distance = 25.449
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1998 TITLE Time = 14.9775 : Distance = 25.46175
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 1999 TITLE Time = 14.985 : Distance = 25.4745
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
LOAD CASE 2000 TITLE Time = 14.9925 : Distance = 25.48725
CL
1 0 0 1.000000000000e-012 0.000000000000e+000 0.000000000000e+000 ...
0.000000000000e+000 0.000000000000e+000 0.000000000000e+000
RESTART WRITE
END
|
Ln:6284 Col:1 6284 |WR| Rec Off No Wrap DOS INS NUM

```

As our time steps / load cases for this example only go up to 2354 we only need to create one final restart datafile. Repeat the procedure above for the second datafile but copy and paste load cases 2001 through to 2354 into the third datafile so it looks like the following figures.

NOTE: For the last restart file we do not need to include the RESTART WRITE command unless we may wish to add further time steps in another restart datafile. This may be required if there is interest in the damped free vibration after the passage of the pedestrian / pedestrian group.

```

Programmer's File Editor - [Simple Footbridge With Pedestrian_3.dat]
File Edit Options Template Execute Macro Window Help

RESTART READ
LOAD CASE 2001 TITLE Time = 15 : Distance = 25.5
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2002 TITLE Time = 15.0075 : Distance = 25.51275
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2003 TITLE Time = 15.015 : Distance = 25.5255
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2004 TITLE Time = 15.0225 : Distance = 25.53825
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2005 TITLE Time = 15.03 : Distance = 25.551
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2006 TITLE Time = 15.0375 : Distance = 25.56375
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2007 TITLE Time = 15.045 : Distance = 25.5765
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2008 TITLE Time = 15.0525 : Distance = 25.58925
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2009 TITLE Time = 15.06 : Distance = 25.602
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2010 TITLE Time = 15.0675 : Distance = 25.61475
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2011 TITLE Time = 15.075 : Distance = 25.6275
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2012 TITLE Time = 15.0825 : Distance = 25.64025
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2013 TITLE Time = 15.09 : Distance = 25.653
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2014 TITLE Time = 15.0975 : Distance = 25.66575
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2015 TITLE Time = 15.105 : Distance = 25.6785
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
Ln1 Col1      1419      |WR      Rec Off No Wrap DOS INS NUM

```

```

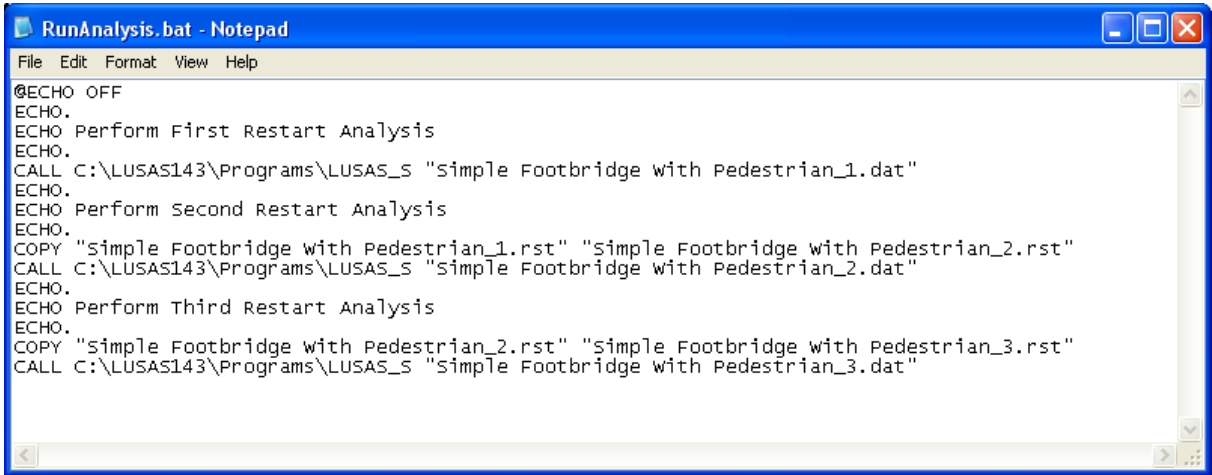
Programmer's File Editor - [Simple Footbridge With Pedestrian_3.dat]
File Edit Options Template Execute Macro Window Help

CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2343 TITLE Time = 17.565 : Distance = 29.8605
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2344 TITLE Time = 17.5725 : Distance = 29.87325
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2345 TITLE Time = 17.58 : Distance = 29.886
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2346 TITLE Time = 17.5875 : Distance = 29.89875
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2347 TITLE Time = 17.595 : Distance = 29.9115
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2348 TITLE Time = 17.6025 : Distance = 29.92425
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2349 TITLE Time = 17.61 : Distance = 29.937
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2350 TITLE Time = 17.6175 : Distance = 29.94975
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2351 TITLE Time = 17.625 : Distance = 29.9625
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2352 TITLE Time = 17.6325 : Distance = 29.97525
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2353 TITLE Time = 17.64 : Distance = 29.988
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
LOAD CASE 2354 TITLE Time = 17.6475 : Distance = 30.00075
CL
  1      0      0      1.000000000000e-012  0.000000000000e+000  0.000000000000e+000 ...
  0.000000000000e+000  0.000000000000e+000  0.000000000000e+000 ...
END
Ln1419 Col1      1419      |WR      Rec Off No Wrap DOS INS NUM

```

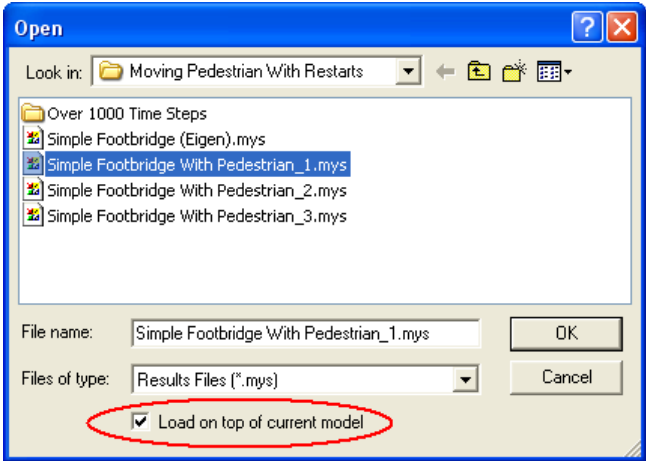
Our remaining tasks are to run the analysis and also provide the capability of loading the results from all of the restart analyses into LUSAS Modeller with ease if there are a significant number of them.

The simplest way of running all of the restart analyses is through a MS-DOS batch file. The batch file that would run all three of the datafiles in sequence is shown in the next figure. In this batch file the key tasks are to run a datafile, copy the restart from that analysis to be the starting restart for the next datafile and so on. The batch file also, as a cosmetic process, echoes to the command window the information about which analysis is currently being run. The location of the batch file that runs LUSAS Solver should be set based on the version of LUSAS and the installation directory on the computer where the analysis is being performed.



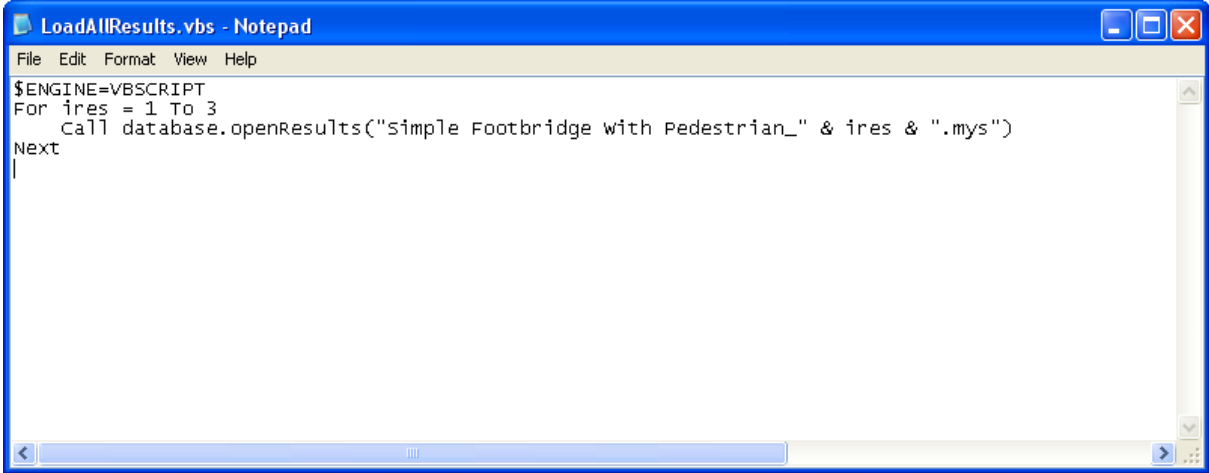
```
RunAnalysis.bat - Notepad
File Edit Format View Help
@ECHO OFF
ECHO.
ECHO Perform First Restart Analysis
ECHO.
CALL C:\LUSAS143\Programs\LUSAS_S "Simple Footbridge With Pedestrian_1.dat"
ECHO.
ECHO Perform Second Restart Analysis
ECHO.
COPY "Simple Footbridge With Pedestrian_1.rst" "Simple Footbridge With Pedestrian_2.rst"
CALL C:\LUSAS143\Programs\LUSAS_S "Simple Footbridge With Pedestrian_2.dat"
ECHO.
ECHO Perform Third Restart Analysis
ECHO.
COPY "Simple Footbridge With Pedestrian_2.rst" "Simple Footbridge With Pedestrian_3.rst"
CALL C:\LUSAS143\Programs\LUSAS_S "Simple Footbridge With Pedestrian_3.dat"
```

For this pedestrian moving load analysis we only have three results files so these could be easily loaded on top of the original model manually one at a time using **Open** toolbar button or the **File > Open...** menu entry and choosing **Results Files (*.mys)** as the file type and ensuring that the **Load on top of current model** option is selected as indicated below.



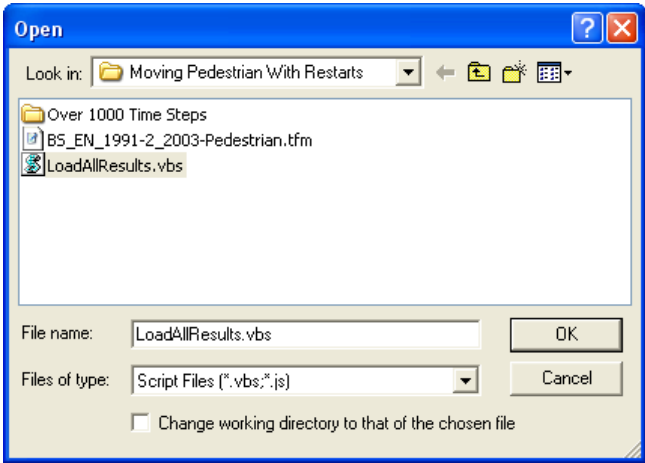
When there is a significant number of restart analyses for larger models this process can be quite laborious and prone to error so the best method is to write a VBScript that will load all of the

results files in one go. An example is shown in the following figure which loops over the three results files loading each of them in turn onto the current model.



```
LoadAllResults.vbs - Notepad
File Edit Format View Help
$ENGINE=VBSCRIPT
For ires = 1 To 3
  Call database.openResults("Simple Footbridge with Pedestrian_" & ires & ".mys")
Next
|
```

This script can be run by clicking the toolbar **Run Script** button or the **File > Script > Run Script...** menu entry and choosing the VBScript file as shown below.



If the results files are not in the same working directory as the model the VBScript file may require their path to also be specified.

The analysis is now complete and ready for post-processing in LUSAS Modeller as normal.