Load Drop on Timber Mat Protection System

***Mukti L. Das**, Ph. D., P.E., F. ASCE*

Principal Engineer, Bechtel Power Corporation

Load Drop on Timber Mat Protection System

This presentation is the result of a study conducted by the following Bechtel engineers:

William H. Johnson
Mukti L. Das
Neha Gidwani
Jaspal S. Saini

Purpose of Present Study

The heavy rigging operation required during construction and routine maintenance of nuclear power plants requires safety assessment of the buried utilities from postulated accidental impact load resulting from load drops or crane boom drops.

Rigging Operation

Steam Generator : 400 to 800 tons

Rigging Operation (Cont'd)

Steam Generator : 400 to 800 tons

Rigging Operation (Cont'd)

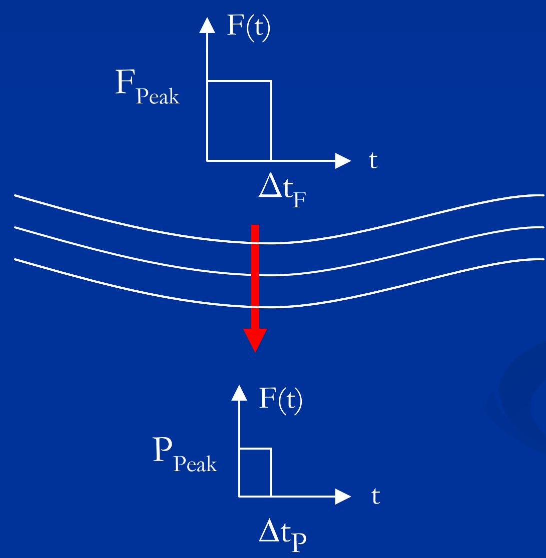
Reactor Pressure Vessel Head : Approximately 200 tons

Applicability of Present Study

The methodology presented here is applicable to general load drop analysis on a variety of surfaces. However, this presentation has particular relevance to load drops on timber mats in nuclear power plants.

Scope of Present Study

Establish a transfer relationships between the applied impulse load at the top of the timber mat protection system and loading at the mat-soil interface.



Evaluation of the buried utilities for an impulse loading at the mat-soil interface is not included in this study.

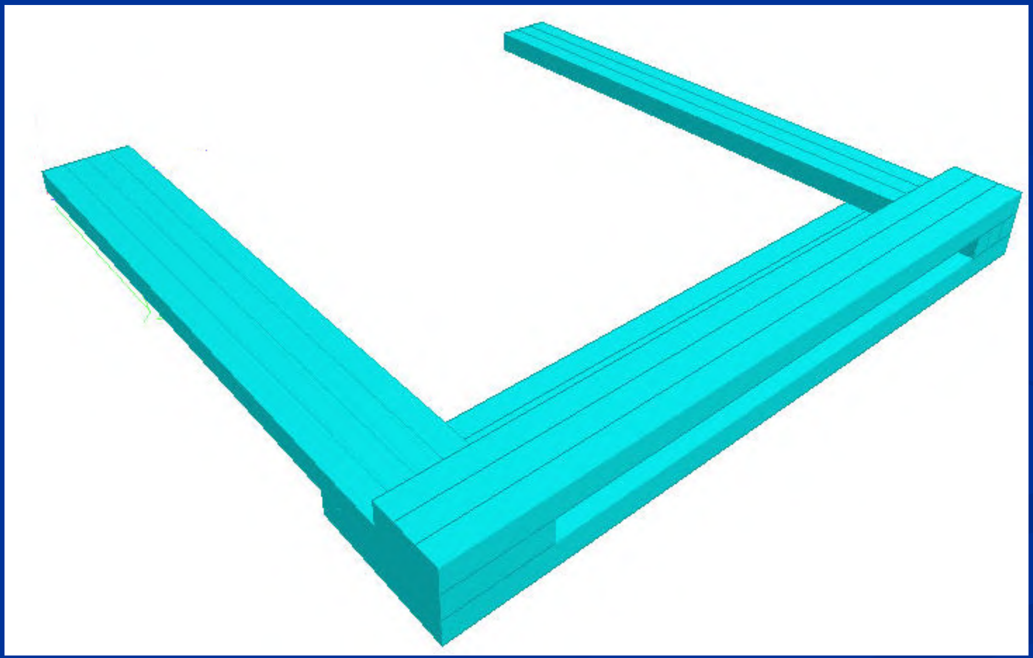
Various Protection Systems

Utilities buried directly under the postulated impact locations may require protection such as timber crane mats, sand bags or gravel mounds to reduce pressure intensity generated from the impact.

Protection System for Present Study

A timber crane mat with 12"x 12" - 30' long timbers, made up of several layers, is selected. The timbers of any layer are arranged orthogonal to those of the adjacent layers.

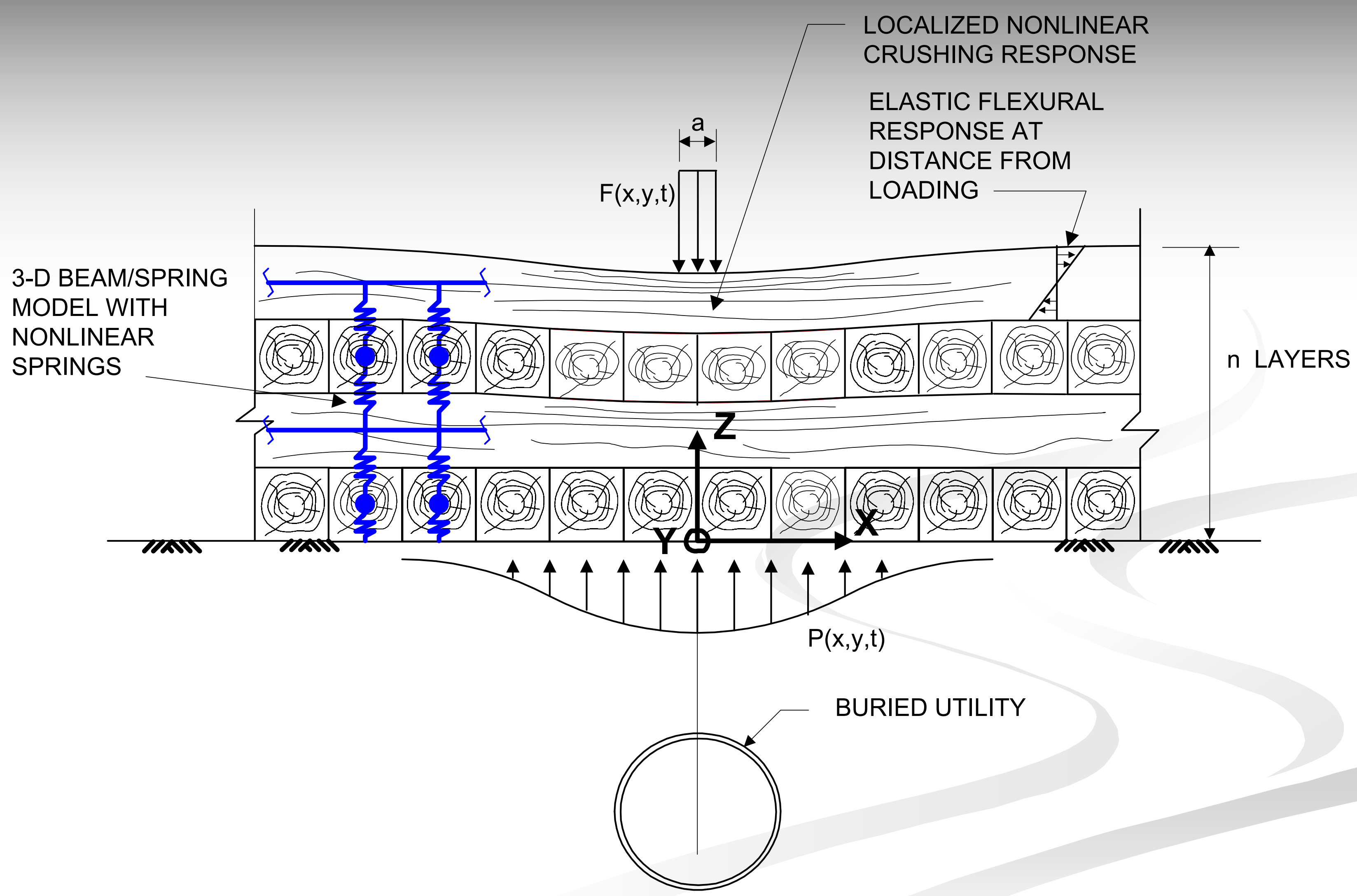
Timber Crane Mat



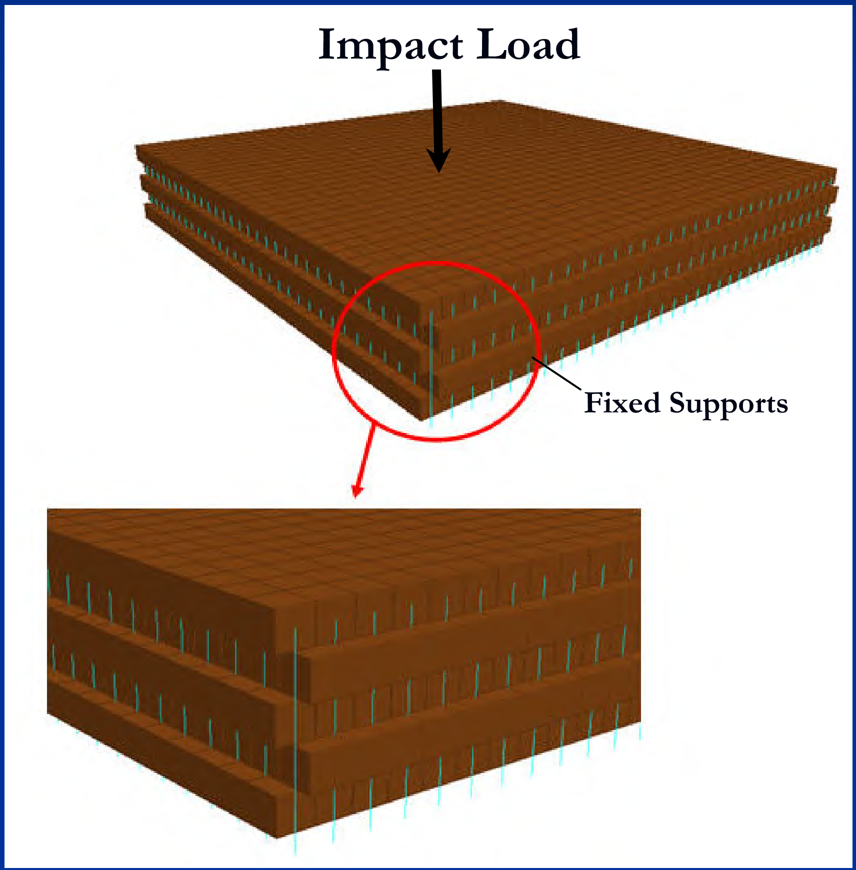
Complexity of Designing Timber Crane Mat for Buried Utility

- Nonlinear behavior of crushed timber
- Compression only interface between two adjacent timber layers
- Compression only interface between timber layer and the supporting soil
- Soil structure interaction between soil and the buried utility

Physical Model



GTSTRUDL Model

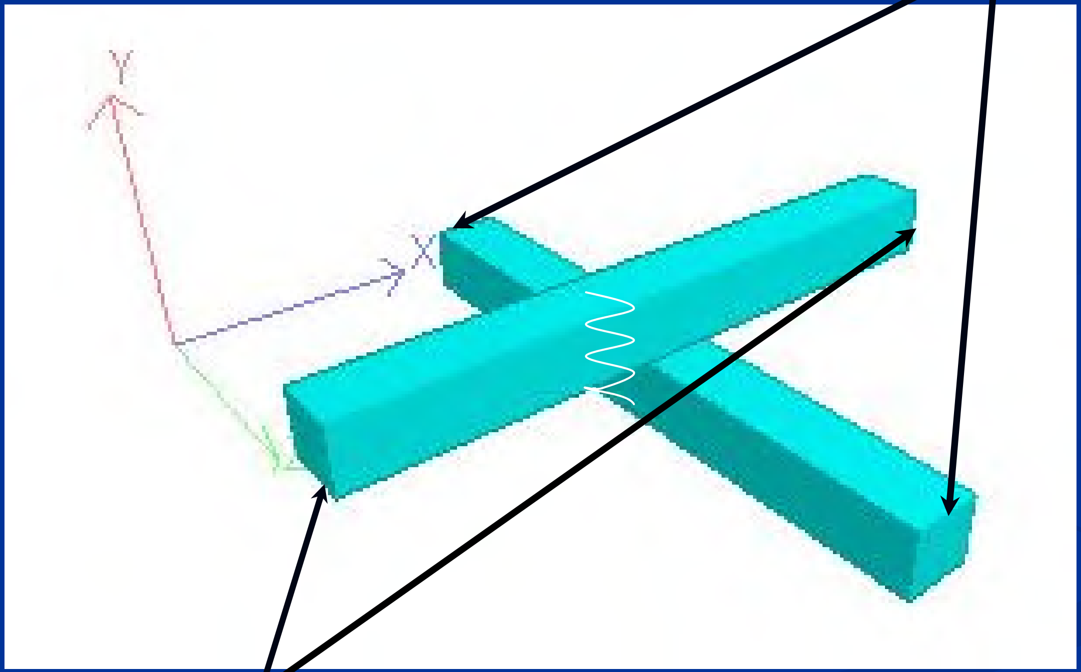


- Each layer has 30 members, 30' long
- Each member is divided into 30 segments
- Total nodes = 961
- Except boundaries, all intersecting nodes are connected with nonlinear springs
- Except boundaries, all nodes of lowest layer are connected to fixed supports with nonlinear springs

GTSTRUDL Model (Cont'd)

Force Y released

Moment X released

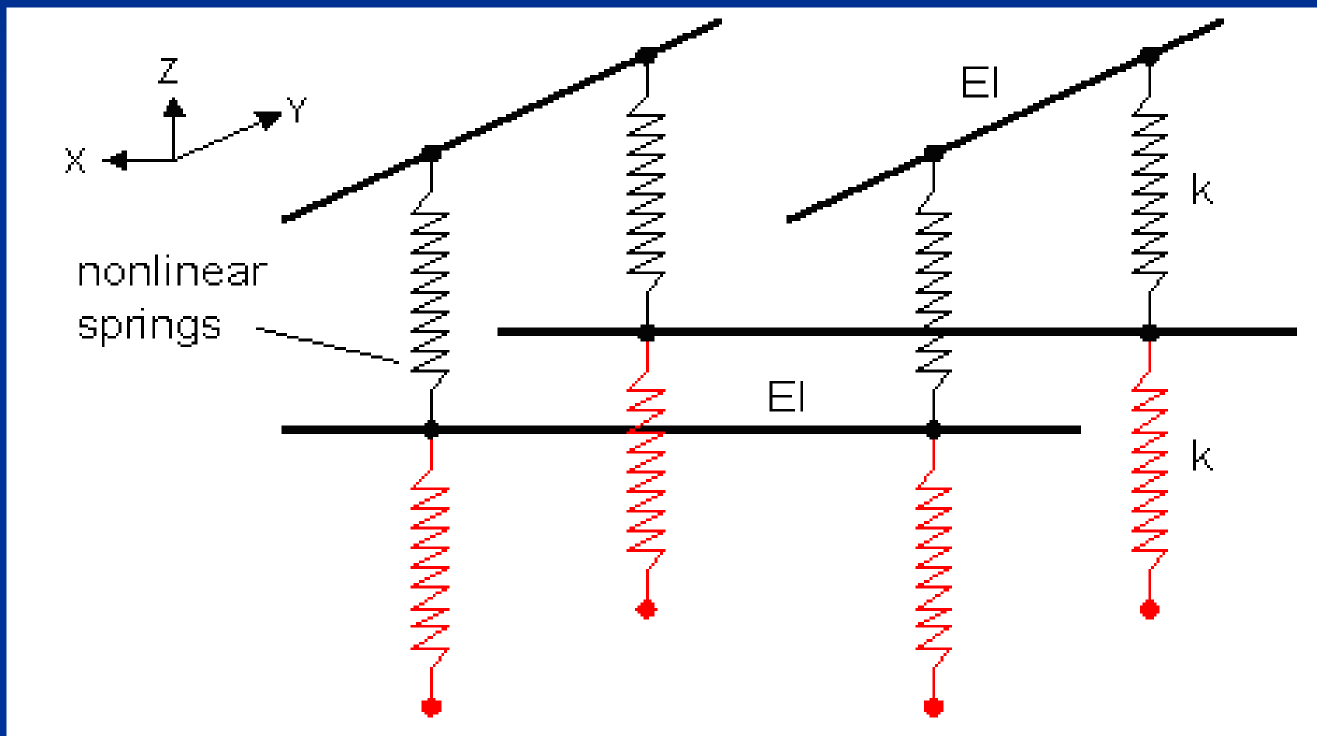


Force Y released

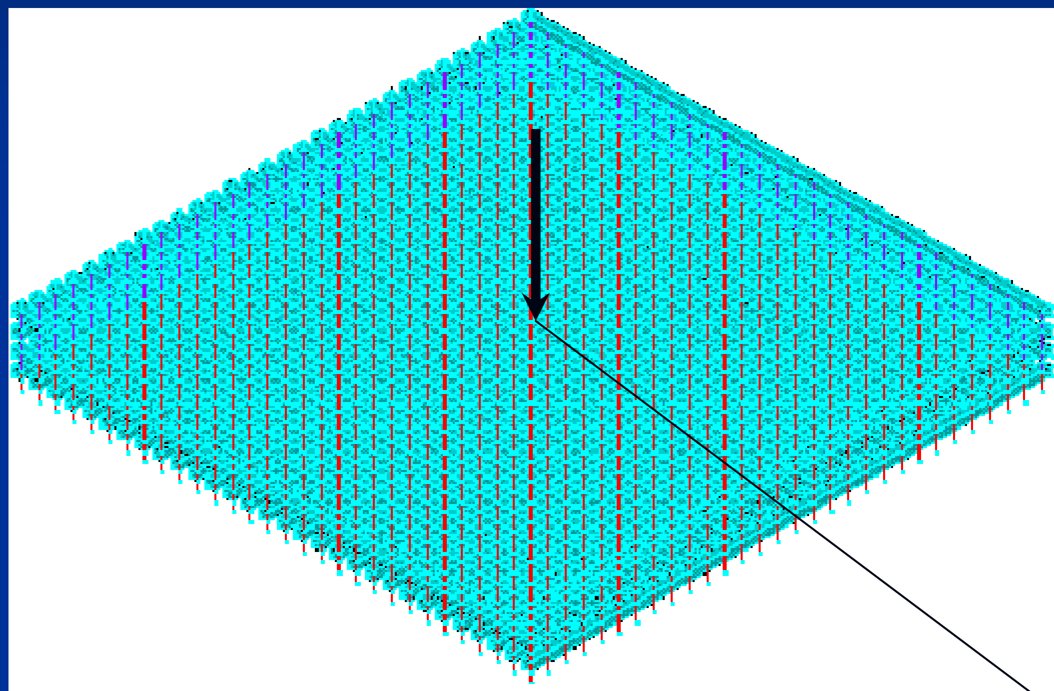
Moment Z released

Intersecting Points are connected with nonlinear springs

GTSTRUDL Model

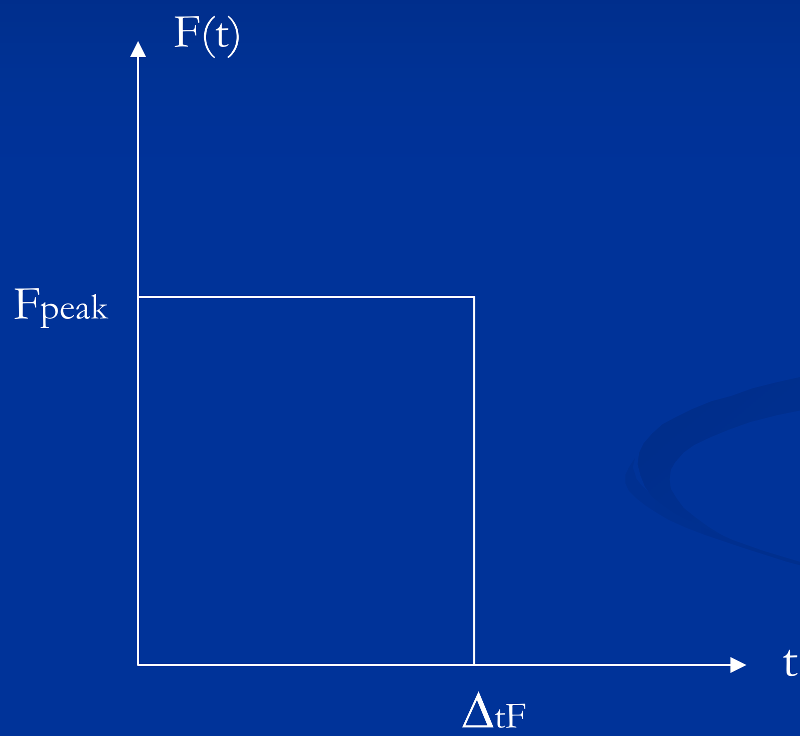


GTSTRUDL Model (Cont'd)



Point of impact (central node of lop layer)

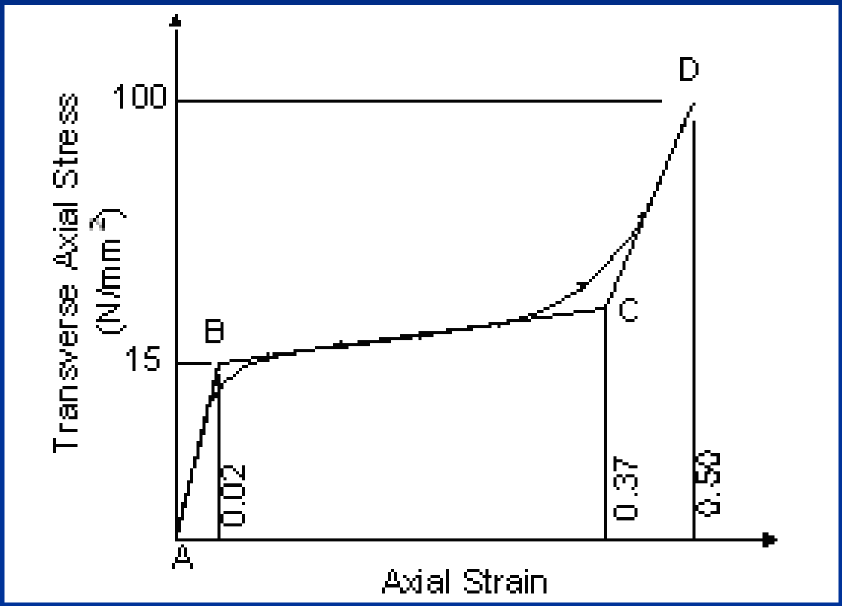
Applied Impulse Load

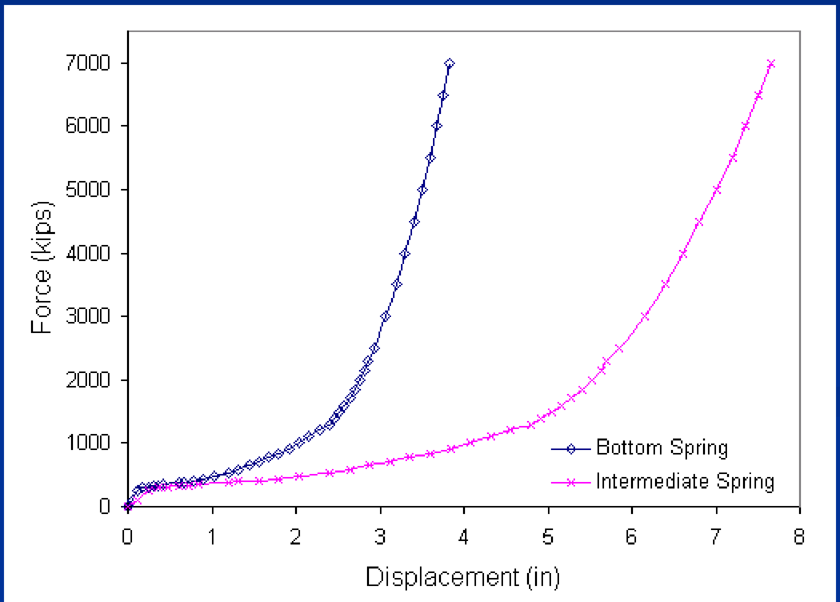


Δ_{tF} = 0.005, 0.01, 0.02

F_{peak} is chosen so that the point of impact (central node of the top layer) produces strain of 0.37 or 0.50

Nonlinear Spring Stiffness

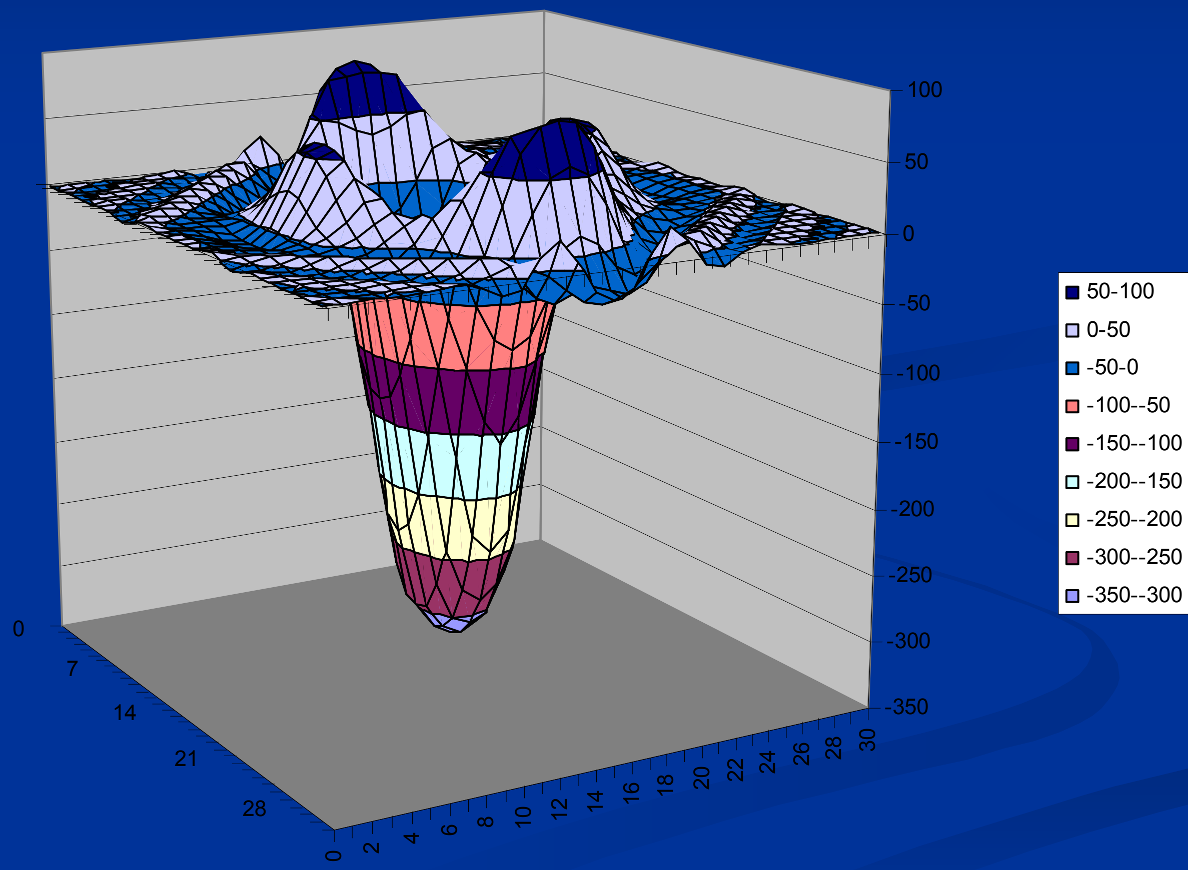




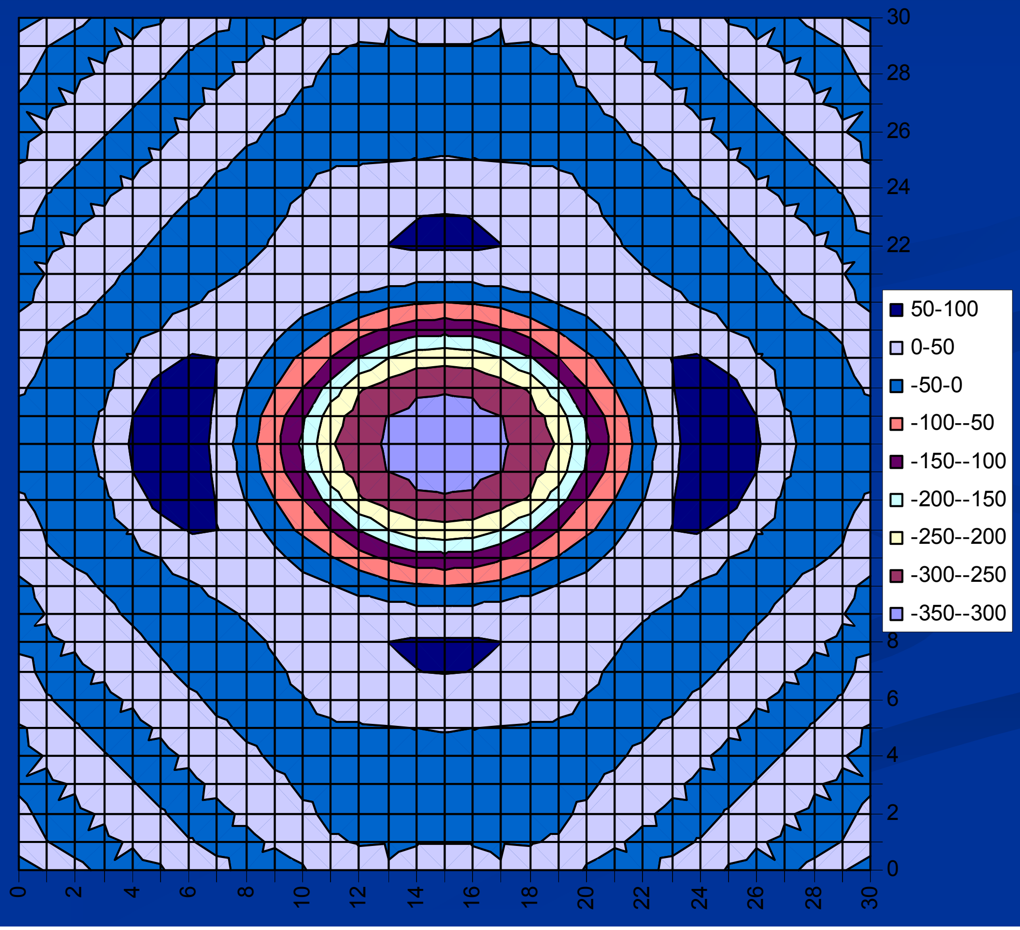
Transverse Axial Stress/Strain for White Oak [Reid and Peng (1997)]

Force/Displacement Calculated from Stress/Strain Relationship

Ground/Timber Mat Interface Pressure for 50% Strain at impact point: 5 Layers



Ground/Timber Mat Interface Pressure for 50% Strain at impact point: 5 Layers (Cont'd)



Response Summary

n	Δ_{tF} (sec)	ε_{peak}	F_{peak} (kips)	P_{peak} (kips)	F_{peak}/P_{peak}	Δ_{tP} (sec)	$R_{equiv} = \sqrt{\frac{\iint P(x,y)dxdy}{\pi P_{peak}}}$ (ft)
2	0.005	0.37	3000	359.53	8.34	2.650E-3	2.83
2	0.005	0.50	4850	664.45	7.30	2.330E-3	2.53
2	0.01	0.37	3000	359.53	8.34	2.650E-3	2.83
2	0.01	0.50	4850	664.48	7.30	2.330E-3	2.53
2	0.02	0.37	3000	359.51	8.34	2.660E-3	2.84
2	0.02	0.50	4850	664.49	7.30	2.320E-3	2.52

Response Summary (Cont'd)

n	Δt_F (sec)	ε_{peak}	F_{peak} (kips)	P_{peak} (kips)	F_{peak}/P_{peak}	Δt_P (sec)	$R_{equiv} = \sqrt{\frac{\iint P(x,y)\,dx\,dy}{\pi P_{peak}}}$ (ft)
3	0.005	0.37	3050	313.24	9.74	3.355E-3	3.36
3	0.005	0.50	4900	365.73	13.40	3.400E-3	3.99
3	0.01	0.37	3050	313.24	9.74	3.360E-3	3.36
3	0.01	0.50	4900	365.74	13.40	3.400E-3	3.99
3	0.02	0.37	3050	313.22	9.74	3.360E-3	3.36
3	0.02	0.50	4900	365.75	13.40	3.400E-3	3.99

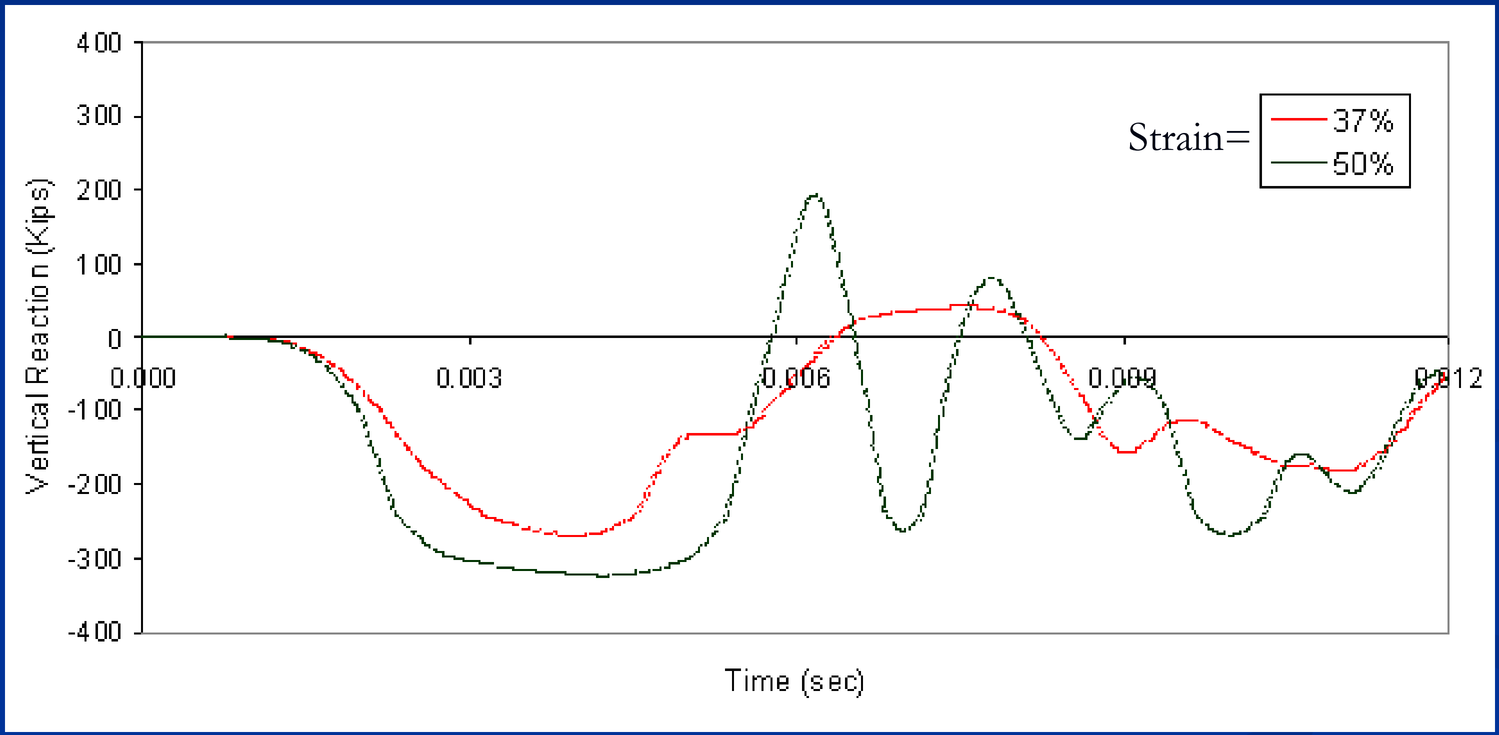
Response Summary (Cont'd)

n	ΔtF (sec)	ε_{peak}	F_{peak} (kips)	P_{peak} (kips)	F_{peak}/P_{peak}	ΔtP (sec)	$R_{equiv} = \sqrt{\frac{\iint P(x,y)\,dx\,dy}{\pi P_{peak}}}$ (ft)
4	0.005	0.37	3100	287.05	10.80	3.680E-3	3.65
4	0.005	0.50	5000	336.24	14.87	4.065E-3	4.41
4	0.01	0.37	3100	286.98	10.80	3.650E-3	3.65
4	0.01	0.50	5000	336.24	14.87	4.060E-3	4.41
4	0.02	0.37	3100	287.07	10.80	3.680E-3	3.65
4	0.02	0.50	5000	336.24	14.87	4.060E-3	4.41

Response Summary (Cont'd)

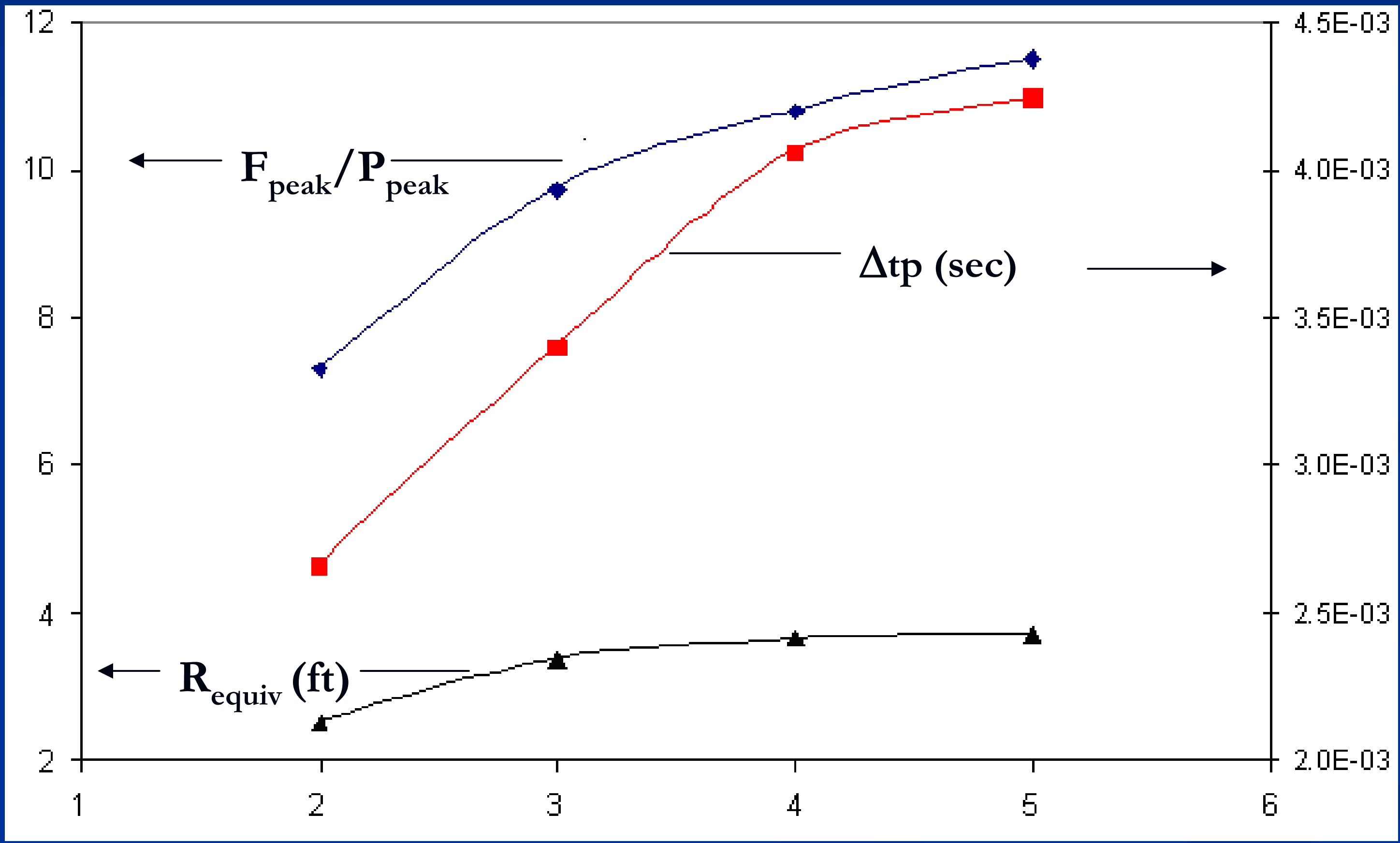
n	Δt_F (sec)	ε_{peak}	F_{peak} (kips)	P_{peak} (kips)	F_{peak}/P_{peak}	Δt_P (sec)	$R_{equiv} = \sqrt{\frac{\iint P(x,y)dxdy}{\pi P_{peak}}}$ (ft)
5	0.005	0.37	3100	269.50	11.51	3.955E-3	3.70
5	0.005	0.50	5090	323.57	15.73	4.230E-3	4.44
5	0.01	0.37	3125	269.28	11.61	3.960E-3	3.72
5	0.01	0.50	5090	323.57	15.73	4.230E-3	4.44
5	0.02	0.37	3125	269.24	11.61	3.960E-3	3.72
5	0.02	0.50	5090	323.58	15.73	4.240E-3	4.44

Typical Time History at Central Node of Ground Interface



For 5 Layers, Δ_{tF} =0.01 and strain at impact point

Transmissibility Relations



Thank You!