



**Blast Effects Design Analysis
Short Course jointly by:
Karagozian & Case (K&C) ,
The University of Western Australia**

**Engineering the United States
Air Force Memorial**



Global Features & Contributors

**India
Sandeep Sharma
Mahindara &
Mahindra**

**China
Honsheng Lu
Hengstar**



Announcements

In This Issue:

Course by Karagozian & Case:

December 1, 2009 for the Blast Effects Design and Analysis Course
Karagozian & Case & The University of Western Australia

New Participant:

Welcome a new participant from China:

Shanghai HengStar Technology – Dr. Hongsheng Lu

Software Coupled with LS-OPT:

ANSA, CAE Pre-Processor

BETA CAE Systems, S.A.

Sincerely,

FEA Information Inc.

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FEA Information Platinum Participants

OASYS Ltd: http://www.oasys-software.com/dyna/en/	JSOL Corporation: http://www.jri-sol.co.jp/english/cae	HP: http://www.hp.com/
ETA: http://www.eta.com	INTEL: http://www.intel.com	ESI Group: http://www.esi-group.com
BETA CAE Systems S.A.: http://www.beta-cae.com	APTEK: http://www.aptek.com	PANASAS: http://www.panasas.com
NEC: http://www.nec.com	Voltaire: http://www.voltaire.com	CRAY: http://www.cray.com
LSTC: http://www.lstc.com		



Course Announcement Blast Effects Design and Analysis

Karagozian & Case (K&C)

The University of Western Australia

Blast Effects Design / Analysis Short Course by K&C

Karagozian & Case (K&C) , The University of Western Australia and The University of Adelaide jointly offer a short course on “Blast Effects Design and Analysis” at the University of Adelaide on December 1 to 2, 2009.

Many K&C's designs for protective structures and systems that were developed through the high fidelity physics based (HFPB) analyses (most of them are LS-DYNA models) will be presented. The program is available at

John Crawford and Shengrui Lan of Karagozian & Case, among others, will be conducting the short two-day course on Blast Effects. The seminar will cover state of the art protective technologies and blast analysis and mitigation scenarios.

http://www.kcse.com/pdfs/BlastEffectsCourse_Australia.pdf.

Among the Course Program are the following:

Introduction:

- Overview: the state-of-the-arts in protective technology
- Protection plan and design for buildings
- Perimeter protection
- Mitigation of debris hazards
- Mitigation of progressive collapse of a building
- Mitigation of internal explosion

Blast loads & Engineering Tools

- Blast loads on structures
- Calculating tools for predicting blast effects
- PI-curves for components, range to effects curves for components
- Dynamic theory—lumped mass versus continuum models
- SDOF: shape function, resistance function, stiffness versus mass, ductility, algorithm
- UFC 3-340-02 / TM 5-1300 / P-397, dynamic increase factors, SDOF charts, P-I tools for predicting building response
- K&C and other design/assessment codes

Ground shock

- Overview, stress wave propagation
- Empirical formulae of stress wave attenuation, comparison and discussion
- Numerical simulation and field blast tests
- Rock mass damage to underground explosions
- Allowable vibration limits for underground structures, criteria for rock spall and explosion communication
- Safe separation distance of underground structures

Ground shock effects on structures

- Allowable vibration limits for above ground structures
- Response spectrum, damage criteria

- Dynamic structural response to high-frequency short duration blast ground motion
- Laboratory tests and numerical calculation
- Damage mechanism of RC Structures with or without masonry infill
- Mitigation

HFPB models, use and theory

- Continuum versus structural FEM modeling
- Formulations: CFD CSD, explicit, implicit, Lagrangian, Eulerian, etc.
- Material models for blast effects: concrete, steel, soil, polymers
- Advanced modeling: fracture, meshfree, adaptive, coupled
- Calculation/simulation examples

Registration is open until Mid November 2009.



FEATURED PAPER

Available On Line

New Design of Roadside Pole Structure: Crash Analysis of Different Longitudinal Tubes using LS-DYNA

<http://www.dynalook.com/european-conf-2009/B-VI-04.pdf>

New Design of Roadside Pole Structure: Crash Analysis of Different Longitudinal Tubes using LS-DYNA

This paper is an investigation into the design of an energy absorbing street pole, concerning the frontal impact of a vehicle. With design engineers now are looking at other ways to improve vehicle occupant safety by focusing on the advantages that can be achieved by improving the crashworthiness of street furniture. The study of axial crush behaviour of metal materials are investigated along with a number of variables such as cross-sectional shape, shell thickness, materials, as well as the velocity affects on tubes. Different simulations are carried out on the effects of bedded crumple initiators placed a various heights from the top of the tube, in determining the desired value of peak load reduction, along with the

effect in energy absorption of the tube. With the conclusion of the desired variables for the design of an energy absorbing tube, the tubes are placed 90 degrees to that of the base of the model street pole to modify the pole design . Simulation of frontal impact of a vehicle and street pole are analysed and compared to that of the energy absorbing street pole concept. Studies are carried out by numerical simulation via the explicit finite element code LS- DYAN. Results compare the absorbed energy and the deflection of each variable, and recommend optimum design for the pole structure which improved vehicle crashworthiness



OASYS Nhance ARUP

**Mahindra & Mahindra Ltd.,
Mumbai, India**

**Knee Bolster Development for Full Frontal Impact with Unbelted Occupant
Courtesy: Sandeep Sharma(Mahindra & Mahindra Ltd, Mumbai, India)**

In the case of full frontal crash with unbelted occupants there is danger of occupant knees impacting on lower portion of instrument panel and glove boxes. This may lead to severe injury in driver and passenger legs. Therefore it is needed to design knee impacting parts of vehicle to absorb the impact energy.

Occupant's knee impacting with the vehicle can be simulated through CAE to get the Force-displacement characteristics of the vehicle knee bolster. Area under this curve gives the energy absorbed and for the optimum performance it should be maximized although there are upper limits of knee force and displacement.

Fig 1 below shows dummy legs oriented in impacting position. Direction and magnitude of velocity at impact are calculated through a separate occupant dummy simulation with the actual test pulse.

Vehicle IP and Knee Bolster

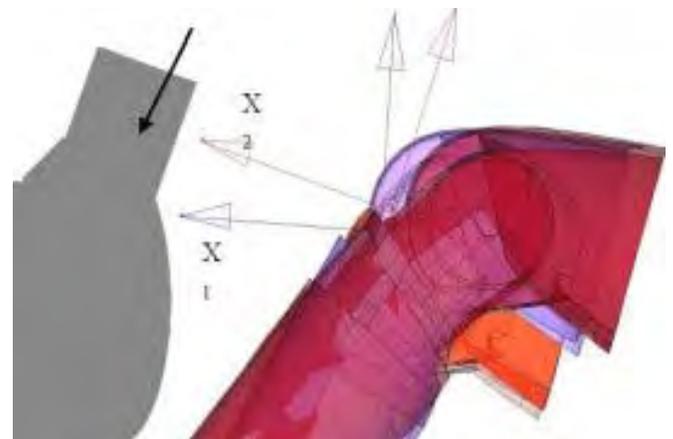


Fig 1 – Impact position of driver and co-driver legs

Driver legs and Passenger legs have different position at impact due to their initial position difference at rest. Local directions X1 and X2, shown in red and blue local coordinate systems are the direction for the velocity for the driver and passenger respectively.

Fig 2 below shows comparison of two Force-deflection curves obtained from CAE.

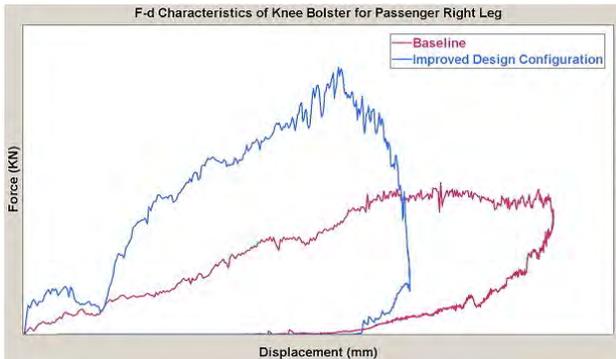
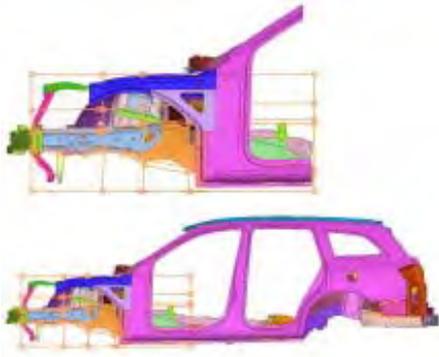


Fig 2 – Force Deflection Characteristics obtained through CAE Simulation

Baseline design curve has low energy absorption as the curve has less enclosed area whereas the curve with the improved design shows a fair amount of energy absorption. Peaks of the curves shows force at the knee joint which is a critical parameter for injury and should not be allowed very high for more and more energy absorption. Displacements of the knees are limited by the deployed airbags trying to keep the unbelted occupant on seating position during the impact.

For any further information on this topic, Kindly contact us at india.support@arup.com

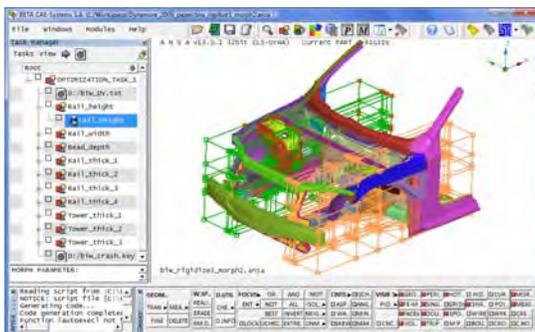


ANSA, LS-OPT, μ ETA: A complete software set for optimization

ANSA, the CAE pre-processor of BETA CAE Systems S.A., since its v12.1.3 is coupled with LS-OPT of LSTC. This highly efficient solution is already been successfully deployed in the Industry. Now, completing a full package for optimization applications, the latest release v6.4.0 of μ ETA post-processor of BETA CAE Systems SA provides a special User Toolbar, the OptimizerSetup, for the extraction of histories and responses from various solver's results. LS-OPT 4.0. of LSTC is able to control the μ ETA post-processing sequence and automatically recognize and use the histories and responses defined in μ ETA.

The ANSA Optimization Task

The Optimization Task is a special tool of ANSA that allows the user to set up the pre-processing of an optimization problem.



Simulation and animation

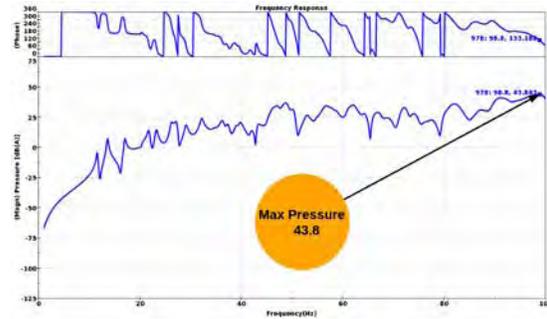
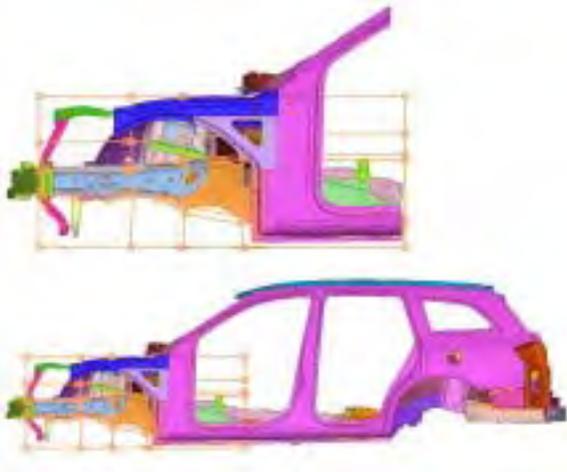
The Optimization Task provides a special tool to simulate and animate the model shape for different combinations of design variable values. Thus the user can check the model behavior before contacting the optimization with LS-OPT.

Model check and report

Full model report can be created for checking model validity. Element quality, mass report and measurements among specific positions could be extracted from the geometrical model. Moreover automatic model fixing can be performed during the optimization loops such as property thickness penetration.

Multi-disciplinary process set up

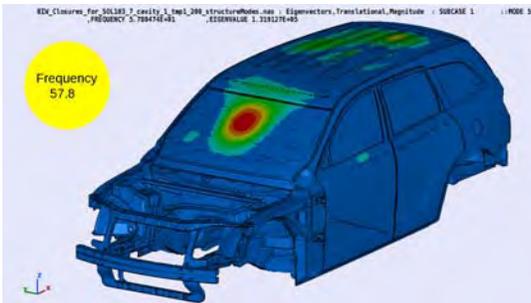
The Optimization Task is capable to handle multiple models that correspond to different analyses and load cases. Morphing is applied commonly to all models to perform identical model shape using a unique design variable file.



Coupling μ ETA to LS-OPT

μ ETA allows the extraction of responses and histories, real and complex, from data deriving from various solvers and prepares all needed files for the easy connection with LS-OPT.

Extracting responses using Annotations

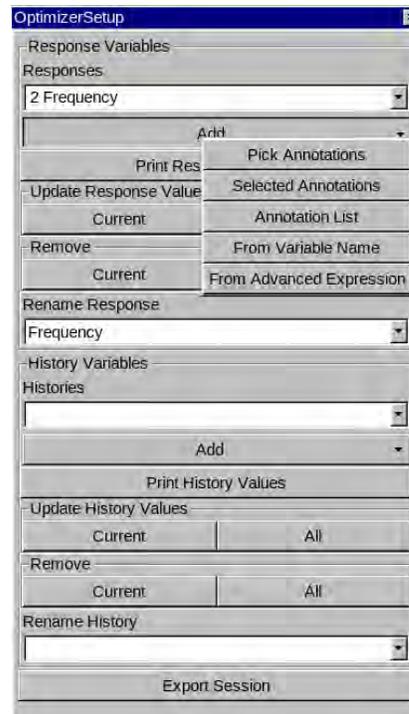


Responses can be defined using the runtime Annotations. This is a comprehensive tool for tracing results from the 3D models or 2D curves. Mathematical functions can also be applied to extract combined results.

Extracting histories using 2D-Plot Tool

For histories definition the 2D-Plot tool of μ ETA offers advanced functionality for handling real and complex history results such as applying filters and mathematical operations on curves, calculating Crash Analysis Criteria, associating curves with the 3D model and many more.

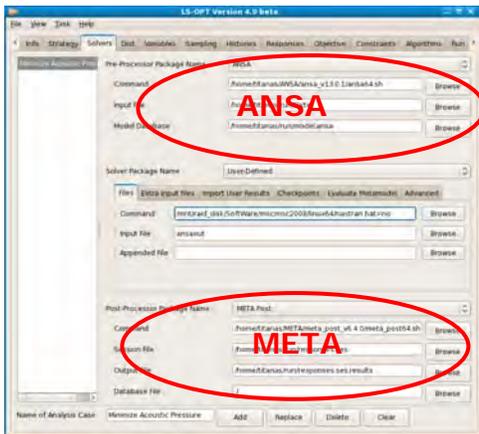
The OptimizerSetup Tool



The OptimizerSetup User Toolbar has been developed in μ ETA for the effortless extraction of responses and histories.

Responses and histories are stored in an ASCII file with a specific and simple format which is recognized by LS-OPT. All necessary actions that the user made in μ ETA until the response definition are recorded in a session file. Using this session file, LS-OPT can reproduce the response extraction for every optimization iterations.

LS-OPT responses TAB

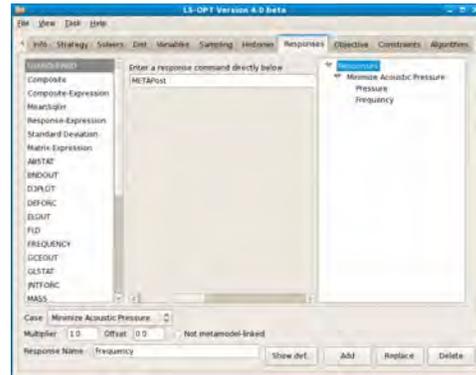


LS-OPT provides a direct coupling to ANSA and μ ETA without the need for any scripting or customization. At the Solver Tab of LS-OPT, the user can define the pre- and post- processing sequence that will run in batch mode for each iteration.

For more information contact

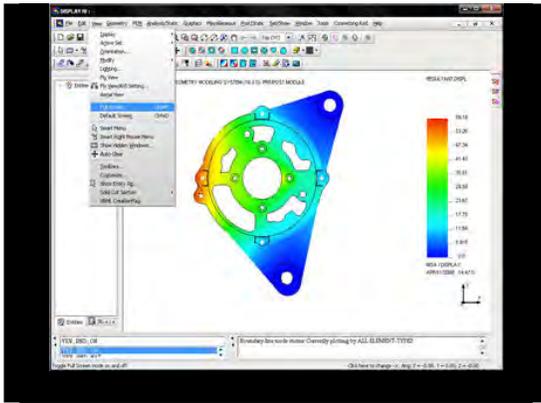
BETA CAE Systems S.A. at: ansa@beta-cae.gr

The design variables, defined in ANSA, are imported in LS-OPT and listed at the Variables tab. In the same way histories and responses defined in μ ETA are recognized automatically and listed in the relative LS-OPT tabs. Hence, there is no need of redefining them in LS-OPT.



Benefits

The combined set of ANSA, LS-OPT and μ ETA offers a complete solution for optimization applications. Seamless integration of the above software provides an efficient problem set-up without the need of any scripting or customization. Since μ ETA can extract responses and histories from numerous solvers, LS-OPT becomes capable for multidisciplinary / multi solver optimization.



India News

Cranes Software Releases the Latest Version of its FEA software suite

NISA V17 Comes with an Enhanced DISPLAY IV & Improved CAD Interoperability

Cranes Software announced the release of the latest version of its leading Finite Element Analysis software, NISA Version 17, today. This significantly improved version offers an enhanced DISPLAY IV, NISA's powerful interactive graphics Pre and Post-processor. The new DISPLAY software streamlines complex finite element modeling, analysis and results interpretation for a better user experience. Additionally, the new DISPLAY has improved interoperability allowing it to interface more easily with a variety of popular CAD file formats.

A major enhancement in DISPLAY IV is the new advanced tetra-meshing capability, allowing users to easily create solid mesh models with minimal effort. New context-based menus and toolbars have been added along with functional keys for quick and easy access to all options. Additionally, contact-element creation based on user-defined tolerances has been added. To enable users to generate reports in HTML with ease, report generation capabilities have been added in the Pre and Post-processing steps.

NISA Version 17 now allows users the ability to create more complex and

detailed models by extending node and element numbers to eight digits allowing much larger problems to be solved. The advanced NISA solvers have also undergone significant improvements. For example, Augmented Lagrangian formulation for surface to surface contact-element has been added. Fatigue analysis of spot-welds is now supported in ENDURE, NISA's fatigue and fracture module. HEAT III, NISA's heat transfer module is now incorporated in EMAG, the electromagnetic module of NISA, to allow coupled electromagnetic and heat transfer analysis. Another significant development in NISA Version 17 is its integration with Engineering Technology Associates' (www.eta.com) software product eta/VPG, an advanced FEA-based system analysis tool.

Mechanical Applications:

- DISPLAY
Pre-Post Processor
- NISA II STATIC / DYNAMIC
Linear/Non-Linear Analyzer
- COMPOSITE
Composite Materials Analysis
- ENDURE
Fatigue & Fracture Mechanics
- OPT

Structural/Shape/Sectional Optimization

- HEAT
Heat Transfer Analysis
- 3D FLUID
Computational Fluid Dynamics
- FEAP
Printed Circuit Board Analysis
- EMAG
Electromagnetic Analysis
- ROTOR
Rotor Dynamics
- DYMES
Multi-Body Mechanical System Analysis
- 3D CAD
CAD / FE Translators

Civil Applications

NISA/CIVIL is a truly integrated & versatile structural engineering software which offers

Structural Engineers a powerful CAD based tool for the Analysis, Design & Detailing of RCC & Steel structures like Buildings, Bridges, Shells, Towers, Irrigation Structures & Water Containment Structures. The software is available in an 8333 nodes & un-limited nodes version. It has excellent reporting and graphing features and automatically generates detailed AutoCAD™ drawings.

NISA DesignStudio (NDS) is a derivative of NISA/CIVIL and is specifically designed for Structural Engineers & Architects who predominantly Analyze & Design RCC & Steel Buildings. Allowing one to design Office Buildings, Apartment Complexes & Industrial Enclosures with up to 3333 nodes, NDS is extremely easy to learn and use. The software has excellent reporting and graphing features and automatically generates detailed AutoCAD™ drawings.

Contact:

Vipul Kinariwala
Phone: (248) 689-0077 x314
Website: <http://www.nisasoftware.com>
Email: sales@nisasoftware.com



Engineering the U.S. Air Force Memorial, Washington DC

Engineering the United States Air Force Memorial, Washington DC

Graphic's clarity can be viewed at:

http://www.oasys-software.com/information/case_studies/air_force_memorial.shtml

"Building this Memorial took a lot of talent and creativity and determination. Like the aircraft whose flight it represents, this Memorial is an incredible feat of engineering"

President George W Bush
Perched high atop a natural ridge overlooking the Pentagon and adjacent to Arlington National Cemetery in Washington DC, the Air Force Memorial evokes the spirit of flight as its three glimmering stainless steel spires appear to soar to the heavens. Designed by the late James Ingo Freed of Pei Cobb Freed & Partners and engineered by Arup, the Memorial was inspired by the US Air Force Thunderbird F-16 fighter jets' "bomb burst" flight maneuver.

Structural Form

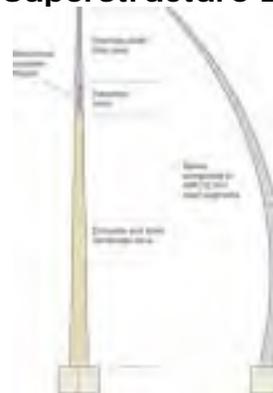
Limited by the maximum height restrictions mandated by the Federal Aviation Authority due to the Memorial's close proximity to Reagan National Airport, the spires vary in height from 270ft (82.3m) to 200ft (61m) - the tallest is only 13ft 9in (4.19m) wide at its base.

The geometry of the tallest spire derives from the intersection of a horizontally-orientated cylinder (which forms the spire's back surface) and two horizontally-orientated and intersecting cones that oppose each other (the intersection of which forms the spire's leading edge). The

resulting shape is a curved spire whose triangular section tapers towards its tip. Each of the two smaller spires is formed by the successive rotation of the tallest about its conical axis by specified angles.

The three spires are founded on a common triangular grade beam bearing on groups of caissons. This system ensures monolithic behaviour of the structure under lateral loads.

Superstructure Design



The curving, tapering shape of the spires is formed by bending and welding 3/4in (19mm) stainless steel plates into the tapering triangular shape. As two faces of each spire are sculpted along conical surfaces, these surfaces are in fact warped out of plane, creating an added degree of complexity to the nuanced form.

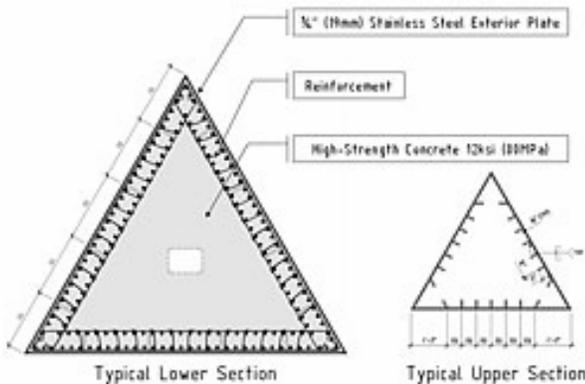
The spires were fabricated off-site in 40ft (12.2m) segments. In the lower two-thirds of the each spire, the segments are

filled with high-strength (12ksi / 80MPa) reinforced concrete for increased stiffness. Above the concrete zone, there is a transition zone with concrete piers, or "fingers", located in the corners. Dampers were included in this section to reduce the spires' susceptibility to galloping wind excitations. Above this the segments transition to hollow stainless steel with internal stiffeners.

At every turn during the design process, the engineers were challenged to make the spires ever more slender. Conscious that every inch shaved from their profiles served to push the monument ever nearer the precipice of instability, the Arup team was nonetheless able to demonstrate through advanced non-linear structural analysis, dynamic computation, rigorous laboratory testing, and ultimately field testing that the intended slenderness was in fact achievable.

Structural Analysis

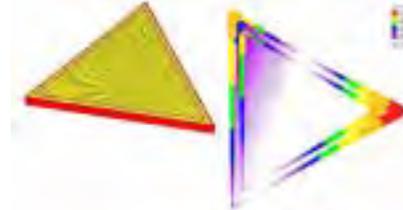
The spires' curved shape makes them tend to flex and slightly compress under their own self weight, stresses that are exacerbated at times by wind loads. When the bending stresses exceed the axial compressive stresses, the internal concrete cracks slightly. The orientation and degree of this cracking directly impacts the spires' effective stiffness along their height.



The magnitude of dynamic wind load the structure experiences is a direct function of its natural frequency, which is proportional to its mass and stiffness.

Since the shape and materials of each spire establish its mass, the wind loads are a function of its stiffness.

The spire's stiffness is a function of the degree of cracking within the internal reinforced concrete, which in turn is influenced by the total effective wind load imposed on the structure. A degree of iteration was therefore required to properly assess the true structural response of the spires to wind load.



The iterative analytical procedure was thus to:

1. create a GSA analytical model of the whole spire based on the assumed cracked cross-sectional stiffness at discrete segments along the height
2. compute the spire's natural frequency based on the assumed cross-sectional stiffness
3. calculate the anticipated magnitude of wind pressure acting on the spire as a function of the spire's assumed natural frequency
4. apply the wind pressure to the GSA stick model and obtain internal axial and flexural forces at discrete segments along the spire's height
5. perform non-linear computational structural analyses on GSA 3D cross-sectional models of each spire segment (comprising of concrete struts and steel bars), applying the axial and flexural forces determined in (4) to each segment in turn; using first principles of structural mechanics and Euclidean geometry, determine the effective bending stiffness of each cross-section under each wind load case

6. modify the analytical stick model with the revised cracked cross-sectional stiffnesses
7. repeat from (2) until the process converges on the calculated spire natural frequency, wind load, and resulting internal stiffness.

Regarding the 3D cross-sectional model analysis, Project Manager Patrick McCafferty said "I wish that we had AdSec at the time. It would have made our lives a lot easier".

This procedure was repeated to determine the internal forces acting on all three spires. Once identified, these forces were then used to size and detail all aspects of the spires, including final skin thickness, internal reinforcement quantities, and anchor bolts.



Conclusion

The simple elegance of the Air Force Memorial belies the complex engineering mechanics that describe its behaviour and response to the environment. The intended aesthetic of the monument was preserved through the combination of advanced structural analysis applied to an innovative solution of custom-designed passive impact dampers. In so doing, the architect's vision of a soaring memorial to the United States Air Force was achieved

<http://www.airforcememorial.org>



Thailand – Singapore - Malaysia

by Kanda Chusook-Sims

Thailand News:

With the introduction of LSTC's no-cost 30-day demonstration license in Thailand, it has afforded many consultants, universities, professors and engineering companies the use of full version LS-DYNA, LS-PrePost, LS-OPT, LSTC Dummy and Barrier Models with technical assistance from LSTC.

Additionally, we are introducing into Thailand the LS-DYNA Learning Version. This version is the full version of LS-DYNA, but is restricted in elements to 10,000. The capabilities are not restricted. We have found this is an excellent way to learn LS-DYNA. It includes LSTC's software products: LS-DYNA, LS-PrePost, LS-OPT, LSTC Dummy and Barrier Models. To keep this limited learning version affordable technical support is limited.

If you would like the 30-day demo please write to me at noi@lstc.com. Additionally, I will be pleased to discuss the LS-DYNA learning version and how to assist your company/university to purchase the LS-DYNA suite of products.

I will be visiting Thailand in October and hope to visit one or two Universities to introduce LS-DYNA material.

About Noi

Kanda Chusook-Sims (Noi) graduated from Chiang Mai University, with a degree in Political Science and Public Administration. Currently employed by LSTC and located in Livermore, CA., You can reach her at noi@lstc.com with your interests and questions on LS-DYNA.

EVENTS in Thailand:

Events (if you have an event you would like posted please send it to me)

ICT & Knowledge Engineering Dec 1-3 2009 – Siam Univ. Bangkok Thailand
<http://ict-ke2009.siam.edu/index.php/ICT-KE2009/ICT-KE2009>

International Conference On Applied Mechanics And Mechanical Engineering 2009

ICHPC 2010 : "International Conference on High Performance Computing"

<http://www.waset.org/conferences/2010/bangkok/ichpc/>
Bangkok, Thailand - December 29-31, 2010



Educational Global Connections

Graphics can be located with the full article at:

http://www.feapublications.com/news_featured_2009/gilat.pdf

Mechanics of Materials Lab at the Ohio State University

Professor Amos Gilat - (614) 292-1269 gilat.1@osu.edu

The Mechanics of Materials Lab deals with the study of the deformation and failure of materials over a wide range of strain rates (with emphasis on high rates) at various temperatures and loading conditions. The lab at the is equipped with state of the art testing machines and instrumentation for mechanical testing of materials in compression, tension, and shear loadings at strain rate ranging from 0.0001 to 5,000 s⁻¹ and temperatures from -150 to 1000 C. Quasi-static tests (strain rate up to 2 s⁻¹) are done with an hydraulic axial/torsional machine. High strain rate tests (strain rates from 400 to 5000 s⁻¹) are done by using the Split Hopkinson Bar (SHB) technique. Intermediate strain rate tests (strain rates from 5 to 200 s⁻¹) are done with a new testing machine that provides accurate results (no ringing).

In addition to the standard methods for measuring forces (moments) and deformations (strains), the Lab has two commercial Digital Image Correlation (DIC) systems that are used for measuring the full-field strain distribution

on the specimen's surface as a function of time during most of the experiments (INCLUDING HIGH STRAIN RATE TESTS). DIC measurements provide accurate description of the state of stress and strain in the specimen, and especially the local failure strain at the location where the specimen breaks.

During the past 27 years the lab has been used for characterizing the deformation and failure of metals, polymers, ceramics, composites, foams, cloths, and other materials in numerous government and industrial projects. Often, the data is used for developing accurate constitutive equations for plasticity (viscoplasticity) and failure models that are implemented in numerical codes such as LS Dyna.

Data during testing is recorded with state of the art electronic digital data acquisition systems. Deliverables from each test are raw data records (loads cell, displacement, strain, temperature, etc.), and processed data (e.g. stress-strain curve from a SHB test). All results are

provided in plots and in digital form (Excel spread sheets) such that they can be incorporated into the numerical codes.

An example of current project is the development of Mat224 in LS-Dyna in which over 300 experiments have been conducted on specimens (all machined from the same 2024 aluminum plate) loaded with a wide range of stress states. These experiments included uniaxial tension and compression, and pure shear, all at various strain rates ranging from 0.0001 to 5000 s^{-1} . Tensile tests of flat and round notched (various size notches) specimens. Plane strain tests of wide flat and notched (various size notches) specimens. Combined biaxial tension-torsion of tubular specimens. Dynamic and quasi-static punch tests of thin-flat plates with punches of different geometries. Uniaxial tension and compression, and pure shear tests at constant strain rate and various temperatures ranging from -50°C to 450°C .

Description of Testing Equipment and Instrumentation

Compression Split Hopkinson Bar: Two compression SHB machines with bars made of titanium 6AL-4V are available. One is made of 0.5 in. diameter bars for testing small specimens made of homogeneous materials. The other is made of 2 in. diameter bars for testing larger-size specimens made of non-homogeneous materials like woven composites and concrete. The incident and transmitter bars are 6 ft. and 6 ft. long, respectively. The loading wave is generated by impacting a projectile bar on the incident bar.

Tensile Split Hopkinson Bar: The apparatus is made of 0.5 in. diameter 7075-T6 aluminum bars. The incident and transmitter bars are 12 ft. and 5.5 ft. long, respectively. The loading wave is generated by the release of a tensile load that is initially stored in half of the incident bar. The waves during a test are measured at two locations on the incident bar, and in one location on the transmitter bar. The specimens (small dog-bone shape) are either glued to the bars, or are attached mechanically with a special fixture.

Torsional split Hopkinson bar: The apparatus is made of 0.875 in. diameter 7075-T6 aluminum bars. The incident and transmitter bars are 12 ft. and 7 ft. long, respectively. The loading wave is generated by the release of a torque that is initially stored in half of the incident bar. The waves during a test are measured at two locations on the incident bar, and in one location on the transmitter bar. The specimens (spool shape) are glued to the bars.

Instron axial-torsion hydraulic machine: Model 1321 machine with capacity of axial force of 20,000 lb and 10,000 lb-in torque. Loads (axial force, and torque) are measured with the load cell of the machine. Axial strain is measured with a Epsilon 3442-004M-050-HT1 extensometer. Shear strain is measured with a special rotational "extensometer". The displacement (and/or rotation) of the actuator is also recorded. The machine is controlled with a MTS Flex Test SE controller. The controller is also used for recording the data. A variety of clamps for mounting specimens are available.

Intermediate strain rate machine:

Custom built apparatus for testing materials in compression at strain rates ranging from 5 s^{-1} to 200 s^{-1} . The machine is a combination of a fast hydraulic actuator and a very long transmitter bar. The actuator applies the load to the specimen that is mounted on the transmitter bar, which acts as a load cell.

Digital Image Correlation (DIC) system:

Two commercial DIC systems (Correlated Solutions) for measuring full-field displacements and strains on the surface of the specimens are available. The systems include two cameras each, all necessary optics, and software for analyzing the recorded images. One system is for quasi-static tests with cameras that can record up to 30 frames per second. The other system is for

dynamic tests with Photron SA1 cameras that can record up to 150,000 frames per second.

Data acquisition in a SHB test: The waves in the bars are measured with strain gages that are connected in a Wheatstone bridge circuit. Each circuit is supplied with a separate floating 20 V source. The output from each bridge is feed into a Tektronix ADA400A differential amplifier. The output from the differential amplifiers is connected to a 4-channels Tektronix TDS 5034B digital oscilloscope. The wave signals are recorded at a rate of 2.5×10^6 samples per second (a point every $0.4 \text{ } \mu\text{s}$). The stress, strain, and strain rate in the specimens are determined from the recorded waves by applying the standard SHB analysis. The analysis is done with MATLAB.

Graphics can be located with the full article at:

http://www.feapublications.com/news_featured_2009/gilat.pdf



China New Business

Shanghai HengStar Technology
Dr. Hongsheng Lu

LS-DYNA Consulting & Training

Newly established in Shanghai, HengStar Technology's corporate vision is technical excellence in customer support, training, consulting, and to be a full service company dedicated to LS-DYNA in China industry. July 2009, Dr. Hongsheng Lu returned to China. One of his goals is establishing a way to assist LS-DYNA users through his training courses, technical support, technical consulting and solutions.

Dr. Lu's main focus, returning to China and establishing Shanghai HengStar Technology, Ltd. (www.hengstar.com), is to assist engineers to effectively use LS-DYNA to improve automobile design, especially in crashworthiness simulation and passive safety.

"Crashworthiness Simulation using LS-DYNA"

To assist engineers with the current knowledge and training, Dr. Lu has scheduled a training course "Crashworthiness Simulation using LS-DYNA" taught by Paul A. Du Bois. This class will be held at Green Garden Hotel in Shanghai on October 21st -24th, 2009. It will be a learning experience and a chance to exchange ideas with other engineers and Paul A. Du Bois.

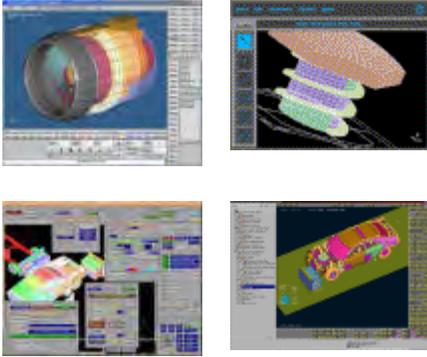
Dr. Hongsheng Lu personally brings to the engineering community a background in

LS-DYNA from LS-DYNA headquarters, LSTC, located in Livermore, CA, where from 2004-2009 he worked as a senior scientist on such projects as developing and implementing EFG in LS-DYNA. Additionally he worked on several projects with automobile companies to improve automobile design by using and implementing the new features of LS-DYNA.

With his main goal of LS-DYNA use in China, feel free to contact Dr. Lu for an LS-DYNA Demo license that includes LS-DYNA, LS-OPT, LS-PrePost, LSTC Dummy and Barrier Models. LSTC's pricing includes all LSTC's software in one pricing: LS-DYNA, LS-OPT, LS-PrePost, LSTC Dummy and Barrier Models. Contact Dr. Lu for pricing, training, consulting information.

About Dr. Lu

Dr. Lu received his bachelor and master degree in mechanical engineering from Jilin University of Technology, and he worked as an engineer in China Academy of Machinery Science and Technology from 1993 to 1997. Dr. Lu got his Ph. D. from the department of mechanical engineering, The University of Iowa, and then he worked as a post doctor in Northwestern University from 2002 to 2004.



Pre Processing

Post Processing

Model Editing

A preprocessor is a program that processes its input data to produce output. This data is then used as input to another program.

BETA CAE Systems S.A.

<http://www.beta-cae.gr/>

Provides complete CAE pre- and post-processing solutions. ANSA, the world wide standard pre-processor and full product modeler for LS-DYNA, with integrated Data Management and Task Automation. μ ETA, a thriving innovative software with special features for the high performance and effortless 3D & 2D post-processing of LS-DYNA results.

Engineering Technology Associates, Inc.

<http://www.eta.com>

FEMB - Engineering Technology Associates' Finite Element Model Builder (FEMB) is a finite element pre- and post-processor for use with all major analysis codes and CAD Software.

Oasys, Ltd

<http://www.oasys-software.com/dyna/en/>

Oasys Primer is a model editor for preparation of LS-DYNA input decks. - Oasys D3Plot is a 3D visualization package for post-processing LS-DYNA analyses using OpenGL® (SGI) graphics.

JSOL Corporation

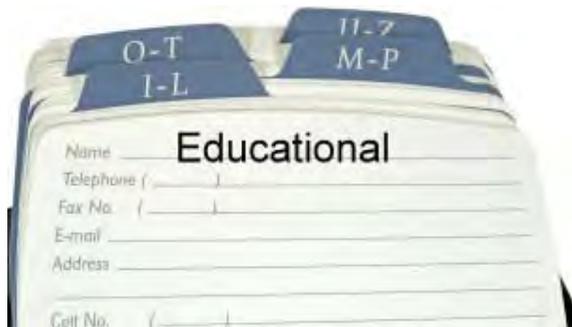
<http://www.jri-sol.co.jp/english/cae/>

JVISION is a general purpose pre-post processor for FEM software. Designed to prepare data for, as well as support, various types of analyses, and to facilitate the display of the subsequent results.

Livermore Software Technology Corporation

<http://www.lstc.com>

LS-PrePost is an advanced interactive program for preparing input data for LS-DYNA and processing the results from LS-DYNA analyses.



Educational Community

Global Connections

China

Tsinghua University

Dr. Qing Zhou

India

Indian Institute of Science

Dr. Anindya Deb

Italy

Prode – Elasis & Univ. of Napoli, Frederico II

Prof. Gennaro Monacelli

Russia

St. Petersburg State Tech. University

Dr. Alexey I. Borovkov

Turkey

Bogazici University

Dr. Sami Kilic

USA

Northwestern University

Dr. Ted Belytschko

Univ. of California – San Diego

Dr. David Benson

Ohio University

Dr. Bhavin V. Mehta

The Ohio State U – ERC/NSM

Dr. Taylan Altan

University of Cincinnati

Dr. Ala Tabiei

University of Nebraska

Prof. John D. Reid

Connecticut State University

Prof. Thomas Vasko



LS-DYNA Distributors

LS-DYNA® Solution Package
One Fee All Inclusive
LS-PrePost® - LS-OPT®
LSTC Dummy Models
LSTC Barrier Models

Alpha order by Country

Australia	Leading Eng. Analysis Providers - LEAP http://www.leapaust.com.au/ info@leapaust.com.au
CANADA	Corp. - MFAC http://www.mfac.com/ galb@mfac.com
CHINA	OASYS Ltd. (software house of Arup) http://www.oasys-software.com/dyna/en stephen.zhao@arup.com
FRANCE	ALYOTECH TECH. http://www.alyotech.fr nima.edjitemai@alyotech.fr
FRANCE	ALLIANCE SVCE. PLUS - AS+ http://www.asplus.fr/ls-dyna v.lapoujade@asplus.fr
GERMANY	CADFEM http://www.cadfem.de/en lsdyna@cadfem.de
GERMANY	DYNAmore http://www.dynamore.de/ uli.franz@dynamore.de
INDIA	OASYS Ltd. (software house of Arup) http://www.oasys-software.com/dyna/en lavendra.singh@arup.com
INDIA	EASi Engineering http://www.easi.com/ rvenkate@easi.com

INDIA	CADFEM Eng. Svce India http://www.cadfem.in/ info@cadfem.in
Italy	EnginSoft SpA http://www.enginsoft.it/ info@enginsoft.it
Italy	DYNAmore http://www.dynamore.de/ uli.franz@dynamore.de
JAPAN	JSOL Corporation http://www.jri-sol.co.jp/english/cae cae-info@sci.jri-sol.co.jp
JAPAN	ITOCHU Techno-Solutions Corp. http://www.engineering-eye.com/ ls-dyna@ctc-g.co.jp
JAPAN	FUJITSU http://jp.fujitsu.com/solutions/hpc/app/lsdyna/
KOREA	Theme Engineering http://www.lsdyna.co.kr/ wschung@kornet.com
KOREA	Korean Simulation Tech. http://www.kostech.co.kr young@kostech.co.kr
Netherlands	Infinite Simulation Systems, BV http://www.infinite.nl/ j.mathjissen@infinite.nl
SWEDEN	Engineering Research AB http://www.erab.se/ sales@erab.se
TAIWAN	Flotrend Corporation http://www.flotrend.com.tw/ gary@flotrend.tw
RUSSIA	State Unitary Enterprise -STRELA info@ls-dynarussia.com

United Kingdom	<p>OVE ARUP & PARTNERS</p> <p>http://www.oasys-software.com/dyna/en/ dyna.sales@arup.com</p>
USA	<p>Livermore Software Tech. Corp. - LSTC</p> <p>http://www.lstc.com/ sales@lstc.com</p>
USA	<p>Engineering Tech. Assc. Inc. - ETA</p> <p>http://www.eta.com/ sales@eta.com</p>
USA	<p>DYNAMAX</p> <p>http://www.dynamax-inc.com/ sales@dynamax-inc.com</p>



Finite Element Analysis (FEA) Consulting & Engineering Service

FEA consultants use a wide range of software simulation programs for controlling the modeling and analysis of structures, systems, products and many other applications. Used by government, homeland security, court trials, and many other industries.

North America

<p>Karagozian & Case (K & C) http://www.kcse.com Shangrui Lan (818) 303-1268</p>	<p>CAE Associates http://www.caeai.com</p>	<p>Schwer Engineering & Consulting Services http://schwer.net Len Schwer (707) 837-0559</p>
<p>KBEC Khan Bui (512) 363-2739</p>	<p>Predictive Engineering http://www.predictiveengineering.com George Laird (800) 345-4671</p>	

EU – Pacific Rim

<p>AU LEAP http://www.leapaust.com Greg Horner 02 8966 7888</p>	<p>UK ARUP http://www.oasys-software.com/dyna/en/ Brian Walker 44 (0) 1212 133317</p>	<p>UK Dutton Simulation http://www.duttonsimulation.com Trevor Dutton 44 (0) 1926 732147</p>
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Software & Hardware Alliances

Software Solutions

SMP/MPP Hardware & OS

MPP & Interconnect MPI

ETA – DYNAFORM

<http://www.eta.com>

Includes a complete CAD interface capable of importing, modeling and analyzing, any die design. Available for PC, LINUX and UNIX, DYNAFORM couples affordable software with today's high-end, low-cost hardware for a complete and affordable metal forming solution.

ETA – VPG

<http://www.eta.com>

Streamlined CAE software package provides an event-based simulation solution of nonlinear, dynamic problems. eta/VPG's single software package overcomes the limitations of existing CAE analysis methods. It is designed to analyze the behavior of mechanical and structural systems as simple as linkages, and as complex as full vehicles.

OASYS software for LS-DYNA

<http://www.oasys-software.com/dyna/en/>

Oasys software is custom-written for 100% compatibility with LS-DYNA. Oasys PRIMER offers model creation, editing and error removal, together with many specialist functions for rapid

generation of error-free models. Oasys also offers post-processing software for in-depth analysis of results and automatic report generation.

ESI Group Visual-CRASH For DYNA

<http://www.esi-group.com>

Visual-Crash for LS-DYNA helps engineers perform crash and safety simulations in the smoothest and fastest possible way by offering an intuitive windows-based graphical interface with customizable toolbars and complete session support. Being integrated in ESI Group's Open VTOS, an open collaborative multi-disciplinary engineering framework, Visual-Crash for DYNA allows users to focus and rely on high quality digital models from start to finish. Leveraging this state of the art environment, Visual Viewer, visualization and plotting solution, helps analyze LS-DYNA results within a single user interface.

APTEK

<http://www.aptek.com>

The MMCD is a graphics-based and menu-driven program that interfaces with the LS-DYNA library of material models and the LS-OPT optimization code. The core of the MMCD is the driver, which calculates the stress-

strain behavior of material models driven by combinations of strain increments and stress boundary conditions, i.e. pure shear stress, and combinations of uniaxial, biaxial, and triaxial compression and tension. MMCD input and output is accessed via pre- and post-processors; graphical user interfaces (GUIs) for easily selecting the material model parameters and load histories, and for plotting the output in both two (stress-strain curves) and three (yield surfaces) dimensions. The pre-processor, driver, and post-processor are combined into a web downloadable software package that operates seamlessly as a single code.

BETA CAE Systems S.A.– ANSA

<http://www.beta-cae.gr>

Is an advanced multidisciplinary CAE pre-processing tool that provides all the necessary functionality for full-model build up, from CAD data to ready-to-run solver input file, in a single integrated environment. ANSA is a full product modeler for LS-DYNA, with integrated Data Management and Process Automation. ANSA can also be directly coupled with LS-OPT of LSTC to provide an integrated solution in the field of optimization.

BETA CAE Systems S.A.– μETA

<http://www.beta-cae.gr>

Is a multi-purpose post-processor meeting diverging needs from various CAE disciplines. It owes its success to its impressive performance, innovative features and capabilities of interaction between animations, plots, videos, reports and other objects. It offers extensive support and handling of LS-DYNA 2D and 3D results, including

those compressed with SCAI's FEMZIP software

Participant LS-DYNA® SMP & MPP Hardware and OS

FUJITSU	HP	HP	HP	HP
Prime Power	PA-8X00	IA-64	Opteron	Alpha
SUN OS 5.8	HP-UX 11.11. and above	HP-UX 11.22 and above	Linux	True 64
INTEL	INTEL	INTEL	NEC	
IA32	IA64	Xeon EMT64	SX6	
Linux, Windows	Linux	Linux, Windows 64	Super-UX	

MPP and Interconnect MPI

CRAY	O/S	HPC Interconnect	MPI Software
CX1	Windows HPC Server 2008, Linux	InfiniB	MSMPI, HP MPI, INTEL MPI
XT5	Linux	SeaStar2	Cray MPI
XT5M	Linux	SeaStar1	Cray MPI
FUJITSU			
Prime Power	SUN OS 5.8		
HP			
PA8000	HPUX		
IA64	HPUX		
INTEL			
IA32	Linux, Windows	InfiniBand (Voltaire), MyriCom	MPICH, HP MPI, OpenMPI
IA64	Linux		MPICH, HP MPI, OpenMPI
Xeon EMT 64	Linux	InfiniBand (Voltaire), MyriCom, PathScale InfiniPath	MPICH, HP MPI, OpenMPI, INTEL MPI
NEC			
NEX SX6	Super-UX		

Training Classes



Training Courses

September 2009

Send listings to agi99@aol.com

Alyotech Technologies located in France

http://www.alyotech.fr/fileadmin/DocumentsTelecharges/Planning_des_ formations_2009_V1_1.pdf

- October 6th & 7th Geo-material and Concrete Modeling
- October 8th & 9th Blast and Penetration
- October 22nd & 23rd The SPH Method in LS-DYNA
- November 18th – 20th Implicit Capabilities in LS-DYNA

CADFEM India

<http://www.cadfem.in/training/overview.html>

- October 8th Introduction to LS-DYNA
- November 5th – Introduction to LS-DYNA

OASYS – UK

<http://www.oasys-software.com/dyna/en/training>

- October 22nd – Implicit Capabilities



Conferences & Events News

Start	Country	2009
Oct 01	Italy	Enginsoft International Conference 2009 http://meeting2009.enginsoft.it/
Oct 21	France	DIGIMAT USERS' MEETING 2009/The Material Modeling Conf. http://www.e-xstream.com/en/digimat-users-meeting-2009
Oct 23	Korea	Korean LS-DYNA User's Conference 2009 (THEME) http://www.lsdyna.co.kr/
Oct 27	Japan	Asian LS-DYNA User's Conference 2009 http://ls-dyna.jsol.co.jp/en/event/uc2009.html
Nov 09	Iran	ICCT09 1st International Conference on Concrete http://www.icct.ir/
Nov 12	Germany	8th German LS-DYNA Forum http://www.dynamore.de/conferences/upcoming-conferences.
Nov. 14	US	SC2009 http://sc09.supercomputing.org/
Nov 18	Germany	ANSYS Conf. & 27th CADFEM Users Meeting http://www.usersmeeting.com/

9th International Symposium Computer Methods in Biomechanics and Biomedical Engineering

www.cmbbe2010.cf.ac.uk

Scope and objectives:

CMBBE2010 is to be held at the Westin Hotel, Valencia, Spain, 24–27 February 2010. The themes and topics for this 9th symposium in the series have been developed through interaction with international experts and therefore reflect the latest development in computer methods in biomechanics, biomedical technology and modelling of biological structures. Key objectives are to highlight and communicate new areas of future potential as well as presenting new techniques that are being successfully applied across medical technology, biomechanics and the healthcare sector. Interdisciplinary research which overarches medical technology, imaging/tissue characterisation, biosciences and applications in clinical practice will be placed at the forefront of the meeting agenda.

LSTC and Arup are two of the sponsors of the symposium.

Symposium Organisers:

John Middleton (Chair), Sam L Evans and Cathy Holt (Cardiff University, UK)

Christopher Jacobs (Columbia University, New York, USA)

Brian Walker (Arup, Birmingham, UK)

Carlos Atienza (IBV, Valencia, Spain)

- 30 Plenary presentations by keynote speakers
- 30 Oral and 6 poster presentation sessions
- Special sessions on emerging topics
- Software and medical technology exhibits
- Sponsored prizes for best research papers and posters

Young researchers are very welcome and reduced fee together with significant student prizes are offered

The meeting has always promoted international collaboration and networking and this is evidenced through the well-known research groups, commercial companies and scientific organisations who continue to present their research and support and sponsor the CMBBE series. If you wish to exhibit, sponsor or organise a special session then please do contact the organisers.

LS-DYNA users are invited to submit papers, where the code has been used in the fields of biomechanics and biomedical engineering.



**The 11th International,
LS-DYNA[®] Users Conference**

June 06-08, 2010

**Hosted by Livermore
SoftwareTechnology Corp.**

To be held at The Hyatt Regency
Dearborn, MI

Abstract Due: December 4, 2009	email abstract to: papers@lstc.com subject line for e-mail – Abstract LS-DYNA Conference 2010	Notification: January 22, 2010
Paper Deadline: March 05, 2010	Conference Papers: The presenter of each accepted paper will receive free admission to the conference, provided that the presenter registers for a room at the Hyatt Regency Dearborn under LSTC Conference registration	

Application Areas Being Accepted for Paper Submission:

- Aerospace
- Automotive Crashworthiness
- Ballistic and Penetration
- Biomechanics
- Civil Engineering
- Compressible Fluid Dynamics
- Electro Magnetics
- Heat Transfer
- Impact and Drop Testing
- Manufacturing Processes
- Metal Forming
- Modeling Techniques
- Nuclear Applications
- Occupant Safety
- Seismic Engineering
- Ship Building
- Transportation
- Virtual Proving Ground

Abstract Length: Approximately 300 words, please include figures, if possible
Paper Length: Maximum of 3000 words, single-spaced, on 8-1/2" x 11" paper
Format: A MS Word template will be provided
Contact: papers@lstc.com

Livermore Software Technology Corp.
(925) 449-2500
<http://www.ls-dynaconferences.com>

8th LS-DYNA Forum 2009 in Germany

DYNAmore invites to the 8th LS-DYNA Forum, November 12th 2009, in Stuttgart, Germany.

Following the successful European LS-DYNA Conference in Salzburg (Austria), this year the German national LS-DYNA conference will be held in form of a one day event with attendance free of charge.

Well known presenters from industry and academia give presentations about their work with LS-DYNA. The main focus of the presentations will be on crash, passive safety, metal forming, and material modelling. Additionally, Dr. John Hallquist (President of LSTC) gives an overview about recent and future developments in LS-DYNA.

The forum will be ideally for LS-DYNA users to share and discuss experience, to obtain information on upcoming features of LS-DYNA and to learn more about new application areas.

The event will be accompanied by an exhibition featuring the latest software and hardware developments related to LS-DYNA.

The attendance of the conference is free of charge – although registration is necessary. For further information

Contact: DYNAmore GmbH
Industriestr. 2
70565 Stuttgart, Germany
Tel. +49 (0) 7 11 - 45 96 00 - 0,
Fax +49 (0)7 11 - 45 96 00 – 29
e-mail: info@dynamore.de
<http://www.dynamore.de>

EnginSoft International Conference

2009 - 1-2 October 2009 – Bergamo – Italy

2nd Announcement and Invitation

Simulation and Virtual Prototyping are seen as key disciplines for achieving progress in engineering and science in the 21st century. In this light, EnginSoft is hosting its International Conference 2009 CAE Technologies for Industry on 1–2 October in Bergamo, Northern Italy - concurrently with the ANSYS Italian Conference 2009.

This occasion has long become one of the leading events in Europe for all those involved in CAE, with record attendances in 2008, 2007...

The Conference Committee has received an overwhelming response to the Call for Papers and has now published a provisional list of outstanding papers that will be presented on the 2 days of the conference.

The program covers a wide range of innovative topics and applications in such areas as: optimization, mechanics, industrial applications, structural engineering, manufacturing process simulation, computational fluid-dynamics, emerging technologies, durability and fatigue, rapid and impact dynamic, CAD/CAE integration....

Photo: Conference Venue - Centro Congressi Giovanni XXIII Bergamo

The preliminary list of papers can be viewed on the official conference website: <http://www.caeconference.com>

The Conferences will present the diversity and impact of CAE Technologies to an international audience of users from various industries with different backgrounds, developers, scientists and researchers. The two Conferences will

offer a highly innovative platform for interaction and exchange of knowledge, development and application results. Moreover, they will reveal convincing visions for the future of engineering simulation in industry, research and the academia.

The program features presentations from leading experts and key companies from around the world highlighting applications in automotive, aerospace, energy, marine, oil&gas, consumer goods, environment, biomedicine and other areas.

In several product update sessions and in the demo room, conference attendees will hear about the latest developments of state-of-the-art CAE software encompassing:

ANSYS - ANSYS CFX – ANSYS Fluent – ANSYS ICEM CFD – modeFRONTIER – ANSOFT - Flowmaster – LS-DYNA - MAGMASOFT – FORGE – FTI – THIRD WAVE SYSTEM – ESACOMP...

A large accompanying exhibition will see the world's leading solution providers showcasing products and services covering all aspects of CAE technologies.

Delegates and exhibitors will use the exhibition as an international networking forum to gain new insights, share experiences and to find new business opportunities.

Follow the Sound of Innovation – Be Inspired about CAE –

Come and meet us in Bergamo !

Logistics:

Bergamo is located 1h drive from Milan.

Nearest Airports: Bergamo BGY 15 minutes

Milan Linate LIN 1 hour

Milan Malpensa MXP 1,5 hours+

We are very pleased to help you in preparing your trip, accommodation and presence !

For further assistance and information, please contact: Dr. Luisa Cunico, l.cunico@enginsoft.it

In the heart of the territory of Lombardy, Bergamo represents a unique entity for its setting, beauty, history, tradition and culture.

The strategic positioning of the city within the system of the airports of Milan, with the nearby international airport of Bergamo-Orio al Serio, guarantees a tight network of daily connections between Italy and abroad, also with low cost carriers.

The direct link with the national motorway system, allows rapid transfers between the other airports of Northern Italy

(in particular with Milan Linate and Milan Malpensa)

For its vitality in business and value of its economic activity, the territory of Bergamo constitutes one of the fundamental hubs of the Italian economy.

Bergamo's Medieval Citta' Alta

But Bergamo is also history, with the beauty of its impressive medieval Citta' Alta, and its nature, placed as it is, at the foot of the beautiful Orobic Alps and near to the delightful Iseo Lake.

The hotels in the city of Bergamo and surroundings offer highest quality, supported by an excellent infrastructure and first-class services rendered by the local people, at very good quality/price

ratio. The layout of the City, its atmosphere, the traditional hospitality of the people, make Bergamo the ideal place to transform any event into a highly enjoyable and unforgettable moment in time.

Visit the main Conference website: <http://www.caeconference.com>

 <p>JAPAN LS-DYNA Users Conference 2009 Dates : October 27(tue) - 28(wed), 2009</p>	<p>Organized by JSOL Corporation October 27th – 28th, 2009</p>
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JSOL Corporation is hosting JAPAN LS-DYNA Users Conference 2009 for two days, in order to provide opportunities for LS-DYNA Users in Japan to share information and to enhance fellowship.

Venue:

27th ANA Hotels Hotel Grand Court NAGOYA

28th The Nagoya Urban Institute

Lecture Categories

Mechanical Design

Manufacturing Technology

Automotive Design

Consumer Product Design

Software/Hardware Development

LS-DYNA/CAE Software Application Technology

Material

Optimization

Quality Assurance

New Technology

Harumi Center Bldg., 2-5-24, Harumi, Chuo-ku, Tokyo 104-0053, Japan

JSOL Corporation, Engineering Technology Division

E-mail : event@sci.jsol.co.jp



Press Releases

Alpha Order

Cray

Panasas

CRAY

News ReleaseCray Awarded Supercomputer Contract From the Korea Meteorological Administration Valued at More Than \$40 Million

SEATTLE, WA, Sep 08, 2009 (MARKETWIRE via COMTEX) -- Global supercomputer leader Cray Inc. (NASDAQ: CRAY) today announced that it has signed a multi-year, multi-phase contract to provide the Korea Meteorological Administration (KMA) with a next-generation supercomputer. Valued at more than \$40 million, the award is one of the largest in the area of operational numerical weather prediction in the world to-date, and will provide KMA with the necessary supercomputing, storage and data management technologies to reinforce its position as one of the world's premier weather forecasting and research centers.

Based in Seoul, South Korea, KMA's mission is operational weather forecasting and climate research for the benefit and welfare of the Korean public and industry. KMA will use Cray's scalable, massively parallel processing (MPP) supercomputers to provide more accurate regional and global numerical model forecasts through

increased model resolution, increased ensemble sizes and the implementation of advanced data assimilation.

"We are quite proud that KMA has once again turned to Cray to provide the necessary supercomputing capabilities to meet the demanding requirements of weather forecasting and climate research, which are important segments for our business," said Peter Ungaro, Cray president and CEO. "Once completed, the Cray supercomputer at KMA will be the largest integrated solution for operational numerical weather prediction in the Asia Pacific region and one of the largest in the world -- another strong proof point for not only our current Cray XT5 supercomputer, but also future systems we are in the process of developing and will be delivering as part of this contract. We are honored to be able to help KMA scientists and researchers provide more detailed and accurate numerical weather predictions in support of their mission of identifying the potential of severe weather systems in a more timely fashion."

Cray was awarded the multi-year contract based on the superior delivered application performance and a robust total solution to KMA's demanding operational

requirement. Once completed, the Cray system will feature a peak performance in excess of 600 teraflops (trillions of calculations per second) and a multi-tiered, multi-petabyte storage, archival and back-up system. The Cray system will be delivered in two phases, with acceptance of both expected during the second half of 2010.

Cray will also provide service and support, including applications support for KMA's operational and research weather and climate models. Additionally, Cray and KMA will continue to expand the successful Earth System Research Center (ESRC), which is a cooperative venture established in 2005 to advance the science of earth system modeling over the East-Asia Pacific region and to leverage the collective knowledge of academia, government and industry by promoting collaboration across these communities.

About the Korea Meteorological Administration

Established in 1949 as the Central Meteorological Office, KMA is a governmental organization dedicated to improving public welfare through the prevention and mitigation of meteorological disasters, by supporting government and business activities such as transportations and water resource management that depend on accurate weather forecasts, and by producing scientific information on climate change. KMA comprises the Forecast, Observation, Climate and Industry and IT bureaus; the NWP officer; NIMR; aviation weather stations; five Regional Meteorological Offices with more than 1,200 employees; and 94 weather and observation stations. The organization collaborates with other

entities engaged in meteorological prediction and research worldwide. Go to <http://web.kma.go.kr/eng/index.jsp> for more information.

About Cray Inc.

As a global leader in supercomputing, Cray provides highly advanced supercomputers and world-class services and support to government, industry and academia. Cray technology enables scientists and engineers to achieve remarkable breakthroughs by accelerating performance, improving efficiency and extending the capabilities of their most demanding applications. Cray's Adaptive Supercomputing vision will result in innovative next-generation products that integrate diverse processing technologies into a unified architecture, allowing customers to surpass today's limitations and meeting the market's continued demand for realized performance. Go to www.cray.com for more information.

Safe Harbor Statement

This press release contains forward-looking statements. There are certain factors that could cause Cray's execution to differ materially from those anticipated by the statements above, including the technical challenges of developing high performance computing systems; the successful passing of acceptance tests; significant reliance on third-party development service and parts suppliers, including their competitiveness with other suppliers and potential delays in the results of their development and in the availability of qualified parts from suppliers; and Cray's ability to keep up with rapid technological change. For a discussion of these and other risks, see "Risk Factors" in Cray's most recent Quarterly Report on Form 10-Q filed with the SEC.

Cray is a registered trademark, and Cray XT and Cray XT5 are trademarks of Cray Inc. Other product and service names mentioned herein are the trademarks of their respective owners.

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206/701-2123
pr@cray.com

Cray Investors: Paul Hiemstra
206/701-2044
ir@cray.com

SOURCE: Cray Inc.
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Panasas, Inc.

FREMONT and SAN FRANCISCO, Calif. – Sept. 22, 2009 – Panasas, Inc., the leading provider of storage for the world’s most performance-intensive applications, today announced it has secured a partnership with Penguin Computing to provide high-performance parallel storage that will power Penguin Computing’s “Penguin on Demand” (POD) high-performance cloud computing service. POD extends the concept of cloud computing by making optimized compute resources designed specifically for high-performance computing (HPC) available on demand. POD is targeted at researchers, scientists and engineers who require surge capacity for time-critical analyses and organizations that need HPC capabilities without the expense and effort required to acquire HPC clusters.

“When we looked at the computing resources that our POD customers

required, we knew we needed to eliminate bottlenecks and deliver a fast and seamless end user experience,” said Charles Wuischpard, CEO at Penguin Computing. “After extensive research, we settled on Panasas because their parallel storage solution offers unprecedented performance and delivers the high-level results we demand.”

“Cloud computing is a hot market and is gaining interest from companies of all sizes and industries due to its many business benefits. To be a successful cloud provider, you need to provide a storage foundation that is massively scalable and easy to use, like Panasas ActiveStor,” said Terri McClure, senior analyst at analyst firm Enterprise Strategy Group. “Because Panasas has a long and impressive track record in providing storage for HPC environments, the company is well-positioned to take advantage of cloud opportunities like the one with Penguin Computing.”

Penguin on Demand Cloud Computing Service

POD provides a computing infrastructure of highly optimized Linux clusters with specialized hardware interconnects and software configurations tuned specifically for HPC environments. Rather than using machine virtualization, as is typical in traditional cloud computing, POD allows users to access a server’s full resources at one time, enabling maximum performance and I/O for massive HPC workloads. Comprising high-density Xeon-based compute nodes coupled with high-speed storage, POD provides a persistent compute environment that runs on a head node and executes directly on the compute nodes’ physical cores. Both

Gigabit Ethernet (GigE) and double data rate (DDR) high-performance InfiniBand network fabrics are available. Jobs typically run over a localized network topology to maximize inter-process communication and bandwidth while minimizing latency.

Panasas ActiveStor Parallel Storage

Panasas provides the most comprehensive family of parallel storage solutions available today. Every Panasas ActiveStor™ system is based on the leading PanFS™ Parallel File System and delivers exceptional performance, scalability and manageability. Leveraging its DirectFLOW® parallel storage access technology, Panasas now supports more than 500,000 servers with cost-effective, data-intensive, and linearly scalable storage solutions. This innovative architecture enables multiple parallel data paths between computing nodes and Panasas ActiveStor storage, thereby eliminating the inherent performance and capacity bottlenecks of today's file systems and file servers. Panasas also dramatically lowers the cost of managing data storage by supporting petabytes of data capacity growth within a single, easily managed namespace and framework.

About Penguin Computing

Penguin Computing specializes in complete integrated HPC clustering solutions. Penguin has been a successful innovator for over a decade, providing Linux HPC solutions to a variety of industries. Penguin's staff, including the originator of the Beowulf Cluster architecture, has unsurpassed experience in delivering a powerful combination of fully integrated HPC clusters, comprehensive cluster management software, and services.

For more information about Penguin Computing and Penguin products, please go to www.penguincomputing.com/.

About Panasas

Panasas, Inc., the leading provider of high-performance storage for the world's most performance-intensive applications, helps commercial, government and academic organizations accelerate their time to results leading to real world breakthroughs that improve people's lives. Panasas' high-performance storage systems enable customers to maximize the benefits of compute clusters by eliminating the storage bottleneck created with legacy network storage technologies. Panasas ActiveStor Parallel Storage Clusters, in conjunction with the ActiveScale® Operating Environment and PanFS™ parallel file system, offers the most comprehensive portfolio of storage solutions for high performance computing (HPC) environments. Panasas is headquartered in Fremont, California. For more information, please visit www.panasas.com.

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Updated - Implementation and Validation of Frequency Response Function in LS-DYNA[®]

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Abstract

A new feature of frequency response function (FRF) computation, has been implemented in LS-DYNA. This feature provides user the opportunity to acquire a spectrum of structural response (displacement, velocity and acceleration) for applied unit harmonic excitations. The harmonic excitations are given in the form of nodal force, with varying frequencies. A benchmark example of a rectangular elastic plate is included to demonstrate the effectiveness and accuracy of this new feature. Effect of damping on the FRF computation is studied. This feature has application in industries involving vibration analysis and modal testing.

1. Introduction

Frequency response function (FRF) is a characteristic of a structure that has a measured or computed response resulting from a known applied harmonic input. Usually this function is given for a range of frequencies. The response can be given in terms of displacement, velocity, or acceleration. FRFs are complex functions, with real and imaginary components. They can also be expressed in the form of magnitude and phase angle pairs.

FRF can be computed using the method of mode superposition, in frequency domain. As the first step, modal analysis is performed for the structure, which provides natural frequencies and vibration modes of the structure. Intermittent modal analysis can be performed in case of existence of prestress. With the application of unit harmonic load condition, and with the analytical Fourier transform, the modal coordinates are obtained in frequency domain. The final solution of FRF is achieved as the sum of influence from all the involved modes.

System damping has important effect on FRF. Damping can be prescribed in a few ways, such as constant modal damping, frequency dependent modal damping or Rayleigh damping. Damping affects not only the magnitude of FRF, but also the phase angle of FRF.

FRF has many applications in industries involving vibration analysis and mode testing, such as auto industry.

2. Implementation of the feature in LS-DYNA

A new keyword `*CONTROL_FREQUENCY_RESPONSE_FUNCTION` has been introduced in LS-DYNA to activate FRF computation. Through this keyword, user provides information about the location, direction, range of frequencies for the harmonic nodal force excitation, and the location where the response functions are requested. Damping information is also provided in the keyword input. The location of the excitation and response area can be given as node, or set of nodes, or set of segments. The direction of force excitation can be in any of the x, y, z directions or given as a vector by using `*DEFINE_VECTOR`. Currently we consider only the case where the excitation is given in the form of nodal force. This feature can work in a single input/multiple output mode, e.g. user can acquire the FRFs at many locations (using `set_node` or `set_segment`) simultaneously due to a single excitation input. For more details about the keyword

`*CONTROL_FREQUENCY_RESPONSE_FUNCTION`, please refer to LS-DYNA® Keyword User's Manual [1].

As modal analysis is the first step for running this feature, the keyword `*CONTROL_IMPLICIT_EIGENVALUE` has to be included in the input. Some other keywords related to implicit solution may also be needed, depending on the type of analysis (linear or nonlinear, etc.).

The results are given in two ASCII database files: `frf_amplitude` and `frf_angle`. They can be accessed by LS-PREPOST's `xyplot` function. The file `frf_amplitude` shows the spectrum of absolute value and `frf_angle` shows the spectrum of phase angle in the range of excitation frequencies.

3. A benchmark example

3.1 Description of problem

Consider a rectangular plate in Figure 1. The size of the plate is given as $a = 0.36\text{m}$, $b = 0.24\text{m}$, $t = 0.002\text{m}$. Material properties are given as density $\rho = 7870\text{ kg/m}^3$, Young's modulus $E = 207 \times 10^9\text{ Pa}$, Poisson's ratio $\nu = 0.292$. Shell element type 6 (S/R Hughes Liu shell) is adopted. Totally 651 nodes and 600 shell elements are used for the modeling. Frequency Response Functions (Compliance, Mobility and Accelerance) in the range of 1-400 Hz are computed and the modes with natural frequencies less than 2000 Hz are used in the computation.

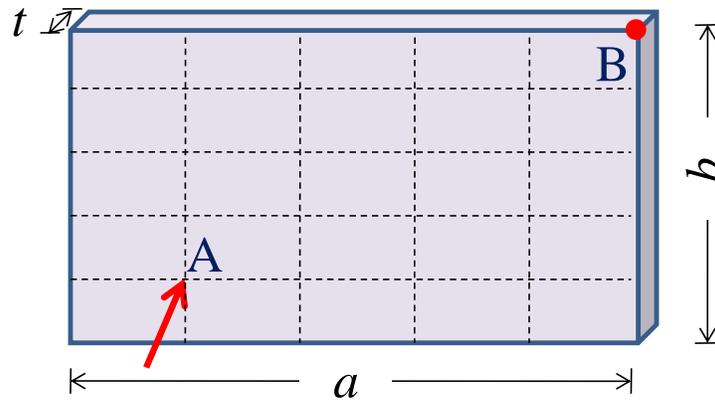


Figure 1. A rectangular plate with free boundaries

3.2 Verification of numerical results

Wang and Tsao performed experimental modal analysis (EMA) and finite element analysis (FEA) for this benchmark problem [2]. In the finite element analysis, the software ANSYS was adopted and the convergence for different elements was studied.

The natural frequencies of the plate obtained by LS-DYNA match reasonably well with the analytical, experimental and ANSYS results given by [2] (see Table 1). The only exception is the 4th mode, where the natural frequency given by experiments is around 6% away from the Analytical, ANSYS and LS-DYNA solutions. The possible reason may be that two small holes are introduced in the plate to hold it during the experiments, which may slightly change the vibration modes of the plate [2].

Mode	Analytical	Experimental	ANSYS	LS-DYNA
1	76.294	76.12	76.835	78.6163
2	81.865	83.00	81.624	81.3628
3	176.806	177.65	177.11	179.6108
4	190.602	201.50	189.88	188.6555
5	220.581	221.70	220.37	219.6902
6	255.791	261.41	254.96	255.1308
7	N/A	329.00	327.88	329.1959
8	N/A	383.23	377.43	379.2899

Table 1. Natural frequencies of the plate (Unit: Hz)

To compute the frequency response functions, two cases are considered. In case 1, the point excitation force is applied at point A and the response is computed at the point A too. The function is called as point FRF. In case 2, the point excitation force is applied at point A and the response is computed at the corner point B. The function is called as transfer FRF.

In Figures 2 and 3 the LS-DYNA results for Accelerance (acceleration/force) amplitude are compared with the results from [2] (experimental and ANSYS). A constant damping ratio $\zeta = 0.01$ is adopted for both LS-DYNA and ANSYS computation. The peak responses always take place at the natural frequencies, as expected. For the amplitude, LS-DYNA results match reasonably well with ANSYS results for the whole range of frequencies. The experimental data has a good match with the numerical results (LS-DYNA and ANSYS) in the low frequencies (e.g. $f < 280$ Hz), but an increasing discrepancy is observed for high frequencies.

To find the reason for this discrepancy, LS-DYNA is rerun with two damping cases. In the first case, the damping is ignored (damping ratio $\zeta = 0$); In the second case, a constant damping ratio $\zeta = 0.01$ is adopted. From Figures 4 and 5, one can see that for low frequencies (e.g. $f < 280$ Hz), the experimental curve is closer to curve C ($\zeta = 0.01$). With the increase of excitation frequency, the experimental curve becomes closer to curve B ($\zeta = 0$). So it is apparent that the damping ratio is actually dependent on frequency and it decreases along with the increase of frequency for this structure. To model the real structures accurately, it is necessary to adopt a frequency-dependent damping. On the other hand, with the FRF feature, LS-DYNA provides user the opportunity to obtain the frequency-dependent system damping ratios — an important structural property, by curve fitting with experimental data.

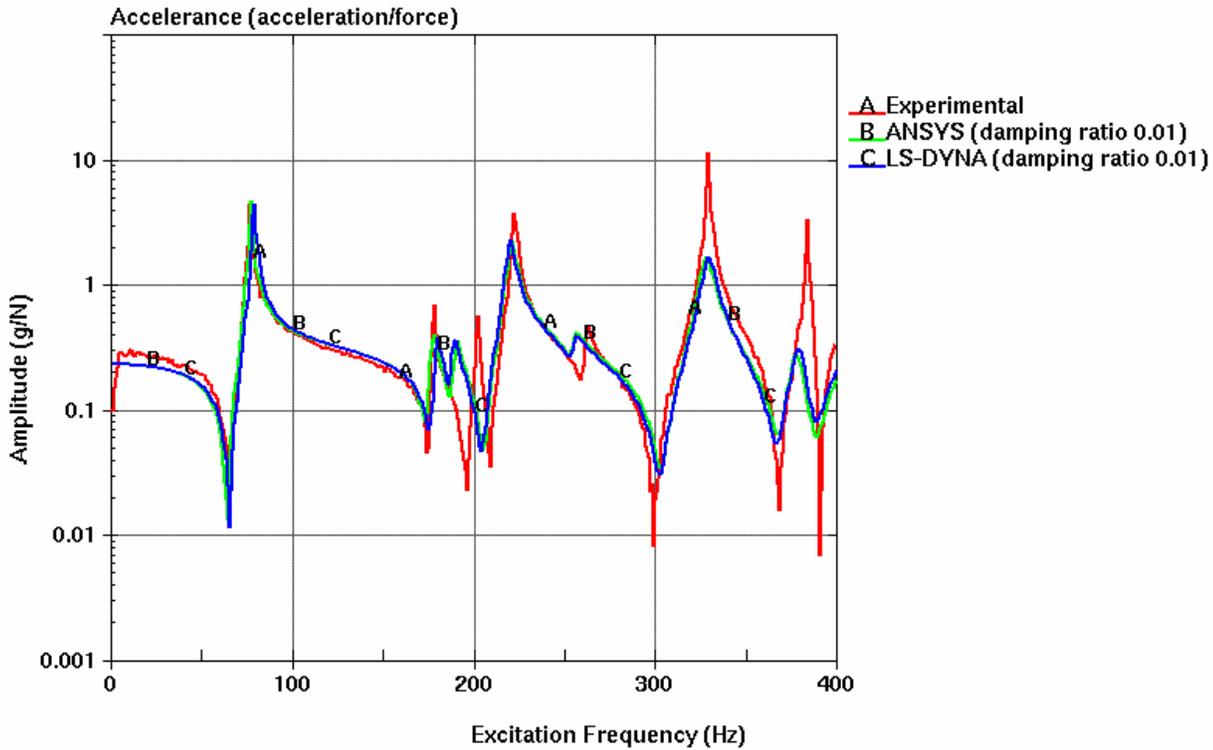


Figure 2. Amplitude of Accelerance for Case 1

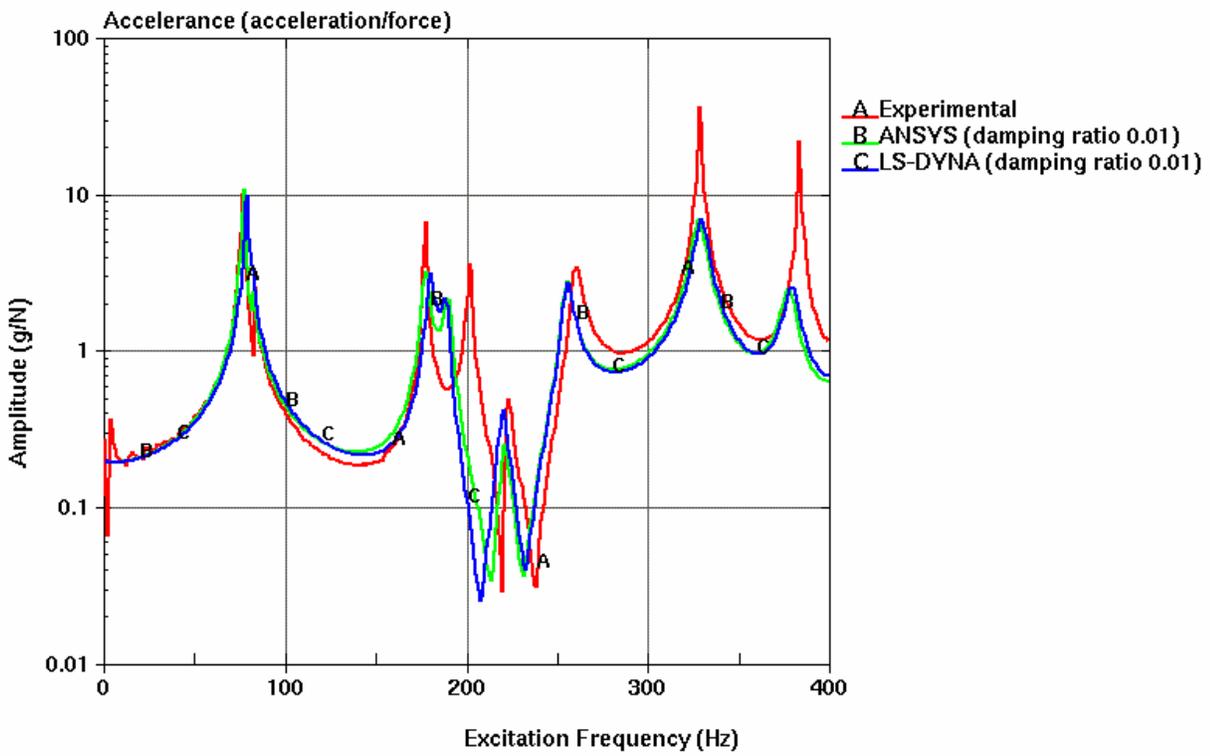


Figure 3. Amplitude of Accelerance for Case 2

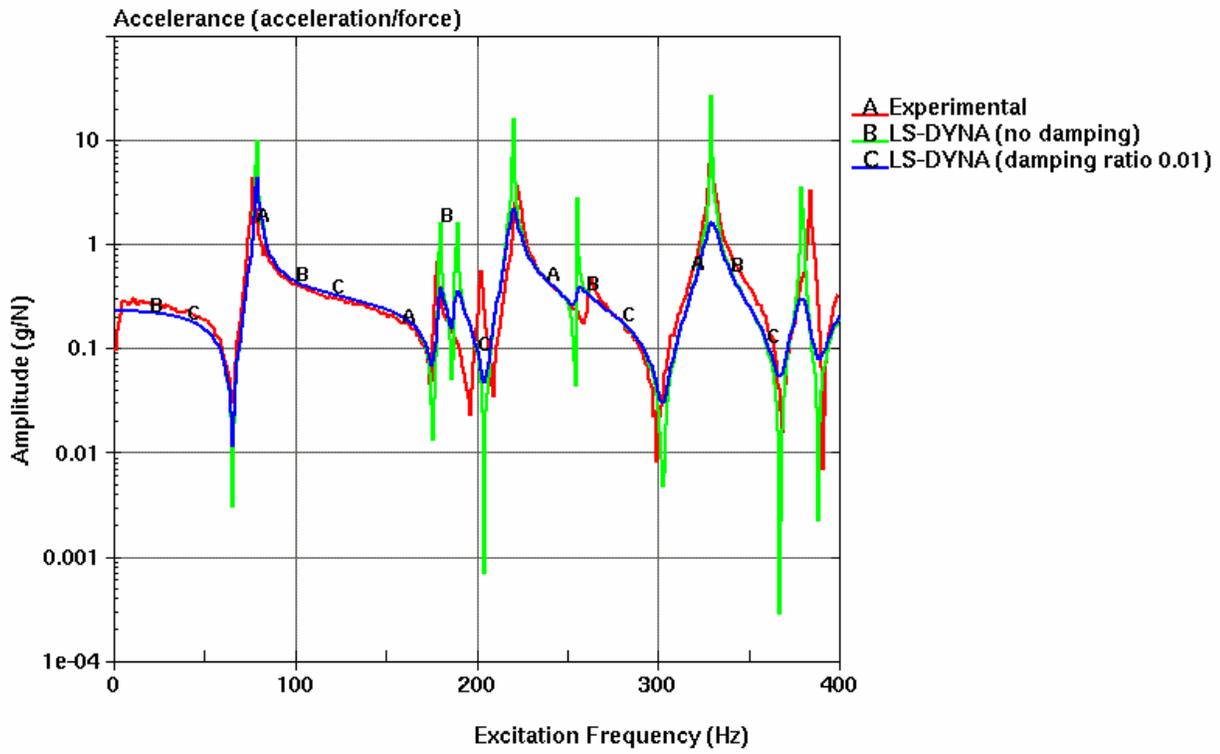


Figure 4. Effect of damping for Case 1

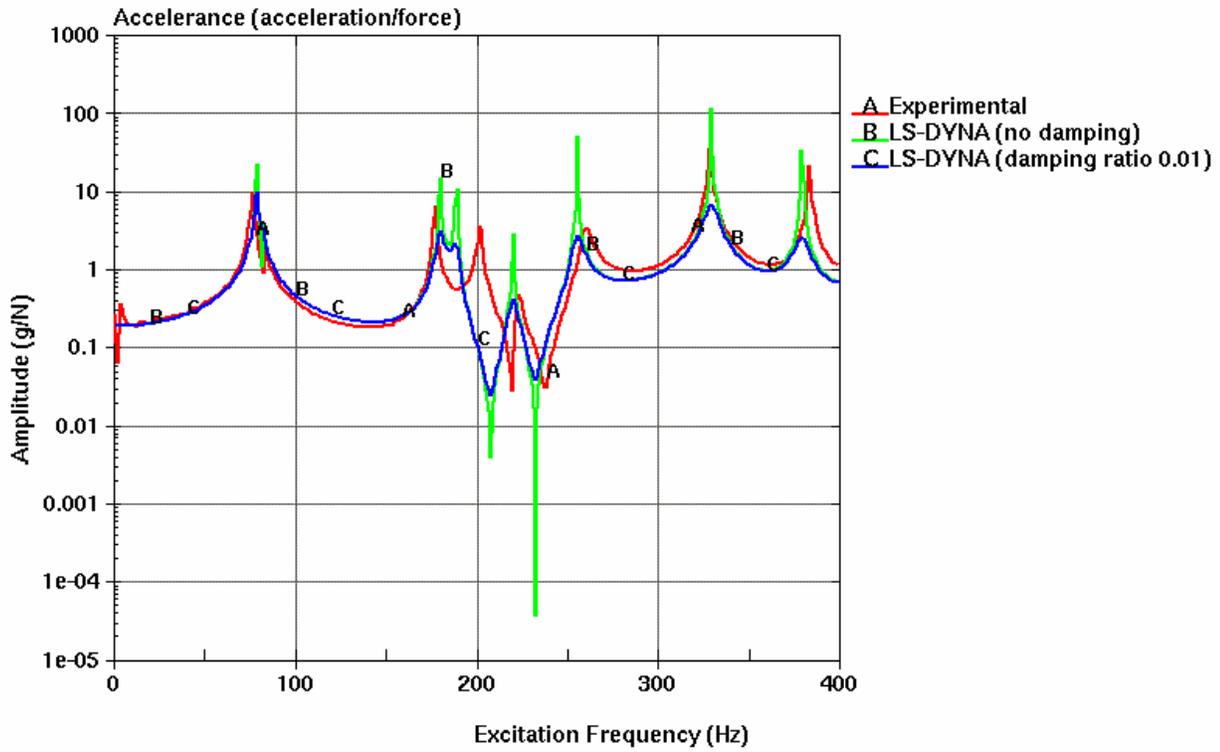


Figure 5. Effect of damping for Case 2

3.3 Study on effect of damping

The Compliance (displacement/force) and Mobility (velocity/force) response for Case 1 (point FRF) and Case 2 (transfer FRF), with and without damping, are given in Figures 6-9.

It is apparent that with consideration of damping, the response becomes smaller than the response without damping.

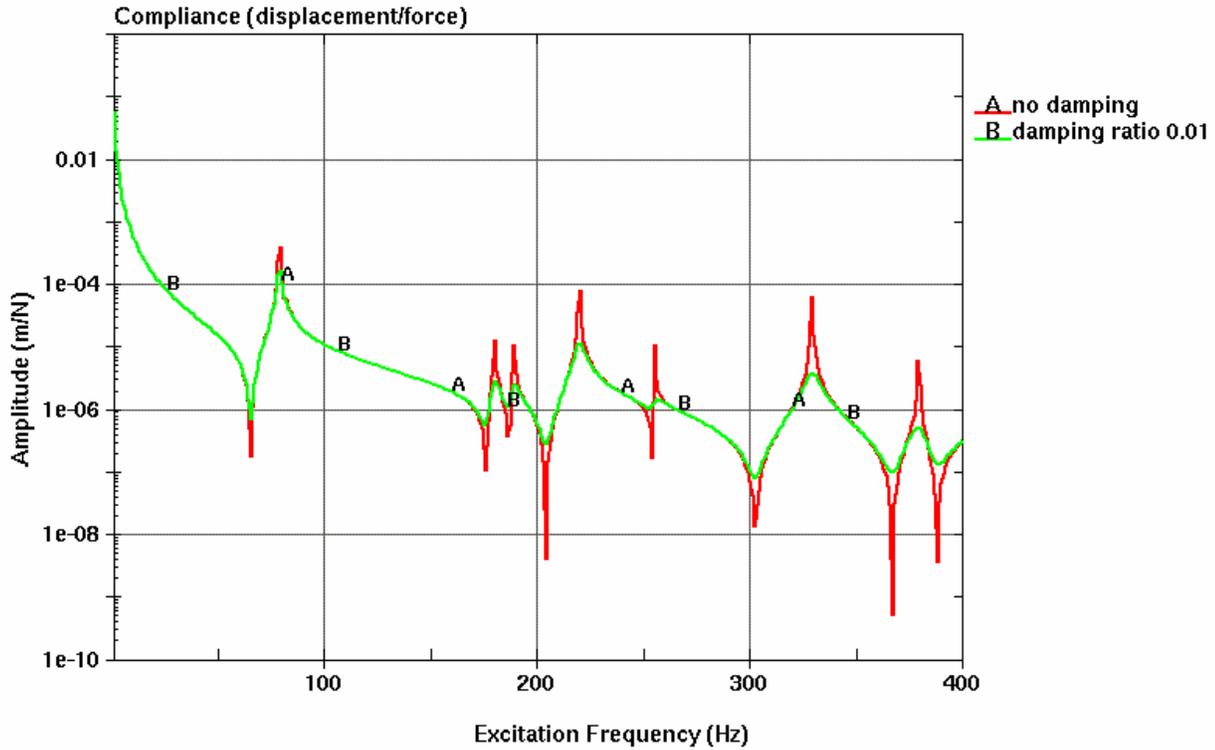


Figure 6. Amplitude of Compliance for Case 1

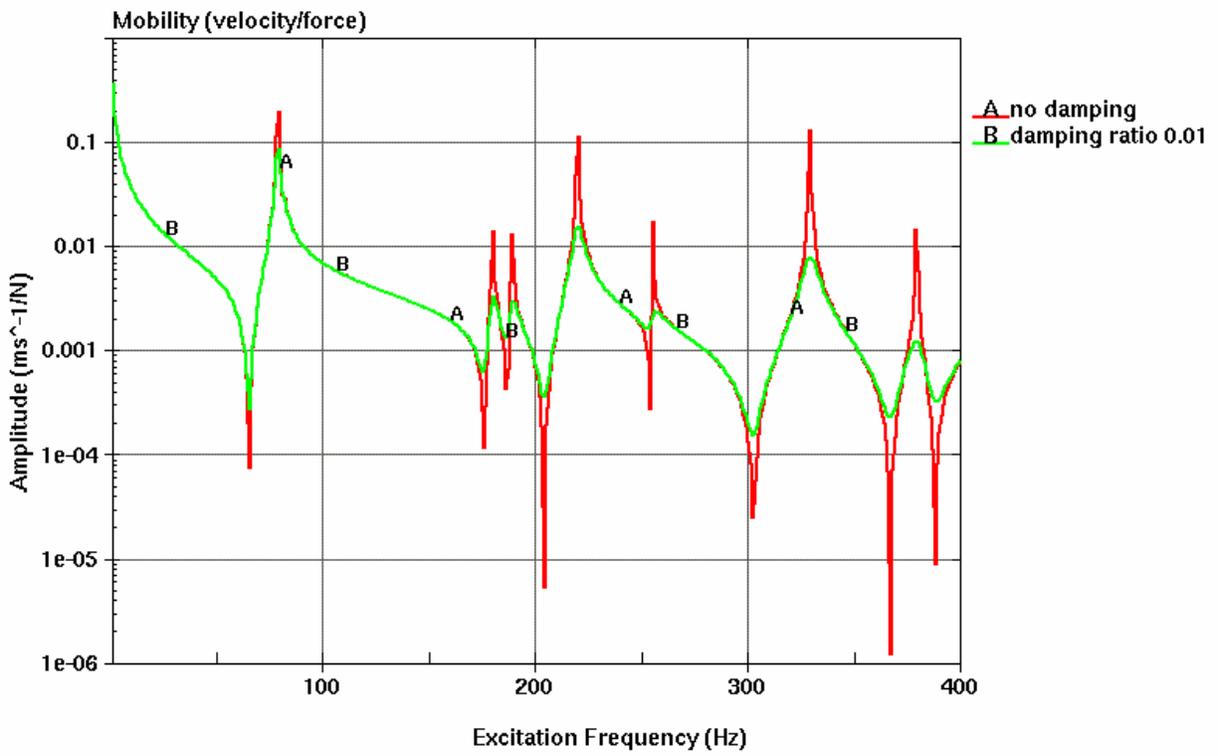


Figure 7. Amplitude of Mobility for Case 1

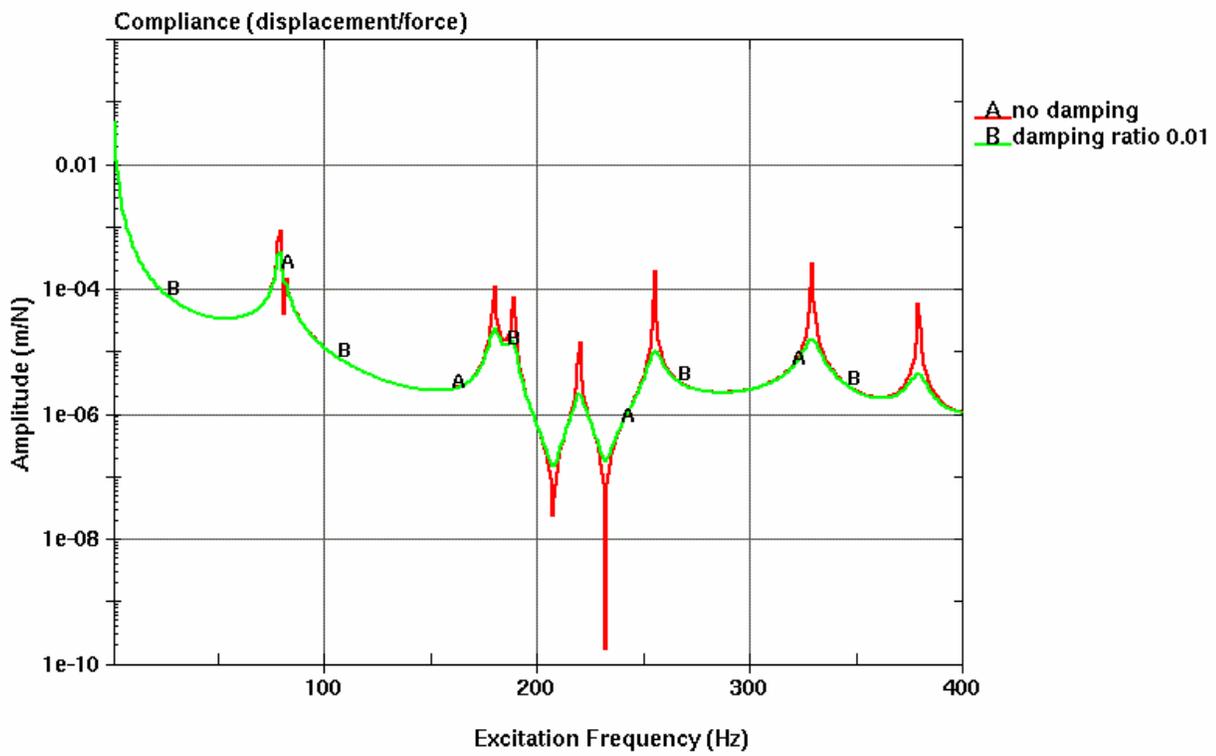


Figure 8. Amplitude of Compliance for Case 2

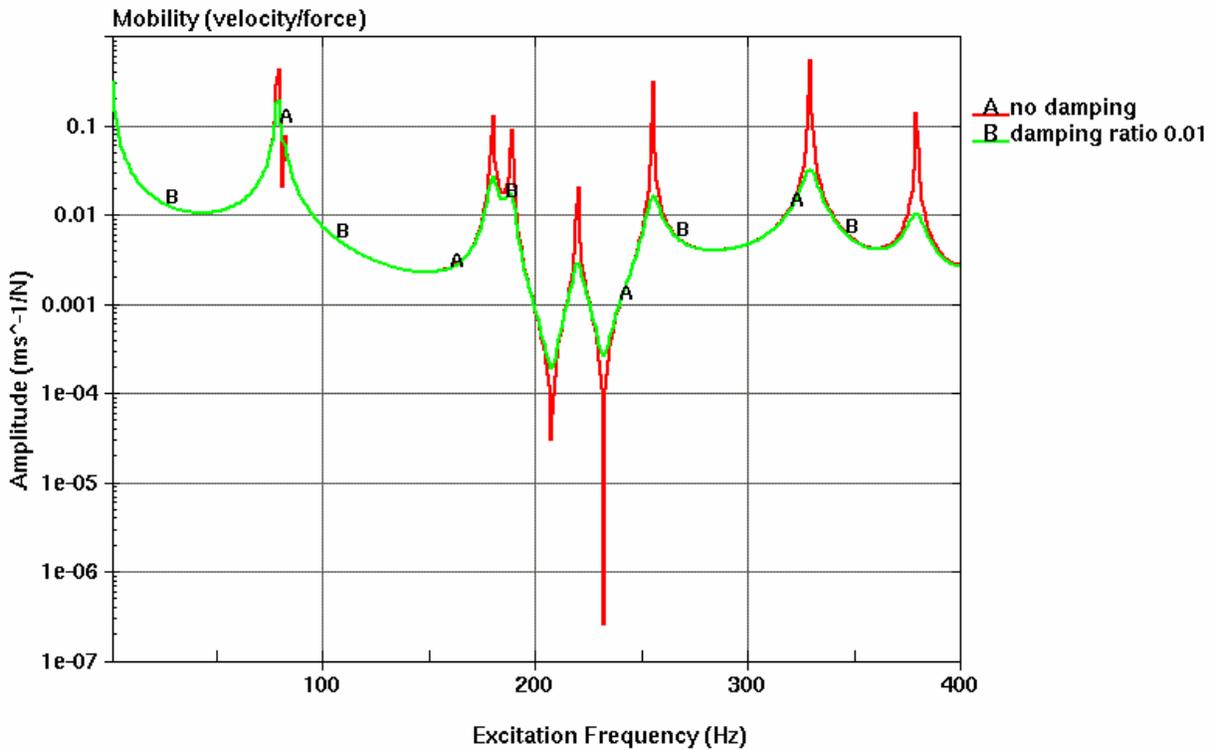


Figure 9. Amplitude of Mobility for Case 2

Conclusion

This paper introduces the implementation and validation of a new feature in LS-DYNA, FRF (frequency response function). A benchmark example of a rectangular plate is studied and the results from experiments, LS-DYNA and ANSYS computations are compared. The comparison indicates that it is necessary to adopt frequency-dependent damping for modeling real structures. Effect of damping on FRF is studied. It is shown that with damping, all the responses have reduced amplitude.

Reference:

1. LS-DYNA[®] Keyword User's Manual, Version 971. Livermore Software Technology Corporation, 2009.
2. Bor-Tsuen Wang, Wen-Chang Tsao, Application of FEA and EMA to Structural Model Verification. *Proceeding of the 10th CSSV Conference Taiwan, 2002*; 131-138.