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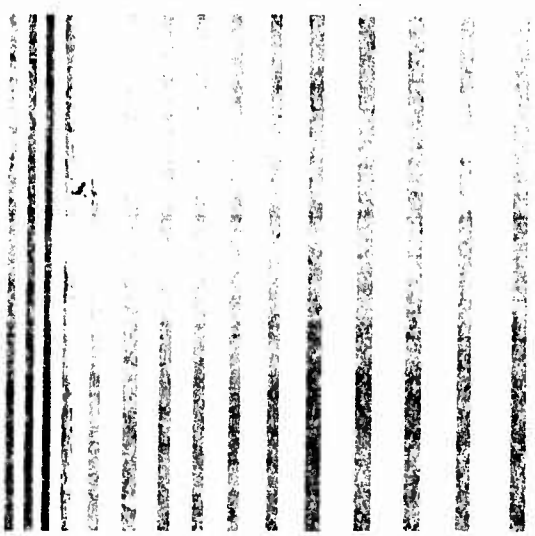

THE SHOCK AND VIBRATION DIGEST

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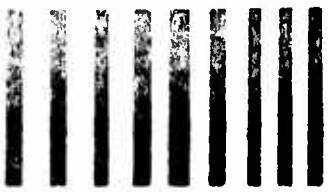


SVIC NOTES

ANOTHER LOOK AT ENVIRONMENTAL STRESS SCREENING

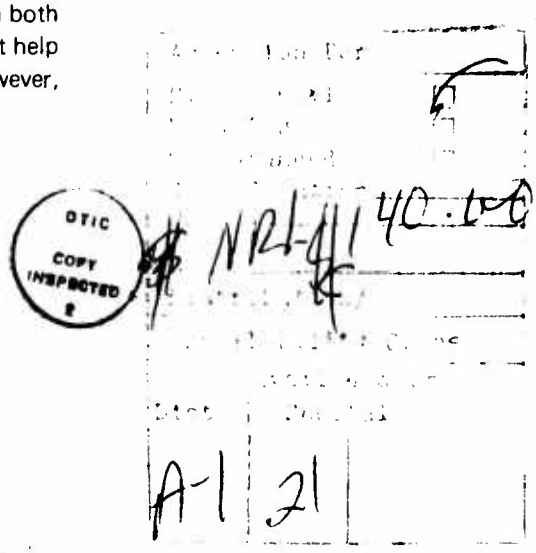
Environmental stress screening has reached the point where it has been largely accepted as a beneficial part of the manufacturing/quality control process for electronic equipment, and it is now required in most Department of Defense equipment development/acquisition programs. Recently, the U.S. Army's Materiel Development and Readiness Command issued a new policy on the management of reliability and maintainability of materiel; it requires environmental stress screening of equipment in the factory to eliminate flaws associated with poor workmanship or defective parts. This same policy calls for the use of thermal cycling and random vibration in the environmental stress screening process, and it requires environmental stress screening at all levels of assembly. The Army's experience with environmental stress screening, to date, has been positive in that it has resulted in more reliable equipment and lower manufacturing costs.

The maturity of environmental stress screening is reflected in the literature that has been published about the environmental stress screening techniques alone; it shows agreement exists on many issues, and many of these relate to vibration. The literature also shows areas where clear cut agreement on environmental stress screening practices is not possible, or better yet, cases where the environmental stress screening requirements should be tailored to the characteristics of the equipment to be screened, the flaws to be weeded out or both. Examples of the latter are the vibration spectra to be used in the environmental stress screening process and the level(s) of assembly at which the material is screened. In both cases the literature provides guidance that might help one to make the proper technical decisions. However, it is also important to realize in both of these cases the decisions may not be based on purely technical considerations.

Even though environmental stress screening has largely matured, some issues still have not been resolved. Environmental stress screening of large assemblies, e.g., equipment racks and large electronics cabinets, is one. I feel the question is not so much how to do it, but whether screening such large items is cost-effective. That is, what types of flaws could be precipitated or detected, and could these same flaws be discovered more readily by using conventional inspection and performance testing techniques. One of the problems associated with using vibration for environmental stress screening large equipment has been the use of a totally inappropriate vibration spectrum. I suspect this has occurred because the dynamic behavior of such large systems was never considered in setting the requirements. The question of whether to exceed the qualification test levels when stress screening equipment is often raised; the answers have ranged from yes to absolutely NO! I tend to agree with the latter answer because if failures occur, it is difficult to determine whether they were caused by manufacturing defects or by overstressing.

To conclude, the literature on environmental stress screening shows it can result in more reliable electronic equipment. Many decisions regarding this process are management decisions, but management must carefully consider the technical facts to arrive at a cost-effective screening process.

R.H.V.



EDITORS RATTLE SPACE

PUBLISHING THE TECHNICAL LITERATURE – BUSINESS OR SERVICE

Examination of current literature and publishing practices has led me to question whether the publishing business is good for those who use the technical literature. For it seems to me that we are seeing less new technology published in more papers.

Over the past twenty years many changes have taken place in the publishing field. Technical societies were once the principal purveyors of the lastest technology. They published selected and reviewed papers in a limited number of journals that served as the source of much of the new technology. There was some sharing of technology in government reports; however, that technology, then as now, found its way into the society journals. Trade magazines contributed in a minor way with distilled literature on the application of technology to practice. These sources of the technical literature remain fairly constant today -- except for a minor expansion in volume.

The explosion in the technical literature arises from other more business-oriented sources. At one time the major publishing houses dealt solely in books and monographs -- distilled literature. Many of these companies now publish one or more technical journals. The business of publishers is to fill these journals with technology -- whether or not it is realistic.

A second general group of new publishers includes pseudo societies and meeting organizers. These publishers range from non profit schools to profit equipment manufacturers. In many cases the "publications" contain no new technology. Often groups of one- and two-page papers are bound into a proceedings volume. It is almost impossible for an engineer to sift through these voluminous proceedings and find anything new.

One result of all this publishing of more papers about less technology is a confused and flabby body of technical work. It is almost impossible to retrieve specific new technology without spending endless hours -- even with the help of modern computer retrieval systems. The retrieved material must then be scanned to determine whether or not it is new and pertinent.

The solution to this problem is more distillers and fewer writers of "original" material -- more books and monographs and fewer journals and magazines. It would be a service to the technical community if the new and old publishers would expand their business into books and monographs rather than new journals and magazines.

R.L.E.

DYNAMIC RESPONSE OF SHELLS CONTAINING FLUID

F.L. DiMaggio*

Abstract. ***This is a survey of papers and reports, most of which were written during the past three years, concerned with the vibrations of deformable shells containing a fluid. Work involving only sloshing effects or including flow-induced vibration is not considered.***

This paper is a continuation of three earlier reviews [1-3]. With a few exceptions the investigations discussed were published during the last three years. As in the previous surveys, studies involving only rigid containers or including a consideration of structural motion caused by fluid flow are not described. Because most of the studies consider irrotational motion of inviscid, incompressible fluids and elastic shell deformability, only exceptions to these assumptions are cited.

The work on fluid-structure interaction discussed in this article finds application in the analysis and design of nuclear reactor components, spacecraft propellant tanks, and liquid storage tanks as well as in biological research involving blood flow and head injury. When a particular application has motivated an author, this is noted.

CONTAINERS OF ARBITRARY OR AXISYMMETRIC GEOMETRY

With the exception of the simplest geometries, such numerical methods as finite difference, finite element, or boundary element methods must be used to solve problems involving fluid-structure interaction.

Among the many possible combinations of nodal variables displacement is often used as the structural node variables; either pressure or displacement is computed for the fluid. Both approaches for the fluid, including compressibility and surface wave effects, have been described in a didactic article by Zienkiewicz and Bettess [4], but the solution of the pressure formulation is emphasized.

Tabarrok [5] used both fluid variables to construct dual variational principles; these can be used as the basis for consistent discretized equations in both fluid and structure. A Hamiltonian functional was presented for use with admissible functions satisfying equilibrium equations in the fluid and structure. Compatibility is then satisfied approximately by extremization. Conversely, a complementary energy integral has been suggested for use with functions satisfying compatibility.

Belytschko [6] emphasized nonlinear problems in a survey of semi-discretization methods including mesh descriptions and accompanying time-integration procedures. He reviewed both explicit and implicit methods and showed that mesh partition techniques are efficient when structure and fluid are integrated by different methods. Several examples were included to illustrate the theoretical presentation. Belytschko and Schumann [7] gave a qualitative report on a seminar in which the state of the art of methods of calculation for fluid-structure interaction problems in light water reactor systems was discussed. Analyses of pressured water reactor loss of coolant accidents and boiling water reactor suppression pools were considered in detail.

A particular finite element formulation that can be used for problems involving large displacements of compressible fluids has been outlined [8]. A three-dimensional eight-node, hexahedral, Lagrangian fluid element was coupled to a three-dimensional plate-shell element and used in conjunction with an explicit integration scheme that incorporated artificial damping. An example involves dynamic loading of a fluid-filled cylindrical vessel containing internal cylinders. A different procedure, when incompressible fluid

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can be assumed, has also been suggested [9, 10]. A boundary element method for the fluid, using dipole elements as singularities, was integrated with a finite element code for the structure. Because only rectangular, but not triangular, dipole elements are available in the code developed, the discretization for curved fluid boundaries can be awkward.

Several papers have proposed extensions or variations of standard finite element formulations. Muller [11] proposed an approximate method of including fluid compressibility that is valid when the compressibility is small or the frequency range of interest is low. Numerical values for the fundamental frequency of a cylinder half filled with water or gas were obtained using this method. Daniel [12, 13] has written two pertinent papers. He extended a substructuring technique originally developed for structural problems to eigenvalue problems involving fluid-filled structures [12]. He showed that fluid compressibility, wall flexibility, and lack of symmetry can be treated in the same manner as physical substructures. Accuracy and efficiency of the method were discussed in connection with several numerical examples. Daniel [13] introduced an effectiveness measure for finite element methods that accounts for both accuracy and computation time. He used this criterion to show that reduction methods for fluid-filled structure eigenvalue problems analogous to that proposed by Hughes for structures alone can be more effective than consistent interpolation solutions.

Several ways to determine the added mass matrix when the container is axisymmetric have been proposed [14, 15]. Coppolino [14], in a report inadvertently excluded from the earlier reviews of this series, has developed a symmetric finite element formulation that utilizes harmonic reduction. He implemented the technique in the NASTRAN code for application to spacecraft propellant tanks. The validity of the procedure was demonstrated by comparison with exact analytical results for filled spherical and cylindrical shells. A first attempt at analyzing a 1/8-scale space shuttle external tank and a comparison with test results was reported. A second volume, not available to this reviewer, apparently describes efforts to improve this analysis. Alternatively a mass matrix in series form, not requiring fluid discretization, was proposed by Ball and Citerley [15] for determining eigenvalues or transient response in conjunction with any structural code.

SPHERICAL AND RECTANGULAR SHELLS

Extensive investigations of the effect of fluid viscosity on the axisymmetric vibrations of spherical elastic shells containing a compressible fluid have been reported by Su [16-18]. He used classical modal expansions for shell response and a boundary layer approximation to account for fluid viscosity. Both real and imaginary branches of the frequency spectra were obtained for free vibrations in vacuo [16]. He found that, except for extremely thin shells, the reduction of the real part of the natural frequencies from both internal and external fluid is negligible for steel shells and water or petroleum in all combinations. For the submerged case a perplexing result is that the introduction of viscosity in the surrounding fluid lowers the radiation damping in some cases. Forced vibrations were also studied [18] for both a concentrated normal force at the shell apex, tangential circumferential line force at the equator, and combinations of the two. Response curves were plotted for petroleum-filled steel shells.

Rectangular liquid propellant containers are used in aerospace vehicles. In order to assess the effect of the flexibility of such partially filled vessels, Bauer [19] considered a rectangular shell with four rigid sides and either of the following: a) an elastic plate or membrane bottom and a free liquid surface or b) a rigid bottom and plate or membrane covering the liquid surface. He used series expansion for both the fluid and plate or membrane to obtain frequency equations in the form of doubly infinite series the solution of which in truncated form led to the plotted frequency spectra.

CIRCULAR CYLINDRICAL SHELLS

Single shells and pipes. A method of fluid-structure interaction analysis has been introduced [20] in which the effects of the flexibility of the container are obtained as a perturbation from the response for a geometrically similar rigid one. This appears to be equivalent to the substructuring described by Daniel [12]. The method was applied to a simulated single downcomber bubble event in a partially filled cylindrical vessel with rigid sides and a flexible bottom. The pressures in the bottom plate and the bubble shape when the bottom is rigid are approximated by those obtained experimentally. A finite difference

scheme was used to obtain results for the deformable bottom plate; these results compared well with experiments. The bottom plate inertia was neglected in this exercise, so that the analysis was quasi-static, but this assumption and several others are not essential.

A similar technique has been proposed by Belytschko and Lin [2], who did not neglect compressibility, and applied to piping systems in finite element form. They demonstrated that, when both rigid and perturbated responses are obtained from computations, a consistent number of modes must be used in both. Three numerical examples -- in which results using this method are compared with straightforward fluid-structure coupling solutions and solutions assuming an incompressible fluid -- indicated that the proposed method works and that the use of added mass models can lead to substantial errors.

Two models have been used in a finite element analysis of piping systems containing compressible fluids [22]. The first model consisted of beam elements for the pipe and bars for the fluid; the second used shell elements and three-dimensional acoustic elements with velocity potential as a nodal unknown. Application of the models to determine response spectra in simple planar and non-planar pipe configurations indicated that the more approximate model was valid up to about two-thirds of the fundamental fluid-filled lumbar mode frequency. The results were sensitive to flexibility factors, which are built into the more accurate shell model of the pipe segments.

A model of liquid storage tanks suitable for seismic analysis has been the subject of three papers by Haroun and Housner [23-25] that have been summarized by Haroun [26]. Hoop finite elements were used for the shell and a boundary element technique for the fluid. Modes and frequencies were first obtained assuming no roof, beam-like modes ($\cos \theta$), a rigid base, and no coupling between sloshing modes and shell vibration modes. It was later shown that the in-plane rigidity of the roof system and the hoop stresses due to the hydrostatic pressure can affect considerably the non-beam ($\cos n \theta$) modes of the shell, when excited; it was confirmed that coupling between sloshing and shell vibrational modes was weak. The model was used to compare calculated steady-state and transient response of various tanks with both scale model experiments and full-scale field tests; good results were reported. It was found that accounting for tank deformability is very important. A simplified mechanical model and procedures have been proposed [26] for use in practical seismic design.

A similar method of analysis for the same problem has been suggested by Fujita [27]. He used a Rayleigh-Ritz rather than a Galerkin method for the fluid, included the sloshing-shell mode coupling from the onset, and allowed for variable shell wall thickness; but he did not address any of the practical complications mentioned above.

Modes and frequencies for partially filled cylinders have also been studied by Lim and Peyt [28], who used finite elements for both shell and fluid in two versions, both including and neglecting compressibility. They concluded that the former model gave better agreement with experiments than the latter. Only an abstract of this article was available to this reviewer.

Experiments have been reported [29] to verify the SING-S code [9, 10]. Frequencies and mode shapes were measured for a steel tank partially filled with water. Good agreement with calculated values was obtained for those modes that could be excited.

A one-dimensional system of a compressible fluid inside a rigid tube with an acoustic pump at one end and a spring mass at the other has been studied [30]. This model, meant to represent the core support barrel of a pressurized water reactor when excited by waves due to circulating pump pulsations, is the same as that used by Belytschko and Lin [21], who cite an earlier study, in one of their examples. An analytical solution for the steady-state response was obtained; parametric results are exhibited as response curves.

A correction and clarification of a comment made in an earlier review [3] about a boundary condition used in a paper by Firth [31] is in order. Private communication revealed that the Dirac delta at the center of the fluid surface (not the base) represented a four inch circular plate vibrating vertically in a four foot diameter tank. Although this was not mentioned in the paper cited [31], an earlier paper by Bentley and Firth [32] makes clear how and why this and the other boundary conditions were chosen.

Coaxial shells and tube bundles. These geometries are common in nuclear reactor applications. An analytical and experimental investigation of a cylindrical shell inside a fluid-filled rigid circular cylinder has been reported [33]. This configuration approximates the thermal liner of a fast flux test facility reactor vessel. The natural frequencies obtained using NASTRAN were about 25 percent higher than the experimental values measured for a 1/14-th scale model. The authors attribute the discrepancy to the difficulty of modeling the shell-boundary conditions. Efforts to excite modes with low circumferential wave numbers failed -- a difficulty also encountered by others [29].

In order to study loss of coolant accidents in a pressurized water reactor, Au-Yang and Galford [34] have developed an approximate analytical technique for determining transient response of a system of two concentric elastic cylinders containing fluid between them. Only beam modes were considered in calculating the shell response by a finite-element piping code; fluid compressibility was approximated by calculating a hydrodynamic mass matrix at the dominant modal frequency of the coupled system (iteratively) rather than at 0 Hz.

With seismic applications in mind, a code for determining stress resultants in several coaxial shells, each partially filled with fluid and subjected to horizontal transient loading, has been developed [35]. The shells were approximated as cantilevered beams. Sloshing was neglected so that the fluid was an added mass; other investigations indicated that the effect of compressibility was only about three percent. The foundation was approximated by attaching a rigid base slab to translational and rotational Kelvin spring-damper bodies. An example calculation was made for the flooded containment vessel of a nuclear plant subjected to an earthquake.

Coaxial cylinders made of acrylic or steel and with fluid in the annulus were used to simulate a reactor vessel with a thermal liner in a completely experimental free-vibration study [36]. Natural frequencies and damping ratios were measured using different combinations of three outside and nine inside cylinders with different thicknesses and diameters. It was concluded that gap size is an extremely important parameter in determining the frequency response and damping ratio of the system and that cylinder flexibilities also have a significant effect.

Natural frequencies of a tube array in a rectangular cavity filled with fluid have been approximated [37] using a homogenization technique, the technique replaces the fluid-tube system by an equivalent compressible fluid. The analysis involved the additional simplification that the tubes were rigid but supported by a spring system that allowed transverse displacements. Experimental results are also presented, but they are of limited interest because air was used as the fluid.

Infinite shells. Biological applications have been the motivation for several studies involving infinite circular cylindrical shells. Misra and Choudhury [38] have shown how the inclusion of viscosity in arterial walls alters the results obtained in an earlier investigation of wave propagation [39] and described in a previous review [3]. Several articles have been published [40-42] that deal with wave propagation in fluid-filled elastic tubes; the parameters in numerical examples were appropriate for arteries containing blood. Shear effects were found to be important for thick shells and high frequencies.

Several other papers of interest but not addressed to biomechanical problems have been published. Fuller and Fahy [43] have calculated real, imaginary, and complex branches of interactive dispersion curves and fluid-shell energy distributions for infinite steel cylinders containing water for the non-axisymmetric $n = 1$ circumferential modes, as well as for the $n = 0$ modes. As has been determined previously, most interaction modes are weakly coupled; i.e., they involve either predominantly fluid or shell motion. In a related paper addressed to applications in vibration control of piping systems, Fuller [44] first obtained both real and imaginary branches of force input mobility of infinite fluid-filled cylinders. The cylinders were vibrating in the $n = 0$, 1, and 2 circumferential modes and driven by line forces around the shell circumference. The cylinders were then used to analyze wave transmission through a ring constraining radial motion and the far field vibrational energy distributions between pipe and fluid resulting from both circumferential line sources or point forces. From the abstract of what appears to be an interesting report written by Lester [45], some of the results obtained by Fuller and Fahy [43] seem to have been

generalized to include thick shells surrounded by as well as containing fluid. Exact elasticity equations were used for the shell to obtain dispersion relations. The relations were solved numerically for real axial wave numbers for various circumferential harmonics.

Two experimental studies involving long tubes have been reported. Horne and Hansen [46] reported a detailed experimental study of sound propagation within water contained in tubes made of polymeric materials. The materials had a range of viscoelastic properties and acoustic impedance comparable to that of water. They used a piston at one end of a liquid column to ensonify it and measured sound pressure level as a function of axial position. Significant sound attenuation was observed in flexible polymeric pipes; more rigid pipes exhibited negligible attenuation. They concluded that viscoelastic materials offer promise for sound attenuation in industrial piping systems. An analytical and experimental study of the behavior of long aluminum and acrylic (PMMA) tubes filled with water or a high density capacitor fluid (Fluorinert), when loaded by the transverse impact of steel cylinders, was conducted by Katsamanis and Goldsmith [47]. Measured antisymmetric strain records were predicted reasonably well by a Timoshenko beam analysis modified by an added fluid mass for impacts of moderate duration; peak amplitude predictions were not as good for the acrylic tubes the viscoelasticity of which was not accounted for in the theory. The authors are aware that to properly account for the effect of breathing and lobar modes a shell theory would be required.

REFERENCES

1. DiMaggio, F.L., "Dynamic Response of Fluid-Filled Shells," Shock Vib. Dig., 7 (5), pp 5-12 (May 1975).

2. DiMaggio, F.L., "Recent Research on the Dynamic Response of Fluid-Filled Shells," Shock Vib. Dig., 10 (7), pp 15-19 (July 1978).

3. DiMaggio, F.L., "Dynamic Response of Fluid-Filled Shells – An Update," Shock Vib. Dig., 13 (6), pp 3-6 (June 1981).

4. Zienkiewicz, O.C. and Bettes, P., "Fluid-Structure Dynamic Interaction and Wave Forces. An Introduction to Numerical Treatment," Intl. J. Numer. Methods Engrg., 13, pp 1-16 (1978).

5. Tabarrok, H., "Dual Formulations for Acousto-Structural Vibrations," Intl. J. Numer. Methods Engrg., 13, pp 197-201 (1978).

6. Belytschko, T., "Fluid-Structure Interaction," Computers Struct., 12, pp 459-469 (1980).

7. Belytschko, T. and Schumann, U., "Fluid-Structure Interactions in Light Water Reactor Systems," Nucl. Engrg. Des., 60, pp 173-195 (1980).

8. Kulak, R., "A Finite Element Formulation for Fluid-Structure Interaction in Three-Dimensional Space," J. Pressure Vessel Tech., Trans. ASME, 103, pp 183-190 (May 1981).

9. Krieg, R. and Hailfinger, G., "Transient, Three-Dimensional Potential Flow Problems and Dynamic Response of the Surrounding Structures; Part I: Description of the Fluid Dynamics by a Singularity Method (Computer Code SING)," J. Comput. Phys., 34 (2), pp 139-163 (Feb 1980).

10. Krieg, R., Goller, B., and Hailfinger, G., "Transient, Three-Dimensional Potential Flow Problems and Dynamic Response of the Surrounding Structures; Part II: Simultaneous Coupling between Fluid and Structural Dynamics (Computer Code SING-S)," J. Comput. Phys., 34 (2), pp 164-183 (Feb 1980).

11. Muller, W.C., "Simplified Analysis of Linear Fluid-Structure Interaction," Intl. J. Numer. Methods Engrg., 17, pp 113-121 (1981).

12. Daniel, W.J.T., "Model Methods in Finite Element Fluid-Structure Eigenvalue Problems," Intl. J. Numer. Methods Engrg., 15, pp 1161-1175 (1980).

13. Daniel, W.J.T., "Performance of Reduction Methods for Fluid-Structure and Acoustic Eigenvalue Problems," Intl. J. Numer. Methods Engrg., 15, pp 1585-1594 (1980).

14. Coppolino, R.N., "A Numerically Efficient Finite Element Hydroelastic Analysis; Volume

1: Theory and Results," NASA CR-2662, Grumman Aerospace Corp., Bethpage, NY 11714 (Apr 1976).

15. Ball, R.E. and Citerley, R.L., "Fluid Mass Matrices for Thin Shell-of-Revolution Tanks," J. Pressure Vessel Tech., Trans. ASME, 102 (4), pp 387-393 (Nov 1980).

16. Su, T.C., "The Effect of Viscosity on Free Oscillation of Fluid-Filled Spherical Shells," J. Sound Vib., 74 (2), pp 205-220 (1981).

17. Su, T.C., "The Effect of Viscosity on Free-Vibrations of Submerged Fluid-Filled Spherical Shells," J. Sound Vib., 77 (1), pp 101-125 (1981).

18. Su, T.C., "The Effect of Viscosity on the Forced Vibrations of a Fluid-Filled Elastic Shell," J. Appl. Mech., Trans. ASME, 50, pp 517-524 (Sept 1983).

19. Baver, H.F., "Hydroelastic Vibrations in a Rectangular Container," Intl. J. Solids Struct., 17, pp 639-652 (1981).

20. Kalumuck, K.M. and Huber, P.W., "A Perturbation Analysis of Fluid-Structure Interactions in a Model Test System," J. Appl. Mech., Trans. ASME, 48, pp 7-14 (Mar 1981).

21. Belytschko, T. and Lin, J.I., "Modal Recovery Methods for Solution of Fluid-Structure Problems," Nucl. Engrg. Des., 71, pp 67-78 (1982).

22. Everstine, G.C., Marcus, H.S., and Quezon, A.J., "Finite Element Prediction Methods for Dynamic Response of Fluid-Filled Elastic 3-D Piping Systems," DTNSRDC - 82/100, David Taylor Naval Ship Research and Development Center, Bethesda, MD 20084 (Jan 1983).

23. Haroun, M.A. and Housner, G.W., "Earthquake Response of Deformable Tanks," J. Appl. Mech., Trans. ASME, 48, pp 411-418 (June 1981).

24. Haroun, M.A. and Housner, G.W., "Dynamic Characteristics of Liquid Storage Tanks," ASCE J. Engrg. Mech. Div., 108 (EM5), pp 783-800 (Oct 1982).

25. Haroun, M.A. and Housner, G.W., "Complications in Free Vibration Analysis of Tanks," ASCE J. Engrg. Mech. Div., 108 (EM5), pp 801-818 (Oct 1982).

26. Haroun, M.A., "Vibration Studies and Tests of Liquid Storage Tanks," Intl. J. Earthquake Engrg. Struct. Dynam., 11, pp 179-206 (1983).

27. Fujita, K., "A Seismic Response Analysis of a Cylindrical Liquid Storage Tank Including the Effect of Sloshing," Bull. JSME, 24 (195), pp 1634-1641 (Sept 1981).

28. Lim, S.P. and Peyt, M., "Free Vibration of a Cylinder Partially Filled with a Liquid," Intl. Conf. Recent Advances Struct. Dynam., Univ. of Southampton, UK, M. Peyt, ed., Vol. II, pp 447-455 (July 7-11, 1980).

29. Eberle, F., Göller, B., Hailfinger, G., and Kadlee, J., "Eigenoscillations of a Fluid-Filled Cylindrical Shell-Comparison between Theoretical and Experimental Results," Paper B5/4, Trans. 6th SMiRT Conference, Paris (1981).

30. Cepkauskas, M.M. and Stevens, J.A., "Fluid-Structure Interaction via Boundary Operator Method," J. Sound Vib., 90 (2), pp 229-236 (1983).

31. Firth, D., "Acoustic Vibration of a Liquid Filled Distorted Circular Shell," Intl. J. Numer. Methods Engrg., 13, pp 151-164 (1973).

32. Bentley, P.G. and Firth, D., "Acoustically Excited Vibrations in a Liquid-Filled Cylindrical Tank," J. Sound Vib., 19 (2), pp 179-191 (1971).

33. Chung, H., Turula, P., Mulcahy, T.M., and Jendrzejczyk, "Analysis of a Cylindrical Shell Vibrating in a Circular Cylindrical Region," Nucl. Engrg. Des., 63, pp 109-120 (1981).

34. Au-Yang, M.K. and Galford, J.E., "A Structural Priority Approach to Fluid-Structure Interaction Problems," J. Pressure Vessel Tech., Trans. ASME, 103, pp 142-150 (May 1981).

35. Stussi, U. and Jemelka, P., "Transient Response of Fluid-Coupled Coaxial Shells," ASCE J. Appl Mech. Div., 107 (EM4), pp 679-692 (Aug 1981).

36. Chu, M.L. and Brown, S., "Experiments on the Dynamic Behavior of Fluid-Coupled Concentric Cylinders," Exptl. Mech., pp 129-137 (Apr 1981).

37. Planchard, J., Remy, F.N., and Sonneville, P., "A Simplified Method for Determining Acoustic and Tube Eigenfrequencies in Heat Exchangers," J. Pressure Vessel Tech., Trans. ASME, 104, pp 175-179 (Aug 1982).

38. Misra, J.C. and Choudhury, K.R., "Effect of Initial Stresses on Wave Propagation in Arteries," J. Math. Biology, 18 (1), pp 353-368 (1983).

39. Rachev, A.I., "Effect of Transmural Pressure and Muscular Activity on Pulse Waves in Arteries," J. Biomech. Engr., 102, pp 119-123 (May 1980).

40. Tait, R.J., Moodie, T.B., and Haddow, J.B., "Wave Propagation in a Fluid-Filled Elastic Tube," Acta Mech. Solida Sinica, Chinese Soc. Theo. Appl. Mech., 38, pp 71-83 (1981).

41. Moodie, T.B., Tait, R.J., and Haddow, J.B., Waves in Compliant Tubes, Ed. F. Mainardi, Pitman (1981).

42. Barclay, D.W., Moodie, T.B., and Madan, V.P., "Linear and Non-Linear Pulse Propagation in Fluid-Filled Compliant Tubes," Meccanica, pp 3-9 (Mar 1981).

43. Fuller, C.R. and Fahy, F.J., "Characteristics of Wave Propagation and Energy Distributions in Cylindrical Elastic Shells Filled with Fluid," J. Sound Vib., 81 (4), pp 501-518 (1982).

44. Fuller, C.R., "The Input Mobility of an Infinite Circular Cylindrical Elastic Shell Filled with Fluid," J. Sound Vib., 87 (3), pp 409-427 (1983).

45. Lester, S.A., "Free Wave Propagation in Fluid-Loaded Thick-Walled Circular Pipes," Rept. No. AMTE(N)-TM81093, DRIC-BR-81307, Admiralty Marine Technology Establishment, Teddington, UK (Nov 1981).

46. Horne, M.P. and Hansen, R.J., "Sound Propagation in a Pipe Containing a Liquid of Comparable Acoustic Impedance," J. Acoust. Soc. Amer., 71 (6), pp 1400-1405 (June 1982).

47. Katsamanis, F. and Goldsmith, W., "Transverse Impact on Fluid-Filled Cylindrical Tubes," J. Appl. Mech., Trans. ASME, 49, pp 149-156 (Mar 1982).

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about aircraft crash dynamics research.

Mr. Gil Wittlin of Lockheed-California Company, Burbank, California has written an update of the three major considerations of aircraft crash dynamics research -- aircraft crash environments, available analytical techniques, and occupant protection -- with regard to recent research efforts in aircraft structural crash dynamics.

AIRCRAFT CRASH DYNAMICS RESEARCH UPDATE

G. Wittlin*

Abstract. Three major considerations of aircraft crash dynamics research include aircraft crash environments, available analytical techniques, and occupant protection. This article presents an update of these considerations with regard to recent research efforts in aircraft structural crash dynamics. The results of an accident history review of large transport airplanes conducted by three major domestic transport airplane manufacturers, and sponsored by the Federal Aviation Administration (FAA) and National Aeronautics and Space Administration (NASA), are presented. Modeling and testing of transport airplane structure are discussed. Recent analyses and tests of helicopter composite fuselage structure are reviewed. Summary reports of general aviation aircraft crash-tests from the NASA-Langley Impact Dynamics Facility are noted. The status of seat-occupant modeling for light aircraft is presented.

In the last decade, modeling of aircraft structures to determine dynamic responses under crash loading conditions has been enhanced by the availability of experimental data. Much of the recent testing has been performed not only to obtain data but also to validate analytical methods and assess design concepts. This article briefly describes some of these efforts as they relate to different aircraft configurations; namely, large transports, military helicopters, and general aviation aircraft. The purpose of this article is to provide a cross section of pertinent material that has been reported within the last three years. It is not possible to include all of the contributions that have become available in this time span.

TRANSPORT CATEGORY AIRPLANES

Recent in-depth studies [2-4] of large transport accidents over the past 20 years reveal that, although no accidents are alike in every respect, broad similarities can be found for groups of accidents. These similarities allow for a rational arrangement of hundreds of accidents into a few candidate crash scenarios (see the Table). Accidents that are initiated when an aircraft is on the ground, and where no unpredictable hazards are involved, are rarely fatal. Conversely, when impact occurs at high speed and with a large impact angle, as accidents away from airports often do, the probability of fatalities is high. Between the extremes the outcome, in terms of occupant survivability, depends on surrounding hazards. Figure 1 [2] shows the distribution of accident severity vs accident type.

Distinct events can occur during a transport airplane accident. The likelihood of occurrence of each event and the involvement of structural systems -- i.e., fuel tank, seat and attachments, fuselage, and wing -- is related to a particular crash scenario. For each potential crash scenario several failure modes could occur; one is illustrated in Figure 2. Each structure-related initial failure can lead to additional structural involvement and subsequent failure. The consequences of these events and failures include fuel tank/line rupture, mass item failure, floor/door deformation, loss of seat integrity, and excessive occupant loads. Hazards to occupants include fire (including smoke and inhalation), trauma, and evacuation fatalities and injuries. A summary of the results of three accident studies is available [5].

Current research efforts related to transport aircraft include the following:

- Drop tests of a medium-sized transport airplane fuselage sections

  These tests involve both a soft frame section and a hard point structure (landing wheel well bulkhead). The post-test configuration for the

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Table. Identification of Candidate Crash Scenarios

CANDIDATE CRASH SCENARIO	IMPACT CONDITIONS	ACCIDENT TYPE	TERRAIN	HAZARD
GROUND-TO-GROUND, OVERRUN	LOW SINK SPEED LOW FORWARD VELOCITY SYM. A/P ATTITUDE GEARS EXTENDED	TAKEOFF ABORT LANDING OVERRUN	RUNWAY HARD GROUND	DITCH MOUND SLOPE SLAB LIGHT STANCHION
AIR-TO-GROUND, HARD LANDING	HIGH SINK SPEED LANDING VELOCITY SYM. A/P ATTITUDE GEARS EXTENDED	HARD LANDING UNDERSHOOT	RUNWAY HARD GROUND	NONE
AIR-TO-GROUND, IMPACT	HIGH SINK SPEED LANDING VELOCITY UNSYM. A/P ATTITUDE GEARS EXTENDED/RET.	UNCONT/CONTROLLED GRD COLLISION STALL UNDERSHOOT	WOODED HILLY	TREES SLOPES BLDGS

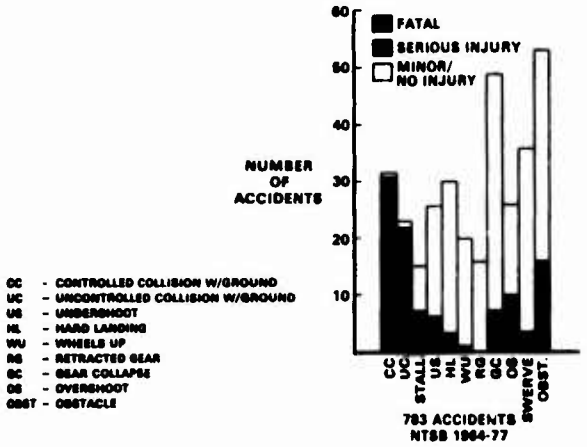


Figure 1. NTSB Accident Data, Injury Severity as a Function of Accident Type

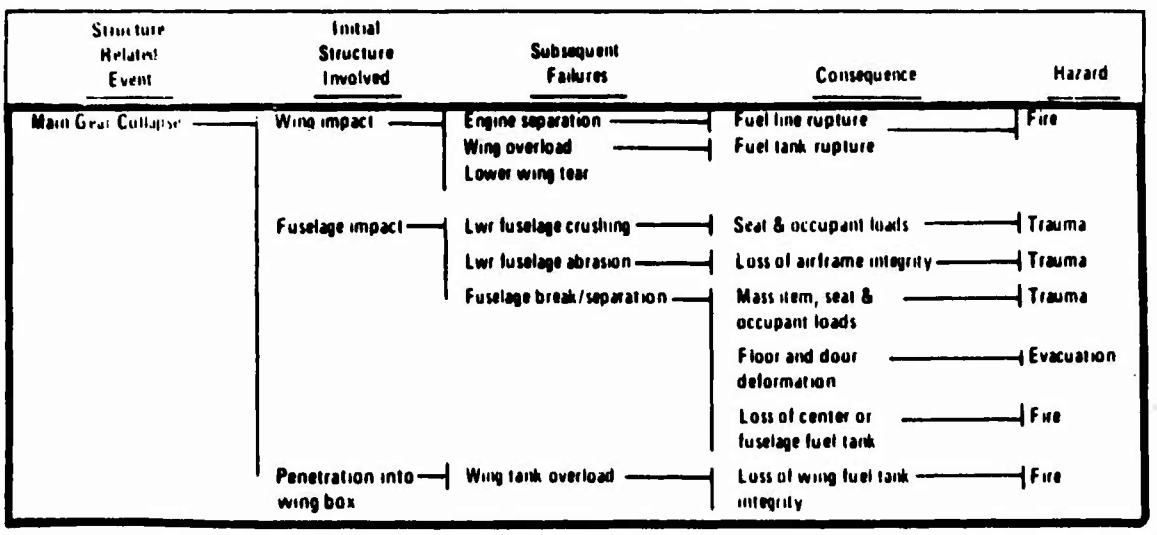


Figure 2. Flow Diagram, Candidate Crash Scenario

soft frame is shown in Figure 3. It can be seen that a substantial amount of crushing occurs. Conversely, the landing wheel well bulkhead (Figure 4) exhibits little or no deformation. As expected the floor loads in the latter tests are significantly higher than in the frame section test. Analysis of test data and modeling of sections continue.

- Preparation for a full-scale medium-sized transport airplane crash test

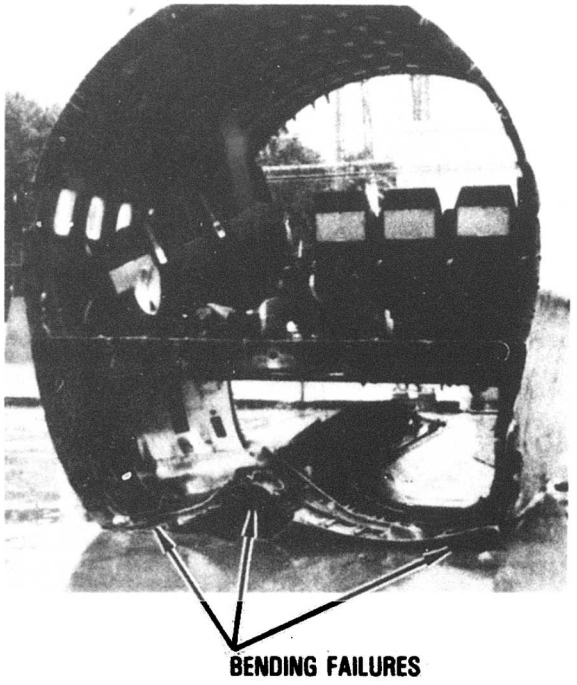
  The section test data will serve as input data for such current programs as DYCAST [6] (Dynamic Crash Analysis of Structures) and KRASH* [7], which are being used to help determine appropriate test impact conditions. The math models developed with both analytical approaches are to be used to predict airframe and floor responses. A full airplane crash test is scheduled for mid-1984. The test results will help establish modeling requirements for transport category aircraft. Some initial analytical studies, which were conducted to determine floor pulses for various crash scenarios, have been described [8, 9].

- Development of a seat-occupant model for transport airplanes (SOM-TA)

  This is an extension of a single-seat-occupant model (SOM-LA) developed for light aircraft to a multiple seat-occupant representation. FAA-CAMI (Civil Aeromedical Institute) test data will be correlated with computer program results.

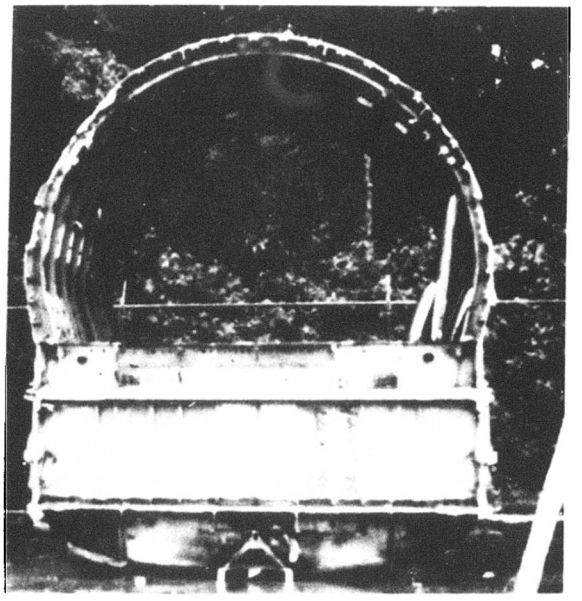
- Fuselage critical technology program

  A NASA-sponsored program is to be initiated to facilitate the development of composite technology for impact dynamics (and acoustic transmission) in fuselage structure of large transport aircraft. The first phase of this pro-



NOTE: NO SEAT FAILURES OCCURRED. ANTHROPOMORPHIC DUMMIES AND SEATS USED FOR THE TEST WERE REMOVED.

Figure 3. Post Test View, Transport Airplane Frame Section



NOTE: SOME SEAT FAILURES WERE NOTED. SEATS AND ANTHROPOMORPHIC DUMMIES HAVE BEEN REMOVED

Figure 4. Post Test View, Transport Airplane Main Landing Gear Wheel-Well Region

*KRASH, a hybrid digital computer program, has provisions to utilize available experimental data as part of the input

gram is expected to extend through 1986. The program is being formulated under a current related project [10].

The results of a study to investigate the dynamic behavior of commuter airplane-related fuselage structures subject to various impact conditions has been reported [11]. The study involved extensive testing of scale-model stiffened aluminum sections for a wide range of wing loads, angles of incidence, and impact velocities. Included is the development of a finite-element, lumped-mass computer program to analyze the behavior of the fuselage structure. The fuselage structure is modeled symmetrically and with straight elements. A reduced stiffness matrix reduces the finite element model size from 368 degrees of freedom (DOF) to 138 DOF. The mass matrix corresponds to the reduced DOF. Only a portion of the major structural elements -- i.e., main frames -- are modeled in the post-yielding region. One approach [11] is an attempt to combine the details of finite-element methods with cost-effective approximations associated with lumped mass techniques. Recommended improvements in modeling are discussed [11], some of which have since been incorporated.

ROTARY-WING AIRCRAFT

Two recent studies [12, 13] show an increased emphasis on composite airframe research. One paper [12] describes an analysis for the advanced composite airframe program (ACAP) of a helicopter design using KRASH. The preliminary math model, shown in Figure 5, contains 21 masses to represent the helicopter. The model was used to demonstrate the feasibility of designing all composite airframe program ACAP to meet the stringent vertical impact conditions required by the U.S. Army. To predict the effect of pitched and rolled impact attitudes on the landing gear and the underside of the forward fuselage a more detailed model, shown in Figure 6, was developed. This model consists of 37 masses; the 27 node points are related to specific masses and move with the respective mass in a fixed relation to the mass. The analysis was used to demonstrate that the ACAP structure meets the crashworthiness requirement, maintains occupant living space, and, in conjunction with crashworthy seats, protects occupants against injurious head accelerations.

The crash impact characteristics of a helicopter composite structure, as determined by test and analysis, have been described [13]. The cabin test section, derived from an ACAP design, is shown in Figure 7. An exploded view of this section, Figure 8, illustrates the various materials used. Both 30 ft/sec pure vertical and a 30 ft/sec vertical with a 20 degree roll impact condition were tested and analyzed. The KRASH model is shown in Figure 9. The KRASH model results were used in conjunction with a NASTRAN** model to size the structure. In addition, DYCAST modeling (Figure 10) of the section was also performed. A comprehensive description of the model, tests, and results are available [13]. The report concludes that "the weight increase due to adding crashworthiness features can be balanced by the weight reduction using composite materials."

Two studies [8, 9] were performed to show compliance within the velocity change envelope (Figure 11) required by U.S. Army specifications [14].

Several studies have been made on structural elements and concepts in support of aircraft design. The U.S. Crash Survival Design Guide [15] describes various energy absorption concepts, including those involving composite materials. In a recent publication [16] the results of a test program to obtain impact behavior data for composite structure that could be used as load-carrying members -- i.e., landing gear, engine mount, transmission mount or seat struts -- is described. Fiber reinforced plastic (FRP) tubes were tested and compared with regard to relative energy absorbing performance. The performance indicators used are shown in Figure 12.

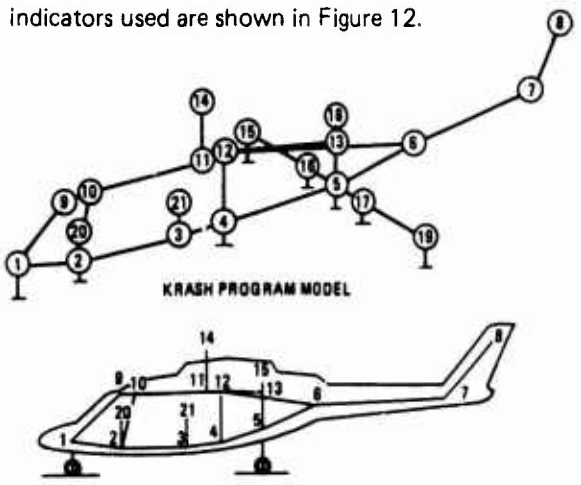


Figure 5. Sikorsky Preliminary KRASH Model

**NASA Structural Analysis Computer Program

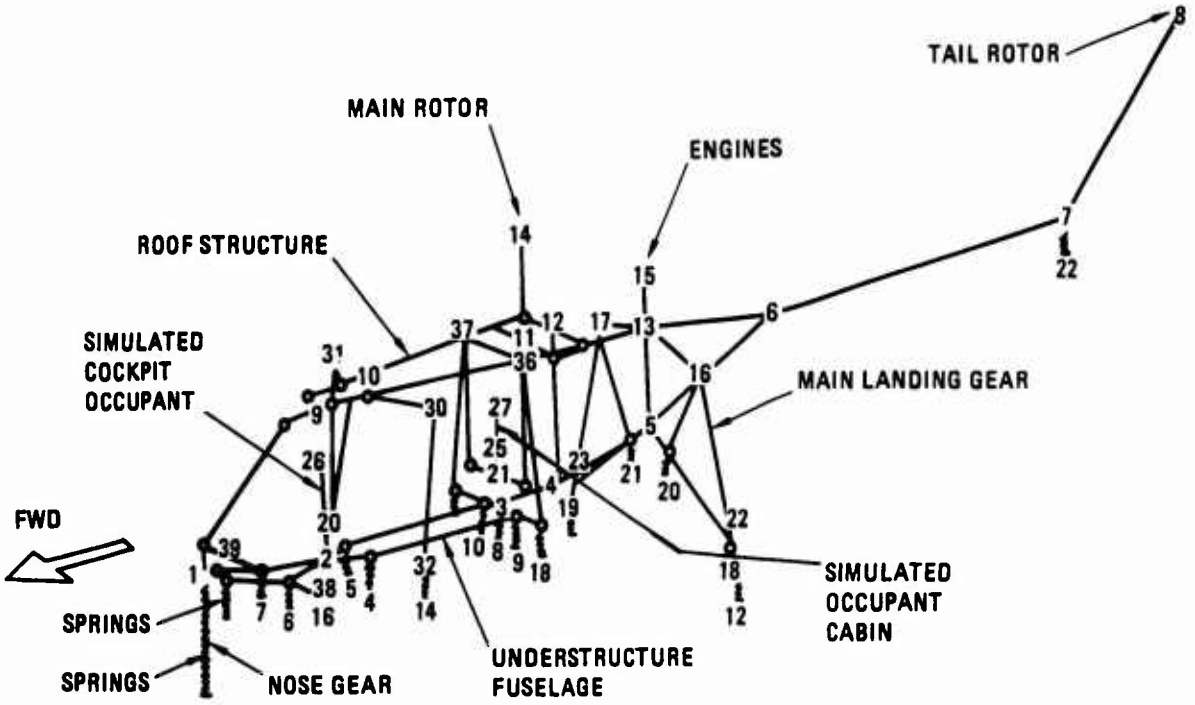


Figure 6. Sikorsky Final KRASH Model

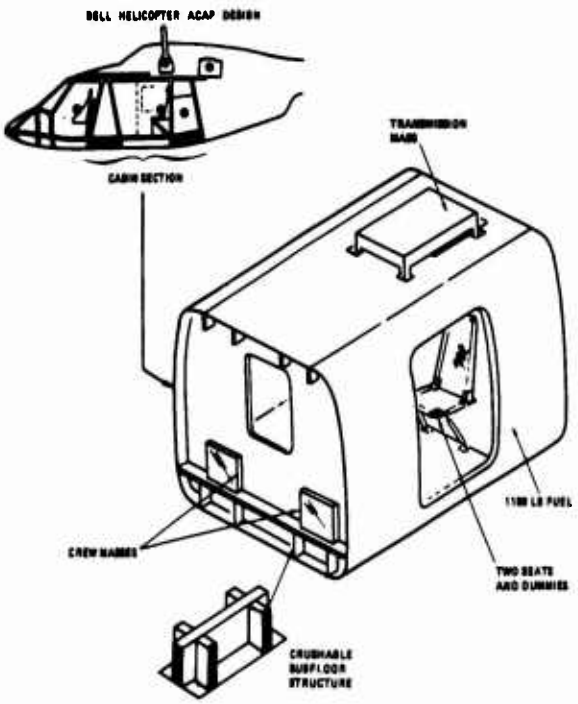


Figure 7. Cabin Test Section Derived from Bell Helicopter ACAP Design

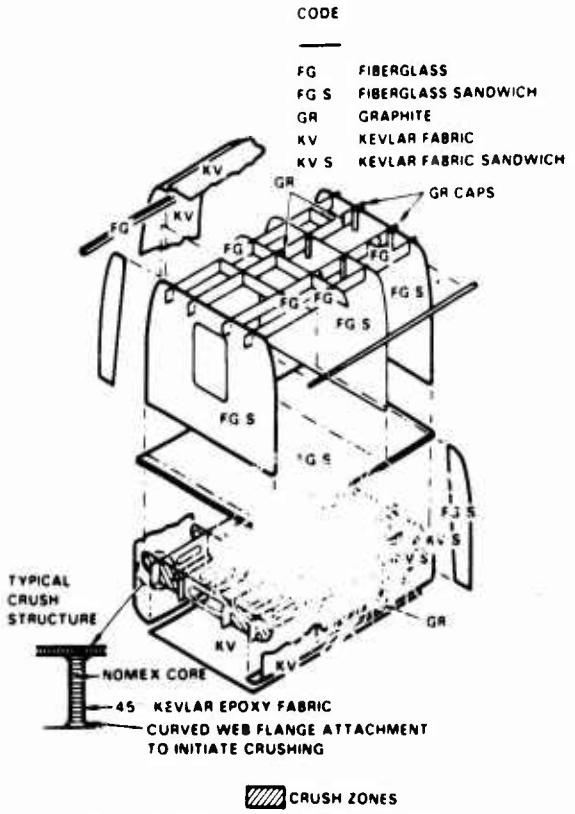


Figure 8. Composite Cabin Test Section, Exploded View

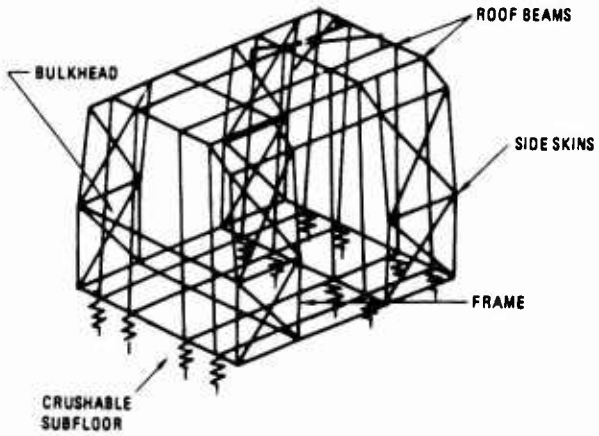


Figure 9. Bell Helicopter Composite Cabin KRASH Model

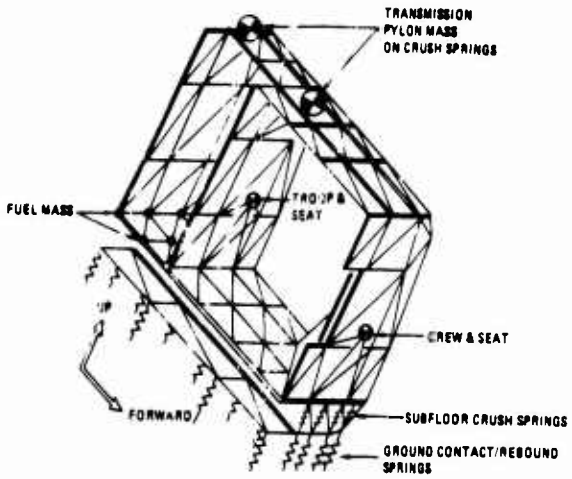


Figure 10. DYCAST Flat Drop Model, Overall View

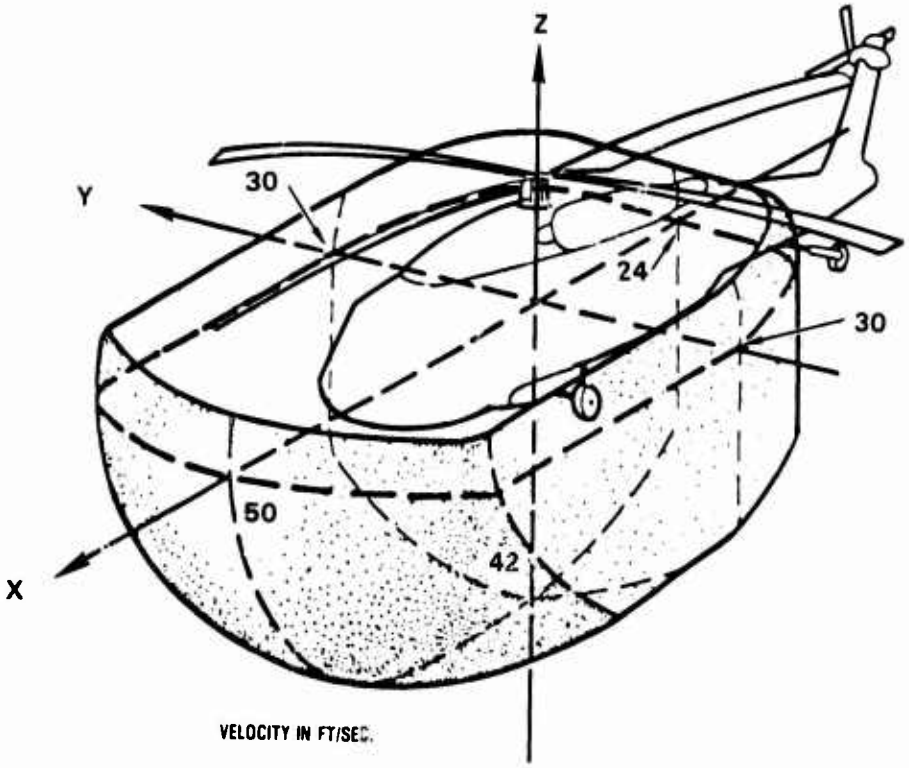


Figure 11. Three-Dimensional Display of Design Velocity Change Envelope for Helicopters

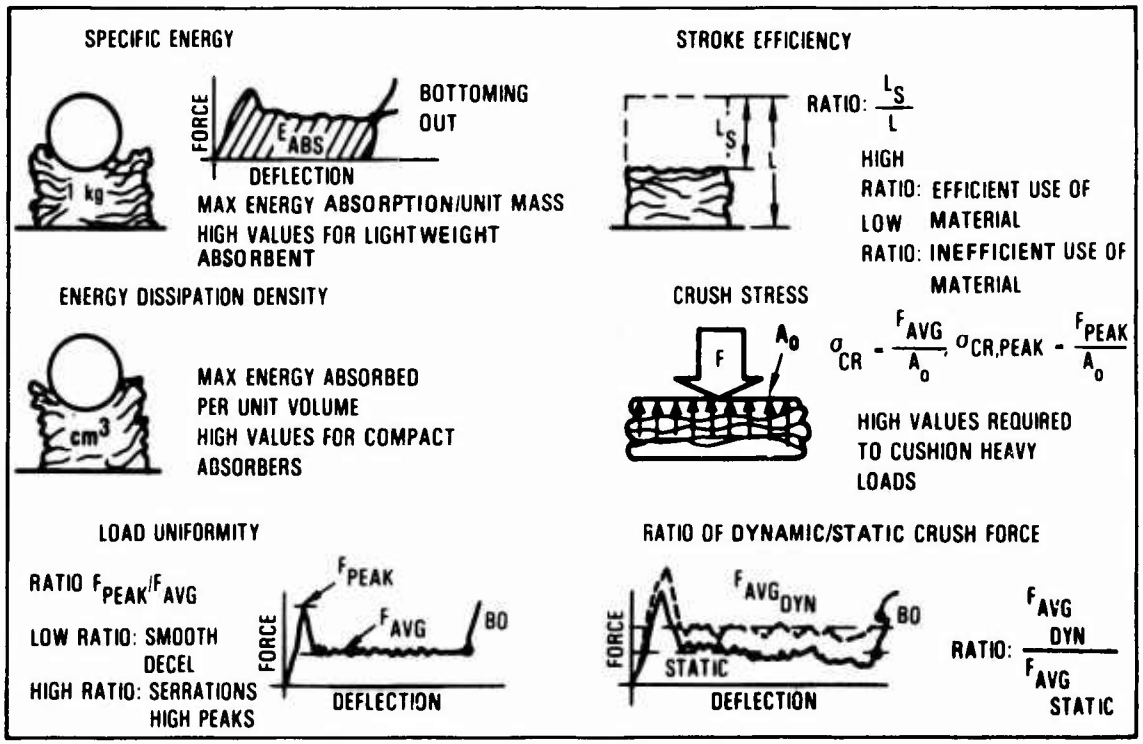


Figure 12. Energy Absorption Terms

GENERAL AVIATION AIRPLANES

In one study [17] five subfloor energy-absorbing concepts were selected for fabrication and test. These concepts are shown in Figure 13 and described below.

- formable keel web. Energy is absorbed by plastic formation of the keel beam web.
- corrugated sandwich web. Energy is absorbed by deforming preformed corrugated webs and crushing the foam filler.
- corrugated web/notched corners/foam. Energy is absorbed primarily by crushing foam. Structurally tailored notched corners reduce load spikes at the intersections of longitudinal keel beams and lateral bulkheads.
- corrugated half-shell. Energy is absorbed by bending deformation of a curved corrugated shell.
- foam-filled cylinder. Energy is absorbed by crushing foam with cylinder walls needed primarily for web shear strength.

Samples of design support test load-deflection data are shown in Figure 14. Energy absorbing concepts were selected for incorporation into floor test sections and fabricated on the basis of test results and the following considerations: capabilities of strength, stiffness, and energy absorption; the need to perform under combined loading and reaction of concentrated loads from seats and large masses; and practicality from cost/producibility and such functional standpoints as routing of wires, controls, and hydraulics. The final concepts selected included

- corrugated web with notched corner intersections
- corrugated half-shell
- north corner intersections with conventional webs
- foam filled cylinder
- canted bulkheads with conventional intersections

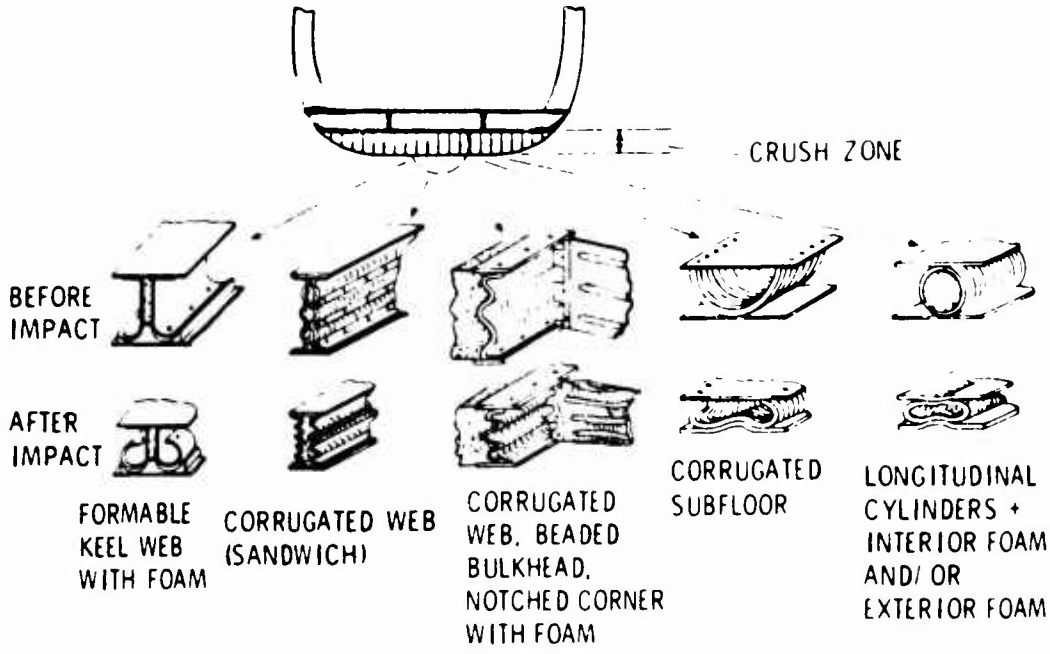


Figure 13. Lower Fuselage Load-Limiting, Energy-Absorbing Concepts

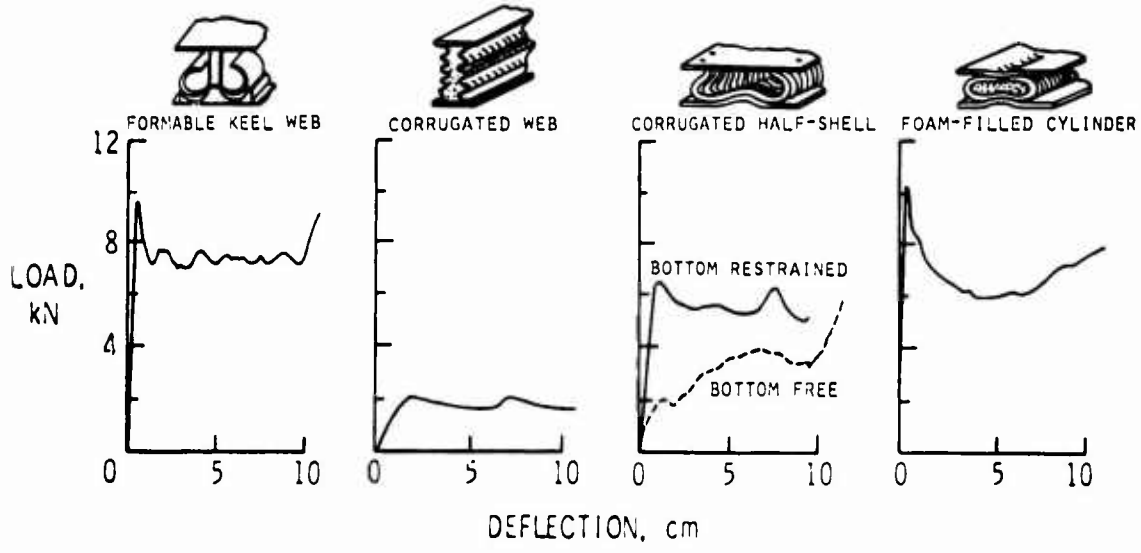


Figure 14. Samples of Load-Deflection Curves from Design Support Tests

Static and dynamic tests were performed. Analyses to predict above-floor occupant mass representations using KRASH gave satisfactory results. Two of the concepts -- the corrugated web with notched corner intersections and notched corner intersections with conventional webs -- were selected as modifications to an existing subfloor of two twin-engine airplanes for future testing as part of the overall NASA general aviation airplane crash test series. A complete description of designs, tests, analyses, results, and conclusions is available [17].

The NASA general aviation airplane crash test program includes several additional reports [18-20]. One [18] provides test results for four low-wing twin-engine airplanes with a truss-reinforced fuselage structure. Another [19] contains a summary of an analysis of crash deceleration pulse data from general aviation airplane crash tests. The report attempts to assess crash deceleration data in relation to such impact parameters as flight path velocity, flight path, and pitch angle. The results of three identical four place, low-wing single-engine airplane specimen crash tests (two on concrete and one on soil) are described in the third report [20].

In November, 1982, program SOM-LA [21] was released into the public domain after many years of development. The purposes of this program are to model and analyze light aircraft seat-occupant behavior. The program is limited to an individual seat and occupant. Results of analysis of aircraft seats using program SOM-LA are available [22], as is an additional seat analysis using crash test pulse data [23].

GENERAL

The first International Symposium on Structural Crashworthiness was held at Liverpool, England, in September, 1983 [24-26]. The implementation of various numerical techniques in aircraft crashworthiness problems was discussed [24]. Also included in the symposium's published reports are data related to the behavior of composite materials and various structural elements under dynamic loading. Rail, ship, and automotive collision protection are also addressed.

CONCLUSIONS

In the last several years a number of reports have been published that are pertinent to aircraft crash analysis. Published data indicate that significant contributions have been provided in many areas. It is anticipated that the results of current and planned research in aircraft crash dynamics will provide opportunities to improve crash design criteria and applicable methodology before the end of the 1980s.

The following points are especially important:

- For large transports three studies have provided input toward the establishment of crash scenarios. Analysis has been initiated to determine anticipated floor pulses. In addition, tests have been performed or are planned to validate computer programs and assess crash design requirements. Research has been initiated to determine composite fuselage technology requirements.

- For rotary-wing aircraft emphasis has been on design evaluation of composites, including the development of crashworthy design concepts for the subfloor region. Math modeling, section tests, and correlation between analysis and test results have been performed.

- For general aviation aircraft, because the NASA crash test program is nearing its conclusion, summary reports of the tests and results are being issued. Energy-absorbing subfloor concepts for light fixed-wing aircraft have been designed, fabricated, and tested. Modeling of occupant-seat response to floor pulses continues; a specialized computer program has been developed, and the test data to validate analysis results are available.

The 1980s should see the successful culmination of several research projects initiated in the previous decade. In particular validation of analytical procedures for predicting aircraft structural dynamic behavior during a crash impact will reduce reliance on full-scale crash testing.

REFERENCES

1. Wittlin, G., "Aircraft Crash Dynamics: Some Major Considerations from the Shock and

Vibration Digest," Shock Vib. Dig., 13 (3), pp 3-15 (Mar 1981).

2. Wittlin, G., Gamon, M.A., and Shycoff, D.L., "Transport Aircraft Crash Dynamics," Lockheed-California Company, NASA CR 165851, FAA Report, DOT/FAA/CT-82/69 (Mar 1982).

3. Widmayer, E. and Brende, O.B., "Commercial Jet Transport Crashworthiness," Boeing Airplane Company, NASA CR 65849, FAA Report DOT/FAA/CT-82/86 (Mar 1982).

4. Cominsky, A., "Transport Aircraft Accident Dynamics," McDonnell Douglas Corp., NASA CR 165850, FAA Report DOT/FAA/CT (Mar 1982).

5. Thomson, R.G. and Caiafa, C., "Structural Response of Transport Airplanes in Crash Situations," NASA TM 85654 (June 1983).

6. Armen, H., Pifko, A., and Levine, H., "Nonlinear Finite Element Techniques for Aircraft Crash Analysis," Aircraft Crashworthiness, University Press of Virginia, pp 517-548 (1975).

7. Gamon, M.A., "KRASH User's Manual," FAA-RD-77-189, Volumes I, II, III, Lockheed-California Company (Feb 1979; revised).

8. Wittlin, G. and Lackey, D., "Analytical Modeling of Transport Aircraft Crash Scenarios to Obtain Floor Pulses," Lockheed-California Company, NASA-CR 166089, FAA Report DOT/FAA/CT - 83-23 (Apr 1983).

9. Wittlin, G., "Analysis of Aircraft Dynamic Behavior in a Crash Environment," J. Aircraft, 20 (9), pp 762-769 (Sept 1983).

10. Contract NAS1-17415 "Study of the Utilization of Advanced Composites in Fuselage Structures of Large Transports," Lockheed-California Company (to be published).

11. Tennyson, R.C. et al, "Study of the Crashworthiness of Light Aircraft Structures," Proc. 22nd Struc. Struc. Dynam. Matls. Conf., AIAA Paper 81-0574.

12. Carnell, B.H. and Pramanik, M., "ACAP Crashworthiness Analysis by KRASH," Sikorsky Aircraft, pres. at AHS Mtg., Philadelphia, PA (Mar 1983).

13. Cronkhite, J.D. and Berry, V.L., "Investigation of the Crash Impact Characteristics of Helicopter Composite Structures," Bell Helicopter Textron Inc., USAAVRAMCOM-TR-82-D-14 (Feb 1983).

14. "Light Fixed-wing and Rotary wing Aircraft Crashworthiness," MIL-STD-1290 (Jan 1974).

15. "Aircraft Crash Survival Design Guide -- Volume III Aircraft Structural Crashworthiness," Simula, Inc., USARTL-TR-79-22c (Aug 1980).

16. Kindervater, C.M., "Energy Absorbing Qualities of Fiber Reinforced Plastic Tubes," pres. at AHS Mtg., Philadelphia, PA (Mar 1983).

17. Cronkhite, J.F. and Berry, V.L., "Crashworthy Airframe Design Concepts," Bell Helicopter Textron, NASA CR 3603 (Sept 1982).

18. Williams, S. and Fasanella, E.L., "Crash Tests of Four Low-Wing, Twin-Engine Airplanes with Truss-Reinforced Fuselage Structure," NASA Tech. Paper 2070 (Sept 1982).

19. Carden, H.D., "Correlation and Assessment of Structural Airplane Crash Data with Flight Parameters at Impact," NASA Tech. Paper 2083 (Nov 1982).

20. Castle, C.B. and Alfaro-Bou, E., "Crash Test of Three Identical Low-Wing Single-Engine Airplanes," NASA Tech. Paper 2190 (Sept 1983).

21. Laananen, D.H., Bolukbasi, A.O., and Coltman, J.W., "Computer Simulation of an Aircraft Seat and Occupant in a Crash Environment," Volumes I and II, Simula, Inc., DOT/FAA/CT - 82/23-1 & 2 (Mar 1983).

22. Laananen, D.H., Neri, L.M., and Nuckolls, C.E., "Crashworthiness Analysis of Aircraft Seats Using Program SOM-LA," SAE Paper 830747 (Apr 1983).

23. Alfaro-Bou, E., Williams, and Fasanella, E., "Determination of Crash Test Pulses and Their

Application to Aircraft Seat Analysis," SAE Paper 810611 (Apr 1981).

24. "Structural Crashworthiness," Edited by Jones, N. and Wierzbicki, T., pres. at Liverpool, England, Butterworth & Co. (Sept 1983).

25. "Structural Crashworthiness Conferences," Intl. J. Mech. Sci., Special Issue, 25 (9-10), pp 613-74 (1983).

26 "Impact Crashworthiness," Intl. J. Impact Engrg., Special Issue, 1 (3) (1983).

BOOK REVIEWS

NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS IN SCIENCE OF ENGINEERING

L. Lapidus and G.F. Pinder
John Wiley and Sons, New York, NY
1982, 677 pages, $44.95

Numerical solutions of partial differential equations assume many forms; parabolic, elliptical, and hyperbolic equations can be solved by a number of numerical methods including finite difference methods (FDM), finite element methods (FEM), collocation, and boundary element procedures. This book attempts to explain these methods.

The book consists of 6 chapters. Chapter 1 discusses fundamental concepts of partial differential equations (PDE) including first order (linear and nonlinear), second order (canonical, linear, quasilinear), and systems of order PDE (characteristic curves and their applications). The chapter concludes with a good analysis of initial and boundary conditions.

Chapter 2 delves into the basic concepts of FDM and FEM. Notation, use of Taylor's series, and operator notation are considered and extended to approximations in two dimensions. The latter part of the chapter introduces FEM including the methods of weighted residuals (Galerkin method, subdomain method, and collocation method). The weighted residual methods are explained; simple matrices that are fundamental to FEM are derived. Parabolic and cubic base polynomials, Lagrangian polynomials, and Hermitian polynomials are described, as are two-dimensional basis functions that comprise the two-dimensional Lagrangian function and approximate functions (weighted residuals). The chapter concludes with a short but interesting explanation of the relationship between FEM and FDM.

Chapter 3 treats finite elements of irregular spaces -- a linear triangular element. The natural coordinates are expressed by area coordinates and quadratic and cubic triangular elements; the result is isoparametric finite elements employing numerical integration. The chapter concludes with isoparametric Hermitian elements in normal and tangential coordinates and boundary conditions for two- and three-dimensional isoparametric elements.

The longest chapter, on parabolic differential equations, covers slightly less than 1/3 of the book. A number of approximations of FDM are considered including the classic explicit approximation, Du Fort-Frankel, and Richardson. The implicit approximations covered are the backward, Crank-Nicolson, and variable weighted. The concepts of consistency and convergence as well as stability in the various FDM approximations are described. The authors relate some of the extensions of the basic concepts of approximations; i.e., influence of lower and higher terms, asymmetric variable coefficients, nonlinear parabolic methods, and box methods. Composite solutions are always feasible for FDM approximations; the authors apply them to global extrapolation and composites of different approximations. Two-space dimensions possess irregular boundaries and utilize alternating direction explicit (ADE) and implicit (ADI) methods. Fractional splitting and hopscotch methods are explained. The FDM part of the chapter concludes with three-dimensional problems using ADI, fractional splitting, and iterative solutions. FEM coverage includes preliminary applications of Galerkin's approximation and the time derivative; i.e., backward, variable weighted implicit, modified, predictive-corrector approximations, and Crank Nicolson extrapolation. FEM approximations in one space dimension include the previously discussed Galerkin, linear, and higher order polynomial basis function approximations plus formulation of the Dirac delta function, orthogonal collocation, and asymmetric weighing procedures. Approximations in two-space dimensions are covered in a similar way and include Galerkin, asymmetric weighing, and isoparametric quadrilateral methods. Lumped and constant time matrices and collocation formulations are considered. The

chapter treats two-space dimensions and directly extends them to the three-dimensional formulation. The reviewer feels that the extremely short section on three-dimensional space should be expanded.

Chapter 5 reports on elliptic PDE. The format, similar to the previous chapter, begins with FDM solution of the elliptical PDE; detailed solutions and explanations are given of five- and nine-point approximation and truncation errors, approximation to biharmonic equations, boundary condition approximation, and matrix forms of the FDM equations. Methods of direct solution entail cyclic or odd:even reduction schemes, iterative concepts, formulation and convergence of point iterative methods, line and block iteration, and ADI methods. A very brief section on three-dimensional space concludes the section on FDM.

The authors continue with FEM methods: Galerkin and collocation approximation methods for elliptical PDE, mixed FEM approximation including biharmonic equation, and the boundary integral equation (BIE) method.

The BIE, rarely found in books on numerical solutions, is a powerful method that originated in structural mechanics. It is used in the fields of heat transfer, fluid flow, electron dynamics, and magnetodynamics. The fundamental theory and its formulation and the linear interpolation function with applications to Poisson equations and nonhomogeneous materials are given. FEM and BIE are then combined. The chapter concludes with a short discussion of three-dimensional structure. The reviewer had previously taken solutions from two separate sources (BIE and FEM) for a three-dimensional structure and was able to extend the stress concentration curve. The BIE is a very powerful method and should become more important in the coming years.

The last chapter focuses upon hyperbolic PDE. Stability and truncation error, Lax-Wendroff approximations, dissipation and dispersion in fluid dynamics, the hopscotch method, mesh refinement, and various finite difference schemes are involved. With regard to second order elliptical PDE the authors discuss explicit and implicit algorithms and mixed systems of PDE. The third order explanation is short but follows the same pattern as the second order.

The authors next present the FEM of the first-order model hyperbolic PDE. This includes Galerkin asymmetric weighing function, dissipation and dispersion, and orthogonal collocation. The concluding sections of this chapter treat two- and three-dimensional formulations, the Adams-Bashforth scheme, and the Lax-Wendroff scheme; discussions of boundary conditions and time approximations (Houbolt, Wilson, and Newmark) are included.

This excellent book contains much information. The reviewer has the following comment: more detailed examples of the methods should have been included as well as computer programs showing the workings of the various methods and schemes. A definition of terms in a table of nomenclature would help the reader, as would an author reference index. The reviewer recommends this volume to both students and experienced personnel interested in numerical solutions of PDE.

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MECHANICS OF SOLIDS WITH APPLICATIONS TO THIN BODIES

G. Wempner
Martinus Nijhoff, The Hague, The Netherlands
1982, 633 pages, $79.00

This text is a republication of a book first published by McGraw-Hill in 1973 as part of its Advanced Engineering Series. According to the author, the main objective of the book is "to build a bridge between the most fundamental concepts of continuous media and the practical theories of structures."

The book follows the deductive approach; thus, equations governing the behavior of the simplest one-dimensional structures are derived from the most general formulation. This reviewer would have preferred more of the inductive or building-block approach throughout, as it is better adapted for teaching purposes. The purely deductive approach can result in the loss of enrollment on the part of some competent students in a course in which such a

text is used. Some students do not have the patience to digest a great deal of theoretical material before they learn how to approach simple structural problems. On the other hand, the entire development of the book must be viewed from the vantage point of the author whose unifying philosophy is that "This book is intended for engineers interested in the applied mechanics of solids."

The printing type is smaller and more difficult to read than the original 1973 McGraw-Hill edition. This is particularly noticeable when tensor equations with multiple indices are involved. And Dr. Wempner is not Professor of Engineering Mathematics, as stated in the title page, but is Professor of Engineering Mechanics at Georgia Institute of Technology.

The chapter titles, given below with brief descriptions, are indicative of the coverage of the book. They are:

- Introduction. The notation to be used in the sequel is developed.
- Deformation. The kinematics of deformation of a continuous body is developed.
- Stress. The concepts of internal forces and stresses are given.
- Behavior of Materials. The theory of elasticity, the incremental theory of plasticity, and the linear theory of viscoelasticity are developed.
- Linear Theories of Isotropic Elasticity and Viscoelasticity. Limitation of linearity, formulation of boundary value problems, solution by complex variables, and quasi-static problems are considered. The correspondence principle for viscoelasticity is derived.
- Extension, Flexure, and Torsion of Rods. Title topics including buckling as well as dynamic problems for a uniform rod are considered.
- Elastic Plates. Basic kinematics, edge conditions, and buckling conditions for thin plates are derived.
- Curved Rods. Strain distribution, stress resultants, constitutive equations, equations of motion, and buckling are included.
- Energy Principles. Topics include strain energy, complementary energy, and stability.
- Curvilinear Coordinates.
- Differential Geometry of a Surface. Chapters 10 and 11 develop the subjects in sufficient depth so that they can be applied to shell theory.
- Theory of Shells. Topics range from the classical theory of thin shells to the capricious nature of buckling in the same.

The coverage of the book is extensive; with careful guidance it can be used profitably by graduate students who have had some preliminary exposure to solid mechanics.

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FATIGUE UNDER COMPLEX LOADING

R.M. Wetzel, Editor
Society of Automotive Engineers, Inc.,
Warrendale, PA, 1977, 207 pages

This book is a remarkable compendium of ten papers prepared by authors representing various agencies. Each of 11 agencies provided funds and time for a test program intended to provide a set of basic data for determining the validity of various fatigue life prediction methods. Three variable amplitude load histories were selected from actual service strain-time histories submitted by the various institutions. After the histories were converted to digital form, a test program was conducted for two different materials. Each agency then analyzed the results and prepared a paper based on its approach to cumulative fatigue damage analysis.

The papers presented are:

- N.E. Dowling, W.R. Brose, and W.K. Wilson (Westinghouse Research Labs.) "Notched Member Fatigue Life Predictions by the Local Strain Approach"

- Thomas M. Johnson (General Motors Proving Ground) "Fatigue Life Predictions of Automotive-Type Load Histories"

- R.W. Langraf, F.D. Richards, and N.R. LaPointe (Ford Motor Co.) "Fatigue Life Predictions for a Notched Member under Complex Load"

- J.M. Potter (Air Force Flight Dynamics Lab) "Spectrum Fatigue Life Predictions for Typical Automotive Load Histories and Materials Using the Sequence Accountable Fatigue Analysis"

- W.R. Brose (Westinghouse Research Labs) "Fatigue Life Predictions for a Notched Plate with Analysis of Mean Stress and Overstrain Effects"

- L. Tucker, S. Downing, and L. Cavillo (Deere and Co.) "Accuracy of Simplified Fatigue Prediction Methods"

- H.O. Fuchs, D.V. Nelson, M.A. Burke, and T.L. Toomay (Stanford University) "Shortcuts in Cumulative Fatigue Damage Analysis"

- D.V. Nelson and H.O. Fuchs (Stanford University) "Predictions of Cumulative Fatigue Damage Using Condensed Load Histories"

- S. Downing, D. Calliart, and T. Bereny (Deere and Co.) "A Neuber's Rule Fatigue Analysis Procedure for Use with a Mobile Computer"

- N.O. Fuchs (Stanford University) "Discussion: Nominal Stress on Local Strain Approaches to Cumulative Damage"

The first paper deals with the concept of a highly strained local area (usually at the root of a notch) embedded in a generally linearly elastic structural element. The Neuber notch formulas for stress based on plastic strain are used to calculate the cyclic stress strain behavior. This behavior is summed to a cumulative damage using a rational Palmgren-Miner process. Various aspects of the RQC-100 and Man-Ten data are discussed to illustrate their applicability. (87 references).

The second paper is based on the Neuber material modeling process, the Morrow process, rain-flow counting procedures, and Miners linear damage rule. (5 references). The third paper presents computer programs for calculating the fatigue life of a notched structural element subjected to complex loading history. The process is generally similar to that in the first two papers. (10 references).

The fourth describes a computer solution for the cumulative damage based on local stress-strain history. The solution is divided into elastic stress spectrum and plastic strain spectrum. The method employs range-pair counting. Basquin's relationship for elastic stress and the Coffin-Manson expression for plastic strain are used to calculate the accumulation of damage. The procedure is generally used by aircraft designers. (18 references).

The fifth paper is based on the work of Raske and Morrow, local stress-strain behavior, and an arbitrary division of the fatigue curve into a plastic strain region and an elastic stress zone. The effect of mean stress is taken into account using an approach suggested by Morrow. (28 references).

The sixth paper compares three fatigue life prediction routines: a load life analysis, nominal stress-life method, and the nominal strain-life analysis. The load life analysis employs the Palmgren-Miner linear damage summation. The nominal stress method is based on the linear damage rule, the rainflow counting procedure, and local strains to stress conversions at concentrated zones such as near a notch. The nominal strain life prediction method uses the linear damage law; a drastically abbreviated load time history is obtained by screening out many peaks and valleys. The final history is then rainflow-counted. (6 references).

The seventh paper describes shortcuts in cumulative damage analyses related to counting procedures. The method suggested is called the ordered overall range counting (OORC) procedure. The article examines several histories based on OORC methods. (13 references).

The eighth paper also describes methods by which load histories can be condensed. One method is called the racetrack method. Also described are the Langraf Method and the Wetzel method. (9 references).

The ninth paper describes a method that can be used in a mobile fatigue testing system (data acquisition

and analysis van). (8 references). The final paper compares nominal stress and local strain approaches to cumulative damage analysis. The summary is concise. (5 references).

Anyone who wishes to be seriously involved in fatigue analysis of cumulative damage should read this book. It is excellent.

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PODSTAWY WIBROAKUSTYCZNEJ DIAGNOSTYKI MASZYN (FUNDAMENTALS OF VIBRO-ACOUSTICAL DIAGNOSTICS OF MACHINES)

C. Cempel
Wydawnictwa Naukowo-Techniczne, Warsaw, Poland
1982, 342 pages (in Polish)

The increase of power and operational velocities of machines from one side and weight/dimensional optimization of mechanical structures from the other side -- both responding to current trends in technology -- have stimulated considerable interest in machinery protection. High vibro-acoustical fields generated by machines as side effects of their operation lead to deterioration of products, create noise pollution, and can result in disastrous machine failures. Vibro-acoustical signals carry a variety of information about the performance of a machine. In particular, information about machine malfunctions is given well ahead of a disastrous mechanical problem. Identification and analysis of vibro-acoustical signals allow the application at the proper time of corrective measures and thus help prevent major failures of machines.

Vibro-acoustical diagnosis, a relatively new branch of applied sciences, is the subject of the C. Cempel's book. It is addressed to mechanical engineers and researchers responsible for machine protection. The book (342 pages) contains 8 chapters, Appendix, List of References (251 items), and Index.

Chapter 1 discusses the physical background of vibro-acoustical processes and the relationship between the performance of a machine and generated vibro-acoustical signals. Chapter 2, "Diagnostic Models of V-a (Vibro-acoustical) Processes," answers the question, "What should be measured during machine operation?" Operational parameters of the machine are correlated with measures and estimates of the generated V-a processes; space, time, and spectral selections are involved.

Based on theory of experiment, probability theory, and statistics Chapter 3, "Estimates of the V-a Processes and Their Application," and Chapter 4, "Cross-correlated Measures of the V-a Processes and Their Application," suggest methods for choosing an adequate measure of the V-a process. They answer the questions of how to measure and how to evaluate and correlate signals. Chapter 5 on diagnosis through mechanical system identification is concerned with mathematical modeling of machines as coupled sets of simple mechanical systems with known impedances and describes methods for identification of the dynamic parameters of machines.

Chapter 6, "Diagnosis of Individual Sections of Machines and Diagnosis of Machine Trains," as well as Chapter 7, "Diagnostics of Reciprocating Machines" illustrate the state of the art in diagnostic methods. These methods are applied to such machine elements as rolling bearings and gearboxes; to individual machines including electric motors, fluid flow rotating machines, reciprocating compressors and combustion engines; and to machine trains such as turbogenerators. Examples of sophisticated computerized systems for machine trains and entire plant monitoring and protection are given. Chapter 8, "Elaboration of Diagnostic Systems," describes applications of known diagnostic methods in field practice. New diagnostic algorithms are suggested that combine theoretical knowledge and field experience in machine dynamics, vibro-acoustics, control theory, and statistics.

Vibro-acoustical diagnostics for machinery protection begins with such problems as determination of normal operational conditions of a new machine and machine behavior during long-term operation. Specification of ideal performance and specification of all possible perturbing modes of vibration are

discussed. V-a diagnostics seeks to answer the following questions:

- What to measure? (Which dynamic process and why this particular one?).
- How to measure? (Which parameter of the process, how often?).
- With what to measure? (Type of instrumentation).
- How to evaluate the results of measurements? (Estimates and corrects actions).

Due to the variety of machines and their performed dynamic processes, newness and unavailability of computerized instrumentation, and the novelty of the vibro-acoustical diagnosis idea, it does not yet provide fully unambiguous answers to the above questions related to individual machines. The book of C. Cempel represents a significant and meaningful contribution to answering these questions. It helps alleviate the lack of well documented case histories in machinery protection. The book certainly deserves translation into other languages.

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SHORT COURSES

JULY

FIELD INSTRUMENTATION AND DIAGNOSTICS

Dates: July 16-19, 1984
Place: Houston, Texas
Dates: September 18-21, 1984
Place: Edmonton, Alberta, Canada
Dates: December 3-6, 1984
Place: Houston, Texas
Objective: To provide a balanced introduction to diagnostic instrumentation and its applications for evaluating rotating machinery behavior. The seminar also covers fundamental rotating machinery behavior and some of the more common machinery malfunctions. It includes a lab session with workshops on data acquisition instrumentation, balancing, oil whirl/whip and rubs, and monitor system calibration.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

FINITE ELEMENTS IN MECHANICAL AND STRUCTURAL DESIGN B: DYNAMIC AND NONLINEAR ANALYSIS

Dates: July 23-27, 1984
Place: Ann Arbor, Michigan
Objective: Covers vibration, material nonlinearities and geometric nonlinearities. Includes normal modes, transient response, Euler buckling and heat conduction. Attendees use personal computers to develop models of several problems and use MSC/NASTRAN in laboratory sessions.

Contact: Engineering Summer Conferences, 200 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109 - (313) 764-8490.

DESIGN AND ANALYSIS OF ENGINEERING EXPERIMENTS

Dates: July 30 - August 10, 1984
Place: Ann Arbor, Michigan
Objective: Recent developments in the field of testing, methods for designing experiments, interpretation of test data, and procedures for better utilization of existing data. Design of experiments with small numbers of test pieces and runs with high dispersion are emphasized. Obtaining maximum information from limited data is stressed.

Contact: Engineering Summer Conferences, 200 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109 - (313) 764-8490.

AUGUST

MACHINERY INSTRUMENTATION AND DIAGNOSTICS

Dates: August 6-10, 1984
Place: Carson City, Nevada
Objective: To assist industry personnel in solving problems associated with machinery vibration programs. Topics include a review of transducers and monitoring systems, application of relative and seismic transducers to various types of rotating machinery, data acquisition and reduction instruments and techniques, and machinery malfunction diagnosis. The seminar includes a lab session with workshops on data acquisition instrumentation, balancing, oil whirl/whip and rubs, and monitor system calibration.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

MACHINERY VIBRATION ANALYSIS

Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Lisle, Illinois
Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be

reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow-speed paper rolls.

Contact: Dr. Ronald L. Eshleman, Director. The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MACHINERY VIBRATION ENGINEERING

Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Lisle, Illinois
Objective: Techniques for the solution of machinery vibration problems will be discussed. These techniques are based on the knowledge of the dynamics of machinery; vibration measurement, computation, and analysis; and machinery characteristics. The techniques will be illustrated with case histories involving field and design problems. Familiarity with the methods will be gained by participants in the workshops. The course will include lectures on natural frequency, resonance, and critical speed determination for rotating and reciprocating equipment using test and computational techniques; equipment evaluation techniques including test equipment; vibration analysis of general equipment including bearings and gears using the time and frequency domains; vibratory forces in rotating and reciprocating equipment; torsional vibration measurement, analysis, and computation on systems involving engines, compressors, pumps, and motors; basic rotor dynamics including fluid film bearing characteristics, critical speeds, instabilities, and mass imbalance response; and vibration control including isolation and damping of equipment installation.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MODAL TESTING

Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: August 27-31, 1984
Place: Santa Barbara, California
Dates: September 17-21, 1984
Place: Ottawa, Ontario
Dates: October 15-19, 1984
Place: New York, New York
Dates: November 5-9, 1984
Place: San Francisco, California
Dates: February 4-8, 1985
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 - (805) 682-7171.

SEPTEMBER

MACHINERY INSTRUMENTATION

Dates: September 12-14, 1984
Place: Calgary, Alberta, Canada
Objective: To provide an in-depth examination of vibration measurement and machinery information systems as well as an introduction to diagnostic instrumentation. The seminar is designed for mechanical, instrumentation, and operations personnel who require a general knowledge of machinery information systems. It is a recommended prerequisite for the Machinery Instrumentation and Diagnostics Seminar.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

OCTOBER

ELECTROEXPLOSIVES DEVICES

Dates: October 16-19, 1984
Place: Philadelphia, Pennsylvania
Objective: Topics will include but not be limited to the following: history of explosives and definitions; types of pyrotechnics, explosives and propellants; types of EEDs, explosive trains and systems, fuzes, safe-arm devices; sensitivity and functioning mechanisms; output and applications; safety versus reliability; hazard sources; lightning, static electricity, electromagnetic energy (RF, EMP, light, etc.), heat, flame, impact, vibration, friction, shock, blast, ionizing radiation, hostile environments, human error; precautions, safe practices, standard operating procedures; grounding, shorting, shielding; inspection techniques, system check-out trouble shooting and problem solving; safety devices, packaging and transportation; specifications, documentation, information sources, record keeping; tagging, detection and identification of clandestine explosives; reaction mechanisms, solid state reactions; chemical deactivation, disposal methods and problem, toxic effects; laboratory analytical techniques and instrumentation; surface chemistry.

Contact: E&P Affairs, The Franklin Research Center, 20th and Race Streets, Philadelphia, PA 19103 - (215) 448-1000.

MECHANICAL ENGINEERING (POWER GENERATION)

Dates: October 22-26, 1984
Place: Carson City, Nevada
Objective: Emphasizes the mechanisms behind various machinery malfunctions. Problems associated with rotating equipment used for power generation are highlighted. The seminar is designed for mechanical, maintenance, and machinery engineers who are involved in the design, acceptance testing, and operation of rotating machinery. Other topics include data for identifying problems and suggested methods of correction. The seminar also includes a lab session.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

UNDERWATER ACOUSTICS AND SIGNAL PROCESSING

Dates: October 22-26, 1984
Place: State College, Pennsylvania
Objective: The course is designed to provide a broad, comprehensive introduction to important topics in underwater acoustics and signal processing. The primary goal is to give participants a practical understanding of fundamental concepts, along with an appreciation of current research and development activities. Included among the topics offered in this course are: an introduction to acoustic and sonar concepts, transducers and arrays, and turbulent and cavitation noise; an extensive overview of sound propagation modeling and measurement techniques; a physical description of the environment factors affecting deep and shallow water acoustics; a practical guide to sonar electronics; and a tutorial review of analog and digital signal processing techniques and active echo location developments.

Contact: Alan D. Stuart, Course Chairman, Applied Research Laboratory, The Pennsylvania State University, P.O. Box 30, State College, PA 16801 - (814) 863-4128.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

ARMY SYMPOSIUM ON SOLID MECHANICS
"Advances in Solid Mechanics for Design and Analysis"
Newport, Rhode Island
October 1-3, 1984

This will be the ninth biennial symposium sponsored by the Army Materials and Mechanics Research Center. The objective of these symposia is to improve the effectiveness of mechanics research for the design of advanced military systems. The transactions of this unclassified symposium will be made available at the meeting. Attendance will be limited to U.S. citizens. The program will include 20-minute presentations and, in addition, a session of brief work-in-progress presentations is planned.

The challenge of developing modern defense systems, as well as improving existing hardware, calls for continued improvements in mechanics capabilities. Advanced technologies are having enormous influence on applied mechanics and engineering design and analysis activities. Therefore, the purpose of this symposium is to provide a forum for communicating recent and projected advances in analytical and experimental solid mechanics, both from a theoretical and applications perspective. The symposium has an additional focus on current and persistent problems which impede systems development.

For further information contact: Army Materials and Mechanics Research Center, Arsenal Street, DRXMR-SM, Watertown, MA 02172 - (617) 923-5259.

Announcement and Call for Papers

SECOND SYMPOSIUM ON THE INTERACTION OF NON-NUCLEAR MUNITIONS WITH STRUCTURES
Panama City Beach, Florida
April 15-19, 1985

The U.S. Air Force, under the sponsorship of Tyndall AFB, Florida, Eglin AFB, Florida, and Kirtland AFB, New Mexico, is organizing a program covering topics in all areas associated with response and behavior of civil engineering materials to external loadings and environments.

Attendance to the Symposium is free but the number of attendees will be limited to 300 and will be handled on a first come, first served basis after an allowance is made for the speakers.

The general subject areas will be concerned with the response and behavior of civil engineering materials to external loadings and environment. Suggested subject areas are: material behavior; constitutive equations -- rock, soil, concrete, metals; blast/structure interaction -- near field, far field, soil, air; failure analysis -- beams, plates, slabs; complete structure; structural response -- blast, kinetic energy, methodology; above ground, below ground; impact and penetration; centrifuge tests and modeling; and weapons environment.

The papers will be selected on the basis of abstracts which are due before August 15, 1984. Abstracts should not exceed 1,000 words and should show authors' affiliations and their addresses. Do not send any classified abstracts. Paper selections will be made and presenters will be notified by September 15, 1984. Manuscripts will be due by January 1, 1985.

For further information contact: Ms. L.C. Clouston, Registrar, P.O. Box 1918, Eglin AFB, Florida 32542 - (904) 882-5614.

Announcement and Call for Papers

RELIABILITY, STRESS ANALYSIS AND FAILURE PREVENTION -- 6TH BIENNIAL CONFERENCE
Cincinnati, Ohio
September 11-13, 1985

The Reliability, Stress Analysis and Failure Prevention Committee of the Design Engineering Division

of ASME will hold its Sixth Biennial Failure Prevention and Reliability Conference as part of the Design Technical Conference to be held in Cincinnati, Ohio, September 11-13, 1985. The general emphasis of this conference will be on the applied aspects of reliability, stress ananlysis and failure prevention.

Papers are invited on the following general topics: failure analysis, fatigue, advanced materials (composites, ceramics, etc.), reliability, data bases and data centers for design engineers, fracture mechanics, stress analysis, design analysis using personal computers, failure criteria and detection of incipient failure.

Papers will be tentatively accepted by a review of abstracts (maximum of 300 words and up to one figure). The deadline for receipt of abstracts is October 15, 1984. Completed papers will be due by December 15, 1984. Each paper manuscript will be reviewed and considered for subsequent publication in the ***ASME Transactions.***

Abstracts, completed papers and questions should be directed to the Conference Chairman: Philip E. Doepker, Section Manager, Dynamics, Babcock & Wilcox Research, 1562 Beeson Street, Alliance, OH 44601 - (216) 821-9110, Ext. 293.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

Government Reports:	NTIS Springfield, VA 22151 (unless otherwise indicated)
Ph.D. Dissertations:	University Microfilms International 300 N. Zeeb Rd. Ann Arbor, MI 48106
U.S. Patents:	Commissioner of Patents Washington, DC 20231
Chinese Publications (CSTA):	International Information Service, Ltd. P.O. Box 24683 ABD Post Office Hong Kong (In Chinese or in English translation)

In all cases appropriate order numbers should be used (last line of citation).

When not available in local libraries, copies of the majority of papers or articles may be obtained at Engineering Societies Center, 345 E. 47th St., New York, NY 10017, or Library of Congress, Washington, DC.

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

A list of periodicals scanned in published in issues 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see No. 1050)

84-1033

Correlation of Experimental to Analytical Structural Dynamics of a Gas Turbine Shell

R. Bush and K. Arin

General Electric Co., Bldg. 262, Rm. 209, 1 River Rd., Schenectady, NY 12345, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 399-402, 8 figs

Key Words: Shells, Gas turbines, Experimental modal analysis, Finite element technique

Results of an experimental modal survey and a finite element analysis of a gas turbine shell are presented. Procedures used for acquisition of the experimental test data and the finite element analysis are discussed.

84-1034

Prediction of Vibration Levels on MCP01 Platform by Means of the Compliance Method and Using Only Experimental Data

I.P. Vanhonacker

Leuven Measurement and Systems, Belgium, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 15-19, 5 figs

Key Words: Compressors, Vibration prediction, Experimental data, Frequency response function, Experimental modal analysis

The MCP01 compressor project involves installing two compression units on the MCP01 platform to recompress gas from Frigg Field on to the treatment terminal. The two compressors, running at ± 4200 RPM, and associated machinery are contained in modules. These modules and a separator module are connected to the solid concrete beams of the main deck via an intermediate load repartition structure. The two compressors and associated machinery can induce in the LRS, modules, cellardecks and living quarters nearby a vibration level detrimental to working conditions and structural integrity. The purpose of this study is to assess the vibration levels and to provide, when necessary, recommendations to cut the vibration levels to allowable limits.

84-1035

Stability Analysis of Turbomachinery Using Constrained Modal Analysis

E.J. Gunter, R.R. Humphris, and H. Springer

Univ. of Virginia, Charlottesville, VA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 228-238, 7 figs, 4 tables, 21 refs

Key Words: Turbomachinery, Modal analysis

This paper deals with the stability analysis of turbomachinery using component modal synthesis. A standard method of damped eigenvalue analysis for a multistation rotor is by the complex matrix transfer method. However, with long connected trains, this procedure runs into numerical difficulty. In the constrained modal method, accurate undamped constrained modes may be calculated using a minicomputer with 100 station rotors. The required constrained planar modes may also be generated by any of the large finite element codes. A numerical procedure has been developed to generate the characteristic polynomial directly for solution of the complex roots or for analysis of stability by the Rough procedure.

84-1036

Dynamic Investigation of the Main Journals of Two-Cylinder Engine Crankshaft with Damping

W. Nadolski and A. Pielorz

Dept. of Mech. Systems, Inst. of Fundamental Technological Res., Polish Academy of Sciences, 00-049, Warsaw, Poland, Intl. J. Mech. Sci., 25 (12), pp 887-898 (1983) 10 figs, 6 refs

Key Words: Shafts, Crankshafts, Damped structures

A model of a crankshaft of a two-cylinder four-stroke engine is considered using torsional waves, taking into account their reflections. The considered model of the crankshaft consists of elastically deformable main journals and rigid bodies. The analytical solutions for the functions utilized for determining displacements at an arbitrary time instant are obtained in the form of recurrence formulae. The stability condition of the solutions is given, under which the displacements of the main journals are relatively small. The plots of displacements are drawn for selected parameters of the crankshaft for the centerlines of crank pins which can be either coincident or shifted.

84-1037

The Application of Noise Criteria to Domestic Air-to-Water Heat Pumps

P.R. Boyce

The Electricity Council Res. Centre, Capenhurst, Nr Chester CH1 6ES, UK, Appl. Acoust., 17 (1), pp 1-19 (1984) 8 figs, 6 tables, 6 refs

Key Words: Pumps, Heat generation, Noise reduction

Domestic air-to-water heat pumps are potential sources of noise disturbance in all but busy urban areas. Previous studies have suggested two criteria which will ensure that very few complaints of noise disturbance actually occur. These criteria are a maximum sound level of 45 dB(A) outside the nearest regularly occupied room, and a maximum sound level of 31 dB(A) inside the main bedroom. In order to use these criteria it is necessary to be able to predict the sound levels which occur at different points relative to any proposed installation. This paper describes a simple procedure for obtaining such estimates from manufacturers' data and site details and discusses the practical aspects of heat pump installations which are important in determining the sound levels produced.

84-1038

Factors Affecting the Modal Frequencies of Reactor Coolant Pumps

A.P. Villasor, Jr. and G.A. Villasor

Westinghouse Electric Corp., Pittsburgh, PA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 239-245, 4 figs, 7 tables, 5 refs

Key Words: Pumps, Cooling systems, Nuclear reactors, Modal analysis, Finite element technique, Computer programs

A reactor coolant pump is analyzed for modal frequencies using appropriate finite elements and the input procedure of the WECAN program. The mathematical model consists of a detailed idealization of the machine parts, the structural support of the pump and the adjoining piping. The effect of the generic range of support/piping combination is studied and the principal modes of the pump in the order of increasing frequency are characterized.

84-1039

Application of Modal Analysis to the Design of a Large Fan-Foundation System

S.C. Ulm

Structural Dynamics Res. Corp., Milford, OH 45150, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 304-310, 10 figs, 3 refs

Key Words: Fans, Interaction: rotor-foundation, Modal analysis, Design techniques, Natural frequencies, Mode shapes, Frequency response function

This paper describes how modal analysis was used to assist in the design of a large fan-foundation system in order to hasten on-line availability and minimize future maintenance problems. The work demonstrates the use of modal analysis in a production environment utilizing software which is commercially available to the engineering community.

84-1040

The Dynamic Calibration of Electro-Magnetic Exciting Force for Rotating Surfaces

Ying Runlan, Xu Bingnan, and Cheng Huaiou

Tongji Univ., Shanghai, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 908-914, 14 figs, 3 tables, 4 refs

Key Words: Experimental modal analysis, Electromagnetic excitation, Rotating machinery, Calibrating, Machine tools

An effective technique of dynamic calibration of electromagnetic exciting force for rotating surfaces is introduced. The basic mathematical model, experimental method, devices of measurement and the mechanism of producing dynamic exciting forces are discussed. Analysis of errors in the results obtained under this method are made. The transfer relationships of dynamic exciting forces between rotating and nonrotating machine tool spindles are proposed.

RECIPROCATING MACHINES

(Also see No. 1276)

84-1041

Finite Element Optimization Techniques of Diesel Engine Structures

N. Lalor

Inst. of Sound and Vib. Res., Univ. of Southampton, UK, SAE Paper No. 820437 (P-106)

Key Words: Diesel engines, Finite element technique, Noise prediction, Optimization

The finite element method is widely used by industry for prediction of stresses and vibration behavior of machines. In recent years noise has been included in the number of constraints that the designers must consider and the finite element model is gradually being introduced as a tool to this end. A method is described by which a static finite element model can be optimized for minimum noise, if necessary within the constraints imposed by existing manufacturing plant, by an automatic iterative procedure. In this way, the most efficient solution to a noise problem can be rapidly obtained.

84-1042

Evaluating Engine Design for Low Noise Using Dynamic Structural Modeling

J. Affenzeller and G.E. Thien

AVL-Prof. List GmbH, Graz, Austria, SAE Paper No. 820435 (P-106)

Key Words: Diesel engines, Noise reduction, Design techniques

A study was carried out to develop a model for the prediction of the vibration transmission from the piston top to the block structure via the crank train and for the prediction of the block noise radiation. This paper outlines the basic work, which was done on a 4-cylinder tractor diesel engine with 98 mm bore. Some remarkable results were obtained; e.g., that the influence of oil film stiffness and damping values on the vibration transmission is of less importance during the combustion period. The influence of design parameters on the vibration transmission is also described.

84-1043

The Use of Finite Element Techniques to Predict Engine Vibration

J.P. Brandeis

Renault Technical Res. Ctr., Regie Nationale des Usines Renault, SAE Paper No. 820436 (P-106)

Key Words: Diesel engines, Finite element technique, Vibration control

Structural analyses were performed on an in-line, four-cylinder, two-liter automotive diesel engine for vibration reduction purposes. Both finite element modeling and experimental structural analysis were performed on the existing design. After applying both of these methods to the same structure, the reliability of the structural model was established. The finite element model could then be used for predicting the effect of design changes on the structural behaviour of the block.

84-1044

Idealization, Measurement and Calculation of an Engine Block

M. Birth and S. Papez

Volkswagenwerk AG, SAE Paper No. 820438 (P106)

Key Words: Engines, Natural frequencies, Noise generation, Finite element technique

This paper describes static, dynamic, and acoustic finite element analyses of the engine block of a water-cooled 4-cylinder in-line engine. The results were later compared to measurements.

84-1045

A Review of Recent Progress in Diesel Engine Noise Reduction

B.J. Chailen and D.M. Croker

Ricardo Consulting Engineers Ltd., SAE Paper No. 820517 (P106)

Key Words: Diesel engines, Noise reduction, Noise source identification

The challenge presented and the progress made in engine noise reduction are reviewed. The excitation sources are examined together with approaches to their reduction. The importance of the engine structure is recognized and mathematically based modeling techniques are described. Recommendations are given for general engine noise reduction techniques.

METAL WORKING AND FORMING

(Also see No. 1040)

84-1046

Mathematical Model of Machine Tool Dynamics via State Space Vector Methodology

Peng Zemin and Wang Guanfu

Tianjin Univ., Tianjin, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 311-315, 1 fig, 2 tables, 3 refs

Key Words: Machine tools, Modal analysis, Viscous damping, State space approach

Non-proportional damping and spring matrices via modal analysis are indications of their relative distribution as well as degree of coupling of the structural system. This could serve as a criterion for establishing the mechanical model with physical co-ordinates for dynamic study. The unknown parameter matrices of the dynamic equations of the mechanical model can be evaluated by taking advantage of the fact that the matrices should be identical with those from modal analysis. Thereupon, the mathematical model of machine tool dynamics can be approached.

84-1047

Modal Analysis of a Production-Mill Stand

E.A. Unver

U.S. Steel Corp., Res. Lab., Monroeville, PA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 648-654, 9 figs, 4 refs

Key Words: Experimental modal analysis, Modal analysis, Chatter, Metal working

A chatter phenomenon is frequently encountered in tandem cold mills where the rolls of one or more four-high stands vibrate in a vertical plane. As a result of this vibrational effect, the production of unacceptable materials and damage to mill components are frequently encountered. This paper describes the modal testing which was carried out to determine the dynamic properties of a production-cold-mill stand, and to identify the modes of vibration which are associated with chatter.

84-1048

Measurement of Polishing Disk Vibrations During Operation (Messung von Schleifscheibenschwingungen während der Bearbeitung)

K. Dannecker

Industrie Anzeiger, 106 (1/2), pp 27-28 (Jan 1984) 4 figs, 4 refs

(In German)

Key Words: Machine tools

Vibration of a polishing disk and a spindle interacting with a work piece is investigated. It was observed that the disk and the spindle caused vibrations in the direction of the grinding force and that the excitation in the active zone caused vibrations of the top surface of the disk. However, these vibrations are soon diminished. The chatter frequencies soon change to lower multiples of the spindle frequency, a phenomena which was also detected in the polishing force. The waviness of the disks, arising during polishing, are measured and the deviation in the direction of rotation is determined. The vibration response observed shows that the vibration of the rotating polishing disk and spindle cannot be neglected in dynamic investigations.

84-1049

The Dynamic Optimum Design for the Wheel Head of a Cylindrical Grinding Machine

Zheng Weizhong

Branch School of Shanghai Jiaotung Univ., Shanghai, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 254-258, 2 figs, 2 tables, 3 refs

Key Words: Machine tools, Optimization, Design techniques

The wheel head of a universal cylindrical grinding machine is analyzed by the structural dynamics method. The wheel head is represented by a lumped parameter model of the vibratory system with four degrees of freedom including the flexibility of the wheel spindle. The receptance of this system is taken as the objective function, and the orthogonal design of regression is made.

84-1050

Experimental and Analytical Modeling of a Machine Tool Spindle Using Component Mode Synthesis

R. Comparin and D.R. Houser

Ohio State Univ., Columbus, OH 43210, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 246-253, 8 figs, 3 tables, 8 refs

Key Words: Machine tools, Spindles, Modal analysis, Experimental modal analysis, Finite element technique, Component mode synthesis

A mathematical model of a machine tool spindle was developed using a component mode synthesis technique. Modal parameters for system components were obtained using dynamic finite elements or experimental modal analysis. The bearings were modeled using linear springs and the damping was modeled using linear viscous dampers. The model was used to predict the forced response of the spindle shaft in the frequency range from 0 to 2500 Hz. The predicted response was limited by the accuracy of the estimates of the normalized mode shapes for the spindle shaft.

STRUCTURAL SYSTEMS

BUILDINGS

84-1051
Along-Wing Motion of Building on Compliant Soil
Y.K. Lin and Wen-Fang Wu
Univ. of Illinois at Urbana-Champaign, Urbana, IL, ASCE J. Engrg. Mech., 110 (1), pp 1-19 (Jan 1984) 6 figs, 1 table, 17 refs

Key Words: Multistory buildings, Buildings, Wind-induced excitation

Theoretical investigation is presented for the along-wind motion of a multistory building under random wind load excitation, taking into account the effect of soil compliancy under the footing. Assuming that the super-structure is composed of identically constructed story-units and the soil behavior is characterized by a known frequency dependent impedance matrix, closed form solutions are obtained for the frequency response functions and the spectral densities of structural response.

84-1052
Forecasting Noise Emissions of Industrial Plants and Buildings
H.U. Haering and K. Polthier
FBI Betriebstechnik, Dusseldorf, W. Germany, S/V, Sound Vib., 19 (12), pp 12-14 (Dec 1983) 4 figs, 3 tables, 2 refs

Key Words: Noise prediction, Industrial facilities, Buildings, Computer programs

Methods of forecasting noise emissions are described. The techniques are illustrated by a sample forecast for a factory building. By considering separately the discrete sources of noise, the effect of selected sound abatement measures can be quickly determined. A computer program has been developed for the calculations.

84-1053
Dynamic Analysis of Multistory Building by Component Mode Synthesis
Jui-Tien Huang
Ph.D. Thesis, Univ. of Pittsburg, 157 pp (1983) DA8327655

Key Words: Buildings, Multistory buildings, Component mode synthesis, Natural frequencies, Mode shapes, Modal analysis, Finite element technique

Modal and transient analyses of a linearly elastic building subjected to ground accelerations are core and time intensive computations. To save computing time and to solve the problem at a lower core requirement, a unique combination of reduction procedures, with fixed-interface component mode synthesis as the central theme augmented by static condensation and Guyan reduction, is formulated and implemented for the given structure and load case.

TOWERS

84-1054
Reliability of Concrete Chimneys under Winds
J. Hseih
Ph.D. Thesis, Univ. of Houston, 269 pp (1983) DA8328387

Key Words: Chimneys, Wind-induced excitation

A reliability analysis of tall reinforced concrete chimneys under wind loads is presented. A first order second moment approach is used for this analysis. An example is presented to illustrate the methodology presented in this study. A tall reinforced concrete chimney, designed in accordance with ACI Code, is used in this example. The procedure presented would enable a designer to assess the lifetime probability of failure; i.e., excessive deflection or exceedance of the ultimate moment capacity of chimneys.

FOUNDATIONS

(Also see No. 1039)

84-1055

Analytical Method of Modal Testing of Large Power Foundation

Li Guihua

Dalian Inst. of Tech., Dalian, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 317-323, 2 figs, 3 refs

Key Words: Foundations, Steam turbines, Turbines, Modal analysis, Mechanical impedance

The modal analysis of a large steam turbine foundation with mechanical impedance techniques is presented. The complex modal parameters are identified through diagram and computer analyses. The mathematical modeling problem for testing data is discussed in detail, and the mathematical expression for complex modal responses of a dynamic foundation under single-point and multi-point disturbing forces are also presented.

84-1056

Effects of Transient Foundation Uplift on Earthquake Response of Structures

Chik-Sing Yim

Ph.D. Thesis, Univ. of California, Berkeley, 126 pp (1983)

DA8329106

Key Words: Earthquake resistant structures, Foundations, Interaction: structure-foundation

The objective of this study is to develop a better understanding of the effects of transient foundation uplift on response of structures, so that the related reduction in earthquake forces can be considered in design of structures. The mathematical models chosen are simple, but incorporate the most important effects of soil flexibility and realistic mechanics of uplifting and impact. In its fixed base condition, the structure itself is idealized as a single-degree-of-freedom system attached to a rigid foundation mat which is flexibly supported.

84-1057

Dynamic Analysis of Multiply Tuned and Arbitrarily Supported Secondary Systems

T. Igusa

Ph.D. Thesis, Univ. of California, Berkeley, 237 pp (1983)

DA8328921

Key Words: Interaction: structure-foundation, Multidegree of freedom systems, Foundations, Vibrating foundations, Modal analysis, Frequency response

Methods of dynamic analysis of linear multi-degree-of-freedom secondary systems subjected to base motion are developed. The analysis takes into account the effects of multiple resonance or tuning, dynamic interaction between the secondary subsystem and its supporting primary subsystem, correlation between modal responses of the primary and secondary subsystems as well as between support motions, non-classical damping, and multiple support excitations. The problem is approached through the systematic use of perturbation methods. Emphasis is placed on deriving theoretically exact yet practical results. Two analysis procedures are developed, one based on modal analysis and the other based on frequency response methods.

HARBORS AND DAMS

84-1058

Seismic Stability Problems in Earth Dam Design

B. Khamenehpour

Ph.D. Thesis, Univ. of California, Berkeley, 137 pp (1983)

DA8328938

Key Words: Dams, Seismic design

Evaluation of the seismic stability of earth and rockfill dams during and following earthquake shaking is an important part of the design procedure. The analysis of seismic stability requires calculation of earthquake-induced shear stresses and accelerations in the embankment and evaluation of their effects on pore water pressures and deformations of the dam. This study examines some of the problems encountered in earthquake-resistant design of earth and rockfill dams. The variation of dynamic response of an embankment in a rectangular canyon with changes in width of the canyon is studied using the computer program TLUSH. The results of a three-dimensional dynamic response analysis of a major dam constructed in a narrow canyon are described and compared with those of two-dimensional dynamic response analyses.

84-1059

Time-Harmonic and Nonstationary Stochastic Vibrations of Arch Dam-Reservoir-Systems

F. Höllinger

Institut f. Allgemeine Mechanik, Technische Universität Wien, Karlsplatz 13, A-1010 Wien, Austria, Acta Mech., 49 (3-4), pp 153-167 (1983) 3 figs, 1 table, 24 refs

Key Words: Dams, Seismic analysis, Harmonic excitation, Stochastic processes

Solutions for the interacting vibrations of a linear elastic arch dam with a linear compressible, three-dimensional, irregularly shaped fluid body are presented. The vibration response is derived for a time harmonic excitation of the arch dam and, with regard to an earthquake analysis, for nonstationary stochastic excitation processes. The expansions of the stochastic responses are based on time-dependent power spectral density functions, demanding the evaluation of the frequency response spectras in advance.

84-1060
Modal Test of a Concrete Gravity Dam

V.P. Chiarito and P.F. Mlakar
U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39180, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 142-148, 10 figs, 1 table, 9 refs

Key Words: Dams, Seismic analysis, Modal analysis, Experimental modal analysis

A modal test of a concrete gravity dam was performed to experimentally verify seismic analysis procedures for this class of structures and to quantify the as-built structural integrity of the particular dam tested. The structure was excited at three locations by a single crest-mounted 17,000-lb inertial mass which was driven by an electrohydraulic servo controlled actuator.

ROADS AND TRACKS

84-1061
Vibratory Compaction of Asphalt Concrete

J.A. Cechetini
Ingersoll-Rand Compaction Div., Compressed Air, 89 (1), pp 12-14 (Jan 1984) 2 figs

Key Words: Concretes, Roads (pavements), Compacting, Vibratory techniques

Vibratory compactors achieve better compaction in fewer coverages than static rollers, meaning greater pavement durability. A Federal Highway Administration study of what determines an adequate compaction is described.

CONSTRUCTION EQUIPMENT

84-1062
Review of Legislation and Test Standards Relating to Construction Site Noise

H.S. Gill
Wilson, Ihrig & Associates, Inc., 5776 Broadway, Oakland, CA 94618, Appl. Acoust., 17 (1), pp 61-79 (1984) 3 tables, 47 refs

Key Words: Construction industry, Noise generation, Standards and codes

A general review of legislation and test standards relating to construction noise is provided, covering both the emission and immission standards. The paper covers the EEC council directives, ISO standards, and legislation and standards in the UK, the USA, the Federal Republic of Germany, France, Belgium, Luxembourg, Denmark, Norway and Japan. The background and development of legislation within the UK relating to construction site noise is also described.

POWER PLANTS

(Also see No. 1038)

84-1063
Modal Analysis of First Wall Tube Banks for Light ION ICF Reactors

R.L. Engelstad and E.G. Lovell
Univ. of Wisconsin, Madison, WI 53706, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 496-500, 12 figs, 3 refs

Key Words: Modal analysis, Nuclear reactor containment

Modal analysis techniques are used to determine the response of structural components for conceptual inertial confinement fusion reactors. The particular design considered uses an annular tube bank as an effective first wall for the reaction chamber. Individual tubes are subjected to repetitive blast loads following each ignition. From the analysis, motion histories and maximum displacements are determined to provide parametric data for design purposes.

84-1064

Evaluation of Condensation Oscillation Loads Using Spectral Analysis Techniques

R.H. Adams and V. Kumar
Central Res. Labs. Div., Sargent Industries, Red Wing, MN, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1063-1070, 10 figs, 7 refs

Key Words: Experimental modal analysis, Nuclear reactor containment, Fluid-induced excitation, Spectrum analysis

An experimental test program was started in 1978 to define and quantify the condensation oscillation (CO) phenomena in the BWR Mark I suppression chamber systems. The program was funded by utilities with Mark I containments, and the results are included in a detailed load definition in the Mark I Containment Program Load Definition Report. Spectral analysis methods are employed to determine the significant load distributions and applied loading frequencies acting on the vent system during the CO phenomena. Test data obtained from full scale testing is utilized in this evaluation.

84-1065

Seismic Qualification of Equipment through Experimental Modal Analysis and Finite Element Analysis

J.H. Bond and S.A. Lehrman
Corporate Consulting and Development Co., Ltd., Research Triangle Park, NC, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 134-141, 6 figs, 4 tables

Key Words: Nuclear power plants, Seismic design, Modal analysis, Experimental modal analysis, Finite element technique

Equipment design specifications for operating and under-construction nuclear power generating stations are becoming increasingly definitive in requirements for seismic qualification of safety-related equipment. The design specifications are reflecting architect/engineer concerns that the seismic qualification analyses are being performed with inaccurate finite element models of equipment by requiring experimental verification of finite element models. Many analysts are comparing experimental modal analysis results to analytical modal analysis results to obtain model verification. This paper details the procedure followed to verify the finite element models of two separate classes of equipment control panels, describes the subsequent finite element analyses performed to provide qualification, and summerizes significant results.

OFF-SHORE STRUCTURES

(Also see No. 1147)

84-1066

Composite Modal Synthesis for Fluid-Structure Coupling Vibration

Yun Wei jun and Duan Gen bao
Shanghai Ship & Shipping Res. Inst., Ministry of Communications, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1049-1055, 7 figs, 1 table, 11 refs

Key Words: Modal synthesis, Interaction: structure-fluid, Off-shore structures

A novel calculating method – composite modal synthesis -- is developed for fluid-structure coupling vibrations. This method is especially applicable to the calculation of ship and offshore fluid-structure coupling vibration.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 1115, 1191, 1243)

84-1067

Application of Modal Analysis Techniques to the Resolution of Some Dynamic Problems in Railways

J.G. Gimenez and L.I. Carrascosa
Construcciones y Auxiliar de Ferrocarriles, S.A. Beasain (Guipúzcoa), Spain, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1075-1084, 14 figs, 5 refs

Key Words: Modal analysis, Experimental modal analysis, Railroad trains, Case histories

The experimental determination of modal parameters in the railway industry has brought about a great improvement due to the development of modern modal analysis techniques. Several cases solved by the use of these techniques, in which the experimental results analysis and its use in theoretical experimental model synthesis are combined, are presented.

SHIPS

(Also see Nos. 1102, 1135)

84-1068

Modal Testing in the Performance Verification Process of Shipboard Equipment

M. Weiss
RCA Government Systems Div., Missile and Surface Radar, Moorestown, NJ 08057, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 394-398, 8 figs

Key Words: Experimental modal analysis, Design techniques, Shipboard equipment response

Incorporation of modal testing into the design verification process for a new electronics cabinet has proved to be a valuable addition to the available vibration test and analysis tools. This paper describes the test and modeling efforts, from the early checks that defined the need for local configuration changes, to subsequent modal tests that were used to refine the finite element model of the cabinet.

AIRCRAFT

(Also see No. 1117)

84-1069

The Identification and Solution of a Jet Engine Vibration Problem Using Digital Dynamic Analysis Techniques

M.P. Bouchard and M.L. Drake
Univ. of Dayton Res. Inst., Dayton, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 267-274, 20 figs, 10 refs

Key Words: Modal analysis, Mountings, Aircraft engines, Jet engines, Engine vibration, Vibration damping, Structural modification techniques

The low speed (N-1) rotor vibration sensors (V-1) of the TF-30, P-3, and P-9 jet engines have historically indicated high vibration levels after routine maintenance. The frequencies of these vibrations correspond to the rotation of the high speed (N-2) rotor. However, the V-2 sensor, which is specifically designed for detection of N-2 related vibration, does not generally indicate the same high vibration levels. Furthermore, the P-100 version of this engine does not exhibit these characteristics. Extensive digital (fast Fourier transform) frequency response analyses and modal analyses were conducted on actual engines and laboratory test setups to identify and solve the problem.

84-1070

The Effect of Suspension Method on Modal Tests of a Business Jet Aircraft

D.C. Cone
Gates Learjet Corp., Wichita, KS, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1056-1062, 18 figs

Key Words: Aircraft, Modal analysis, Experimental modal analysis, Suspension systems (vehicles)

Modal testing as a means of validating vibration analysis is a very necessary part of an aircraft development program. This paper presents the results of modal tests of a business jet aircraft on a soft, decoupled suspension system and on the landing gear, as well as comparisons with analysis for the two suspension methods. The results of a modal test using "hard mounting" of the aircraft and the resultant decoupling of the suspension in the analysis along with the analytical correlation are also presented.

84-1071

Modal Analysis on a French Military Plane Using a Multiple Input Excitation

C. Hutin and G. Catteau
Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 487-495, 7 figs, 1 ref

Key Words: Experimental modal analysis, Aircraft, Multipoint excitation technique

Several modal analysis tests were carried out on plane structures, including a French military plane. The aim of this paper is to present the test conditions and the different configurations of excitation, to state results obtained by the two methods used and their interpretation, and to specify conclusions which can be drawn from this test.

84-1072

Generic Approach to Determine Optimum Aeroelastic Characteristics for Composite Forward-Swept-Wing Aircraft

G.A. Oyibo

Fairchild Republic Co., Farmingdale, NY, AIAA J., 22 (1), pp 117-123 (Jan 1984) 19 figs, 1 table, 22 refs

Key Words: Aircraft, Flutter

Aeroelastic tailoring, a concept which is critical to the development of forward-swept-wing aircraft, is presented as a multivariable optimization problem in which all of the variables have to be considered – a departure from the current practice in which the fiber orientation angle seems to be the only variable used in the tailoring process. The results for aeroelastic divergence are presented in this paper.

84-1073

Dynamic Stability of Flexible Forward Swept Wing Aircraft

T.A. Weisshaar and T.Z. Zeiler

Purdue Univ., West Lafayette, IN, J. Aircraft, 20 (12), pp 1014-1020 (Dec 1983) 18 figs, 1 table, 18 refs

Key Words: Aircraft, Flutter, Stability

The importance of including aircraft rigid-body modes in the aeroelastic analysis of forward swept wing aircraft is discussed. Several examples are used to show that body-freedom flutter and aircraft aeroelastic divergence, not wing divergence, are the primary vehicle aeroelastic instabilities to be encountered by forward swept wing aircraft. These instabilities are shown to occur close to the wing divergence speed, but depend upon the aircraft geometry and inertial characteristics as well as wing stiffness.

84-1074

A Root Locus-Based Flutter Synthesis Procedure

P. Hajela

Stanford Univ., Stanford, CA, J. Aircraft, 20 (12), pp 1021-1027 (Dec 1983) 10 figs, 3 tables, 15 refs

Key Words: Aircraft, Flutter

An efficient generalized constraint is proposed in the context of a nonlinear mathematical programming approach for the minimum weight design of wing structures for flutter considerations. The approach is based on a root locus analysis procedure that is better suited for flutter redesign than the conventionally used V-g method. The approach is implemented and results presented for representative structural models.

84-1075

Control of Aeroelastic Divergence

R.R. Chipman, A.M. Zislin, and C. Waters

Grumman Aerospace Corp., Bethpage, NY, J. Aircraft, 20 (12), pp 1007-1013 (Dec 1983) 12 figs, 4 tables, 15 refs

Key Words: Aircraft, Aerodynamic loads, Aircraft wings, Active control

On forward-swept-wing aircraft, aerodynamic destiffening of the primary wing-bending mode can cause coupling with the short-period mode, potentially resulting in a low-frequency dynamic instability. For a clamped wing this coupled mechanism degenerates into conventional static wing divergence. Studies of a fundamental analytical model of this mechanism show that active control of the clamped wing is possible only through the use of displacement feedback. Control laws for the clamped wing are evaluated and also assessed when body freedom is restored. Additionally, control laws are synthesized directly for a more refined representation of the unrestrained vehicle.

84-1076

Effects of Atmospheric Turbulence on a Quadrotor Heavy Lift Airship

M.B. Tischler and H.R. Jex

U.S. Army Res. and Tech. Labs., Moffett Field, CA, J. Aircraft, 20 (12), pp 1050-1057 (Dec 1983) 9 figs, 15 refs

Key Words: Aircraft, Wind-induced excitation, Turbulence

The response of a quadrotor heavy lift airship to atmospheric turbulence is evaluated using a four-point input model. Results show interaction between gust inputs and the characteristic modes of the vehicle's response. Example loop closures demonstrate tradeoffs between response regulation and structural loads.

84-1077

Computations of Unsteady Transonic Aerodynamics Using Prescribed Steady Pressures

K.-Y. Fung and A.W. Chung

Univ. of Arizona, Tucson, AZ, J. Aircraft, 20 (12), pp 1058-1061 (Dec 1983) 3 figs, 1 table, 15 refs

Key Words: Computer programs, Airfoils, Aerodynamic stability

An inverse procedure is used to obtain the steady-state flowfield and the airfoil shape corresponding to an input steady pressure distribution. Unsteady effects can then be studied using the time-linearized code UTFC, or the LTRAN2 code using the airfoil shape found by the inverse procedure. Experimental results are used as input and the computed unsteady response is compared with the measured values.

84-1078
Dynamic Load Measurements with Delta Wings Undergoing Self-Induced Roll Oscillations

D. Levin and J. Katz
Technion, Israel Inst. of Tech., Haifa, Israel, J. Aircraft, 21 (1), pp 30-36 (Jan 1984) 17 figs, 9 refs

Key Words: Aircraft wings, Aerodynamic loads

The aerodynamic forces acting on a delta wing mounted on a free-to-roll sting-balance apparatus were measured. Two wing planforms having leading edge sweeps of 76 and 80 deg were tested; however, only the wing with the 80 deg sweep would undergo periodic self-induced roll oscillations. The time dependent forces and roll angles for this wing were then recorded for various test conditions.

84-1079
A Vortex-Lattice Method for Calculating Longitudinal Dynamic Stability Derivatives of Oscillating Delta Wings

D. Levin
NASA Ames Res. Ctr., Moffett Field, CA, AIAA J., 22 (1), pp 6-12 (Jan 1984) 7 figs, 2 tables, 23 refs

Key Words: Aircraft wings, Aerodynamic loads

A nonsteady vortex-lattice method is introduced for predicting the dynamic stability derivatives of a delta wing undergoing an oscillatory motion. The analysis is applied to several types of small oscillations in pitch. The computed results for damping in pitch are compared with several other methods and with experiments, and are found to be consistent and in good agreement.

84-1080
A Dynamic Model for Aircraft Poststall Departure

M.A. Hreha and F.H. Lutze
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, J. Aircraft, 21 (1), pp 62-68 (Jan 1984) 9 figs, 1 table, 21 refs

Key Words: Aircraft, Aerodynamic loads

An aerodynamic model is developed for use with a numerical simulation of vehicle motion for the purpose of analyzing high-angle-of-attack behavior including poststall departure. The model consists of a nonlinear lifting line theory that includes unsteady wake effects due to a discrete, nonplanar vortex system. Each lifting surface is modeled with discrete vortex segments and their associated control points. The wing, horizontal, and vertical tail are treated in this manner.

84-1081
Computations and Aeroelastic Applications of Unsteady Transonic Aerodynamics About Wings

P. Guruswamy and P.M. Goorjian
Informatics General Corp., Palo Alto, CA, J. Aircraft, 21 (1), pp 37-43 (Jan 1984) 7 figs, 1 table, 23 refs

Key Words: Aircraft wings, Aerodynamic loads, Computer programs

Comparisons were made of computed and experimental data in three-dimensional unsteady transonic aerodynamics, including aeroelastic applications. The computer code LTRAN3, which is based on small-disturbance aerodynamic theory, was used to obtain the aerodynamic data. A procedure based on the U-g method was developed to compute flutter boundaries by using the unsteady aerodynamic coefficients obtained from LTRAN3. All of the studies were conducted for thin, unswept, rectangular wings with circular-arc cross sections.

84-1082
A Survey of Serious Aircraft Accidents Involving Fatigue Fracture

G.S. Campbell and R. Lahey
Natl. Res. Council of Canada, Montreal Rd., Ottawa, Ontario, Canada K1A OR6, Intl. J. Fatigue, 6 (1), pp 25-30 (Jan 1984) 4 figs, 7 tables, 33 refs

Key Words: Fatigue life, Aircraft, Crash research (aircraft)

A world-wide survey of serious aircraft accidents involving fatigue fracture has been carried out. The study includes not

only fatal accidents, but also those in which the damage to the airframe was substantial or greater. The accidents cover civil and, to a limited extent, military aircraft.

84-1083
Airport Noise Control Strategies
P.A. Cline
Federal Aviation Admn., Washington, DC, Rept. No. FAA/EE-83-3, 91 pp (June 1983)
AD-A133 137

Key Words: Aircraft noise, Airports, Noise reduction

This report provides a comprehensive listing of noise control strategies employed by the nation's airports. Forty-four categories of noise control actions have been identified and are in use, singly or in combination, by over 540 airports.

MISSILES AND SPACECRAFT

(Also see Nos. 1105, 1130, 1221, 1244)

84-1084
Galileo Modal Tests/Multiple Sine Dwell
M. Trubert
Jet Propulsion Lab., Pasadena, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 809-812, 3 figs, 1 table, 2 refs

Key Words: Spacecraft, Multiple sine dwell method, Modal analysis, Experimental modal analysis

The modal test program of the Galileo spacecraft has been recently completed. The tests were done using the multiple sine dwell method for the project test. All the major modes, i.e., the loads inducing modes of the spacecraft, were identified. Only preliminary, limited results are available. An unexpected finding of the test is that insignificant nonlinearities of some of the major modes exist.

84-1085
The Advanced Methods Used on the Galileo Spacecraft Modal Survey
R.N. Coppolino, S.R. Ibrahim, D.L. Hunt, and R.C. Stroud
Aerospace Corp., El Segundo, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 813-819, 3 figs, 15 refs

Key Words: Spacecraft, Modal analysis, Experimental modal analysis, Single-point excitation technique, Multipoint excitation technique, Frequency domain method, Time domain method

The Galileo spacecraft modal survey was performed using the classical tuned-multi-exciter sinusoidal dwell. A parallel research program used alternative methods of excitation, data acquisition, and data analysis. The objective of this research was to demonstrate the effectiveness of these methods in determining spacecraft modal properties. This paper presents an overview of those advanced acquisition and analysis methods.

84-1086
Comparison of Various Modal Test Analysis Results
Jay-Chung Chen
California Inst. of Tech., 4800 Oak Grove Dr., Pasadena, CA 91109, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 820-824, 8 tables, 5 refs

Key Words: Spacecraft, Modal analysis, Experimental modal analysis, Multipoint excitation technique

The comparisons of Galileo spacecraft modal test results obtained by the multi-shaker sine dwell method and the multi-point random method are compared.

84-1087
Design of a Large Space Structure Vibration Control Experiment
F.M. Ham, J.W. Shipley, and D.C. Hyland
Harris Government Aerospace Systems Div., Melbourne, FL, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 550-558, 15 figs, 11 refs

Key Words: Experimental modal analysis, Spacecraft, Vibration control

A ground-based dynamics and controls test program is designed for use with an actual large space structure (LSS). Critical concerns in LSS dynamics and controls are addressed including: low frequency vibration modes, close modal spacing, parameter uncertainties, nonlinearities and coupling of modes through damping. The overall objectives of the designed ground test program include: the validation of LSS systems identification techniques, the validation of LSS control system techniques, the evaluation of actuator and sensor placement methodology and the validation of LSS computer models.

84-1088

Statistical Identification of the Dynamic Parameters of an Astromast from Finite Element and Test Results Using Bayesian Sensitivity Analysis

J.-G. Beliveau, M. Massoud, P. Bourassa, C. Lauzier, F. Vigneron, and Y. Soucy
Université de Sherbrooke, Quebec, Canada, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 89-95, 4 figs, 2 tables, 3 refs

Key Words: Parameter identification technique, Spacecraft, Spacecraft antennas, Modal analysis

This paper describes a process of parameter estimation of an astromast boom used in large flexible satellite systems. Three finite element models are prepared in which the mass and the stiffness matrices are functions of material properties. The modal parameters of the boom are calculated from these models and compared with experimental results based on single point harmonic excitation tests.

84-1089

DSCS Multi-Shaker Sine Modal Testing

R. Spykerman, R. Winslow, and C. Stahle
General Electric Co., King of Prussia, PA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 163-171, 19 figs, 1 ref

Key Words: Modal analysis, Experimental modal analysis, Multipoint excitation technique, Spacecraft

This paper presents the results of analytical and experimental applications of a multi-shaker sine (MSS) test technique to a complex spacecraft structure. An analytical study examines the application of the MSS technique to the DSCS III. The study includes modal grouping, shaker positioning, convergence and accuracy of mode shape measurements.

84-1090

Modal Survey Testing/Mathematical Model Verification, a Cost Effective Approach for Shuttle Payloads

A. Stroeve
Ball Aerospace Systems Div., Boulder, CO 80306, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 501-505, 6 figs, 6 tables, 6 refs

Key Words: Modal analysis, Experimental modal analysis, Space shuttles

A cost-effective practical approach is presented to perform a modal survey test for shuttle type payloads combined with the mathematical model verification of the payloads. The software type interfaces required with the modal survey test equipment are discussed.

84-1091

Acoustic Test Response Analysis of the Space Shuttle Orbiter Body Flap

J.S. Cheng, M. Dunham, and J. Joanides
Space Systems Group, Rockwell International, Downey, CA 90241, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 635-637, 5 figs

Key Words: Space shuttles, Modal analysis, Experimental modal analysis, Finite element technique

Random response analysis of the space shuttle Orbiter body flap subjected to acoustic test excitation, which induced damages in several hinges and clips, is presented. An integrated approach of modal analysis technique correlating testing and finite element data is applied to the mathematical modeling with emphasis on response prediction.

84-1092

Galileo Modal Test and Pre-Test Analysis

Jay-Chung Chen and M. Trubert
California Inst. of Tech., 4800 Oak Grove Dr., Pasadena, CA 91109, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 796-802, 3 figs, 6 tables, 5 refs

Key Words: Spacecraft, Modal analysis, Experimental modal analysis

The objective of the Galileo spacecraft modal test is to verify the analytical model for loads analysis. The associated pre-test analysis is described and the design of the modal test based on the pre-test analysis results is explained. The methodologies used in the performance of the test including the excitation system and data acquisition system are described.

BIOLOGICAL SYSTEMS

HUMAN

(Also see No. 1321)

84-1093

Data Acquisition and Analysis for the Galileo Spacecraft Modal Survey

H.P. Bausch and R.C. Stroud

Wyle Labs., Norco, CA, Intl. Modal Anal. Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 803-808, 11 figs, 4 refs

Key Words: Spacecraft, Modal analysis, Experimental modal analysis, Multiple sine dwell method

The Galileo spacecraft modal survey had some unique and demanding data-acquisition and data-analysis requirements. A variety of excitation and analysis techniques were used. This paper describes the data acquisition and analysis aspects of this multiapproach test program. The purpose and objectives of the modal survey, as well as the technical approach, are discussed. Hardware and software features are described, including developments which were accomplished in preparation for the modal survey.

84-1094

Modal Testing of a Large Test Facility for Space Shuttle Payloads

D.C. Talapatra and J.M. Haughton

NASA/Goddard Space Flight Ctr., Greenbelt, MD, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 1-7, 32 figs, 2 tables, 3 refs

Key Words: Test facilities, Modal analysis, Experimental modal analysis, Space shuttles

The shuttle payload test facility (SPTF) is a large structure, dimensionally identical to the space shuttle cargo bay. It was designed and built for conducting modal surveys and static load tests on space shuttle payloads. Modal characteristics of the SPTF were determined earlier using the finite element technique. In order to validate the finite element solutions, modal testing was conducted.

84-1095

Steering Assembly Performance and Driver Injury Severity in Frontal Crashes

D.F. Huelke

Univ. of Michigan Medical School, Ann Arbor, MI, SAE Paper No. 820474 (SP-507)

Key Words: Collision research (automotive), Human response

An analysis of 211 automobiles having the ball-type E.A. device (GM cars - 1972-1980), involved in frontal crashes, was made to determine the relationship between driver injury and the steering assembly.

84-1096

A Computer Model for Simulating an Unrestrained Driver in Frontal Collisions

S.L. Stucki and M.U. Fitzpatrick

Natl. Highway Traffic Safety Admn., SAE Paper No. 820469 (SP-507)

Key Words: Collision research (automotive), Steering gear, Human response

This paper discusses the development, test case simulation and preliminary sensitivity study of a computer model designated SCORES (Steering Column and Occupant Response Simulation). The model was developed to simulate an occupant impacting a steering assembly in a frontal collision. During the impact event, the program describes the rotation and deformation of the wheel about the column, rotation, displacement and stroke of the column due to occupant loading and intrusion.

84-1097

The Role of the Vehicle Front End in Pedestrian Impact Protection

S. Daniel, Jr.

Natl. Highway Traffic Safety Admn., SAE Paper No. 820246 (SP-513)

Key Words: Collision research (automotive), Human response

National annual accident statistics for pedestrians and cyclists are presented along with a breakout of injuries matched with vehicle impact location and other causation factors. Results of full-scale accident simulation tests using surrogates to investigate the relationship between impact response and injury severity for several body regions are presented. Accident investigation data, full-scale accident simulation research test data, and computer modeling data aimed at determining the effects of vehicle front surface structure geometry on pedestrian injury patterns and severity are presented. The general approach to pedestrian injury mitigation through vehicle modification is discussed. A discussion of motorcyclist injury patterns is also presented.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see No. 1156)

84-1098

Mounting Design for Rotary Pumps

G.P. Balfour

Noise Ctr., Lucas Industries, London, UK, SAE Paper No. 820507

Key Words: Mountings, Rotary pumps, Pumps, Diesel engines

The emergence of high speed diesel engines for cars has emphasized the problems of mounting fuel injection pumps onto engines. Some engine manufacturers are using sheet steel pressings or thin cast brackets which allow the pump to vibrate in resonance in the engine firing frequency range. This increases the likelihood of failure of these brackets in service due to metal fatigue. A theoretical analysis of a simple bracket enables the essentials of the problem to be understood and it allows possible design solutions to be evaluated. This theoretical analysis is complemented by experimental evidence from actual brackets.

84-1099

Dynamics of Piping Systems on Ductile Support

Hong-Ming Lee

Ph.D. Thesis, Univ. of California, Berkeley, 118 pp (1983)
DA8328954

Key Words: Piping systems, Supports, Snubbers

The dynamics of piping systems supported with ductile restrainers is studied. Several shaking table tests are summarized. Experimental results show the capability of such restrainers to replace conventional snubbers. To support the application of this new design approach to piping systems, a new nonlinear algorithm for step-by-step integration is developed. Example problems validate the new program and show its accuracy and efficiency.

84-1100

Evaluation of Current Energy-Absorbing Steering Assemblies

C.J. Kahane

Natl. Highway Traffic Safety Admn., SAE Paper No. 820473 (SP-507)

Key Words: Energy absorption, Steering gear

The National Highway Traffic Safety Administration staff evaluated the actual costs, benefits and crash performance of current energy-absorbing steering assemblies as part of its review of existing major regulations. The evaluation was based on statistical analyses of Fatal Accident Reporting System, National Crash Severity Study and Multidisciplinary Accident Investigation data, cost analyses of production steering assemblies and review of test results.

84-1101

Modal/Structural Analysis of NOVA Laser Structures

H.J. Weaver, J.W. Pastrnak, and D.E. Fields

Lawrence Livermore Natl. Lab., Univ. of California, Livermore, CA 94550, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 763-768, 11 figs, 11 tables, 2 refs

Key Words: Mountings, Laser structures, Modal analysis, Experimental modal analysis, Vibration control

NOVA is the latest in a series of powerful laser systems designed to study the feasibility of initiating a controlled fusion reaction by concentrating several laser beams on a small fuel target. The laser components, turning mirrors,

and target chamber are all mounted on large steel frame structures. This paper discusses the linking of the analytical and experimental study for one of the NOVA structures.

84-1102
Energy Absorption by Porous Slender Bodies

G.C. Nihous
Ph.D. Thesis, Univ. of California, Berkeley, 96 pp (1983)
DA8328998

Key Words: Energy absorption, Barges, Wave energy

This study examines the hydrodynamic performance of a slender barge wave-power absorber. The barge is assumed to have perforations along its length below the waterline. Sea water can freely flow through these openings and induce the motion of water columns inside the barge. It is assumed that some of the energy associated with the oscillatory displacement of the columns is extracted. In order to do so, water turbines can be fitted in the columns or air turbines can be connected to the vent of a plenum above the columns. The most difficult part of the present analysis is to determine the flow around the barge in a given incident wave field. In particular, one must be able to describe the interaction between the fluid outside of the perforations and the water columns.

84-1103
Overview of Design Approaches for Optimizing Fatigue Performance of Suspension Systems

D.J. Bickerstaff, J.E. Birchmeier, and W.R. Tighe
Ford Motor Co., Dearborn, MI, SAE Paper No. 820676 (P-109)

Key Words: Suspension systems (vehicles), Ground vehicles, Trucks, Fatigue life, Design techniques

An overview of some design processes is presented, emphasizing fatigue considerations for suspension system components. Emphasis is placed on the use of nonlinear, dynamic modeling as a tool for designing vehicles to exceed customer fatigue requirements.

84-1104
Matrix Viscosity and Cavity-Size Distribution Effects on the Dynamic Effective Properties of Perforated Elastomers

G.C. Gaunaurd and J. Barlow
Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, J. Acoust. Soc. Amer., 75 (1), pp 23-34 (Jan 1984) 9 figs, 15 refs

Key Words: Elastomers, Hole-containing media, Acoustic absorbers, Underwater structures, Sound waves, Wave absorption

This study introduces a novel methodology to predict the (frequency-dependent) effective material parameters characterizing the dynamic behavior of viscoelastic substances containing many randomly located air-filled perforations. These composite materials have uses as underwater sound absorbers. The methodology is an extension of earlier work pertaining to the case of gas-filled perforations in nonabsorbing matrices. That prior work is extended to the case of absorbing matrices containing ensembles of cavities of various sizes following several arbitrary size-distribution functions.

84-1105
ACOSS Fourteen (Active Control of Space Structures)

R.J. Benhabib, H.K. Flashner, and F.C. Tung
TRW Space and Tech. Group, Redondo Beach, CA, Rept. No. RADC-TR-83-51, 260 pp (Mar 1983) AD-A133 411

Key Words: Active vibration control, Vibration control, Spacecraft

ACOSS Fourteen is one of a series of studies for the development of a unified structural dynamics and control technology base to support future development of large space systems. The major emphasis in these studies in the past has been on generic control law development for active vibration suppression. The emphasis is now shifting towards hardware development and experimental verification of the technology. ACOSS Fourteen studies the definition, design and plan for an on-orbit, Shuttle-based Proof of Concept demonstration and stability enduring designs which extend previous designs and treat noncolocated actuator-sensor control systems, while remaining insensitive to modal truncation and inaccurate structural models.

SPRINGS

84-1106
Reduction of Suspension Spring Forces by a Modal Procedure

N. Gupta and R.J. Bernhard

Ray W. Herrick Labs., Purdue Univ., West Lafayette, IN 47907, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 977-983, 6 figs, 5 tables, 3 refs

Key Words: Modal analysis, Suspended structures, Compressors, Springs

A significant part of the noise generated by a suspended body in a shell can be reduced by decreasing the suspension spring forces. Time integration analysis programs, with test verification, have successfully proven this approach for low frequency noise. However, another method of predicting spring forces is a modal procedure which utilizes the shaking forces associated with the suspended body. The modal method evaluates the dynamic spring forces, the modal spring forces, and the modal participation factors to determine the effects of a change in suspension configuration on reduction of spring forces.

BLADES

(Also see No. 1183)

84-1107

Fourier Analysis of Nonlinear Structural Response

T.J. Lagnese and D.J. Koester

Universal Energy Systems, Dayton, OH 45432, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 208-217, 14 figs, 19 refs

Key Words: Blades, Turbomachinery blades, Coulomb friction, Modal analysis, Experimental modal analysis

Some aspects of dry friction damping are experimentaliy investigated by means of a digital data processing technique. The experimental technique identifies narrow frequency bandwidth quasi-linearity of the nonlinear response of a single turbine blade in a fixture. The nonlinear response data is compared with analytical results for a two-degree-of-freedom model of the blade.

BEARINGS

(Also see Nos. 1205, 1275)

84-1108

Controlling the Dynamic Characteristics of a Hydrostatic Bearing by Using a Pocket-Connected Accumulator

M.J. Goodwin, C.J. Hooke, and J.E.T. Penny

Dept. of Mech. and Civil Engrg., North Staffordshire Polytechnic, UK, IMechE, Proc., 197 (C), pp 255-258 (Dec 1983) 5 figs, 10 refs

Key Words: Bearings, Tuning

This paper describes a theoretical and experimental investigation of the dynamic characteristics of a capillary-compensated oil-lubricated hydrostatic bearing which has an accumulator connected to the bearing pocket via a second capillary restrictor. Results show that by careful selection of accumulator and restrictor the bearing can be tuned to give an optimum system performance. Such a facility can be of considerable use if the hydrostatic bearing is being used to support other machinery, for example in the support of journal bearings used with flexible rotors.

84-1109

The Sources of Damping in Rolling Element Bearings under Oscillating Conditions

T.L.H. Walford and B.J. Stone

Welwyn Electric Ltd., Bedlington, Northumberland, UK, IMechE, Proc., 197 (C), pp 225-232 (Dec 1983) 10 figs, 1 table, 13 refs

Key Words: Bearings, Rolling contact bearings, Damping coefficients, Stiffness coefficients

An analysis is presented of the stiffness and damping which may be expected from a rolling element under oscillating conditions. The level of damping, which may be expected from a complete bearing plus the necessary joints, is then examined. It is shown that the assumption of no damping in the joints yields theoretical levels of damping which are substantially less than the levels measured experimentally.

84-1110

Performance of Dynamically Loaded Journal Bearings. Part 1: Effect of Varying Bearing Geometry and Oil Supply Conditions

W.L. Cooke

Thermal Systems Div., Natl. Engrg. Lab., East Kilbride, Scotland, Rept. No. NEL-683-PT1, ISSN-0305-1439, 56 pp (Mar 1983)

N83-34337

Key Words: Bearings, Journal bearings, Internal combustion engines

The performance of hydrodynamic journal bearings, particularly those of internal combustion engines, was assessed on an engine bearing simulator under a wide range of loadings. A system for measuring dynamic journal/bush displacement was developed. Data on the effects of bearing geometry and other parameters on oil flow and journal/bush displacement are presented.

84-1111
Velocity and Pressure Distribution in a Plane Aerostatic Bearing with Bearing Surfaces Oscillating Against Each Other (Geschwindigkeits- und Druckverteilung in einem ebenen aerostatischen Lager bei gegeneinander oszillierenden Lagerflachen)

D. Thelen
C. Schenck AG, Darmstadt, Konstruktion, 35 (12), pp 487-493 (Dec 1983) 12 figs, 8 refs
(In German)

Key Words: Bearings, Stability

The method of calculation is based on conservation theorems for impulse and mass flow of a compressible medium. After simplifying the equations, which are based mainly on the special geometry of the flow field, an analytical solution is derived which gives the pressure in the bearing clearance as function of location and time. The validity of the solution is limited by moderate pressure conditions; i.e., the velocity during the exit from bearing clearance must remain substantially below sound velocity. The results of the calculation are illustrated by several examples.

GEARS
(Also see No. 1143)

84-1112
Maximum-Conjugacy Gearing

Y. Watanabe and W.S. Rouverol
Nissan Diesel Motor Co., Ltd., Japan, SAE Paper No. 820508 (P-106)

Key Words: Gears, Noise reduction, Geometric effects

Gear tooth characteristics that minimize noise excitation are identified, and a new "maximum-conjugacy" tooth form is described that employs these characteristics to reduce gear noise excitation to approximately 15% of that of conventional gearing. Kinematic action, relative torque capacity, and comparative manufacturing costs are discussed. Noise reductions obtained from employing the new gearing in the timing train of a small diesel engine are evaluated for the full range of engine speeds.

84-1113
Dynamic Response of Spur Gear Teeth

G.L. Ostiguy and I. Constantinescu
Ecole Polytechnique, Montreal, Quebec, Canada, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 286-291, 6 figs, 10 refs

Key Words: Gear teeth, Spur gears, Finite element technique, Natural frequencies, Mode shapes, Modal analysis

An application of the finite element technique for the solution of two-dimensional dynamic loading problems is presented. The method is used for the evaluation of the natural frequencies and mode shapes of a spur gear tooth and for the study of its transient response during the meshing period. The transient response of the system under time-varying moving loads is determined by the modal analysis method and the problem is solved by computer. Numerical results are presented for metal and plastic gears.

FASTENERS
(Also see No. 1208)

84-1114
Effects of Bond Deterioration on Seismic Response of Reinforced Concrete Frames

F. Filippou
Ph.D. Thesis, Univ. of California, Berkeley, 214 pp (1983)
DA8328871

Key Words: Joints (junctions), Frames, Reinforced concrete, Seismic response

An analytical model is developed which accounts for the bond deterioration between reinforcing steel and surrounding concrete in predicting the hysteretic behavior of reinforced concrete members and joints. The procedures developed are confined to the behavior of interior and exterior beam-column joints. These solutions are then used to illustrate the significance of the hysteretic behavior of joints in the seismic response of R/C moment resisting frames.

84-1115

Using Experimental Modal Analysis to Characterize Automobile Body Joints and Improve Finite Element Analysis

M.R. Good and D.J. Macioce
Structural Measurement Systems, Inc., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 106-110, 3 figs, 4 refs

Key Words: Modal analysis, Experimental modal analysis, Automobiles, Finite element technique, Joints (junctions)

The purpose of this research is to utilize experimental and analytical modal analysis tools to obtain a best overall model of automobile body joints. Detailed mini-modals are performed on loaded and unloaded joints to obtain accurate experimental models using well-established modal testing techniques.

84-1116

An Analytical and Experimental Investigation of Rail Fastening Systems in Travelling Cranes

J. Oda, K. Yamazaki, H. Yoshida, and K. Nakada
Dept. of Mech. Engrg., Kanazawa Univ., Japan, Intl. J. Mech. Sci., 25 (12), pp 935-944 (1983) 14 figs, 3 tables, 2 refs

Key Words: Fasteners, Cranes (hoists), Railroad tracks, Overhead cranes, Beams, Elastic foundations

The clamping effect of rail fastening systems in a travelling crane is studied by theoretical and experimental techniques. For the theoretical model, a model of a unit rail length with a pair of rail fasteners is first considered. From the results, the changes of the clamping forces in the joint bolts and the rail displacements were obtained and compared with the experimental values.

84-1117

Statistical Crack Propagation in Fastener Holes under Spectrum Loading

J.N. Yang and R.C. Donath
George Washington Univ., Washington, DC, J. Aircraft, 20 (12), pp 1028-1032 (Dec 1983) 8 figs, 2 tables, 16 refs

Key Words: Fasteners, Holes, Crack propagation, Aircraft

A simple crack growth rate-based statistical model for fatigue crack propagation in fastener holes under spectrum loadings is proposed and investigated. A method for analyzing the crack growth rate data in order to calibrate the model parameters is presented. Emphasis is placed upon crack propagation in the small crack size region where the statistical dispersion is very significant.

84-1118

Nonlinear Dynamic Response of a Spacecraft Appendage by Modal Analysis

J.H. Leete
TRW Space and Tech. Group, Redondo Beach, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 345-354, 15 figs, 1 table, 1 ref

Key Words: Modal analysis, Fasteners, Spacecraft antennas

The tracking and data relay satellite (TDRS) has several antennas that are attached with hinges and are retained in the stowed position for launch by pin pullers. Since the hinge pins and the pin-puller pins are slightly smaller than their respective holes, there is some free play that is important in the dynamic response of the antennas. Response to sine vibration tests display the frequency shift and jump phenomenon that are characteristics of a nonlinear resonator with a stiffening spring. A finite element model of the TDRS antenna module was tuned to match the modal frequencies that would occur if the hinges did not have free play.

84-1119

Dynamic Couplings Between Mechanical System and Its Surroundings

K.S. Wang and S.T. Chu
Natl. Tsing-Hua Univ., Hsinchu, Taiwan, Rep. of China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1043-1048, 5 figs, 4 refs

Key Words: Joints (junctions), Coupled systems, Boundary condition effects, Beams

The present study shows that a complicated system can be decoupled into two subsystems through the examples of the vibrations of segment beams.

84-1120

Prediction of Damping for Flexible Spacecraft Appendages

M.L. Soni
Univ. of Dayton Res. Inst., Dayton, OH 45469, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 218-222, 4 tables, 3 refs

Key Words: Joints (junctions), Spacecraft, Damping coefficients

Flexible components connected through relatively rigid structural connections characterize spacecraft structures. These structural connections or joints are a major energy sink in such structures. Owing to complex spring and damping characteristics of the joints and lack of compatible synthesis procedures, the damping prediction of spacecraft structure has been a difficult problem. This paper presents the developments of a component coupling procedure and an empirical model of a structural joint that enable the prediction of damping for the built-up structure.

LINKAGES

84-1121
Seismic Behavior of Active Beam Links in Eccentrically Braced Frames
K.D. Hjelmstad
Ph.D. Thesis, Univ. of California, Berkeley, 168 pp (1983)
DA8328912

Key Words: Linkages, Frames, Seismic design

An eccentrically braced frame is a structural framing system in which the axial forces in the bracing members are transferred either to other braces or to columns through shear and bending in short beam segments called active links. The active link acts as a fuse, dissipating large amounts of input energy upon lateral overloading of the structure. Eccentrically braced frames are well suited for use in seismic regions because they can possess both a high elastic stiffness and good ductility. The results of an experimental study of the behavior of active links are presented. The second part of the paper concerns the elasto-plastic analysis of eccentrically braced frames, with emphasis on accurately modeling the active link elements.

STRUCTURAL COMPONENTS

CABLES

84-1122
Comparison of Modal Analysis, Energy Methods, and Finite Element Analysis for Estimation of Natural Frequencies
L.L. Blakely
Polaroid Corp., Cambridge, MA, Intl. Modal Analysis Conf., Proc., 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 580-584, 4 figs, 4 refs

Key Words: Modal analysis, Experimental modal analysis, Beams, Plates, Cantilever beams, Finite element technique, Energy methods

Theoretical and experimental methods of determining the natural frequencies of a short, cantilever beam composed of plates are compared. Experimental modal analysis results are compared to results from Rayleigh quotient beam and plate approximations and finite element models. The importance of correctly modeling boundary conditions and coupled behavior is discussed.

84-1123
Cable Element Models for Dynamic Analysis
M.L. Gambhir and B.deV. Batchelor
Thapar Inst. of Engrg. and Tech., Patiala, India, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 535-539, 4 figs, 24 refs

Key Words: Cables, Finite element technique, Modal analysis

Three nonlinear cable element models of various degrees of refinement for the dynamic analysis of cable supported systems are described. The class of elements described retain geometric nonlinearities while allowing for the elastic deformations.

84-1124

Three Dimensional Aeroelastic Stability of a Bundle of Two Conductors

Y.T. Tsui

Hydro-Quebec Res. Inst., Varennes, Quebec, Canada, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 512-517, 7 figs, 13 refs

Key Words: Transmission lines, Fluid-induced excitation, Modal analysis

Bundled conductors bring out a new kind of vibration called wake-induced oscillation, or, in power line parlance, subspan oscillation. The wake-induced oscillation is caused by the aerodynamic forces exerting on the leeward conductor which lies in the wake of the windward conductor. Two dimensional analysis of this problem has been thoroughly studied. The present paper treats this problem three dimensionally via a finite element method.

BARS AND RODS

84-1125

Dynamics of a Bar of Asymmetric Cross-Section

Z. Wesolowski

Inst. of Fundamental Technological Res., Polish Academy of Sciences, Warszawa, Poland, J. Engrg. Math., 17 (4), pp 315-321 (Dec 1983) 6 figs, 2 refs

Key Words: Bars, Variable cross section

An elastic bar of asymmetric cross-section is supported at two points and loaded by constant gravity force and axial force. The principal bending moments are assumed to be proportional to the principal curvatures, and the torque proportional to the twist. The equations of motion reduce to the sine-Gordon equation. The solutions corresponding to one soliton and to the collision of two solitons are given.

84-1126

Longitudinal Vibrations of Rods of Finite Length with Radial Deformation

J.J. Wu and Wen-Hwa Chen

U.S. Army Armament Res. and Dev. Ctr., Benet Weapons Lab., LCWSL, Watervliet Arsenal, Watervliet, NY 12189, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, p 20, 4 refs

Key Words: Rods, Longitudinal vibration

An approximate theory of dynamics of rods was formulated by Mindlin and Herrmann in 1951. The unique feature of this theory is that it can model the longitudinal as well as the radial motions of a rod and yet has retained the simplicity of one dimensional problem in the axial direction. Solutions pertaining to rods of infinite length were given also by Mindlin and Herrmann. This paper presents vibration solutions of this rod model with finite lengths.

84-1127

Modal Analysis of Rod Arrays Submerged in Flowing Fluid

T.T. Wu

Westinghouse Electric Corp., Pittsburgh, PA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 452-464, 6 figs, 5 tables, 9 refs

Key Words: Modal analysis, Rods, Submerged structures, Interaction: structure-fluid, Fluid-induced excitation

An analytical method to predict the vibration mode shapes and frequencies of rod arrays submerged in fluid for both free vibration and dynamic instability is presented.

84-1128

Nonlinear Vibration Analysis of Stack-Like Structures by the Perturbation Method

I-Chen Chang

College of Staten Island, City Univ. of New York, Staten Island, NY, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 518-527, 9 figs, 10 refs

Key Words: Rods, Chimneys, Cranes (hoists), Towers, Modal analysis, Wind-induced excitation, Seismic excitation, Perturbation theory

Stacks, cranes and towers of pressure vessels are constantly subjected to severe damage by dynamic forces created by moving load, wing load, and seismic vibration. Based on a simplified mathematical model of the cantilever rod, trans-

verse vibration is investigated using a perturbation [illegible]. A numerical example is presented which uses the det[illegible]d frequency of vibration and displacements to work out a stress analysis of the skirt support of a vertical pressure vessel.

BEAMS

(Also see No. 1122)

84-1129

Chaotic Vibrations of a Beam with Non-Linear Boundary Conditions

F.C. Moon and S.W. Shaw
Cornell Univ., Ithaca, NY 14853, Intl. J. Nonlin. Mech., 18 (6), pp 465-477 (1983) 10 figs, 19 refs

Key Words: Beams, Forced vibration

Forced vibrations of an elastic beam with nonlinear boundary conditions are shown to exhibit chaotic behavior of the strange attractor type for a sinusoidal input force. These chaotic motions have a narrow band spectrum of frequency components near the subharmonic frequencies. Digital simulation of a single mode mathematical model of the beam using a Runge-Kutta algorithm is shown to give results qualitatively similar to experimental observations.

84-1130

The Dynamic Analysis of a Space Lattice Structure via the Use of Step Relaxation Testing

G.F. Mutch, H. Vold, and F. Vigneron
General Electric CAE International Inc., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 368-377, 15 figs, 5 refs

Key Words: Grids (beam grids), Spacecraft components, Experimental modal analysis, Step relaxation method, Low frequencies

The use of step relaxation as a method of excitation of typically very flexible structures having very low natural frequencies is attractive by virtue of the generation of a high level low frequency force input to the structure. However, signal processing problems have been associated with this technique primarily due to the non-Fourier transformable nature of the force input signal. The problem is avoided in a new technique which is original due to the performance of a linear transformation of the input signal, necessarily applied also to the response, rendering the signal Fourier transformable. The application of this new technique is demonstrated as it was applied to the identification of the low frequency modes of a space lattice structure used for the deployment of solar panels on a communication satellite.

84-1131

Bispectral Identification of Nonlinear Mode Interactions

DooWhan Choi, Jung-Hua Chang, R.O. Stearman, and E.J. Powers
College of Engrg., Univ. of Texas at Austin, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 602-609, 6 figs, 10 refs

Key Words: Beams, Spectrum analysis, Modal analysis, Parametric excitation

A parametrically excited thin beam with a finite-amplitude vertical base motion of a discrete frequency is employed to demonstrate combination resonance modes and nonlinear interactions between classical normal modes of the beam.

84-1132

Modification of Finite Element Models Using Experimental Modal Analysis

B.J. Dobson
Royal Naval Engrg. College, Manadon, Plymouth, Devon, UK, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 593-601, 18 figs, 2 tables, 4 refs

Key Words: Finite element technique, Experimental modal analysis, Testing techniques, Beams

This paper describes a validation study conducted on a cantilever beam in which a point defect was introduced. Techniques are described for converting incomplete modal parameter data into spatial information in terms of pseudo-flexibility and stiffness matrices. Using these matrices it is shown that inaccurately modeled regions of the finite element idealization may be identified.

84-1133

Development of Mass and Stiffness Matrices for an Analytical Model Using Experimental Modal Data

J.C. O'Callahan, P. Avitabile, and R. Leung

Univ. of Lowell, Lowell, MA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 585-589, 6 tables, 10 refs

Key Words: Modal analysis, Experimental data, Mass matrices, Stiffness methods, Matrix methods, Beams

Approximate techniques for developing mass and stiffness matrices from experimental modal data for a system model are presented. The matrices are obtained by a modal inverse of the experimental data. Truncated data sets are considered since this is the usual form of modal data. The techniques are implemented for a simple beam.

84-1134

Time Dependent Deflections in Reinforced Concrete Beams under Cyclic Loading

D.J. Carreira

Ph.D. Thesis, Illinois Inst. of Tech., 206 pp (1983) DA8317233

Key Words: Beams, Reinforced concrete, Cyclic loading

A method to predict the time related deflections of simply supported reinforced concrete beams under cyclic loading and unloading is presented. The method is a numerical integration method, based on material parameters with physical significance. It does not require a large computer storage capacity and can be used in manual calculations aided with a programmable calculator. This method includes the time dependent strains in plain concrete, the stress-strain relationships for concrete in compression and in tension, the moment-curvature relationship, and the time dependent deflections.

84-1135

Reliability of a Ship Hull in the Fracture and Fatigue Modes of Failure

A.K. Thayamballi Mathummal

Ph.D. Thesis, Univ. of California, Berkeley, 258 pp (1983)

DA8329065

Key Words: Ship hulls, Girders, Fatigue life

A method for assessing the fatigue reliability of the ship hull girder is presented. The structural loads and the time dependent strength are described statistically. Fracture mechanics concepts are used in describing the growth of a crack in a stiffened plate panel and in computing the failure stress of the panel under tensile loads. The use of this procedure in the selection of inspection intervals is discussed. The method is illustrated by an example computation.

CYLINDERS

84-1136

Measuring the Mechanical Properties of Apple Tissue Using Modal Analysis

G. Van Woensel, E. Verdonck, R. Snoeys, and J. De Baerdemaeker

Katholieke Universiteit Leuven, Laboratorium voor Landbouwmechanisatie Kardinaal Mercierlaan, 92 3030 Leuven, Belgium, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 506-511, 7 figs, 2 tables, 9 refs

Key Words: Experimental modal analysis, Fruit, Spheres, Cylinders

Along with the grade of intactness, fruit firmness is an important factor for the quality criteria on which the consumers acceptance for apples is based. Two methods for measuring the fruit firmness (a destructive one and a non-destructive one) are compared. The results of the two methods were compared, and the suitability of each method was evaluated.

COLUMNS

84-1137

Columns: Static and Dynamic Interactive Buckling

S. Sridharan and R. Benito

Washington Univ., St. Louis, MO 63130, ASCE J. Engrg. Mech., 110 (1), pp 49-65 (Jan 1984) 7 figs, 3 tables, 17 refs

Key Words: Columns, Dynamic buckling

The interaction of local and overall buckling in thin-walled columns is considered. A finite strip method in conjunction with the theory of mode interaction is developed to study the problem. The method is applicable to doubly symmetric cross sections carrying uniform stress or monosymmetric

cross sections subjected to uniform end compression. Imperfection-sensitivity surfaces are presented for stiffened panels and I-section columns. A brief parametric study on I-section columns is presented to illustrate the effect of flange slenderness and the ratio of local to Euler critical load on the maximum load carried.

FRAMES AND ARCHES

(Also see Nos. 1114, 1121)

84-1138

Lateral Vibration of Compression Members

R.J. Edwardes

Ph.D. Thesis, Univ. of New South Wales (Australia) (1983)

Key Words: Frames, Plates, Lateral vibration

The dynamic behavior of a class of frame and plate structures subject to in-plane loading is examined. Both conservative and non-conservative loading systems are addressed. Material behavior is linear elastic, and during vibration, displacements are assumed small. An understanding of load-frequency relationships forms the foundation for a dynamic criterion for stability which is able to predict the critical behaviour of nonconservatively loaded structures, whereas the more traditionally applied static criterion is unsuccessful.

84-1139

Influence of Design Modifications on the Vibrational Characteristics of Plane Frame Structure

M.M. El Nomrossy

Military Technical College, Cairo, Egypt, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Sons. by Union College, Schenectady, NY, Vol. II, pp 960-962, 1 fig, 2 tables, 5 refs

Key Words: Natural frequencies, Mode shapes, Structural modification techniques, Tuning, Modal analysis, Experimental modal analysis

The vibrational characteristics of a complicated structure depend on the corresponding characteristics of its constituent elements and their mutual connection. In this paper the changes in the vibrational characteristics are correlated with the changes in the mechanical properties of the structure elements.

PLATES

(Also see Nos. 1122, 1138)

84-1140

Aeroelastic Flutter and Divergence of Stiffness Coupled, Graphite/Epoxy Cantilevered Plates

S.J. Hollowell and J. Dugundji

Flight Dynamics Lab., Wright-Patterson AFB, OH, J. Aircraft, 21 (1), pp 69-76 (Jan 1984) 6 figs, 6 tables, 21 refs

Key Words: Plates, Cantilever plates, Flutte

An analytical and experimental investigation was conducted to determine the aeroelastic flutter and divergence behavior of unswept, rectangular wings simulated by graphite/epoxy, cantilevered plates with various amounts of bending-torsion stiffness coupling. The analytical approach incorporated a Rayleigh-Ritz energy formulation and unsteady, incompressible two-dimensional aerodynamic theory. Flutter and divergence velocities were obtained using the V-g method and compared to results of low-speed wind tunnel tests. Stall flutter behavior was also examined experimentally.

84-1141

Determination of Modal Coupling in Vibrating Rectangular Plates

G. Caldersmith and T.D. Rossing

Dept. of Physics, Northern Illinois Univ., DeKalb, IL 60115, Appl. Acoust., 17 (1), pp 33-44 (1984) 5 figs, 16 refs

Key Words: Plates, Rectangular plates, Modal coupling

In square isotropic plates, some of the degenerate mode pairs are split in frequency due to coupling between longitudinal and transverse strain (which might be called Poisson coupling), and the same splitting of degenerate modes can occur in rectangular orthotropic plates having a certain length/width ratio. This coupling is studied in free plates of aluminum and spruce (quarter cut and skew cut) and Poisson's ratios are determined from the frequency ratios of the modes.

84-1142

Modal Analysis of Plates with Partial Constrained-Layer Damping Treatments

K.K. Stevens and R.A. Bhat

Florida Atlantic Univ., Boca Raton, FL, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 201-207, 14 figs, 15 refs

Key Words: Plates, Modal analysis, Viscoelastic damping

Application of modal analysis techniques in the determination of the modal parameters and mode shapes of an edge-fixed rectangular plate with a constrained-layer viscoelastic damping treatment extending over a portion of the surface is described. The test specimen and test procedures are discussed, and experimentally-determined values of the system natural frequencies and loss factors for varying degrees of damping treatment are presented and compared with predicted values. Information also is presented on the influence of the damping treatment on the flexural mode shapes of the plate.

84-1143

Modal Analysis of a Gear Housing Plate Using Acoustic Intensity Measurements

R. Singh, G.J. Zaremsky, and D.R. Houser

Ohio State Univ., Columbus, OH 43210, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 784-790, 9 figs, 1 table, 21 refs

Key Words: Plates, Gear boxes, Modal analysis, Acoustic intensity method, Experimental modal analysis

The methodology and results of an in-situ acoustic intensity measurement technique, used to estimate the first seven natural frequencies and mode shapes of a surface plate of a gear housing, are presented.

84-1144

A New Method for Nonlinear Dynamic Analysis of Composite Skew Plates

M. Sathyamoorthy

Clarkson College of Tech., Potsdam, NY 13676, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 825-829, 5 tables, 12 refs

Key Words: Plates, Skew plates, Composite structures, Nonlinear theories, Modal analysis

Geometrically nonlinear static and dynamic analysis of composite plates have received considerable attention in the literature in recent years. In the case of skew plates, several approximate solutions are available based mainly on single-mode functions. The geometry of a skew plate presents several difficulties in obtaining reliable solutions, particularly when the plate is made of composite material and the skew angle is not very small. The purpose of this paper is to investigate a new method which has been successfully used for the nonlinear modal analysis of beams.

84-1145

An Approximate Model for the Extension and Flexural Vibrations of Elastic Plates

E.A. Ünver, A. Kalnins, and G.C. Gaunaurd

U.S. Steel Corp., Res. Lab., Monroeville, PA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1024-1034, 16 figs, 8 refs

Key Words: Plates, Layered materials, Sound waves, Wave radiation, Wave reflection, Wave transmission, Approximation methods, Longitudinal vibration, Flexural vibration

Acoustic reflection and radiation from, and transmission through an elastic layer separating two fluid media are subjects of interest in many practical situations. The aim of this study is to find the simplest plate model that can be used without sacrificing any of the important features of the plate's dynamics, and without getting involved in the mathematical complexity of the exact theory.

SHELLS

84-1146

Nonlinear Geometric, Material and Time Dependent Analysis of Reinforced Concrete Shells with Edge Beams

Esmond Chi-Yiu Chan

Ph.D. Thesis, Univ. of California, Berkeley, 371 pp (1983)

DA8328815

Key Words: Shells, Reinforced concrete, Nonlinear response, Numerical methods

A numerical method of analysis has been developed to study the nonlinear response of reinforced concrete structures with special emphasis on shells with edge members. Nonlinear

material, nonlinear geometry and the time dependent effects of creep and shrinkage are included in the analysis. The structural response is traced through its elastic, inelastic and ultimate load ranges. A finite element displacement formulation coupled with a time step integration solution is used. An incremental and iterative scheme based upon constant imposed displacement is used so that structures with local instabilities or strain softenings can also be analyzed.

84-1147

Vibration Tests of Thin-Cylindrical Shells

V.C.M. DeSouza and J.G.A. Croll
Universidade Federal Fluminense, Niteroi, Brasil,
Exptl. Tech., 8 (1), pp 21-23 (Jan 1984) 1 fig, 1 table, 8 refs

Key Words: Shells, Cylindrical shells, Off-shore structures, Wave forces, Vibration tests

This article is part of an initial study to determine the nature of the transient dynamic response of marine shells subjected to wave-induced dynamic loading. To ensure that linear-thin-shell theory provides a reliable modeling of the natural resonance states, tests have been carried out on two cylindrical-shell models.

84-1148

Investigation of the Sound Radiation Mechanism from the Shell of Hermetic Refrigerant Compressors

M. Waser and J.F. Hamilton
Purdue Univ., West Lafayette, IN 47907, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 791-795, 9 figs, 3 refs

Key Words: Shells, Compressors, Sound waves, Wave radiation, Experimental modal analysis

A major portion of the noise from small hermetic reciprocating compressors used in household refrigerators is radiated by the vibration of the compressor shell. An approach is presented to relate the dynamical characteristics of the shell with the sound radiation. The natural frequencies and associated mode shapes of the shell with a stationary (nonrunning) compressor are determined using impact excitation and an FFT system with a modal analysis package.

PIPES AND TUBES

(Also see No. 1099)

84-1149

Trouble-Shooting in Power-Plant Piping through Combined Test and Analysis

Zs. Revesz and F. Ferroni
Electrowatt Engrg. Services Ltd., CH-8022, Zurich, Switzerland, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 926-929, 4 figs, 9 refs

Key Words: Piping systems, Power plants (facilities), Fluid-induced excitation, Modal analysis, Experimental modal analysis

An example of how today's advanced measurement techniques contribute to efficient problem solving with the use of suitable software is presented. The subject of the investigation is hydrodynamically excited vibration in a large power piping system. The paper gives an overview of the theoretical background and presents intermediate and final results from the case studied, using computer graphics for better understanding of details.

84-1150

Analysis of Grand Coulee Pumping Plant Discharge Pipe Vibrations

R.V. Todd
Div. of Design, Bureau of Reclamation, Denver, CO, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 292-297, 7 figs, 5 refs

Key Words: Piping systems, Stiffener effects, Natural frequencies, Mode shapes, Modal analysis

Since installation in the early 1950s, the upper exposed sections of the six discharge pipes at Grand Coulee Pumping Plant have vibrated due to pump excitation. Intermediate stiffeners of "H" construction were added which effectively reduced the vibration to a low level; however, a 300-mm longitudinal crack formed in the pipe at one of the stiffeners. To determine the stress levels, a finite element analysis was performed. A sample section of pipe was initially modeled and the results compared with those predicted by the original analysis.

84-1151

Dynamic Analysis of a Coupled Large Piping/Small Piping System with Closely Spaced Modes

C.-W. Lin and T.C. Esselman

Westinghouse Electric Corp., Pittsburgh, PA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 149-156, 1 table, 6 refs

Key Words: Piping systems, Seismic analysis, Modal analysis

For seismic response spectrum analysis of a piping system consisting of a large piping coupled with a small piping, a beat type of motion may result when the two systems have similar modal response magnitudes and the frequencies are close to each other. In such a case, the conventional approach of using a closely spaced mode formula may severely overestimate the true magnitude of response. In this paper, the two modal coefficients are proved to have opposite signs. The nature of the modal coefficients for the model with closely spaced modes is studied to arrive at a most probable maximum response for a random vibration motion input. Two formulas are then developed to obtain reduction coefficients to compute a more realistic subsystem response.

84-1152

In Situ and Laboratory Benchmarking of Computer Codes Used for Dynamic Response Predictions of Nuclear Reactor Piping

P. Bezler, M. Subudhi, and S. Shteyngart

Brookhaven Natl. Lab., Upton, NY, Rept. No. BNL-NUREG-51680, 76 pp (May 1983)

NUREG/CR-3340

Key Words: Piping systems, Nuclear reactors, Computer programs

The ongoing program to develop analytical piping benchmark solutions for the verification of piping analysis methods has been extended to the consideration and use of physical test results. This report provides a description of the first endeavors in this effort. Specifically the results of benchmark evaluations for a laboratory tested piping system undergoing forced seismic excitation and an in situ tested power plant piping run executing free vibrations are described.

DUCTS

84-1153

Two-Dimensional Nonlinear Theory of Shocked Sound Propagation through Nonuniform Ducts Carrying High Subsonic Flows

K. Uenishi

Ph.D. Thesis, George Washington Univ., 214 pp (1983)

DA8321585

Key Words: Ducts, Sound waves, Wave propagation

A two-dimensional nonlinear theory of sound propagation through a high-subsonic throat is derived including the development of shock waves in the acoustic field. This study is an extension of a one dimensional nonlinear theory previously studied. The analysis is carried out using the method of matched asymptotic expansions, which yields a set of outer and inner equations of motion in the subsonic region and in the near sonic throat region, respectively.

84-1154

Acoustical Wave Propagation in Cylindrical Ducts: Transmission Line Parameter Approximations for Isothermal and Nonisothermal Boundary Conditions

D.H. Keefe

The Biomechanics Inst., P.O. Box 420, Boston, MA 02215, J. Acoust. Soc. Amer., 75 (1), pp 58-62 (Jan 1984) 4 figs, 15 refs

Key Words: Ducts, Sound waves, Wave propagation

Approximate expressions are given for the characteristic impedance and propagation wavenumber for linear acoustic transmission through a gas enclosed in a rigid cylindrical duct. These expressions are most complicated in the transition zone where the thermoviscous boundary layers are on the order of the tube radius. The approximations are accurate to within 1% for all frequencies and tube diameters except within the transition zone where the approximations are accurate to within 10%. A simple modification of the transmission line parameters is presented for the case where the tube walls are nonisothermal.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 1062, 1154)

84-1155

Digital Processing Revitalizes Old Techniques

D.M. Croker

Ricardo Consulting Engineers Ltd., SAE Paper No. 820366 (P-106)

Key Words: Acoustic intensity method, Digital techniques, Active noise control

The application of modern digital processing techniques to acoustic intensity measurement, structural engine research using the "Banger" rig, and active noise control is discussed and illustrated.

84-1156

Identification of Energy Sources and Absrobers

G. Rasmussen and P. Rasmussen

Bruel & Kjaer, 2850 Naerum, Denmark, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 970-976, 15 figs, 1 table, 6 refs

Key Words: Sound generation, Vibrating structures, Energy absorption

Measurements of acoustic intensity in the very near field of a vibrating surface reveal information about the location of sources and sinks. Information about vibration behavior may be obtained this way. The vibrational energy flow may also be measured, and by proper measuring technique, the magnitude and the direction of flow may be measured as well as the amount of energy absorbed.

84-1157

A Numerical Method for Computing the Sound Radiated by Vibrating Structures

B. Soenarko and A.F. Seybert

Bandung Inst. of Tech., Bandung, Indonesia, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 963-969, 8 figs, 20 refs

Key Words: Sound generation, Vibrating structures, Sound waves, Wave radiation, Experimental modal analysis, Finite element technique

This paper discusses the application of an advanced numerical method for the solution of radiation problems governed by Helmholtz's equation. The method is useful for computing the sound radiated by a structure given either experimental modal analysis data or finite element model data. A general result for the surface and field velocity potential is derived. This result includes the case where the surface may have a non-unique normal (e.g. at the edge of a cube). The method is used to obtain numerical solutions to two well known radiation problems for which analytical solutions are known: the pulsating sphere and the oscillating sphere. The method is also used to solve two radiation problems in which the bodies have edges and corners, i.e., radiation from a circular cylinder and from a pulsating cube.

84-1158

Acoustic Diffraction by an Impedance-Covered Edge

M. Marsan

Pennsylvania State Univ., State College, PA, Rept. No. ARL/PSU/TM-83-95, 142 pp (June 15, 1983) AD-A133 266

Key Words: Sound waves, Wave diffraction, Acoustic impedance

The prediction of the sound scattered by impedance covered wedges is obtained by use of dual integral equations. The impedance of each face of the wedge is modeled as a point reacting complex quantity which is independent of the other face.

84-1159

Low Frequency Acoustic and Electromagnetic Scattering

S.I. Hariharan and R.C. Maccamy

NASA Langley Res. Ctr., Hampton, VA, Rept. No. REPT-83-43, NASA-CR-172203, 28 pp (Aug 1983) N83-34660

Key Words: Sound waves, Wave scattering, Low frequencies

This paper deals with two classes of problems arising from acoustics and electromagnetics scattering in the low frequency stations. The first class of problem is solving Helmholtz equation with Dirichlet boundary conditions on an arbitrary two dimensional body while the second one is an interior-exterior interface problem with Helmholtz equation in the exterior. These solutions greatly differ from the zero frequency approximations. For the Dirichlet problem numerical examples are shown to verify the theoretical estimates.

84-1160

Geometrical Theory of Diffraction by an Open Rectangular Box

P. Saha and A.D. Pierce

School of Mech. Engrg., Georgia Inst. of Tech., Atlanta, GA 30332, J. Acoust. Soc. Amer., 75 (1), pp 46-49 (Jan 1984) 6 figs, 11 refs

Key Words: Sound waves, Wave diffraction

Predictions based on the geometrical theory of diffraction for sound radiation from a source within an open rigid rectangular box are compared with a set of experimental and numerical results obtained by Furue, Terai, and Matsu'ura (9th International Congress of Acoustics, Madrid, Spain, July 1977). The comparison with the experimental results shows a substantial verification of the theory.

84-1161
The Transition Matrix for Acoustic and Elastic Wave Scattering in Prolate Spheroidal Coordinates

R.H. Hackman

Acoustics Branch, Naval Coastal Systems Ctr., Panama City, FL 32407, J. Acoust. Soc. Amer., 75 (1), pp 35-45 (Jan 1984) 1 fig, 19 refs

Key Words: Sound waves, Elastic waves, Wave scattering

A spheroidal-coordinate-based transition matrix is derived for acoustic and elastic wave scattering. The formalism is based on Betti's third identity and an appropriately chosen set of vector spheroidal basis functions. Transition matrices are obtained for the scattering from an elastic inclusion in an elastic medium and in an inviscid fluid.

84-1162
Generalized Analysis of Sound Scattering by Diffusing Walls

Gen-hua Dai and Y. Ando

Inst. Acoust., Academia Sinica and Drittes Physikalisches Institut, Universität Gottingen, Acustica, 53 (6), pp 296-301 (Oct 1983) 7 figs, 7 refs

Key Words: Sound waves, Wave scattering, Walls

The two-dimensional, generalized diffraction theory is developed for a periodic diffusing wall, consisting of walls of arbitrary rectangular profile and of arbitrary acoustic impedance at the bottom. From the boundary conditions to be satisfied by the plane waves in the free half-space and the eigenwaves in the walls, a simultaneous infinite system of linear equations is derived from which the sound reflection of the wall can be solved. Two examples are given. One of them is used to demonstrate the effect of the present theory, emphasizing the importance of the evanescent waves to the total scattered field. Another one is concerned with the quadratic-residue sequence diffuser and shows again that this kind of diffuser is favorable.

84-1163
Underwater Sound Generation by Breaking Wind Waves

B.R. Kerman

Boundary Layer Div., Atmospheric Environment Service, Downsview, Ontario, Canada M3H 5T4, J. Acoust. Soc. Amer., 75 (1), pp 149-165 (Jan 1984) 13 figs, 73 refs

Key Words: Sound waves, Underwater sound, Wind-induced excitation

The problem of identifying the source of wind-generated underwater sound is reviewed. Amalgamated observations of the ambient noise reveal a similarity structure, both in the acoustical spectrum and wind dependency, which allows for a considerable simplification of the problem. Mechanisms of sound generation are discussed with particular reference to oscillating bubbles. Air entrainment by breaking waves and the probabilistic distribution of bubbles are discussed. A model for underwater noise generation by bubbles oscillating in a breaking wave is proposed. It is argued that the most intense sound is associated with bubbles the radius of which is comparable to the Kolmogorov scale length. A slight three-eighths wind dependency is predicted for the frequency of the maximum intensity. Agreement in structure and order of magnitude is demonstrated.

84-1164
Numerical Synthesis and Inversion of Acoustic Fields Using the Hankel Transform with Application to the Estimation of the Plane Wave Reflection Coefficient of the Ocean Bottom

D.R. Mook

Woods Hole Oceanographic Instn., MA, Rept. No. WHOI-83-27, 231 pp (Sept 1983)
AD-A133 156

Key Words: Sound waves, Wave reflection, Underwater sound

The plane wave reflection coefficient is an important geometry independent means of specifying the acoustic response of a horizontally stratified ocean bottom. It is an integral step in the inversion of acoustic field measurements to obtain parameters of the bottom and it is used to characterize

an environment for purpose of acoustic imaging. This thesis studies both the generation of synthetic pressure fields through the plane wave reflection coefficient and the inversion of measured pressure fields to estimate the plane wave reflection coefficient. These are related through the Sommerfeld integral which is in the form of a Hankel transform. The Hankel transform is extensively studied in this thesis and both applications.

84-1165

Acoustic Pulse Scattering from Impedance Covered Cylinders

A. Khavaran

Ph.D. Thesis, The Pennsylvania State Univ., 137 pp (1983)

DA8327514

Key Words: Sound waves, Wave scattering, Cylinders

An expression for the acoustic scattered pressure from an impedance-covered cylinder due to an incident plane pulse is obtained analytically. The application of Fourier transform on time and subsequent Sommerfeld-Watson transformation results in separate expressions for geometrically reflected pressure and for creeping (or circumferential) waves. Using Gauchy contour integration theorem and saddle-point methods, the inverse Fourier transform is evaluated. The impulse response and convolution theorem have been utilized to obtain an expression for the scattered pressure for incident harmonic pulse train and FM pulses.

84-1166

Acoustic Diffraction by an Impedance-Covered Wedge

M. Marsan

Ph.D. Thesis, The Pennsylvania State Univ., 141 pp (1983)

DA8327524

Key Words: Sound waves, Wave diffraction, Wedges

The prediction of the sound scattered by impedance covered wedges is obtained by use of dual integral equations. The impedance of each face of the wedge is modeled as a point reacting complex quantity which is independent of the other face. The solution was constructed as an angular spectrum to satisfy the boundary conditions and Sommerfeld radiation condition. The solution kernel was obtained exactly and is in terms of circular functions. The solution for the diffracted pressure exhibits clearly the role of the incident and reflected shadow boundaries and shows there is one minimum in the scattered field which depends on the two surface impedances. For backscattered pressures, the solution exhibits two minima. In all cases, the scattered pressure becomes negligible near the wedge surfaces.

84-1167

Determining Vibration, Radiation Efficiency, and Noise Characteristics of Structural Design Using Analytical Techniques

P.A. Hayes and C.A. Quantz

Noise Control Tech., Cummins Engine Co., Inc., Columbus, IN, SAE Paper No. 820440 (P-106)

Key Words: Vibrating structures, Noise generation, Finite element technique

An analytical method is presented for calculating vibrations and radiation efficiencies from a structural model. The three areas addressed are determining the dynamic characteristics of structures using finite element techniques; generating input functions from empirical data; and calculating radiation efficiencies of the structure from a finite element model. Finally, a systematic method is presented for combining these parameters to calculate sound power. Experimental results demonstrate the accuracy and applicability of this technique in the development of low noise hardware.

84-1168

Short-Range Acoustic Intensity Vectors of the Pekeris Shallow Water Model

E.A. Skelton

Admiralty Marine Tech. Establishment, Teddington, UK, Rept. No. AMTE(N)/TM83065, DRIC-BR-88937, 28 pp (Aug 1983)

AD-A133 430

Key Words: Underwater sound, Sound waves, Wave propagation

Intensity vectors of the Pekeris model are calculated from values of acoustic pressure and particle velocity which are obtained by numerical integration. Plots of the vectors, for the cases of no-seabed, a rigid seabed and fast and slow seabeds, illustrate the potential usefulness of the intensity vector approach as an aid to understanding the physics of underwater sound propagation.

84-1169

The Coherent Green's Function for Acoustic Propagation in a Random Ocean

D.R. Palmer
Natl. Oceanic and Atmospheric Admn., Atlantic Oceanographic and Meteorological Lab., 4301 Rickenbacker Causeway, Miami, FL 33149, J. Acoust. Soc. Amer., 75 (1), pp 125-132 (Jan 1984) 1 fig, 35 refs

Key Words: Sound waves, Wave propagation, Underwater sound, Oceans, Green function

An algorithm has been derived for calculating the coherent Green's function of an acoustic wave propagating in an ocean possessing index-of-refraction fluctuations. This function is related to the so-called strength parameter which can be used to characterize the statistics obeyed by the acoustic field. The geometric optics approximation is not made. Consequently, it is necessary to generalize the usual form of the Markov approximation. This is done in analogy with Dashen's investigations. This analysis accounts for the ocean boundaries and the depth dependence of the mean index of refraction. It is, however, restricted to convergence zone propagation. The phenomenological model of internal waves introduced by Garrett and Munk is used to describe the random fluctuations in the index of refraction. The analysis is based on the use of a Feynman path integral. The algorithm consists of solving the parabolic equation using the split-step Fourier algorithm technique with an effective index of refraction term. The presence of the internal wave fluctuations are reflected in this term through an imaginary piece which attenuates the coherent Green's function.

84-1170

Acoustic Stuides of Broadband Scattering from a Model Rough Surface

P.D. Thorne and N.G. Pace
Inst. of Oceanographic Sciences, Crossway, Taunton, Somerset, UK, J. Acoust. Soc. Amer., 75 (1), pp 133-144 (Jan 1984) 19 figs, 37 refs

Key Words: Sound waves, Wave scattering, Underwater sound

Experimental measurements of the normal incidence underwater acoustic backscatter from a model rough surface having Gaussian statistics with a rms height 0.22 cm and a correlation length 1.9 cm are presented. Scattering measurements were obtained over the frequency range 20-1200 kHz for a variety of transmitter and receiver distances from the model surface. A novel feature of the experiment was the use of a parametric array as the wideband, highly directional acoustic source. An important aspect of the study is the use of a Fresnel phase approximation in the development of the theoretical expressions; this approach allows an understanding of the range dependence of the scattering coefficients. Theoretical and experimental values of the normal incidence scattering coefficients show good agreement over the range of frequencies and transmitter/receiver distances employed.

84-1171

The Field of Sound-Intensity at a Short Distance in Front of an Arrangement of Emitters (Das Schallintensitätsfeld vor Strahleranordnungen in geringer Entfernung)

K. Kammeringer and W. Schweiger
Institute f. Bauphysik, Fakultät f. Bauingenieurwesen und Architektur, Universität Innsbruck, Acustica, 53 (6), pp 290-295 (Oct 1983) 8 figs, 9 refs
(In German)

Key Words: Sound intensity

The sound intensity at a test point is given as the temporal mean value of the product of the total sound pressure and the total sound particle velocity. These two complex scalar quantities are the sums of the sound pressures or of the values of sound particle velocities obtained from the individual emitters at the test point. Under this assumption, an equation can be derived in which the whole intensity can be represented as a sum of the products of the separate coefficients of intensity. Thus, the distribution of intensity can be easily calculated and graphically represented with a computer.

84-1172

Flexible Noise-Shielding Systems (Biegeweiches Schallschutzsystem)

Industrie Anzeiger, 106 (3), pp 18-19 (Jan 11, 1984) 5 figs
(In German)

Key Words: Noise reduction, Noise barriers, Traffic noise

Sound causes flexurally stiff systems to vibrate in the audible frequency range; while flexible systems are excited to long wave flexural vibrations in the low inaudible frequency range. Thus, a flexible system of the same weight has higher noise reducing characteristics than a stiff one. The utilization of this property in noise shields, e.g., around compressors, mixers, as well as in barrier walls near railroads or expressways, is described.

84-1173

Equivalent Level of Railroad Noise With and Without Barrier

R. Makarewicz

Inst. of Acoustics, A. Mickiewicz Univ., Matejki 48/49, 60-769, Poznan Poland, Appl. Acoust., 17 (1), pp 45-59 (1984) 9 figs, 9 refs

Key Words: Equivalent sound levels, Traffic noise, Railroad trains, Noise barriers

This paper presents models for predicting the equivalent level, L_{eq} of railroad noise. For open terrain two cases are considered: with and without ground effects (second section). On the assumption that, at a given point $L_{eq} = L^*_{eq}$ is required, the problems of barrier length, height and position are discussed (third section). Examples of the application of presented theories are given.

84-1174

A Method of Traffic Noise Prognosis

B. Buna and L. Vereb

Inst. for Transport Sciences, Budapest, Hungary, Appl. Acoust., 17 (1), pp 21-31 (1984) 5 figs, 7 refs

Key Words: Traffic noise, Noise prediction

This paper describes a simple method for the calculation of changes in noise levels generated by the vehicle population of a country as a whole in future time related to present population. The changes of the total number of vehicles, the introduction of quieter vehicles and the condition of wear of the running stock are taken into account in the model and the change in L_{eq} level is used as the output parameter. The calculated changes in L_{eq} values are about the same as those of L_{10}. The application examples of the model show that this simple method seems to be helpful for decision makers. The examples also allow conclusions for noise control strategy to be developed.

84-1175

An Analytical Model for Noise Generated by Axial Oscillations of Unbaffled Cylindrical Elements

N.D. Perreira and D. Dawe

Univ. of Texas at Austin, Austin, TX 78712, J. Acoust. Soc. Amer., 75 (1), pp 80-87 (Jan 1984) 9 figs, 28 refs

Key Words: Cylinders, Machinery noise, Noise prediction

A simple method to predict the noise generated by cylindrical-shaped machine elements in axial vibration is presented. An approximation of the Helmholtz integral equation valid when the receiver-source distance is much greater than either the cylinder's diameter or length is used to determine the acoustic pressure generated by axial oscillations of cylinders at any aspect ratio or frequency. The results are used in developing free-field and reverberent field design contours. Experimental evidence points to the validity of the prediction model. Included are two design problems and solutions that show the method can be used to reduce noise generated by cylindrical shaped bodies.

84-1176

Noise Control and Modal Analysis: A Survey

R.J. Bernhard

Ray W. Herrick Labs., Purdue Univ., West Lafayette, IN 47907, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 777-783, 39 refs

Key Words: Modal analysis - experimental, Noise reduction, Machinery noise

A common design criterion for household appliances, manufacturing equipment, transportation vehicles, and other machinery is the reduction of radiated noise. Because the physics of sound radiation is complicated, attempts at noise control design has often been unguided and the results correspondingly disappointing. Recently, more systematic techniques of predicting and measuring sound fields have been developed. This paper surveys noise control techniques and highlights the applications of modal analysis.

SHOCK EXCITATION

(Also see No. 1187)

84-1177

Analysis and Attenuation of Disturbance Vibrations in Notched Bar Impact Testing

X.-Q. Dong

Natl. Metrological Inst., Beijing, The Peoples Rep. of China, Intl Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 275-279, 8 figs

Key Words: Metals, Fracture properties, Bars, Discontinuity-containing media, Impact tests, Modal analysis - experimental

In order to estimate the fracture behavior of metal under the influence of the main test parameter temperature and high

deformation velocity at the presence of a notch the notched bar impact testing is performed. In this experiment the dynamic load-time and load-displacement relationship is evaluated by means of an instrumented pendulum Charpy machine. Based on this diagram it is possible to intensively judge material properties, e.g., loads or deflection at general yield and at initiation of ductile fracture or the respective values at cleavage fracture.

84-1178
Numerical Computations of Turbulence Amplifications in Shock Wave Interactions

T.A. Zang, M.Y. Hussaini, and D.M. Bushnell
NASA Langley Res. Ctr., Hampton, VA, Rept. No. REPT-83-10, NASA-TM-85413, 35 pp (Apr 1983) N83-34227 and AIAA J., 22 (1), pp 13-21 (Jan 1984) 9 figs, 7 tables, 35 refs

Key Words: Interaction: shock waves-boundary layer, Turbulence

Numerical computations are presented which illustrate and test various effects pertinent to the amplification and generation of turbulence in shock wave turbulent boundary layer interactions. Several fundamental physical mechanisms are identified. Idealizations of these processes are examined by nonlinear numerical calculations. The results enable some limits to be placed on the range of validity of existing linear theories.

84-1179
Nonlinear Resonant Wave Motion of a Weakly Relaxing Gas

W. Ellermeier
Institut f. Mechanische Verfahrenstechnik und Mechanik, Bereich Angewandte Mechanik, Universität Karlsruhe (TH), Postfach 6380, D-7500 Karlsruhe 1, Fed. Rep. Germany, Acta Mech., 49 (1-2), pp 11-31 (1983) 13 figs, 29 refs

Key Words: Shock tubes

A relaxing, viscous and heat conducting gas in a closed tube is excited by a sinusoidally oscillating piston. Neglecting all irreversible changes by the requirement of small amplitude excitation and weak influence of damping a nonlinear one-dimensional theory is presented to describe the standing wave near the fundamental mode of the undamped system. Within a certain frequency band around the resonance frequency shock waves travel back and forth in the tube. The dependence of shock-frequency-band-width on the excitation amplitude and the damping parameters is discussed.

VIBRATION EXCITATION

(Also see No. 1139)

84-1180
Barrier Crossing Due to Transient Excitation

P.T.D. Spanos and G.P. Solomos
Univ. of Texas, Austin, TX 78712, ASCE J. Engrg. Mech., 110 (1), pp 20-36 (Jan 1984) 4 figs, 6 tables, 22 refs

Key Words: Stochastic processes, Damped structures, Single degree of freedom systems, Random excitation

The first-passage time problem for the response amplitude of a linear lightly damped single-degree-of-freedom oscillator under evolutionary random excitation is considered. A Markovian approximation of the amplitude allows the use of a Fokker-Planck equation for the formulation of the problem. This equation is solved exactly for the special case of a step function-modulated stationary excitation. These results are used in determining a solution for the general excitation case via a Galerkin technique. Pertinent digital simulation data demonstrate the reliability and extreme efficiency of the developed solution method.

84-1181
Response of a Gyropendulum Subject to Parametric Excitation

V. Krishnan
Inertial Systems and Instrumentation Div., Vikram Sarabhai Space Centre, Trivandrum, India, IMechE, Proc., 197 (C), pp 233-237 (Dec 1983) 4 figs, 8 refs

Key Words: Pendulums, Parametric excitation, Stabilization, Harmonic excitation

This paper concerns the response of a gyropendulum subject to vertical harmonic excitation. Instability of the Mathieu type is shown to occur, the principal region of instability lying about the nutational frequency of the system. Experimental results are presented which clearly indicate the validity of the theoretical prediction. It is also shown that an unstable gyroscopic system can be stabilized by vibrating the equipment with the proper choice of vibration parameters. In such cases, the additional stabilizing factor has been analytically derived. Based on the above analysis, practical suggestions for instrument design are also provided.

84-1182

Summary of Excitation Signals for Structural Testing

M. Good and R. Rost

Structural Measurement Systems, Inc., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 566-571, 18 refs

Key Words: Modal analysis - experimental

Excitation constraints, signals, and multiple input/output methods for estimating frequency response functions are described. Future excitation methods are discussed.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 1069, 1273)

84-1183

An Application of Modal Analysis for Evaluating the Effectiveness of Constrained Layered Damping Composite

S. Rajesham and V.C. Venkatesh

Universiti Teknologi Malaysia, Kuala Lumpur 15-01, Malaysia, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 280-285, 8 figs, 2 tables, 7 refs

Key Words: Experimental modal analysis, Viscoelastic damping, Saws, Circular saws, Blades

In this paper, reference is made to a case where experimentally determined modal parameters are used for evaluating and comparing the effectiveness of metal constrained layered high damping composite, a visco-elastic polymer, when applied to a saw blade.

84-1184

Design of Damped Structures Using Modal Analysis

M. Thomas and R. Elmaraghy

Centre de recherche industrielle du Québec, Sainte-Foy, Québec, Canada, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 223-227, 14 figs, 6 refs

Key Words: Modal analysis, Damped structures, Design techniques

The vibration produced by mechanical systems increases the structural fatigue of machines and mechanical components and is often at the origin of noise problems. Diagnosis of the vibration sources and correction measures are difficult tasks which require a deep understanding of the physical phenomena involved. The use of composite and viscoelastic materials is an answer to control the vibration levels by converting mechanical energy into thermal energy. In order to predict the efficiency of a damping treatment, an understanding of the dynamic and mechanical behavior of these materials is necessary. With modal analysis, which enables rapid identification of resonant frequencies, mode shapes and modal parameters, a designer can optimize the application of viscoelastic damping materials for real structures.

84-1185

Experimental-Theoretical Study of Modal-Space Control

G.R. Skidmore, W.L. Halluer, Jr., and R.N. Gehling

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 66-74, 8 figs, 9 refs

Key Words: Active damping, Active vibration control, Spacecraft, Modal analysis - experimental

This paper presents a theory of multiple-actuator excitation and/or control of individual vibration modes, with control being the primary emphasis. Then the paper describes an experiment in which modal-space control was applied to a laboratory beam-cable structure. Active damping was produced in the three lowest modes (all under 10 Hz) of the structure by a feedback control system consisting of a single velocity sensor, an analog controller, and three force actuators. Both open-loop and closed-loop transient responses to specified initial conditions were measured. The experimental results are compared with theoretical predictions.

84-1186

Stable Response of Damped Linear Systems

D.W. Nicholson and D.J. Inman

Naval Surface Weapons Ctr., White Oak, MD 20910, Shock Vib. Dig., 15 (11), op 19-25 (Nov 1983) 49 refs

Key Words: Damped sytems, Linear systems, Stability

This paper updates and expands a previous review concerned with several aspects of the response of damped mechanical systems. Topics include asymptotic stability, oscillation conditions, forced response bounds, and eigenvalue localization. Considerable progress has been made on the last three topics but little on the first. Several simple new results are stated.

84-1187
Criterion of Multiple Collisions in a Simple Mechanical System with Viscous Damping and Dry Friction

A. Pielorz and W. Nadolski

Inst. of Fundamental Technological Res., Swietokrzyska 21, 00-49, Warsaw, Poland, Intl. J. Nonlin. Mech., 18 (6), pp 479-489 (1983) 9 figs, 2 refs

Key Words: Coulomb friction, Viscous damping, Impact pairs

A criterion has been formulated for single and multiple central collisions of two rigid bodies of a simple mechanical system that can be either conservative or non-conservative. Analytical discussion has been confined to investigations of the possibility of appearance of four successive collisions between the bodies with damping neglected and two collisions when viscous damping and Coulomb dry friction are considered.

FATIGUE

(Also see Nos. 1103, 1280, 1314)

84-1188
Fatigue Considerations in Use of High-Strength Sheet Steel

R.W. Landgraf

Ford Motor Co., Dearborn, MI, SAE Paper No. 820700 (P-109)

Key Words: Fatigue life, Steel

The fatigue behavior of representative classes of high-strength low-alloy and dual phase steel is reviewed. Cyclic properties describing stress-strain and strain-life relations are used to quantitatively assess material variability as well as processing and environmental effects. Examples of the use of this materials information in design analysis and, in particular, component down-gaging are then presented.

84-1189
Fundamentals of Fatigue Analysis

R.W. Landgraf

Ford Motor Co., Dearborn, MI, SAE Paper No. 820677 (P-109)

Key Words: Fatigue life

An overview of the basic concepts involved in performing a fatigue analysis is presented as an introduction to a series of specialized papers dealing with the development of fatigue information and its use in engineering design. Following a brief account of the fatigue process and failure definition, methods for describing fatigue resistance are discussed. Cumulative damage concepts based on fatigue life curves are then demonstrated.

84-1190
Demonstration of Fatigue Life Calculations

T.M. Johnson

General Motors Proving Ground, Milford, MI, SAE Paper No. 820678 (P-109)

Key Words: Fatigue life, Simulation

The purpose of this demonstration is to simulate many of the operations involved in an actual fatigue life calculation exercise. A "component" will be manufactured" from "raw materials." A "service environment" will be defined and an "S/N" curve will be developed for the component. "Material Characteristics" will be empirically defined, and fatigue life calculations will be made using several techniques. Actual "component fatigue tests" will be conducted and compared with calculated fatigue lives. Attempts will be made to introduce much of the jargon and vocabulary used in fatigue life analysis.

84-1191
Crack Initiation Fatigue - Data, Analysis, Trends and Estimation

B.E. Boardman

Deere & Company Technical Ctr., Moline, IL, SAE Paper No. 820682 (P-109)

Key Words: Fatigue life, Steel, Ground vehicles, Data processing, Crack propagation

This paper presents a summary of fatigue properties for steels common to the ground vehicle industry and their literature references. There is discussion of several errors which can occur by applying statistical analysis or accepting reported fatigue properties without a critical review of the results. Techniques are shown for estimating the fatigue properties when no data exists or as one step in the validation process for statistically determined or reported data.

84-1192

Monotonic and Fatigue Characterizations of Metals

N.R. LaPointe

Test Operations and Engrg. Services., Ford Motor Co., SAE Paper No. 820679 (P-109)

Key Words: Fatigue life, Metals

Monotonic and cyclic properties for metals are reviewed. Conventional stress based fatigue characterizations of S-N curves and mean stress plots are illustrated. Strain based mechanical hysteresis concepts are used to express cyclic stress-strain properties, and fatigue properties when combined with fatigue data. These properties are useful for a computer based materials data file for engineering applications. Cyclic deformation behavior for cyclic creep and stress relaxation is illustrated. A fatigue notch characterization is given based upon Neuber's Rule.

84-1193

Field Data Classification and Analysis Techniques

K.H. Donaldson, Jr.

MTS Systems Corp., SAE Paper No. 820685 (P-109)

Key Words: Fatigue life, Data processing

This paper gives guidelines on possible decision making procedures in the collection and reduction of data acquired in the field. Presented are the specific details of several data analysis algorithms that are commonly used in conjunction with cumulative fatigue damage assessment. Data rate formulae for quantifying certain digitizing effects and characterizing field service time histories are given. Methods for reducing time histories to amplitude distributions are discussed. Specific data reduction criteria and algorithms are given for time at level, level crossing, range counting, and rainflow counting techniques.

84-1194

Corrosion and Fretting Effects on Fatigue

D.W. Hoeppner

Univ. of Toronto, Toronto, Ontario, Canada, SAE Paper No. 820687 (P-109)

Key Words: Fatigue life, Fretting corrosion

This paper presents a brief introduction to both the corrosion (fatigue) and fretting (fatigue) processes. The potential effect of these phenomena on fatigue integrity is discussed. Methods of anticipating, preventing, alleviating, or estimating fatigue life are discussed in relation to maintaining the desired component integrity related to the overall design philosophy.

84-1195

Constant Amplitude Fatigue Life Assessment Models

H.S. Reemsnyder

Res. Dept., Bethlehem Steel Corp., Bethlehem, PA, SAE Paper No. 820688 (P-109)

Key Words: Fatigue life, Crack propagation

The applications of the stress-life, local strain, linear elastic fracture mechanics, and component test models to the prediction of constant amplitude fatigue life are reviewed. Predictions of cycles to crack initiation in a component by the stress-life and local strain models are illustrated by examples and compared to results of tests on the component. Estimation of the cycles of crack propagation to fracture of the component is demonstrated by an example of the application of linear elastic fracture mechanics. The prediction of the total life of a component by a combination of the local strain and fracture mechanics models is discussed and illustrated.

84-1196

Variable Amplitude Fatigue Life Estimation Models

D. Socie

Univ. of Illinois at Urbana-Champaign, Urbana, IL, SAE Paper No. 820689 (P-109)

Key Words: Fatigue life, Bibliographies

This paper reviews fatigue life estimation techniques. The methods are the result of many researchers and practicing engineers. No attempt is made to cite individual contributions. A bibliography of useful sources of information is included.

84-1197

Using Fatigue Crack Propagation Mechanism Maps to Predict Changes in Propagation Mechanisms

Zhang Ping-sheng, Hu Zhi-zhong, and Zhou Hui-jiu
Res. Inst. of Strength of Metals, Xi'an Jiaotong Univ., Xi'an, Shaanxi Province, Peoples Rep. of China,
Intl. J. Fatigue, 6 (1), pp 49-53 (Jan 1984) 6 figs, 1 table, 16 refs

Key Words: Fatigue life, Crack propagation

The conditions determining the fatigue fracture mechanism in quenched and tempered steel are discussed with reference to fatigue crack propagation mechanism (FCPM) maps. Criteria for the change from one fatigue mechanism to another are presented.

84-1198

A Cumulative Model of Fatigue Crack Growth and the Crack Closure Effect

G. Glinka, C. Robin, G. Pluvinage, and C. Chehimi
Warsaw Tech. Univ., 02-524 Warsaw, ul. Narbutta 85, Poland,
Intl. J. Fatigue, 6 (1), pp 37-47 (Jan 1984) 10 figs, 2 tables, 34 refs

Key Words: Fatigue life, Crack propagation

A model of fatigue crack growth based on an analysis of elastic/plastic stress and strain at the crack tip is presented. It is shown that the fatigue crack growth rate can be calculated using the local stress/strain at the crack tip by assuming that a small highly strained area, existing at the crack tip, is responsible for the fatigue crack growth, and that the fatigue crack growth may be regarded as the cumulation of successive crack re-initiations over a distance. Calculated fatigue crack growth rates are compared with experimental ones for low and high strength steel.

84-1199

A Mathematical Equation Relating Low Cycle Fatigue Data to Fatigue Crack Propagation Rates

Y.Y. Liu and F.S. Lin
Northwestern Polytechnical Univ., Xian, Shaanxi, Peoples Rep. of China,
Intl. J. Fatigue, 6 (1), pp 31-36 (Jan 1984) 4 figs, 4 tables, 17 refs

Key Words: Fatigue life, Alloys, Crack propagation

A mathematical equation is derived to predict fatigue crack growth rates on the basis of a J integral analysis from the fatigue fracture behavior of low cycle fatigue samples. According to this equation, the fatigue crack propagation curves can be predicted if low cycle fatigue data and an initial microcrack size are available. The results obtained from this study show that the predicted fatigue crack propagation rates for Ti-24V, Ti-6Al-4V and Al-6Zn-2Mg alloys are very close to experimental values.

84-1200

Monotonic and Cyclic Crack Tip Plasticity

L. Guerra-Rosa, C.M. Branco, and J.C. Radon
Centro de Mecânica e Materiais da Universidade Técnica de Lisboa, Instituto Superior Técnico, 1096 Lisboa Codex, Portugal,
Intl. J. Fatigue, 6 (1), pp 17-24 (Jan 1984) 9 figs, 4 tables, 23 refs

Key Words: Fatigue life, Steel

Monotonic and cyclic plastic zone sizes were measured in a medium strength ferrite-pearlite steel (BM 45) tested in fatigue at 25 Hz at room temperature. Two methods were applied: microhardness and the recently developed 'fatigue in compression' technique. The results obtained are discussed in terms of accuracy and reliability.

84-1201

Cyclic Response and Inelastic Strain Energy in Low Cycle Fatigue

D. Lefebvre and F. Ellyin
Univ. of Sherbrooke, Sherbrooke, Quebec, Canada J1K 2R1,
Intl. J. Fatigue, 6 (1), pp 9-15 (Jan 1984) 8 figs, 4 tables, 18 refs

Key Words: Fatigue life, Steel

The cyclic response of ASTM A-516 Gr 70 carbon low alloy steel subjected to fully-reversed constant strain- or stress-controlled cycles has been determined. The cyclic stress/strain relationship of the material was obtained through a least squares fit technique. Stable hysteresis loops at half life for various strain ranges are presented.

84-1202

Micromechanisms of Fatigue Crack Growth in Aluminium Alloys

D. Rhodes, K.J. Nix, and J.C. Radon

Institut f. Werkstofftechnologie, GKSS Forschungszentrum, W. Germany, Intl. J. Fatigue, 6 (1), pp 3-7 (Jan 1984) 6 figs, 1 table, 15 refs

Key Words: Fatigue life, Crack propagation, Aluminum

The fatigue crack growth characteristics of high-strength aluminium alloys are discussed in terms of behavior during mechanical testing and fracture surface appearance. For a wide range of crack growth rates, the crack extends both by the formation of ductile striations and by the coalescence of micro-voids. Dimples are observed at stress intensities very much less than the plane strain fracture toughness, and this is explained in terms of the probability of inclusions lying close to the crack tip. The striation formation process is described as a combination of environmentally-enhanced cleavage processes and plastic blunting of the crack tip.

84-1203

Fatigue Curves of Synthetic Materials and Safety Factors under Asymmetric Loads (Ermüdungskurven für Plaste und Sicherheitskoeffizienten bei unsymmetrischen Beanspruchungen)

M. Nowak

Institut f. Materialkunde und Technische Mechanik der Technischen Hochschule Wroclaw, Poland, Maschinenbautechnik, 32 (11), pp 507-511 (Nov 1983) 10 figs, 16 refs

(In German)

Key Words: Fatigue life

Correction of formulas for the calculation of safety factors in the determination of fatigue life of synthetic materials under simple state of stress is presented. The correction takes the time of exposure (aging) into consideration.

84-1204

Endurance Testing in Practice

P. Leenders

ERC Nieuwegein, The Netherlands, Ball Bearing J., 217, pp 24-31 (Oct 1983) 10 figs, 4 refs

Key Words: Fatigue life, Fatigue tests, Bearings, Test facilities

This article describes the SKF endurance testing facilities and the rigidly controlled life testing process.

84-1205

Endurance Testing in Theory

T. Andersson

ERC Nieuwegein, The Netherlands, Ball Bearing J., 217, pp 14-23 (Oct 1983) 6 figs, 4 refs

Key Words: Fatigue life, Rolling friction, Bearings

This article gives an introduction to basic rolling contact fatigue theory and discusses the consequences of the stochastic (random) character of the bearing life for the planning and evaluation of endurance tests. Some recent endurance test results are presented showing the increases in endurance achieved by SKF standard production bearings.

84-1206

Rolling Contact Fatigue

T.E. Tallian

SKF, King of Prussia, PA, Ball Bearing J., 217, pp 5-13 (Oct 1983) 8 figs, 8 refs

Key Words: Fatigue life, Rolling friction

Fatigue spall formation is described using engineering models. The models described account for normal load, lubrication, surface microgeometry and material quality.

84-1207

Review of Investigations of Aeronautical Fatigue in the Federal Republic of Germany

O. Buxbaum and D. Schuetz

Fraunhofer-Gesselschaft zur Foerderung der Angewandten Forschung e.V., Darmstadt, Lab. fuer Betriebsfestigkeit, Fed. Rep. Germany, Rept. No. LBF-S-166, ISSN-0721-5320, 252 pp (1983) (Pres. at 18th Intl. Comm. on Aeron. Fatigue (Icaf), Toulouse, 1983)

N83-34387

Key Words: Fatigue life, Crack propagation, Aerodynamic loads

Measurement and analysis of operational loads; mathematical modeling of dynamically loaded structures; fatigue behavior of joints and of notched and unnotched materials; fatigue life prediction and low cycle fatigue; and crack propagation, fracture mechanics and residual static strength are reviewed. Fatigue of fiber reinforced plastics; strength degradation of composites due to environmental influences; and full scale tests, testing procedures, and test evaluation are discussed.

84-1208

Fatigue of Spot-Welded Lap Joints

G. Matsoukas, G.P. Steven, and Y.W. Mai
The Univ. of Sydney, Sydney, New South Wales 2006, Australia, Intl. J. Fatigue, 6 (1), pp 55-57 (Jan 1984) 4 figs, 6 refs

Key Words: Fatigue life, Welded joints, Joints (junctions)

The fatigue properties of spot-welded lap joints under a constant mean load made from 1.2 and 3 mm sheet thickness stainless steel with one, two or three-spot welds in series are reported. A log plot of cyclic load range versus fatigue life shows that for a given sheet thickness and fixed load range, fatigue life increases with the number of spot welds. Oil has a beneficial effect by increasing the fatigue life of the welded joints. A fracture mechanics analysis is carried out on the data by treating the spot weld as a crack.

ELASTICITY AND PLASTICITY

84-1209

Determination of the Material Constants of an Anisotropic Lamina by Free Vibration Analysis

W.P. De Wilde, B. Narmon, H. Sol, and M. Roovers
Dept. of Structural Analysis, Brussels Free Univ. (V.U.B.), Pleinlaan, 2, B-1050 Brussels, Belgium, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 44-49, 1 fig, 5 refs

Key Words: Composite structures, Layered materials, Elastic properties, Flexural vibration, Finite element technique, Modal analysis

The paper presents a method for determining the elastic constants of a transverse isotropic or orthotropic lamina, used in composite laminates. Free flexural vibration analysis is used, in order to give average elastic constants over the domain of the lamina. A theoretical Rayleigh-Ritz analysis of the free vibrations of a lamina with four free edges allows to set up the dependence of the eigenvalues on the material properties and a set of unknown constants. Finite element analysis is used to establish an estimation of the unknown parameters.

WAVE PROPAGATION

(Also see Nos. 1154, 1160, 1161, 1162)

84-1210

An Experimental Study of Interaction Between Surface Waves and a Surface Breaking Crack

C.H. Yew, K.G. Chen, and D.L. Wang
The Univ. of Texas at Austin, Austin, TX 78712, J. Acoust. Soc. Amer., 75 (1), pp 189-196 (Jan 1984) 9 figs, 1 table, 19 refs

Key Words: Wave propagation, Cracked media

The interaction between surface waves and a surface breaking crack is studied experimentally. In this study, the surface wave is generated by dropping a small ball on the long side of a large plate. The wave motions are monitored on both sides of the crack with a pair of piezoelectric transducers.

84-1211

A Piston-Type Porous Wavemaker Theory

A.T. Chwang and W. Li
Inst. of Hydraulic Res., The Univ. of Iowa, Iowa City, IA 52242, J. Engrg. Math., 17 (4), pp 301-313 (Dec 1983) 9 figs, 7 refs

Key Words: Wave makers, Wave propagation

The linearized porous wavemaker theory developed by Chwang has been applied to analyze the small-amplitude surface waves produced by a piston-type porous wavemaker near the end of a semi-infinitely long channel of constant depth. Analytical solutions in closed forms are obtained for the free-surface wave profile, the hydrodynamic pressure distribution, and the net force on the wavemaker. The "wave-trapping" phenomenon due to resonance is also discussed.

84-1212

Diffraction of Torsional Waves by a Rigid Disc Lying in an Infinitely Long Elastic Cylinder Bonded to an Infinite Medium

B.M. Singh and R.S. Dhaliwal
Univ. of Calgary, Calgary, Alberta, Canada, Acta Mech., 49 (3-4), pp 275-280 (1983) 2 figs

Key Words: Torsional waves, Wave diffraction

This paper contains an analysis of interaction of torsional waves normally incident on a rigid circular disc located in an infinite elastic cylinder. The cylinder is bonded with an infinite medium. Both the infinite cylinder and infinite medium are of dissimilar materials, homogeneous and isotropic. The solution of the problem is reduced into a Fredholm integral equation of the second kind. The numerical solution of the Fredholm integral is obtained. Numerical values of the stress intensity factor at the rim of the circular disc have been obtained.

84-1213

The Effect of the Ground on the Propagation of a Spherical Wave (Effet du sol sur la propagation d'une onde spherique)

R. Seznec and M. Berengier
Societé Metravib, 24 bis, Chemin des Mouilles, F-69130 Ecully, Acustica, 53 (6), pp 269-280 (Oct 1983) 13 figs, 3 tables, 32 refs
(In French)

Key Words: Sound waves, Wave propagation, Ground effect

A collection of methods is given which allow the determination of the complex specific impedance of the ground, resulting from attenuation measurements in the propagation path of a sound wave near the surface of an absorbing ground.

84-1214

Generation of SH-Type Waves Due to Non-Uniformly Moving Stress-Discontinuity in Layered Anisotropic Elastic Half-Space

P.C.Pal
Department of Physics and Mathematics, Indian School of Mines, Dhanbad-826004, India, Acta Mech., 49 (3-4), pp 209-220 (1983) 4 figs, 7 refs

Key Words: Seismic waves, Wave propagation, Layered materials, Anisotropy

A study is made of the generation of SH-type waves at the free surface of a layered anisotropic elastic medium due to a stress discontinuity moving with non-uniform velocity along the interface of the layered half-space. The exact solution for the displacement function is obtained by the Laplace and Fourier transforms method combined with the modified Cagniard method. Solution is discussed on the basis of ray theory. Formations of different wave pattern are also illustrated with figures. Some special cases are also derived.

84-1215

Experiments and Theory of Wave-Soil Interactions

T. Yamamoto and B. Schuckman
Rosenstiel School of Marine and Atmospheric Science, Univ. of Miami, Miami, FL, ASCE J. Engrg. Mech., 110 (1), pp 95-112 (Jan 1984) 12 figs, 2 tables, 34 refs

Key Words: Wave propagation, Soils, Clay soils

Wave damping and motion of clay beds are measured in a wave tank for various soil and wave conditions. The propagator matrix theory for continuously layered plasto-elastic beds is used to model the wave-soil interactions. In most cases, the theory agrees well with the experimental results. Wave damping and bed motion increase nonlinearly with wave height. Wave damping mechanism of clay beds is the Coulomb friction between grains. Model-prototype scaling examples are made for application of the model data to design situations.

84-1216

Diffraction of Waves and Singular Stresses in a Soft Ferromagnetic Elastic Solid with Two Coplanar Griffith Cracks

Y. Shindo
Dept. of Mech. Engrg. II, Tohoku Univ., Sendai 980, Japan, J. Acoust. Soc. Amer., 75 (1), pp 50-57 (Jan 1984) 8 figs, 16 refs

Key Words: Elastic waves, Cracked media, Wave diffraction

Magnetoelastodynamic stress intensity factors are computed for diffraction of normally incident longitudinal waves by two coplanar Griffith cracks in a soft ferromagnetic elastic solid. The solid is permeated by a uniform magnetostatic field normal to the crack surface. The problem is formulated by means of integral transforms, and reduced to the solution of a singular integral equation of the first kind. Numerical calculations are carried out and stress intensity factors are obtained for several values of frequency, magnetic field, and geometrical parameter.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see Nos. 1071, 1101, 1106, 1176, 1182, 1273, 1274, 1287, 1292, 1303, 1311, 1317, 1325, 1326)

84-1217

Modal Parameter Estimation via Shaker vs Speaker Excitation

H.J. Weaver and J.K. Dowdell
Lawrence Livermore Natl. Lab., Univ. of California, Livermore, CA 94550, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Sponsored by Union College, Schenectady, NY, Vol. II, pp 887-893, 9 figs, 2 tables

Key Words: Parameter identification technique, Modal analysis - experimental, Acoustic techniques, Shakers, Glass, Laser structures

When dynamically testing delicate laser components (e.g. an elliptical glass laser disc) it is often impossible to provide a direct contact excitation source such as an impact hammer or shaker. This is because of the delicate and/or brittle nature of the material from which the components are constructed. The alternate approach that is often used in a test of this type is to excite the component with an acoustic speaker. In this paper a small series of tests in which the modal parameters obtained by using a speaker as an excitation source are compared to those obtained on the same object when the excitation was provided by a shaker are described.

84-1218
Impact Testing Considerations

D. Corelli and D.L. Brown
Quixote Measurement Dynamics, Inc., Cincinnati, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 735-742, 11 figs, 1 table

Key Words: Dynamic tests, Impact tests, Modal analysis - experimental

Major problems in using impact testing for structural dynamics and means for dealing with them are discussed. Once it is determined that impact excitation is the right technique, selection of correct hammer tip and correct calibration of measuring system are discussed. The reduction of signal to noise ratio can be achieved by using specially designed force and response windows and by increasing energy input to a structure by exciting it with a series of randomly spaced impacts. Overloading and filter ringing are also considered.

84-1219
Feasibility of Impact Technique for Studying Nonlinear Systems

S.K. Tamhane
IBM Corp., San Jose, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 378-382, 9 figs, 3 tables, 5 refs

Key Words: Modal analysis - experimental, Impact excitation, Nonlinear systems, Error analysis

This paper attempts to quantify the amount of error introduced by applying the impact technique to a nonlinear system. Careful manipulation of this technique by setting instrument ranges of the ADC (Analog/Digital Convertor) levels to automatically restrain data acquisition to certain input levels can reduce this error. Examples are presented of working systems correlating results from the impact technique to analysis and using random-noise excitation.

84-1220
An Estimation Method for Rotational Degrees of Freedom Using a Mass Additive Technique

C. Yasuda, P.J. Riehle, D.L. Brown, and R.J. Allemang
Takasago Technical Inst., Mitsubishi Heavy Industries, Ltd., Takasago, Hyogo Pref., Japan, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 877-886, 10 figs, 4 tables, 17 refs

Key Words: Modal analysis - experimental, Rotational degrees of freedom, Mass additive technique, Parameter identification technique

This paper deals with a procedure for estimating rotational degrees of freedom at measurement points on a structural system. The technique employs a mass additive procedure where a rigid mass is added to the structure at the point of interest. The rigid body motion of the added mass is measured using six or more independent translational transducers.

84-1221
Evaluation of Flecs Modal Data

K.J. Zimmermann, M. Foletta, and Y. Deger
Aerospace Engrg. Office, Zurich, Switzerland, Rept. No. REPT-29.1-136/NT, ESA-CR(P)-1752, 133 pp (Oct 1982)
N83-33935

Key Words: Modal analysis, Simulation, Satellites

The modal data of a dummy structure designed to dynamically represent a typical communication satellite are analyzed to physically update an existing finite element model of the structure. The dynamic characteristics are presented by two sets of real mode parameters, one obtained by test, the other by analysis, containing 30 modes and 133 dynamic degrees of freedom. The adaptation was performed semiautomati-

cally by applying differential sensitivity algorithms. Using single-parameter changes to correct the stiffness of the finite element model improvements are achieved after a few iteration steps.

84-1222
Identifiability of Flexible Structure Parameters

S.M. Joshi and G.L. Goglia
Old Dominion Univ., Norfolk, VA, Rept. No. NASA-CR-173049, 15 pp (July 1983)
N83-33932

Key Words: Modal analysis, Parameter identification techniques, Antennas

This report investigates the identifiability of modal parameters of flexible structures. Expressions are derived for Cramer-Rao lower bounds for the modal parameters, that is, frequencies, damping ratios and mode shapes or slopes. The optimal initial state, which maximizes the trace of the Fisher information matrix in the absence of persistent input, is obtained. The concepts discussed are applied to a finite-element model of the 122 meter hoop/column antenna.

84-1223
The Use of Strain Gauges in Force Determination and Frequency Response Function Measurements

B. Hillary and D.J. Ewins
Imperial College of Science and Tech., London, UK, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 627-634, 10 figs, 1 table, 10 refs

Key Words: Beams, Frequency response function, Accelerometers, Strain gauges

Using a uniform cantilever beam as a test piece, both accelerometers and strain gauges have been employed to measure frequency response functions for six different stations along the length of the beam. The resulting curves have been analyzed by a simple modal identification method, thus producing alternative mathematical models for the beam. The beam has also been subjected to two simultaneous sinusoidal forces of differing magnitude and phase over a range of frequencies, and the responses and forces measured. Using both the numerical models and the measured responses, the two forces have been determined from a least-squares estimation procedure, and the results compared with the measured forces. It was found that the strain-related model gave more accurate force estimates than the acceleration or inertance model.

84-1224
Verification of Modal Testing and Analysis Techniques for Predictions of Dynamic Strain in Impact Loaded Structures

J.M. Komrower and M.P. Pakstys
Electric Boat Div., General Dynamics Corp., Groton, CT, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 620-626, 9 figs, 4 tables, 9 refs

Key Words: Modal analysis - experimental, Strain gauges, Strains, Shock tests

Modal testing technology is emerging as an effective engineering tool to identify structural dynamics modal parameters. Now it is being extended to predict dynamic strain in critical areas of structures that must be able to maintain structural integrity under severe impact loads. This paper describes the verification efforts of the modal strain testing technique for a basic beam and plate structure which was tested on a standard impact shock machine.

84-1225
A Study of the Vibration Measurement Method Using Unequalized Random Excitation

Li Huzeng, Tong Zhongfang, Cheng Yaodong, and Sun Yueming
Zhejiang Univ., Hangzhour, Zhejiang, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 748-755, 7 figs, 1 table, 7 refs

Key Words: Measurement techniques, Random excitation, Modal analysis - experimental

The vibration measurement method using unequalized random excitation for studying the dynamic properties of a structure is worth notice. In this paper the law of evolution of the input of the structure under test from that of the exciter is obtained, which leads to a simple method for measuring natural frequencies of structures with small damping. These results were verified experimentally.

84-1226

A Method for the Derivation of Optimal Modal Parameters from Several Single-Point Excitation Tests

J. Kirshenboim and D.J. Ewins
Imperial College of Science and Tech., London, UK,
Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 991-997, 5 figs, 15 refs

Key Words: Modal analysis - experimental, Single point excitation technique

This paper presents a systematic approach for the conduct of a modal survey using the single-point sine excitation method by which the quality of the data is checked before the analysis stage and the quality of the final analyzed results is quantified. When more than one column of the receptance matrix is measured and analyzed, several estimates for the modal parameters are obtained which are generally not consistent. A method for estimating an optimal set of modal parameters has been developed and is demonstrated by an experimental example.

84-1227

Single and Multiple Input Modal Analysis -- A Comparison of Averaging Techniques

C. Van Karsen and R.J. Allemang
Structural/Kinematics, Troy, MI, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 172-178, 19 figs, 5 refs

Key Words: Modal analysis, Testing techniques, Single point excitation technique, Multipoint excitation technique, Time domain method, Averaging techniques, Cyclic averaging

Previous studies have shown the validity of using multiple inputs for the estimation of frequency response functions. Both single and multiple input measurement techniques are susceptible to bias errors such as leakage and variance errors such as a noisy measurement environment. This work describes a time domain averaging technique that reduces leakage and how it is applied to the single and multiple input frequency response estimation process. An automotive structure was used as the test specimen.

84-1228

Multiple Input Estimation of Frequency Response Functions

R.J. Allemang, R.W. Rost, and D.L. Brown
Univ. of Cincinnati, Cincinnati, OH 45221, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 710-719, 25 figs, 14 refs

Key Words: Modal analysis - experimental, Multipoint excitation technique, Frequency response function

The accurate measurement of the frequency response function is vital to the estimation of the system modal parameters. The use of the single input/output theory to formulate the equations for the frequency response function is a special case of the theory involving multiple inputs. The results of the multiple input approach provide frequency response functions that are comparable to the single input/output case but with a reduction in the time required per measurement, if hardware limitations can be ignored. The multiple input/output computational procedure constrains the modal frequency and damping to be consistent within the different frequency response functions. One computational procedure, using the Gauss elimination approach, is explained and applications of up to four inputs are reviewed for different types of excitation.

84-1229

Application of Multi-Point Random Excitation and Polyreference Analysis to a Centrifugal Blower

G.L. Nessler, J.R. Crowley, A.J. Wolfer, and H.I. Vold
Structural Dynamics Res. Corp., Milford, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 720-727, 4 figs, 2 refs

Key Words: Modal analysis - experimental, Multipoint excitation technique, Random excitation, Blowers

The procedure for applying multi-point random excitation is investigated. Data quality checks are discussed and comparisons are made between single-point random and multi-point random.

84-1230

Automatic Force Appropriation - A Review and Suggested Improvements

P. Ibanez and K.D. Blakely
ANCO Engineers, Inc., Culver City, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol II, pp 903-907, 3 figs, 6 refs

Key Words: Modal analysis - experimental, Periodic excitation, Multipoint excitation technique

This paper demonstrates a technique for the enhancement of multipoint sinusoidal excitation for modal analysis.

84-1231

Multi-Input Software Working on Array Processor

G. Catteau and C. Hutin

Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 481-486, 3 figs, 1 ref

Key Words: Modal analysis - experimental, Multipoint excitation technique, Polyreference method

The aim of this paper is to describe a new system based on the use of array processor, in which software working with the modern methods such as multi-input excitation and polyreference algorithm was implemented.

84-1232

Excitation Functions for Structural Frequency Response Measurements

N. Olsen

Lake Stevens Instrument Div., Hewlett Packard, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 894-902, 19 figs, 1 table, 6 refs

Key Words: Modal analysis - experimental, Frequency response function, Periodic excitation, Random excitation, Transient excitation

The fourier transform based Dynamic Signal Analyzer has found wide spread use in recent years in the measurement of structural frequency response functions in modal analysis applications. This paper comperes the various excitation functions in use and lists the advantages and disadvantages of each type. The general excitation categories considered include random periodic, transient, steady state sine and operating. The parameters compared include window/leakage errors, measurement speed, signal to noise ratios, linear/nonlinear systems, RMS to peak force ratios and the effects of exciter/structure impedances. A discussion of the characteristics of electrodynamic exciters driven by both current and voltage amplifiers is presented with respect to the effects on the measurement of force. The properties of burst random excitation in conjunction with voltage driven exciters is defined and compared via measurement with the traditional true random and swept sine burst excitation types.

84-1233

High-Powered Analysis of Vibration Spectra

J. Litz

Hewlett-Packard Co., Marysville, WA, Mach. Des., 56 (2), pp 79-83 (Jan 26, 1984) 4 figs

Key Words: Frequency analyzers

New developments in microprocessor-based FFT signal analyzer technology are described and the key features, i.e., high frequency resolution, wide dynamic range and digital averaging are discussed.

84-1234

Frequency Domain Method for the Prediction of the Ultrasonic Field Patterns of Pulsed, Focused Radiators

W.N. Cobb

Appl. Mechanics, Yale Univ., New Haven, CT 06520, J. Acoust. Soc. Amer., 75 (1), pp 72-79 (Jan 1984) 8 figs, 21 refs

Key Words: Transducers, Frequency domain method

A theoretical model is presented which can be used to calculate the pressure field patterns of pulsed, focused ultrasonic radiators in attenuating and nonattenuating media. Pressure pulses are calculated by superimposing continuous wave solutions at discrete frequencies. Due to the speed of the method, time signals can be calculated at many positions in the transducer beam in a reasonable amount of time. To test the model, theoretical predictions for the pressure signals are compared to hydrophone measurements for a conventional diagnostic transducer. In addition, signal envelopes are studied in order to determine the effects of attenuation and dispersion on the imaging characteristics of a focused radiator. This work may have significant application to the design of transducers for specific imaging purposes or to the analysis of the imaging process.

84-1235

Multi Axial Acceleration Measurement: A Review of Transducers and Their Installation (Mehrkomponenten-Beschleunigungs-Messung: Überblick über Aufnehmer und ihre Einsatzbedingungen)

S. Wollitzer and E.-U. Saemann

Curt-Risch-Institut f. Dynamik, Schall- und Messtechnik, Universitat Hannover, Callinstrasse 32,

D-3000 Hannover 1, Fed. Rep. Germany, Techn. Messen-TM, 50 (12), pp 443-453 (Dec 1983) 14 figs, 19 refs
(In German)

Key Words: Accelerometers, Transducers

After an introductory survey of different transducers the advantages and disadvantages of multi axial pick-ups are discussed. Except for one system all types of pick-ups suitable for mass production make use of one seismic mass for each component. All these pick-ups are working on piezoelectric or piezoresistive effects.

84-1236
Quartz Crystal Oscillators and Their Effects on the Scale Stability and Standardization of Electronic Distance Meters

J.M. Rueger
Ph.D. Thesis, Univ. of New South Wales, Australia (1983)

Key Words: Oscillators, Quartz crystals, Callbrating

This study examines the effects of quartz crystal oscillators on the stability and the calibration of scale (standardization) of short-range electronic distance meters. A wide range of parameters which cause changes and instabilities in the oscillator frequency (and thus in the metric scale of distance meters) is investigated. The magnitude of these effects is determined and the ultimate accuracy of laboratory calibration techniques evaluated.

84-1237
A Flexible Multichannel Measurement System for Dynamic Analysis

H. Van der Auweraer, P. Van Herck, and R. Snoeys
Katholieke Universiteit Leuven, Departement Werktuigkunde, Celestijnenlaan 300B, 3030 Leuven, Belgium, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 194-199, 4 figs, 20 refs

Key Words: Modal analysis - experimental, Measuring instruments

A flexible measurement system was developed, based upon following modules: single channel signal data-acquisition; a system controller to direct the data-flow, and which is capable to handle up to 64 input modules; a programmable signal generator.

84-1238
A Multi Channel Modal Analysis System

D.S. Hanna, J.M. Keller, and M.A. Clifton
Bolt Beranek and Newman, Inc., New London, CT 06320, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 179-184, 3 figs, 2 refs

Key Words: Modal analysis, Measuring instruments

A system has been developed that minimizes the effects of these constraints by using the high signal-to-noise ratio afforded by stepped sine testing and the high speed data acquisition capability of today's digital devices. A multiple channel tracking filter approach is used in which the vibration responses at points on the structure are measured at discrete driving frequencies throughout the frequency range of interest. The capabilities and limitations of this system are discussed as they apply to modern modal analyses. The results of a system evaluation on a small test structure and future applications are also discussed.

84-1239
Normal Mode Testing Using Multiple Exciters under Digital Control

B.S. Gabri
Cranfield Data Systems, Cranfield Inst. of Tech., Cranfield, Bedford, UK, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 185-193, 11 figs, 5 refs

Key Words: Modal analysis - experimental, Measuring instruments, Multipoint excitation technique

The use of multipoint sinusoidal excitation in vibration testing is a technique which has been employed for a considerable period of time for aeronautical and aerospace applications in order to complement a theoretical analysis. It is the purpose of this paper to briefly review the so called Normal Mode method, and to describe a mini-computer-based system capable of simultaneously controlling an exciter array and sampling data from a number of response positions and subsequently analyzing the stored data upon test completion.

84-1240

A Technique for Modal Data Acquisition in Remote Locations Using Hand Portable Instrumentation

W.D. Strunk and B.W. VanHoy

Union Carbide Corp., Oak Ridge, TN, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 8-14, 9 figs, 3 refs

Key Words: Modal analysis - experimental, Experimental data, Measuring instruments

A method for collecting analog modal test data using hand portable, battery powered equipment has repeatedly proven to be very successful during the past two years at the various Department of Energy projects and facilities.

84-1241

Response of Elastic Cylinders to Convective Flow Noise I. Homogeneous, Layered Cylinders

S.H. Francis, M. Slazak, and J.G. Berryman

Bell Labs., Whippany, NJ 07981, J. Acoust. Soc. Amer., 75 (1), pp 166-172 (Jan 1984) 5 figs, 10 refs

Key Words: Sonars, Arrays, Fluid-induced excitation

One of the noise mechanisms experienced by passive towed sonar arrays is that of convective flow noise due to boundary layer turbulence generated as the array moves through the water at a fixed tow speed. The purpose of the present work is to arrive at quantitative predictions of the effects of convective flow noise using relatively simple model calculations. Line arrays are modeled as homogeneous, layered cylinders while turbulent eddies are modeled as random pressure fluctuations traveling at the convective speed of the eddies (about 80%) of the tow speed. The qualitative difference between solid and liquid fills is explained with this analysis. Solid-filled arrays are more susceptible to convective flow noise than are liquid-filled arrays because the noise-carrying shear waves are highly attenuated in the liquid. The detailed analysis is presented both for homogeneous cylinders and for cylinders with multiple homogeneous layers. Examples are presented to illustrate the analysis and the numerical methods employed in the calculations.

84-1242

A Method for Designing Stingers for Use in Mobility Testing

L.D. Mitchell and K.B. Elliott

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 872-876, 3 figs, 4 refs

Key Words: Modal analysis - experimental, Mobility method

This paper presents an approximate method for sizing the interconnection of a mobility test shaker to the structure being tested. A systematic means for the selection of the stinger's flexural stiffness and shaker suspension to reduce the influence of the shaker's rotatory inertia on the modal data being taken is presented. An example of the misuse of stingers and its correction is included.

84-1243

An Evaluation of Test Procedures for Vehicle Exterior Noise

D. Morrison and P.E. Waters

Ricardo Consulting Engineers Ltd., SAE Paper No. 820367 (P-106)

Key Words: Traffic noise, Noise measurement, Measuring instruments, Measurement techniques

Two new test procedures are proposed. One is a drive-by test which reproduces similar operating conditions to ISO R362, but without the anomalies inherent in that procedure. The second is a stationary test that will give good correlation with the drive-by test and can be used for development, production conformity and enforcement testing.

84-1244

Design, Construction and Performance of an Inertia-Mass Modal Test Facility

C. Voorhees and G. Clark

RCA Astro Electronics, Princeton, NJ, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 743-747, 8 figs

Key Words: Modal analysis - experimental, Test facilities, Spacecraft

The development of a large inertia-mass modal test facility is presented. Objectives and requirements of the test facility will be considered, as well as details of fabrication, and evaluation of performance.

84-1245

Measurement of Rigid Body Modes for Dynamic Design

N. Okubo and T. Furukawa
CAMAL Chuo Univ., Tokyo, Japan, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 545-549, 18 figs, 2 refs

Key Words: Modal analysis - experimental, Rigid body modes, Building block approach

For experimental building block approach or substructuring in dynamic design, the measurement of rigid body modes of each component of the structure in free-free state is required. The rigid body modes influence much the level of total response after assembling the components. This paper first deals with the experimental technique how to support the component and to excite it in order to realize the free-free state, then describes a software program developed to determine the location of the center of gravity, the moment of inertia for rigid body modes based on the measured frequency response functions.

84-1246

Modal Synthesis of Two Substructures with Soil-Structure Interaction for Seismic Loads

Shih-Che Cheng and P.R. Millarke
Martin Marietta Corp., Vandenberg AFB, CA 93437, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 157-162, 1 fig, 9 refs

Key Words: Modal synthesis, Substructuring methods, Interaction: soil-structure, Seismic analysis

This paper presents a methodology of modal synthesis of two substructures for seismic analysis. The supporting structure degrees of freedom which define the soil-structure interface and the access arm-structure interface are retained, while modal truncation is performed on the constrained modes at the substructure level. The soil-structure interface is treated so that soil damping, which is derived from the elastic half-space theory, can be separated from modal damping of the tower.

84-1247

Analytical and Geometric Substructuring via Dual Modal Space Structural Modification

Y.W. Luk and L.D. Mitchell
Zonic Corp., Milford, OH 45150, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 50-57, 13 figs, 5 refs

Key Words: Structural modification techniques, Substructuring methods, Tuned dampers

This paper extends the capability of the dual modal space structural modification method described in a previous paper, by introducing substructuring.

84-1248

The Analysis of Dynamic Behaviours of a Computer Disk Unit

N. Okubo, K. Yokoki, and Y. Sato
CAMAL, Chuo Univ., Tokyo, Japan, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 643-647, 14 figs, 2 refs

Key Words: Computer disks, Modal analysis - experimental, Structural modification techniques

A swing-arm type computer disk unit was analyzed by the experimental modal analysis for structural modification. Two types of gimbal structure were compared by special measurement technique on excitating and detecting the response with an optical fiber. The dynamic behaviors of the assembly of casing part and positioning one were measured as well as in decomposed condition. Finally the total dynamic behaviors of the disk unit were analyzed under operating condition.

84-1249

Direct Structural Modification Using Frequency Response Functions

J.R. Crowley, A.L. Klosterman, G.T. Rocklin, and H. Vold
Structural Dynamics Res. Corp., Milford, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenecatdy, NY, Vol. I, pp 58-65, 14 figs, 9 refs

Key Words: Structural modification techniques, Frequency response function

This paper presents the basic theory behind direct structural modification using experimental frequency response functions. Also it examines some of the applications, advantages and disadvantages of the technique.

84-1250

Design Optimalisation of Dynamical Structures by the Combined Use of Modal Analysis (M.A.) and the Finite Element Method (F.E.M.)

H. Sol, E. Verdonck, R. Snoeys, and W.P. De Wilde
Katholieke Universiteit Leuven, Departement Werktuigkunde, Celestijnenlaan 3ØØB, B-3Ø3Ø Leuven, Belgium, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 769-776, 10 figs, 1 table, 7 refs

Key Words: Sports equipment, Modal analysis - experimental, Finite element technique, Design techniques

An experimental analysis test of tennis rackets was carried out in order to obtain the modal parameters. Finite element models were developed and used for the solution of the dynamical eigenvalue problem. The modal parameters obtained by both methods were compared. The deviation between the experimental and numerical results were used to correct the finite element input-data, based on sensitivity calculations of the modal parameters to material and cross-section changes. The correction procedure was repeated until an acceptable agreement was reached.

84-1251

The Role of Eigenvectors in Practical Modalized-Observer Design

J.C. Chung, A.N. Andry, Jr., and E.Y. Shapiro
Lockheed California Co., Burbank, CA 91529, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 830-835, 2 figs, 18 refs

Key Words: Modal analysis, Design techniques

This paper examines the role of left eigenvectors on two competing design objectives: maximizing system robustness, and minimizing transient response error. Design requirements on left eigenvectors are established to give a satisfactory compromise between system robustness and transient response error.

84-1252

The Determination of Correlation Between Structure Vibration and Radiated Noise by Modal Analysis

Huang Ji Xi
Changchun Motor Vehicle Res. Inst., Changchu, Jilin, China, Intl. Modal Anaysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 984-990, 5 figs, 3 tables, 8 refs

Key Words: Modal analysis, Diesel engines, Sound waves, Wave propagation, Noise reduction, Structural modification techniques, Sound generation

This paper presents modal analysis of basic structures of diesel engines. A theory of determining the correlation between structure vibration and radiated noise by modal analysis is established the correctness of which has been proved mathematically and experimentally. The theoretical and experimental noise curves of basic structures of engines are plotted and found coincident to each other. Detailed consideration is given to the use of this theory by example solution. The paper points out that the theory above-mentioned provides a relationship among the vibration, noise, and strength of a single structure.

84-1253

System Identification of Vibrating Structures – a Review

K. Vepa
General Products Div., I.B.M., San Jose, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 97-105, 75 refs

Key Words: System identification techniques, Frequency response, Structural modification techniques, Time domain method, Modal analysis - experimental

The purpose of this paper is to review the field of system identification as applied to vibrating structures. The review gives an integrated view of the following areas: structural frequency response testing, structural dynamics modification or the modification of vibration modes and frequencies obtained from test, synthesis of mass and stiffness matrices from test data, and time domain approaches to the vibrating structure problem.

84-1254

Implementation of the Dual Modal Space Structural Modification Method

Y.W. Luk and L.D. Mitchell
Zonic Corp., Milford, OH 45150, Intl. Modal Analysis

Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 930-936, 11 figs, 6 refs

Key Words: Structural modification techniques, Mode modification technique, Modal analysis - experimental

The theory of the dual modal space structural modification method has been previously presented. This paper implements this theory on real-world structures described by three-dimensional space (i.e., x, y, z). The analytical database for the structure is built by experimental modal analysis methods. Examples are included to illustrate the modification and verify the theory.

84-1255

Rotational Degrees-of-Freedom in Structural Modification

R.G. Smiley and B.A. Brinkman
Entek Scientific Corp., Cincinnati, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 937-939, 3 figs, 2 tables

Key Words: Structural modification techniques, Rotational degrees of freedom, Beams, Design techniques, Modal analysis - experimental

This paper focuses on the procedure of incorporating rotational DOF into analyses performed by programs designed only for linear DOF. Examples of considerations at the measurement stage and at the analysis stage are given. In addition, a discussion about the visual qualification of rotational DOF measurements is presented.

84-1256

Structural Modifications Using Finite Substructures

L. Patrick
Magnetic Peripherials, Inc., Minneapolis, MN, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 953-959, 2 figs, 2 tables, 3 refs

Key Words: Structural modification techniques, Substructuring methods, Design techniques, Computer programs

The modal coordinate transformation method of modeling design changes is limited by the need to compute stiffness, mass and damping values. A method of defining simple substructures and tying these substructures to the main structure is presented in this paper. The substructures are defined from their physical size and material properties. From their definition eigenvalues (natural frequencies) and eigenvectors (shape vectors) are computed directly based on textbook solutions. The method differs from the finite element method in that physical stiffness and mass matrices are not computed. The method has been programmed for the computer and has been successful in analyzing proposed structural changes.

84-1257

Study of a Structural Modification Procedure with Three Dimensional Beam Elements Using a Local Eigenvalue Modification Procedure

J.C. O'Callahan and Chaur-Ming Chou
Univ. of Lowell, Dept. of Mech. Engrg., Lowell, MA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 945-952, 9 figs, 33 refs

Key Words: Structural modification techniques, Beams, Local eigenvalue modification procedure, Design techniques, Modal analysis - experimental, Finite element technique

A three-dimensional beam element is used to modify system modal parameters obtained from either finite element methods or experimental modal testing using the local eigenvalue modification procedure. The process is applied to various problems involving substructuring, fixed-end boundary condition modification and stiffness modification of a plate structure.

84-1258

Reanalysis - A User-Oriented Computer Program for the Reanalysis of Structural Systems

B.P. Wang, F.H. Chu, and D.W. Gross
Univ. of Virginia, Charlottesville, VA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 940-944, 2 figs, 3 tables, 4 refs

Key Words: Computer programs, Structural modification techniques, Design techniques

A general structural dynamic reanalysis and synthesis computer program is discussed in this paper. Based on the modal data of the original system, the vibration characteristics of modified systems can be computed efficiently using reanaly-

sis formulations. In reanalysis, the modified system modal characteristics are computed. In the synthesis option the user specifies the elements to be modified and a target natural frequency, the program will then compute the magnitude of modification required to achieve this frequency. Two reanalysis formulations are discussed.

84-1259
Application of the Component Synthesis with Least Squares Method to Achieve the Desired Frequencies and Mode Shapes

G C.F. Tsai and J.A. Palladino
General Electric Co., Lynn, MA 01910, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 28-34, 4 refs

Key Words: Component mode synthesis, Least squares method, Natural frequencies, Mode shapes, Engine vibration, Design techniques

The methods of component synthesis and least squares are combined to develop a technique in which system parameters can be determined for given constraints on frequency placement and mode shapes. This method is applied to a simplified installation of a turbo-propeller engine. Proper stiffnesses of mounts are determined so that the engine-nacelle structure system has no natural frequency in the vicinity of propeller operating speed range and that the mode shapes are consistent with flutter stability criteria.

84-1260
Reduced Component Modes in a Damped System

K.H. Ghlaim and K.F. Martin
Univ. of Wales Inst. of Science and Tech., Cardiff, UK, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 683-689, 4 figs, 3 tables, 9 refs

Key Words: Modal analysis, Component mode analysis, Damped systems

In this paper substructures are connected physically by elastic springs and dashpots to form a system, each substructure being analyzed by a component mode method. A matrix set involving eigenvalues and eigenvectors of the substructures, together with a (connection) matrix is solved to give the complex roots of the system. Reduction is applied by approximating the substructures by a reduced set of eigenvalues and an equally reduced set of displacements in the eigenvector.

84-1261
A General Superelement Approach by the Component Mode Synthesis Method

Chi-Fan Shu and Fei-Hon Chu
RCA Astro-Electronics, Princeton, NJ, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 676-682, 6 figs, 3 tables, 10 refs

Key Words: Modal analysis, Component mode synthesis, Finite element technique

This paper takes a fresh look at the component mode synthesis method in order to add to the advantages which can be obtained from the method and to simplify its implementation.

84-1262
The Method of Mode Synthesis with Complex Mode Substructures

Qin Jun
Zheng Zhou Res. Inst. of Mech. Engrg., Zheng Zhou Henan Province, People's Rep. of China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 858-864, 6 figs

Key Words: Modal synthesis, Component mode synthesis

In this paper, the traditional theories of mode synthesis are extended to derive the method of mode synthesis when the substructures have complex modes. In this case using the principal mode set to apply coordinate transform to the impedance matrix would bring considerable error into the result. The original transfer function was used by the author to establish a transfer function which has equivalent mobility in the lower frequency range.

84-1263
Computer Graphics for Modal Character

Li-sheng Yu

Hangzhou Inst. of Electronic Engrg., China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 616-619, 5 figs, 6 refs

Key Words: Graphic methods, Computer-aided techniques, Modal analysis

In order to make a systematic and intensive study for a dynamic system, various experimental data may be made modal identification using computer. In this paper a set of drawing methods which were designed using positive-negative intersect method and polished spline fitting method.

84-1264
A Time Domain Linear Model Estimation Technique for Global Modal Parameter Identification

J. Leuridan and H. Vold
Univ. of Cincinnati, Cincinnati, OH 45221, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 443-451, 14 figs, 12 tables, 15 refs

Key Words: Modal analysis, Parameter identification technique, Global fitting method, Viscous damping, Time domain method

A finite difference linear model, relating multiple inputs to multiple outputs, is developed for a viscous damped mechanical structure. The parameters in this model are estimated using all available input-output data simultaneously. An estimate for the modal parameters is consecutively calculated from the parameters in this linear model.

84-1265
On the Use of Constraint Equations in the Global Fitting Algorithms of Transfer Functions

J.G. Giménez and L.I. Carrascosa
Construcciones y Auxiliares de Ferrocarriles, S.A. Beasain (Guipúzcoa) Spain, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 998-1003, 1 fig, 2 tables, 9 refs

Key Words: Modal analysis - experimental, Global fitting method

Global fitting methods have been a very useful tool in the field of experimental modal analysis permitting more accurate and reliable results. In this paper the authors present an improvement in the implementation of these methods in the computer by means of the use of constraint equations in the case of proportional damping.

84-1266
Obtaining Global Frequency and Damping Estimates Using Single Degree-of-Freedom Real Mode Methods

L. Patrick
Magnetic Peripherials, Inc., Minneapolis, MN, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 425-431, 12 figs, 3 tables, 4 refs

Key Words: Modal analysis - experimental, Curve fitting, Single degree of freedom systems, Global fitting method

A noninteractive curve fitting method using a single degree of freedom algorithm is presented in this paper. The method eliminates the art of curve fitting frequency response function measurements. A set of tests and a sorting procedure for curve fit estimates is defined. The tests provide information to improve measurements. The sorting procedure results in a global estimate of modal frequency and damping. The method has been programmed for the computer and has proved to give consistent results.

84-1267
A Simplified Frequency Domain MDOF Curve-Fitting Process

R.G. Smiley, Y.S. Wei, and K.D. Hogg
Entek Scientific Corp., Cincinnati, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 432-435, 10 figs, 2 tables, 4 refs

Key Words: Modal analysis - experimental, Curve fitting, Multidegree of freedom systems, Frequency domain method

Extraction of modal parameters by single measurement curve fitting techniques, while not as all-encompassing as multiple reference or multiple measurement techniques, will always be an important part of the modal testing, simply because many small-scale troubleshooting projects can easily be managed with simpler techniques. This paper describes a simplification to a method previously presented in the literature based around the use of orthogonal polynomials. Examples are given that show effects of truncation, frequency resolution, noise, and modal density. Also in-

cluded is a discussion regarding the usefulness of the technique in fitting all measurements to obtain mode shape information, frequency, damping, and amplitude.

84-1268
The Practical Use of the Polyreference Modal Parameter Estimation Method

J.R. Crowley, D.L. Hunt, G.T. Rocklin, and H. Vold
Structural Dynamics Res. Corp., Milford, OH, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 126-133, 12 figs, 9 refs

Key Words: Modal analysis, Polyreference method, Parameter identification technique, Experimental modal analysis

This paper describes the utilization of the polyreference technique and provides practical examples illustrating the concepts. Other publications have compared this technique to previously developed estimation methods.

84-1269
Applications of the Poly Reference Technique in Experimental Modal Analysis

S.M. Crowley and R.J. Allemang
Univ. of Cincinnati, Cincinnati, OH 45221, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 111-117, 13 figs, 9 tables, 10 refs

Key Words: Polyreference method, Modal analysis - experimental, Automobiles, Aircraft

The poly reference complex exponential algorithm uses frequency response data from multiple exciter locations in a global least squares fashion. This algorithm, as implemented, uses the impulse response functions obtained by inverse Fourier transforming the measured frequency response functions into the time domain. Several test cases are discussed to demonstrate the characteristics of the technique. Specifically, the capability to uncouple closely spaced modes by analyzing response data from several input locations and the robustness of the solution process in the presence of random uncorrelated noise.

84-1270
The Rotating Vector Method for Decoupling of Beating Signatures in Modal Analysis

Chang-Sheng Li and Min-Her Chen
Inst. of Naval Architecture, Natl. Taiwan Univ., Taipei, Taiwan 107, Rep. of China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 118-125, 18 figs, 2 tables, 9 refs

Key Words: Rotating vector method, Damping coefficients, Frequency response, Vibrating structures, Elastic properties

In this report a precise data processing technique, the rotating vector method, and its theory for the prediction of damping ratio and response frequencies of an elastic structure in vibration has been introduced.

84-1271
Bond Graph Time Simulations Using Extracted Modal Parameters from the Nova Spaceframe

J.W. Pastrnak
Lawrence Livermore Natl. Lab., Univ. of California, Livermore, CA 94550, Int. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 403-407, 9 figs, 4 refs

Key Words: Modal analysis, Bond graph technique

The purpose of this paper is to demonstrate a procedure used to simulate a structure using bond graph modeling techniques that incorporate a limited number of normal modes previously measured from an experimental modal analysis.

84-1272
Modal Synthesis: A Performing Way of Using Modal Analysis

D. Bonnecase and J. Roumagoux
Metravib Co., Lyon, France, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 728-734, 14 figs

Key Words: Modal synthesis, Modal analysis

Modal synthesis of substructures is presented for three types of practical problems: determination of characteristics and locations of connection elements between substructures, substructures not available simultaneously, and interpretation of the substructures participation in the modes formation of the whole structure.

DYNAMIC TESTS

(See Nos. 1085, 1086, 1094)

DIAGNOSTICS

(Also see Nos. 1210, 1309)

84-1273

Changes in Modal Parameters Resulting from Small Cracks

P. Gudmundson
Tre Konsulter AB, Box 57, S-185 00 Vaxholm, Sweden, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 690-697, 9 figs, 1 table, 8 refs

Key Words: Modal analysis, Natural frequencies, Damping coefficients, Crack detection, Diagnostic techniques

The changes in the modal parameters resulting from small cracks are theoretically investigated. Analytical expressions are defined for the determination of changes in eigenfrequencies and the damping which results from cyclic plastic deformations close to the crack tips. These results are applied to common structural geometries. As examples, the theoretically determined eigenfrequency changes of an edge-cracked beam are compared to measurements and the damping of a bar with a central crack is determined for longitudinal vibrations.

84-1274

Advanced Composite Damage Detection Using Modal Analysis Techniques

J.J. Tracy, G.C. Pardoen, and D.J. Dimas
McDonnell Douglas Astronautics Co., Huntington Beach, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 655-660, 5 figs, 4 tables, 7 refs

Key Words: Diagnostic techniques, Composite materials, Impact excitation, Modal analysis

In this study modal analysis techniques were used to investigate the effects of impact damage in advanced composite materials. A series of four graphite epoxy laminated plates were fabricated using various fiber types and stacking sequences.

84-1275

Analysis of Bearing Damage

M. Faultersack
Federal Mogul Corp., SAE Paper No. 820626

Key Words: Cylindrical bearings, Ball bearings, Failure analysis, Diagnostic techniques

Bearing damage mechanisms resulting from non-fatigue modes such as contamination, lack of lubrication, misalignment and improper handling are discussed. Included is also a discussion of fatigue modes of bearing damage. Tapered, cylindrical and ball bearings are incorporated into the discussion.

84-1276

Fault Detection in Internal Combustion Engines Using an Acoustic Signal

A. Ordubadi
Bolt Beranek and Newman, Inc., SAE Paper No. 820365 (P-106)

Key Words: Failure analysis, Internal combustion engines, Acoustic techniques

The engine block vibration is the result of the structural response of the engine to its internal forces. The engine malfunctions which affect these forces also affect the vibration signal. The aim of this study was to demonstrate the feasibility of using engine block vibration for diagnosis of combustion faults. A four-cylinder diesel engine was used for this study. In order to detect variations in combustion force (or equivalent cylinder pressure trace), this signal was reconstructed from the engine block vibration. Measured and modified structural responses were used to reconstruct cylinder pressure trace.

BALANCING

84-1277

T55 Power Turbine Rotor Multiplane-Multispeed Balancing Study

M.R. Martin
Mechanical Technology, Inc., Latham, NY, Rept.

No. MTI-83TR55, NASA-CR-167891, 118 pp (Feb 1982)
N83-33894

Key Words: Balancing techniques, Turbines

A rotor dynamic analysis of the T55-L-11C engine was used to evaluate the balancing needs of the power turbine and to optimize the balancing procedure. As a result, recommendations were made for implementation of a multiplane-multispeed balancing plan. Precision collars for the attachment of trial weights to a slender rotor were designed enabling demonstration balancing on production hardware.

84-1278
Structural Dynamics Characteristics Using Impact Tests
B.B. Seth and N.L. Field
Ford Motor Co., 24500 Glendale Ave., Redford, MI 48239, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 915-920, 5 figs, 7 refs

Key Words: Balancing machines, Impact tests

This paper describes an application of impulse testing to identify the dynamic characteristics of a hard mount balancing machine. Stringent limits on the accuracy of the unbalance measurement can be achieved by signal to noise ratio enhancement through proper design of the balancing machine. Impact tests have been used to determine the response of structure sub-components, using the transducers built into the machine. Results of impact tests have been used to determine the transmissibility characteristics of the machine.

84-1279
Exact Point Speed Method for Balancing of Non-Linear Rotors
A. El Khatib and S.S. Al Annaz
Faculty of Engrg., Alexandria Univ., Egypt, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, Fl, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 259-266, 3 figs, 12 refs

Key Words: Dynamic balancing, Balancing techniques, Rotors

This work discusses how the dynamic response of rotor systems can be represented in terms of mobilities, in a manner analogous to that of influence coefficients. It also shows that the mobilities of a linear rotor system follow the reciprocal theorem. The two-plane dynamic balancing problem has been formulated in terms of mobilities and exact point - speed solution obtained thereof. Lastly methods for using more than one trial weight run to account for non-linearities of the system and to minimize residual unbalance have been proposed with the complete simple procedures to be followed in these cases.

MONITORING
(Also see No. 1309)

84-1280
Application of a Peak-Valley Detector for Secant Stiffness Measurements
R. Stiffler
Materials Response Group, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Exptl. Tech., 8 (1), pp 17-20 (Jan 1984) 8 figs, 5 refs

Key Words: Monitoring techniques, Fatigue life, Composite materials

A technique using a peak-valley detector with a multi-channel data-acquisition unit was successful in monitoring the change in the secant stiffness of composite specimens during cyclic-fatigue loading. Because this technique computes the secant modulus every five seconds, the response of the composite specimen can be monitored with good fidelity even toward the end of its life when its stiffness decreases rapidly. This peak-valley detector is also used in conjunction with an analog switch to half the cycling of the specimen after a certain degradation in stiffness develops, thus allowing investigation of the damage state in the composite by NDE and other techniques.

ANALYSIS AND DESIGN

ANALOGS AND ANALOG COMPUTATION

84-1281
Modal Analysis Using the Time Series Analysis Method (AR or ARMA Model) and Its Computer Program Design
Tang Zhao-qian and Qiu Yang

Xian Jiao-tong Univ., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 559-565, 4 figs, 14 refs

Key Words: Modal analysis, Time series analysis method, Computer programs

In this paper, the basic conceptions and fundamental relations between the time series analysis and the modal analysis are first described and then, considerations concerning the design of computer program for the modal analysis using the time series analysis method are discussed.

ANALYTICAL METHODS

(Also see No. 1252)

84-1282

Comparison Between Analytical and Vectorial Methods of the Synthesis of Equations of Motion

Z.J. Goraj

Inst. of Aeronautical Engrg. and Appl. Mechanics, Technical Univ. of Warsaw, Poland, IMechE, Proc., 197 (C), pp 265-274 (Dec 1983) 7 figs, 9 refs

Key Words: Equations of motion

In this paper the advantages and weak points of the analytical and vectorial methods of the derivation of equations of motion for discrete systems are considered. The analytical method is discussed especially with respect to Boltzmann-Hamel equations, as generalized Lagrange equations.

84-1283

Approximate Determination of Eigenfrequencies in Damped Lumped-Mass Elastic Systems

S.A. Paipetis and M. Croustalis

Univ. of Patras, Patras, Greece, Acustica, 53 (6), pp 281-289 (Oct 1983) 1 fig, 1 table, 13 refs

Key Words: Elastic systems, Damped systems, Natural frequencies, Approximation methods

The application of Graeffe's method or root-squaring process for the approximate determination of the eigenfrequencies of lumped-mass multi-degree-of-freedom elastic systems with damping has been investigated. The various procedures of solution were examined by means of specific examples, involving various combinations of real roots and complex pairs of the characteristic algebraic equation. It was found that eigenfrequencies can be determined at the desired accuracy for any number of degrees of freedom by simple algebraic means and also that suitable algorithms based on the present method can be constructed, leading to minimal computer effort, as compared with other conventional techniques.

84-1284

The Application of Variational Methods for the Free and Forced Vibration Analysis of Generalized Bending Systems - An Interactive Computer Graphics Study

J.R. Gartner

Univ. of Connecticut, Storrs, CT 06268, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1017-1023, 8 figs, 1 table, 7 refs

Key Words: Modal analysis, Variational methods, Continuous parameter method, Galerkin method, Rotors, Beams, Plates, Computer-aided techniques

The method of Galerkin is applied to obtain a multi-degree-of-freedom representation of the distributed parameter system. Each degree of freedom so obtained is a macroscopic evaluation of the system. One of the prime purposes of the study is to have a versatile method of analysis so as to analyze relatively complex designs on small size computers.

84-1285

Elements for the Modal Analysis of Symmetric and Non-Symmetric Transfer Matrix Structures

R. Bigret

Alsthom-Atlantique, Le Bourget, France, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1035-1042

Key Words: Modal analysis, Transfer matrix method

Modal structural analysis assumes that the transfer matrices are symmetric. Some structures have non-symmetric transfer matrices: the right-hand eigenvectors are proportional to the residual matrix columns; and the left-hand eigenvectors are proportional to the residual matrix rows. The terms in the residual (modal) matrix are associated by a relationship. Local, total, and overall coherences on the transfer matrix and the matrices formed from the application matrices are defined.

84-1286

The Impedance Matrix in Finite Dynamic Element Method for Free Vibration Analysis

Jingyu Chen and Lingcheng Zhao
Fuzhou Univ., Fuzhou, Fujian Province, People's Rep. of China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 705-709, 3 figs, 1 table, 6 refs

Key Words: Modal analysis, Finite element technique, Impedance technique, Matrix methods, Plates - rectangular

Currently used finite dynamic elements are all expressed by frequency expansions of both mass and stiffness matrices. Thus, for a finite dynamic element a set of mass and stiffness matrices of successive orders must be established. In present paper a new concept of impedance matrix for finite dynamic element is proposed. Hence there is no need to derive mass and stiffness matrix expansion terms separately and the formulation of finite dynamic element is simplified significantly.

84-1287

A General Algorithm for Decoupling Equations of Motion Using Non-Orthogonal Measured Modes

C.F. Chao and F.H. Chu
RCA/Astro-Electronics Div., Princeton, NJ, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 324-329, 5 tables, 8 refs

Key Words: Equations of motion, Modal analysis, Transformation techniques, Spacecraft

A new transformation method is developed to decouple the equations of motion of vibration system. This method uses an incomplete set of non-orthogonal measured modes directly.

84-1288

Modal Analysis in Non-Conservative Dynamic Systems

M. Ahmadian and D.J. Inman
State Univ. of New York at Buffalo, Buffalo, NY 14260, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 340-344, 27 refs

Key Words: Modal analysis

This work examines the existence and use of classical normal modes in the modal analysis of general non-conservative structures. The problems addressed here are those resulting from systems which can be modeled by second order linear vector differential equations with constant coefficient matrices. Specifically, conditions for the existence of classical normal modes in various classes of problems as given by previous authors are compared, along with methods of calculating the appropriate modal coordinates.

84-1289

Extension of Modal Analysis to Nonlinear Structure by Using Hilbert Transform

T. Vinh, A. Haoui, and Y. Chevalier
Laboratory of structure, Institut Supérieur des Matériaux et de la construction Mécanique 3, Rue Fernand Hainaut 93407 Saint-Quen France, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 852-857, 9 figs, 5 refs

Key Words: Modal analysis, Nonlinear systems, Hilbert transforms

Hilbert transform (HT) is used to analyze transfer response of mechanical structures by linearization. We emphasize the possibility of using HT as a linear criteria of the structure itself even when nonlinearities are hidden and strong. For the identification of nonlinearities, use of statistical moments is suggested.

84-1290

Time Series Generation Using the Auto-Regressive Moving-Average Model

E.F. Samaras
Ph.D. Thesis, Columbia Univ., 160 pp (1983)
DA8327289

Key Words: Time series analysis method, Autoregressive moving-average models

The present study develops a technique for generating sample functions of a homogeneous Gaussian vector process with the aid of the autoregressive-moving-average method.

The method uses a recursive equation involving a vector process to be simulated and a Gaussian white noise vector process. Once the coefficient matrices of the recursive equation are determined in accordance with the prescribed cross-correlation matrix of the vector process, its sample function vector is digitally generated with computational ease.

84-1291
A Matrix Perturbation of Vibration Modal Analysis

Chen Su-Huan, Liu Ying-Li, and Huang Dun-Pu
Jilin Univ. of Tech., Changchun, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Sponsored by Union College, Schenectady, NY, Vol. II, pp 698-704, 2 tables, 8 refs

Key Words: Modal analysis, Matrix methods, Perturbation theory

In this paper, a matrix perturbation of vibration modal analysis is developed. This method is applicable not only for the structures with different natural frequencies but also for the degenerate systems with repeated natural frequencies. According to this theory, the effect of the hanging elastic elements on the modal parameters of the free-free systems is discussed. A correction procedure is presented to obtain the modal parameters of the free-free systems. Finally, a digital example is given to demonstrate the application of the procedure.

84-1292
Frequency and Response Analysis of Structural, Mechanical and Robotic Systems Using Spatial Irregular Finite Line Element, Mode Uncoupling and Matrix Exponential Methods

C. Bagci
Tennessee Technological Univ., Cookeville, TN 38505, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Sponsored by Union College, Schenectady, NY, Vol. II, pp 836-851, 10 figs, 35 refs

Key Words: Modal analysis, Elastodynamic response, Error analysis

Three-dimensional finite line element with irregular joint freedoms and irregular orientation of cross-sectional principal axes is introduced and applied for the frequency and elastodynamic analysis of structural systems having arbitrarily oriented members, kinematic connections in spatial orientations and subjected to displacement, forcing and damping excitations. Numerical results are compared with those by classical solutions.

84-1293
Iterative Bracketing of Smallest (Largest) Eigenvalues of a Pair of Hermitean Matrices (Iterative Einschliessung der kleinsten (grössten) Eigenwerte eines hermiteschen Matrizenpaares, II)

S. Falk
Institut f. Angewandte Mechanik, Technische Universität Braunschweig, Postfach 3329, D-3300 Braunschweig, Bundesrepublik Deutschland, Acta Mech., 49 (1-2), pp 111-131 (1983) 6 figs, 12 refs
(In German)

Key Words: Eigenvalue problems

A new theory is given improving the results of Krylov-Bogoljubov and Temple for the simultaneous bracketing of one or more eigenvalues. Bounds for the smallest and largest eigenvalues can be calculated as close to the exact outer eigenvalues as wanted.

84-1294
Mechanics of a Cameroonian Xylophone Using Euler-Helmholtz Approximations

N.L. Josue
ENSP, Univ. of Yaounde, Cameroon, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Sponsored by Union College, Schenectady, NY, Vol. I, pp 362-367, 2 figs, 3 refs

Key Words: Musical instruments, Euler beams, Helmholtz resonators

In this paper, we model Xylophone members as Euler beams and calabashes underneath them as Helmholtz resonators. The natural frequencies of vibration of both the beams and calabashes are found.

84-1295
Numerically Efficient Procedures for Dynamic Contact Problems

N. Madsen

Wilmore Hall, Auburn Univ., AL, Intl. J. Numer. Methods Engrg., 20 (1), pp 1-14 (Jan 1984) 1 fig, 4 tables, 5 refs

Key Words: Numerical methods, Impact response, Finite element technique

The solution of dynamic contact (elastic impact) problems, complicated by the changing nature of the contact area, is addressed. If a finite element approach is used, the system matrices vary with the contact area. If the problem is properly formulated, such changes are rank one.

84-1296
A Solution to the Implicit Eigenvalue Problem

P.H. Kulla

RESSULT, 8201 Soechtenau, W. Germany, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 472-480, 2 tables, 10 refs

Key Words: Eigenvalue problems

Many eigenvalue solvers do exist. If a system is described by mass, stiffness and damping matrices, a system reduction will give rise to poles and result in a formulation which falls outside the scope of standard procedures. A solution to this implicit eigenvalue problem is presented in the paper. The procedure allows for the exact and efficient solution of certain problems which were solved by approximation earlier.

84-1297
A Quadratic Reduction Method for Eigenvalue Problems

T.C. Cheu, C.P. Johnson, and R.R. Craig, Jr.

Allison Gas Turbine Operation, General Motors Corp., Indianapolis, IN 46206, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 667-675, 3 figs, 3 tables, 8 refs

Key Words: Eigenvalue problems, Reduction methods, Quadratic reduction

A computer algorithm is developed to reduce the size of eigenvalue problems and to obtain the approximate eigenvalues and eigenvectors. Instead of physically substructuring the large structural systems, the nested dissection method is used to number the finite element nodes such that the structural systems considered are automatically divided into multilevel substructures. The global stiffness and mass matrices resulted from the numbering scheme have a very special pattern of sparsity. A numerical method is introduced to reduce these global matrices into a smaller quadratic eigenvalue problem.

84-1298
Upper and Lower Bounds to Eigenvalues by Weighting Function Approximations

I.N. Bodur and R.D. Marangoni

Rensselaer Polytechnic Inst., Troy, NY 12181, Intl. J. Solids Struc., 19 (12), pp 1099-1114 (1983) 5 figs, 5 tables, 12 refs

Key Words: Boundary value problems, Eigenvalue problems

A method is developed making use of variational principles and Rayleigh's quotient which yields lower bounds to eigenvalues. The method is the counterpart of the Rayleigh-Ritz method in the sense that the results obtained from both methods will improve, i.e., approach the exact value, as more and more terms are considered. Both rely on variational principles. They are similar systematically and conceptually, and this method yields lower bounds to eigenvalues which cannot be obtained from the Rayleigh-Ritz method. Therefore, with the results from both methods the eigenvalues can be bracketed into a small region. The most important advantage of the method is the lower bounds to all eigenvalues can be obtained from the solution of one transcendental equation.

84-1299
Lower Bound on Deformation for Dynamically Loaded Rigid-Plastic Structures

W.J. Stronge

Dept. of Engrg., Univ of Cambridge, Cambridge CB2 1PZ, UK, Intl J. Solids Struc., 19 (12), pp 1049-1063 (1983) 9 figs, 1 table, 23 refs

Key Words: Boundary value problems, Rigid plastic properties, Time-dependent excitation

A lower bound on maximum deformation is determined for rigid-plastic structures subjected to time dependent loads. This bound on deformation amalgamates and slightly extends two previous bounds. It is easily calculated based on an assumed velocity field that is kinematically admissible.

Comparisons are made between this bound, the complementary upper bound by Robinson, and the analytical solution for maximum deformation of five different structural elements. Thus, characteristics of the structure and applied tractions that affect accuracy of the bound are examined. In two cases, the stress field transition from bending at small deformations to membrane stresses at large deformation is demonstrated.

MODELING TECHNIQUES

84-1300
Validation of Finite Element Models Using Scaled Models and Double Pulse Holographic Techniques

M.K. Rao, M.P. Zebrowski, and H.C. Crabb
Ford Motor Co., Allen Park, MI 48101, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 408-414, 9 figs, 1 table, 14 refs

Key Words: Finite element technique, Holographic techniques, Modal analysis - experimental, Computer programs

An analytical model validation technique utilizing scaled plastic modeling and holographic testing which can be implemented early in a design cycle, before prototype availability is described. A detailed automotive frame finite element model was analyzed using the NASTRAN finite element program.

84-1301
Finite Element Model Adjustment Using Experimental Vibration Data

H. Berger, J.P. Chaquin, and R. Ohayon
Office Natl. d'Etudes et de Recherches Aerospatiales (ONERA) BP 72 92322 Chatillon Cedex, France, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 638-642, 11 figs, 5 refs

Key Words: Finite element technique, Modal analysis - experimental, Error analysis

The method presented in this paper consists in: a localization of errors in the forecasting model, and a linear parametrization of the erroneous areas.

84-1302
The Use of Complex Versus Normal Modes in Structural Model Improvement

Chih Lin and S.R. Ibrahim
Univ. of Texas, Austin, TX, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 415-424, 2 figs, 3 tables, 16 refs

Key Words: Modal analysis, Mathematical models, Normal modes, Complex modes

An algorithm is presented that computes a set of normal modes from the corresponding measured complex modes. The computed normal modes are then used in the Berman's technique to improve an analytical approximated mass matrix. A numerical experiment is conducted to validate the proposed theory. Results show that the use of computed normal modes in the correction procedure produces better improvements in the mass matrix than the use of approximated ones if complex modes exist in the measured range.

84-1303
Correlation of Finite Element and Modal Test Studies of a Practical Structure

J. Sidhu and D.J. Ewins
Imperial College of Science and Tech., London, UK, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 756-762, 6 figs, 2 tables, 3 refs

Key Words: Finite element technique, Modal analysis - experimental, Spacecraft

A new method has been developed for correlating the results from both finite element and modal test studies of a structure. The method provides a means of compering analytical and experimental models in such a way that any differences between them can be identified and located. The procedure requires the stiffness and mass matrices to be supplied from the first (theoretical) model together with some of the modal properties (natural frequencies and mode shapes) from the same analysis plus the corresponding modal properties obtained from the second (experimental, modal test) study. An important feature of the method is its ability to function with only a limited amount of data. This has distinct advantages when dealing with measured data from practical engineering structures.

84-1304
Modal Analysis of Fluid-Structure High D.O.F. Sys-

tem and Animation of the Mode Shape on Graphic Display

M. Hautfenne, A. Cormeau, and M. Bardiaux

Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 465-471, 6 figs, 1 table, 6 refs

Key Words: Computer programs, Modal analysis, Interaction: structure-fluid, Multidegree of freedom systems, Graphic methods

The purpose of this paper is to present an industrial application of FLUSTRU and a graphical post-processing of the computed results. FLUSTRU is a finite element code for fluid-structure interaction, developed in a Lagrangian formulation.

84-1305

Selection of Measurement and Parameter Uncertainties for Finite Element Model Revision

K.D. Blakely and W.B. Walton

The MacNeal-Schwendler Corp., Los Angeles, CA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 82-88, 6 figs, 11 refs

Key Words: Finite element technique, Least squares method

Both the analyst and the experimentalist are required for verification of large finite models. The analyst contributes the initial model and uncertainties in selected structural parameters; the experimentalist contributes the test data and uncertainties in the measurements. The least-squares minimization procedure for model refinement is explored. A two-degree-of-freedom model is used to illustrate the effects of relative parameter and measurement uncertainties with regard to the best-fit model. Effects of relative measurement uncertainties versus relative parameter uncertainties are shown for this simple model, giving insight into the least-squares minimization procedure in general and to the selection of the uncertainties in particular.

STATISTICAL METHODS

(See No. 1180)

PARAMETER IDENTIFICATION

(Also see Nos. 1222, 1253)

84-1306

An Evaluation of a Least-Squares Time-Domain Parameter Identification Method for Free-Response Measurements

K.E. Smith

Wavetek Rockland Scientific Corp., Northvale, NJ 07647, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 610-615, 6 figs, 1 ref

Key Words: Parameter identification technique, Least squares method, Time domain method

An evaluation of a parameter identification technique proposed by W.R. Smith has been carried out. The least squares time-domain procedure operates on either single free or impulse response records or simultaneously on multiple records. The technique makes extensive use of closed form estimates to significantly reduce computation time. Results from various simulations are reported. This paper will present the development and evaluation of the method presented by Smith.

84-1307

Discussion on Some Problems of Parametric Identification

Lin Li-Chung and Tung Ju-Ming

Central-South Inst. of Mining and Metallurgy, People's Rep. of China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 865-871, 4 refs

Key Words: Parameter identification technique, Modal analysis

In this paper, three problems of parametric identification are discussed. The recursive formulas of equivalent stiffness and equivalent mass are proved on skeleton graphics of the linear system with multiple degrees of freedom. The special features of complex mode are expounded and the united expansion of mobility function according to complex mode and real mode are derived. The relationships between mass, stiffness, and damping matrices and complex modal parameters of system are derived.

84-1308

Identifying the Structure Modal Parameters by Using Optimized-Iteration Method for the Primary Value

Huang Dun-pu, Yuang Son-Xin, and Wang Shu-Lan

Changchun Motor Vehicle Res. Inst., Changchun, Jilin, The People's Rep of China Intl. Modal Analysis Conf., Proc. 2nd, Orlando FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1010-1016, 3 refs

Key Words: Modal analysis, Parameter identification technique, Modal superposition method, Trucks

The correlation between the structure response and modal parameters is based on the modal superposition theorem by which a simple and efficient program for calculating the modal parameters could be made. But the processing of test data, if used as primary value directly, indicates that the values obtained from iterative calculation usually diverge and no correct result could be obtained. A method for optimizing the primary value has been developed.

84-1309

A New Approach Modeling Complex Mechanical System and Estimating Modal Parameters

Wang Zhifan

Huazhong Univ. of Science and Tech., Wuhan, China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1004-1009, 2 figs, 5 refs

Key Words: Modal analysis, Parameter identification technique, Autoregressive moving-average models, Grinding machinery, Monitoring techniques, Diagnostic techniques

A new approach modeling complex mechanical system and estimating model parameters is developed in this paper. Assuming that measured output of the system is contaminated by observation white noise, an innovation model of the system investigated is identified with the measuring system. The statistical properties of input white noise and observation white noise are estimated. Then, an autoregressive moving-average model describing the dynamics of the system investigated can be factorized from the innovation model by statistical principle. Based on this modeling approach, vibration signals of a cylindrical grinding machine were used for the identification and analysis of the grinding machine system under the actual working conditions.

84-1310

Modal Parameter Estimation by Z-Transformation Method

T. Ushijima

Bridgestone Tire Co., Ltd., Yokohama, Japan, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 437-442, 9 figs, 5 tables, 6 refs

Key Words: Modal analysis, Parameter identification technique, Autoregressive moving-average models, Z-transform method

A dynamic system of a lineer mechanical structure is expressed as an autoregressive moving average model from the equivalence relationships between the Laplace transformation and the Z-transformation. This paper presents an estimation technique for the parameter of the dynamic system using actual input and output sequences which vary with time. This technique is also useful for a multi-input and output system.

84-1311

Data Dependent Systems Approach to Modal Parameter Identification

S.M. Pandit and N.P. Mehta

Michigan Technological Univ., Houghton, MI 49931, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 35-43, 3 tables, 16 refs

Key Words: Parameter identification technique, Modal analysis, Data dependent systems, Time domain method, Signal processing techniques

The application of data dependent systems is proposed for the identification of modal parameters of oscillatory mechanical systems. Time-domain difference equation models derived from and dependent purely upon observed free-response information are shown to quantitatively characterize the dynamic properties of the system. The theoretical background is presented in detail; its validity is established by simulation studies using lumped parameter systems under various structural and environmental conditions. Advantages and special features of the data dependent system approach are discussed.

84-1312

The Identification of Vibration Parameters by Using Time Series Analysis Method - Experimental Part

Hong Zhong-Yu, Chung Wei-Lun, Wang Xi-Shang, and Li Zhi-Hu

Zhengzhou Res. Inst. of Mech. Engrg., Zhengzhou,

Henan, People's Rep. of China, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 383-389, 6 figs, 5 tables, 5 refs

Key Words: Modal analysis - experimental, Parameter identification technique, Computer programs

In this paper the undamped natural frequency and damping ratio of a rotor-bearing-foundation frame system model is identified using time series analysis method.

84-1313

A Mathematical Expression of Random Decrement Technique

Zhang Jing-hui and Tang Zhan-qian

Xian Jiao-tong Univ., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 355-361, 2 figs, 8 refs

Key Words: Modal analysis, Parameter identification technique, Random decrement technique, Covariance function

The random decrement technique has been used successfully in modal parameters identification of vibration systems. In this paper, a mathematical expression for the random decrement characteristic signal is derived. It shows that the random decrement characteristic signal and the covariance functions are equivalent qualitatively. An example of three degree freedom system is given to examine the conclusion which is deduced in this paper.

DESIGN TECHNIQUES

(Also see Nos. 1254, 1255, 1256, 1257, 1258)

84-1314

Life Time Prediction Based on the Combined Use of Finite Element and Modal Analysis Data

E. Verdonck and R. Snoeys

Katholieke Universiteit Leuven, Departement Werktuigkunde, Celestijnenlaan 3ØØB, 3Ø3Ø Leuven, Belgium, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 572-579, 11 figs, 4 tables, 7 refs

Key Words: Fatigue life, Finite element technique, Modal analysis - experimental

The finite element method along with modal analysis data are used to do life prediction of structures. A procedure for the methodology is described.

84-1315

An Efficient Scheme for Modal Analysis Applications

M. Val and R. Elmaraghy

Centre de recherche industrielle du Quebec, Sainte-Foy, Quebec, Canada, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1071-1074, 13 figs, 3 refs

Key Words: Modal analysis, Design techniques, Computer-aided techniques

The use of modal analysis, where applicable, reveals to the design engineer valuable information related to the designed prototype and guides him for any required design modifications with respect to the vibratory behavior of the prototype elements. The use of this approach in the field of CAD-CAT results in a shorter schedule and reduces the ultimate design cost of the new product.

84-1316

Solution of a Gimbal Line-of-Sight Stabilization Problem Utilizing Experimental Modal Analysis

E.J. Tanner and R.C. Varga

Westinghouse Electric Corp., Baltimore, MD, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 921-925, 11 figs

Key Words: Modal analysis - experimental, Gimbals, Minimum weight design

A weight reduction program, initiated on a production electro-optical gimbal system which satisfied line-of-sight stabilization requirements, is described.

COMPUTER PROGRAMS

(Also see No. 1281)

84-1317

EDASP: Structural Modification Program

W. Djordjevic, Tsi-Ming Tseng, and S. Anagnostis Stevenson & Associates, 458 Boston St., Topsfield, MA, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 75-81, 7 figs, 2 refs

Key Words: Computer programs, Structural modification techniques, Modal analysis

A microcomputer software package which accepts modal testing data, or analytical data of a similar nature as the original data base is described. The software is capable of predicting structural response due to base excitation represented by base input acceleration time-histories, base input shock (earthquake) spectra or random input at one or more locations on the structure (equipment).

84-1318

Linking of Modal and Finite Elements in Structural Vibration Analysis

O. Friberg, R. Karlsson, and B. Åkesson

Chalmers Univ. of Tech., S-412 96, Gothenburg, Sweden, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 330-339, 3 figs, 2 tables, 10 refs

Key Words: Modal analysis, Finite element technique, Computer programs

A modal element is defined as a body or substructure described solely through its natural vibration properties: angular eigenfrequencies, modal masses, and a number of pertinent eigenmode translations and rotations at discrete positions of interest. These modal parameters may have been found experimentally or theoretically. Modal damping will not be included in the present study.

84-1319

Finite Element Analysis with a Personal Computer

E.C. Willstaedt and M.S. Darlow

Rensselaer Polytechnic Inst., Troy, NY, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 298-303, 2 figs, 5 refs

Key Words: Finite element technique, Computer programs

This paper describes a finite element analysis package that is in use on a personal computer. The program package analyzes problems in three areas -- torsion, heat transfer, and elasticity. Presently only small two dimensional, isotropic problems can be handled. The maximum degrees of freedom for torsion and heat transfer are 427, while elasticity has twice this number. In addition to describing the program package, appropriate modifications to improve and expand the package are discussed, together with the relative advantages and disadvantages of using a personal computer for finite element analysis.

84-1320

SADDLE: A Computer-Aided Structural Analysis and Dynamic Design Language

S.D. Rajan

Ph.D. Thesis, Univ. of Iowa, 252 pp (1983)
DA8327417

Key Words: Computer programs, Design techniques

The SADDLE program is a tool for computer-aided design of structural and mechanical systems. The system is divided into four parts -- the pre-processor, the 'analyzer,' the 'synthesizer,' and the post-processor. The structural model and the design data are generated by the pre-processor. This article describes the software.

84-1321

Effect of Restraining Belts in Preventing Vehicle-Occupant/Steering-System Impact

R.L. Huston, M.W. Harlow, and R.F. Zernicke

Univ. of Cincinnati, Cincinnati, OH, SAE Paper No. 820471 (SP-507)

Key Words: Computer programs, Collision research (automotive), Seat belts

Restraining belt configurations are studied to determine their effectiveness in restricting occupant motion and occupant impact with the steering system. The study is conducted using a computer simulation model. In the study, a head-on collision is simulated and the occupant response, with various

restraint configurations, is monitored. The results demonstrate the effectiveness of the shoulder belt/lap belt combination as opposed to lap belts alone in preventing occupant impact with the steering system.

84-1322

A Systematic Approach to Evaluate the Development or Purchase of Engineering Software

T.L. Shipley

Entek Scientific Corp., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 390-393

Key Words: Computer programs

This paper outlines a systematic approach to the justification process in selecting engineering software and includes a specific example.

84-1323

Non-Linear System Simulation by the Modal Method

H. Ito, E. Kobayashi, and S. Murai

Komatsu Ltd., Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 528-534, 14 figs, 2 refs

Key Words: Structural modification techniques, Modal synthesis, Transient response, Computer programs

When the modal synthesis method is applied to analyze the dynamic characteristics of complex structures, it is very useful because of the accuracy and low computing cost. In this method, it is generally assumed that the structure has the linear characteristics. However, under the actual operating condition, the structure usually has the non-linear characteristics which includes gap and friction between components. For example, the non-linearity of the suspension affects significantly the ride quality of the vehicle. A new method for the nonlinear system simulation of complex structures is described. The operating condition combines a modal synthesis method with a modal transient response method. This paper illustrates the procedure of this method and a computer program. An example applied to the ride quality problem is shown.

84-1324

Modelling of Spatial Mechanisms' Plain Analogues and Their Analysis and Designing Using Machine Graphics

J.M. Uplisashvili

Georgian Polytechnical Inst., 77 Lenin str., Tbilisi 380075, USSR, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. I, pp 540-544

Key Words: Computer programs, Graphic methods, Structural modification techniques

A method for developing computer programs is described. These programs enable the designer to display intermediate graphic design of new mechanisms, thus facilitating the structural modification of the design.

GENERAL TOPICS

CRITERIA, STANDARDS, AND SPECIFICATIONS

(See No. 1062)

BIBLIOGRAPHIES

84-1325

Modal Analysis Bibliography -- An Update - 1980 - 1983

L.D. Mitchell and L. Mitchell

Tejay Co., Box 641, Blacksburg, VA 24060, Intl. Modal Analysis Conf., Proc. 2nd, Orlando, FL, Feb 6-9, 1984, Spons. by Union College, Schenectady, NY, Vol. II, pp 1098-1114

Key Words: Modal analysis, Bibliographies

This bibliography contains a partial list of the 1980-1983 modal analysis citations. In some cases citations have been included that refer to the use of modal techniques in other fields of investigation in an effort to promote the cross fertilization of ideas.

84-1326

Experimental Modal Analysis Bibliography

R.J. Allemang

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This list is intended to primarily cover topics directly related to experimental modal analysis and includes limited references to related areas such as finite element analysis or analytical modeling procedures when those references refer to constraints or requirements that need to be placed upon the experimental modal analysis procedure.

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- Strings and Ropes
- Cables
- Bars and Rods
- Beams
- Cylinders
- Columns
- Frames and Arches
- Membranes, Films, and Webs
- Panels
- Plates
- Shells
- Rings
- Pipes and Tubes
- Ducts
- Building Components

ELECTRIC COMPONENTS

- Controls (Switches, Circuit Breakers)
- Motors
- Generators
- Transformers
- Relays
- Electronic Components

DYNAMIC ENVIRONMENT

- Acoustic Excitation
- Shock Excitation
- Vibration Excitation
- Thermal Excitation

MECHANICAL PROPERTIES

- Damping
- Fatigue
- Elasticity and Plasticity
- Wave Propagation

EXPERIMENTATION

- Measurement and Analysis
- Dynamic Tests
- Scaling and Modeling
- Diagnostics
- Balancing
- Monitoring

ANALYSIS AND DESIGN

- Analogs and Analog Computation
- Analytical Methods
- Modeling Techniques
- Nonlinear Analysis
- Numerical Methods
- Statistical Methods
- Parameter Identification
- Mobility/Impedance Methods
- Optimization Techniques
- Design Techniques
- Computer Programs

GENERAL TOPICS

- Conference Proceedings
- Tutorials and Reviews
- Criteria, Standards, and Specifications
- Bibliographies
- Useful Applications

CALENDAR

JULY 1984

21-28 8th World Conference on Earthquake Engineering [Earthquake Engineering Research Institute] San Francisco, CA *(EERI-8WCEE, 2620 Telegraph Avenue, Berkeley, CA 94704)*

AUGUST 1984

5-9 3rd International Conference on Solid Lubrication [ASLE] Denver, CO *(ASLE Hqs.)*

6-9 West Coast International Meeting [SAE] San Diego, CA *(SAE Hqs.)*

12-16 International Computers in Engineering Conference and Exhibit [ASME] Las Vegas, NV *(ASME Hqs.)*

19-25 XVIth International Congress on Theoretical and Applied Mechanics [International Union of Theoretical and Applied Mechanics] Lyngby, Denmark *(Prof. Frithiof Niordson, President, or Dr. Niels Olhoff, Executive Secretary, ICTAM, Technical University of Denmark, Bldg. 404, Dk-2800 Lyngby, Denmark)*

SEPTEMBER 1984

9-11 Petroleum Workshop and Conference [ASME] San Antonio, TX *(ASME Hqs.)*

11-13 Third International Conference on Vibrations in Rotating Machinery [Institution of Mechanical Engineers] University of York, UK *(IMechE Hqs.)*

30-Oct 4 Power Generation Conference [ASME] Toronto, Ontario, Canada *(ASME Hqs.)*

OCTOBER 1984

7-11 10th Design Automation Conference and 18th Mechanisms Conference [ASME] Cambridge, MA *(Prof. Panos Papalambros, Mechanical Engineering and Applied Mechanics, The University of Michigan, Ann Arbor, MI 48109 - (313) 763-1046)*

8-12 Acoustical Society of America, Fall Meeting [ASA] Minneapolis, MN *(ASA Hqs.)*

9-11 13th Space Simulation Conference [IES, AIAA, ASTM, and NASA] Orlando, FL *(Institute of Environmental Sciences, 940 E. Northwest Hwy., Mt. Prospect, IL 60056 - (312) 255-1561)*

15-18 Aerospace Congress and Exposition [SAE] Long Beach, CA *(SAE Hqs.)*

17-19 Stapp Car Crash Conference [SAE] Chicago, IL *(SAE Hqs.)*

22-24 ASME/ASLE Lubrication Conference [ASME/ASLE] San Diego, CA *(ASLE Hqs.)*

22-25 Symposium on Advances and Trends in Structures and Dynamics [George Washington University and NASA Langley Research Center] Washington, DC *(Prof. Ahmed K. Noor, Mail Stop 246, GWU-NASA Langley Research Center, Hampton, VA 23665 - (804) 865-2897)*

DECEMBER 1984

3-5 International Conference on Noise Control Engineering [International Institute of Noise Control Engineering] Honolulu, Hawaii *(William W. Lang, Chairman, INTER-NOISE 84, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603)*

3-6 Truck and Bus Meeting and Exposition [SAE] Dearborn, MI *(SAE Hqs.)*

9-13 ASME Winter Annual Meeting [ASME] New Orleans, LA *(ASME Hqs.)*

FEBRUARY 1985

25-Mar 1 International Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1985

18-21 30th ASME International Gas Turbine Conference and Exhibit [Gas Turbine Division of ASME] Houston, TX *(International Gas Turbine Center, Gas Turbine Division, ASME, 4250 Perimeter Park South, Suite 10R. Atlanta, GA 30341 - (404) 451-1905)*

APRIL 1985

8-12 Acoustical Society of America, Spring Meeting [ASA] Austin, TX *(ASA Hqs.)*

15-19 2nd Symposium on The Interaction of Non-Nuclear Munitions with Structures [Tyndall AFB, FL; Eglin AFB, FL; and Kirtland AFB, NM] Panama City Beach, FL *(Ms. L.C. Clouston, Registrar, P.O. Box 1918, Eglin AFB, FL 32542 - (904) 882-5614)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE: American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME: American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF: International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE: Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
67 Alexander Dr.
Research Triangle Park, NC 27709

SAE: Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE: Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA: Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375

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