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SVIC NOTES

CORPORATE MEMORY

I think there is a problem today with the corporate memory of the shock and vibration community. Consider what today's retiree has seen in the last 35 to 40 years. There has been a continual evolution of higher technology based systems such as missiles, jet engines, satellites, manned spacecraft, supersonic aircraft and hardened strategic structures. With each technical increase, there has been a concomitant increase in the severity of the dynamic environments. Materials, such as high temperature alloys, organic and metal matrix composites and elastomeric (damping) compounds, have been developed to withstand these more severe environments. Finally, the advent of the digital computer has forever changed the way we analyze structures, process environmental data or perform tests in the environmental laboratories. I am not suggesting that an organization suffers an irreparable loss when someone retires who has personally witnessed these 40 years of developments in shock and vibration technology. Rather, I am asking the question, "Exactly *what* does an organization lose and how can they compensate for the loss?"

It is really a problem in information retrieval. Someone who has witnessed the developments knows exactly which documents contain the most useful information; they probably have personal copies of some of these and/or a bibliography listing them. They know which organizations or people made what developments and they know the names of many experts in the field. In a word, they have a starting point for quick access to shock and vibration information generated over the last four decades. The ability to easily access information is what is lost when they retire.

An organization can do several things to compensate for this loss. New employees, as well as old, should be able to capitalize on their organization's corporate memory. Training programs for new employees should be established to help them learn how to access the useful documents both inside and outside the organization. They should be made aware of centralized sources of information, such as the Shock and Vibration Information Center (SVIC), or professional societies such as the IES, ASME, SAE, AIAA, etc. SVIC's resources include index's to the Shock and Vibration Bulletin, literature reviews and monographs. The novice should be encouraged to attend the technical symposia organized by SVIC and to professional societies. The preservation of "corporate memory" is enhanced by interacting with their peers at such meetings. SVIC and the professional societies have been working on this problem directly for many years. The sum of their output stands as a good first approximation to the "corporate memory" of the shock and vibration community.

J.G.S.

EDITORS RATTLE SPACE

COPYRIGHT LAW - 1982

The copyright law of 1976 was supposed to provide equity among authors, publishers, and users of original works. After five years under this law it is time to evaluate its effects on the transfer of technology.

To date engineers have never been interested in the copyright process. Their time has been freely given to generate technical information without direct compensation -- except for book royalties. That is not to say benefits have not been received by engineers who publish regularly. Recognition, credits toward promotion, and secondary advertising of one's capabilities are among the benefits accrued by engineers who take the time to publish their work. The copyright law did not greatly affect many engineers. Except for more forms and paper work the modus operandi of the engineer has not changed during the past five years. So why should we be concerned about the law?

The people who are in the middle of the technology transfer cycle -- the publishers -- have the most to gain or lose with copyright laws. The free use of excellent copying machines is a direct attack on the viability and profitability of publishers. Users of published material for direct profit, including libraries, have eroded the position of publishers. In fact a major lawsuit is now being pursued against a corporate library for failure to compensate a publisher for widespread employee copying. It takes money to edit, print, and distribute magazines, journals, and books. Publishers cannot be satisfied with recognition and secondary benefits derived by engineers. There must be an incentive to continue to invest money in technical publications. Without publishers there will be no technology transfer. Perhaps users should think about this fact when they copy a paper or book -- as I have often seen happen.

Surveys conducted by the federal government have confirmed that copying has increased during the past five years. There is no indication that compensation has increased; therefore, it is business as usual, and the 1976 copyright law is not producing the desired result.

What will happen in the future? All of us complain about the high cost of printed material. But as the volume of material printed by publishers decreases (largely because of copying), the cost of publications will go up to defray the fixed costs of editing and printing. This means that if the copyright law is not strengthened either corporations alone will be able to afford books and journals or publication will cease because publishers will not be able to continue their efforts.

R.L.E.

APPROXIMATE TECHNIQUES FOR PLASTIC DEFORMATION OF STRUCTURES UNDER IMPULSIVE LOADING, III

W.E. Baker*

Abstract. Topics of this review on approximate techniques for plastic deformation of structures under loading include research-oriented analyses, design-oriented analyses, and relevant experiments. A brief closure concludes the review; references since 1979 are listed.

This review updates two previous reviews on the same topic in 1975 [1] and 1979 [2]. It supplements the earlier reviews and covers only work reported since 1979. The reader should acquire the previous reviews for a reasonably complete coverage of this specialized topic.

RESEARCH-ORIENTED ANALYSES

Most of the recent published papers on research-oriented analyses are continuations or spin-offs of previous studies by P.S. Symonds, N. Jones, and their coworkers.

Symonds' recent contributions [3-9] include primarily large-deflection approximations and strain-rate effects. Structural elements studied are circular plates and simple plane frames with members of rectangular cross section; the frames have either a central mass that is loaded impulsively or no added mass and are subjected to a uniform distributed impulse. Assumed deformation patterns for the frames are shown in Figure 1.

Jones has several recent papers [10-13]. One excellent survey paper [10] also includes discussions on the more general topic of dynamic structural response. There has been increasing concern in recent work in estimating dynamic shear effects in simple structural elements [11-13]; see Figures 2 and 3. Other recent research-oriented papers on approximate analysis methods for impulsive response are available [14, 15].

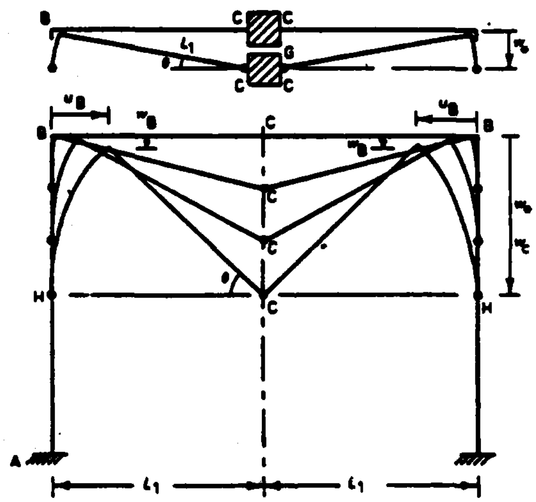

Figure 1. Deformation Patterns for Impulsively Loaded Plane Frames [4]

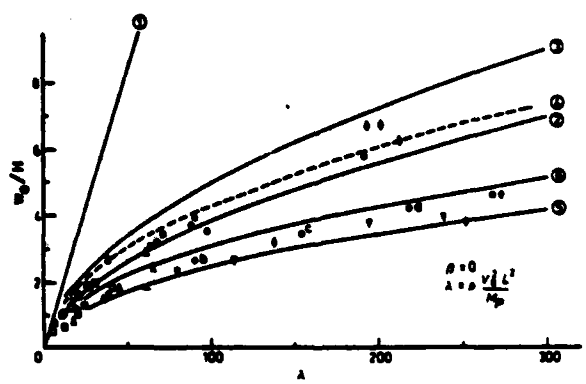

Figure 2. Dimensionless Maximum Displacements vs Scaled Applied Impulse for Clamped Beams, Various Theories, and Test Results [10]

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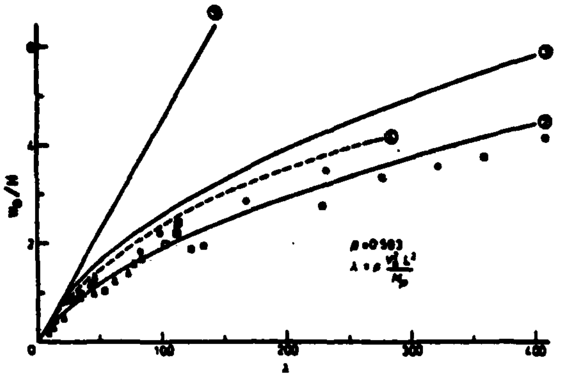

Figure 3. Dimensionless Maximum Displacements vs Scaled Applied Impulse for Fully Clamped Rectangular Plates, Various Theories, and Test Results [10]

DESIGN-ORIENTED ANALYSES

The use of energy-balance methods to estimate the maximum deformations in impulsively-loaded structures has been discussed [1], as has the concept of scaled P-i diagrams for rapid estimation of maximum response of dynamically-loaded structures [2]. Work has continued on these two topics. A complete current discussion of the use of energy-balance methods has been published [16], as has a compilation of a number of closed-form deformation prediction formulas that can be specialized to impulsive loads [17]. A number of these formulas are given in the table.

Scaled P-i diagrams for rapid estimation of maximum response of blast-loaded structural elements have been published [16]. Figure 4 is typical of a set of curves for beam elastic-plastic bending. Each curve represents the loci of combinations of scaled applied pressure and applied specific impulse that yield the same maximum response. Both maximum strain and deformation can be obtained for a variety of boundary conditions by using values inset in the figure.

The interest in dynamic shear effects evidenced in several research-oriented papers [10, 11, 13] is also apparent in design-oriented work. Studies on dynamic shear failure of reinforced-concrete slabs have been reported [18, 19]. A typical design graph is shown here as Figure 5. It gives dynamic increase factors for shear (compared to maximum shear stresses under the same applied peak pressure B) for slabs of different strengths and stiffnesses.

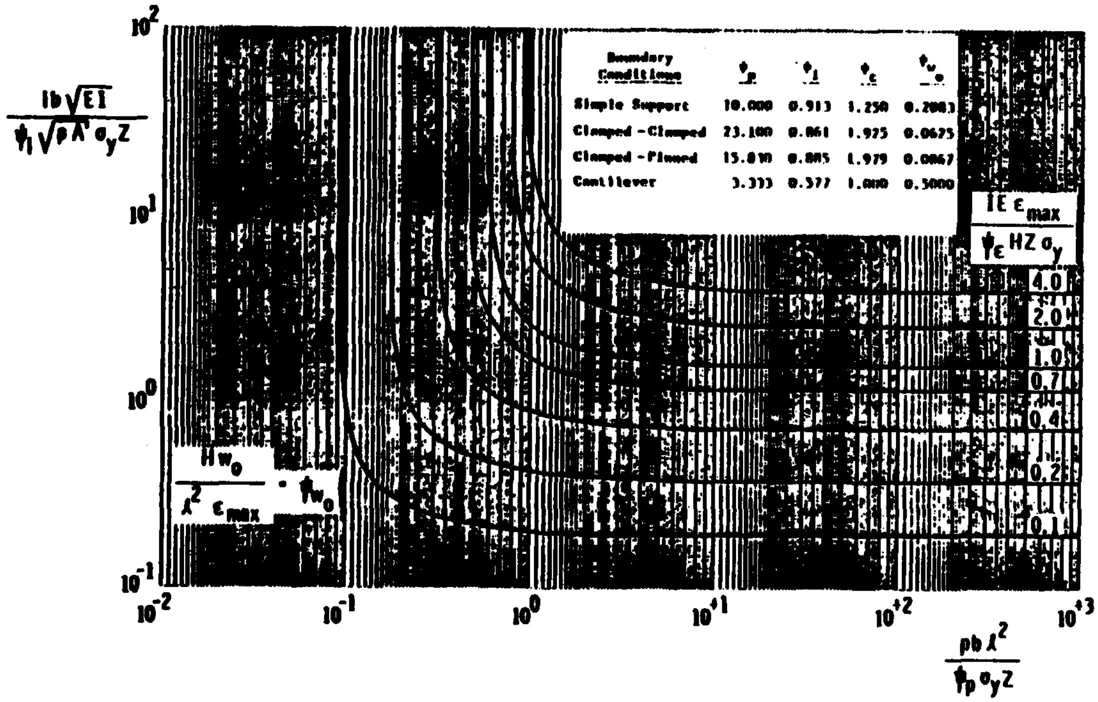

Figure 4. Elastic-Plastic Energy Solution for Bending of Blast-Loaded Beams [16]

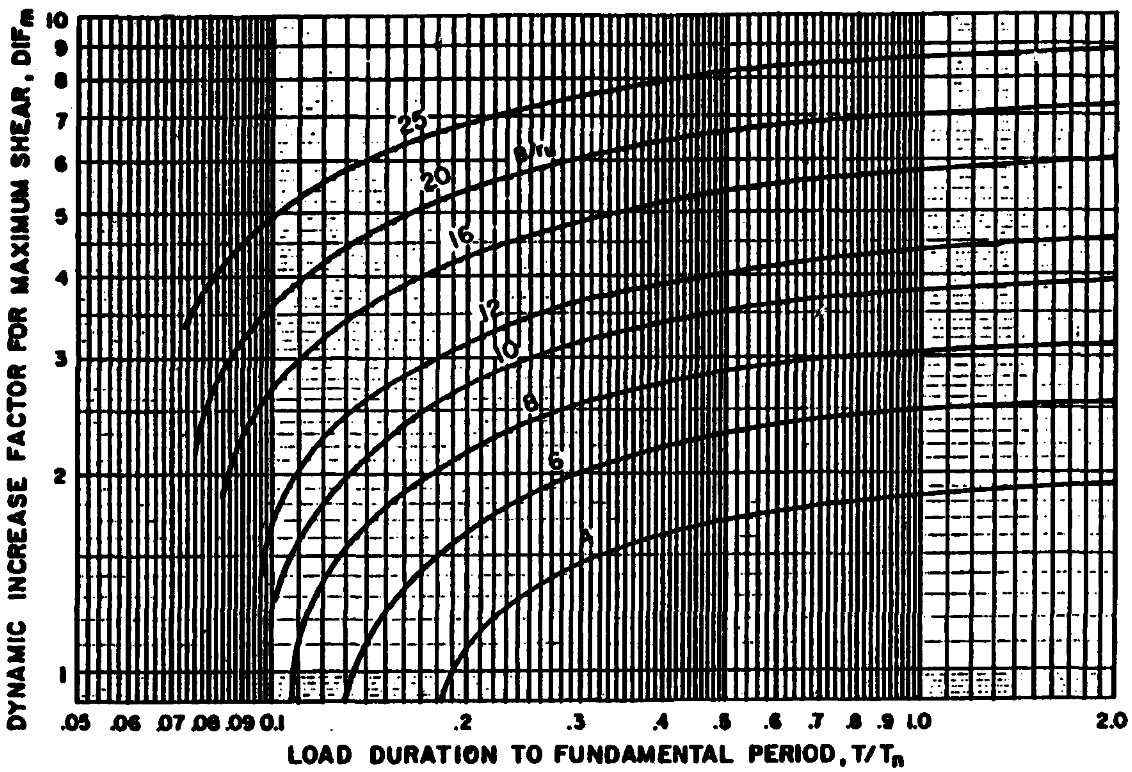

Figure 5. Maximum Dynamic Increase Factors for Support Shears of Simply Supported Square Plates: Approximate Solution for Plastic Response Range [19]

EXPERIMENTS

Many of the more recent research-oriented papers contain comparisons of analytic predictions and test data and therefore validation of the analyses. Figures 2 and 3 show such comparisons; others are available [3-6]. An experimental study of response of impulsively-loaded circular plates has been published [21].

Most distributed impulsive loads have been applied experimentally by contact or near-contact high explosives [20, 21], but a recent paper [22] reports another well-controlled technique for such loading involving explosion of etched copper mesh by capacitor discharge.

CLOSURE

As noted in the 1979 review [2], both research-oriented and design-oriented work continues on approximate methods for dynamic response of impulsively-loaded structures. Trends are toward inclusion of large deformation effects, strain-rate effects, and strain-hardening effects. They can be included in the approximate methods in a relatively simple manner that is seldom possible in more exact or detailed methods. It is heartening to see more comparisons of analytic predictions with test results. Disheartening is the lack of true landmark papers and the apparent lack of communication between research professors and the design engineering community.

TABLE.
Closed-Form Equations for Prediction of Maximum Deformations of Impulsively-Loaded Structural Elements

STRUCTURAL ELEMENT	COORDINATE SYSTEM ORIGIN	DEFORMED SHAPE	STRAIN BEHAVIOR	RESPONSE FORMULA	REFERENCE
Cantilever beam	Beam root	$\frac{w}{w_o} = (1 - \cos \frac{\pi x}{2\ell})$	Rigid plastic	$\frac{w_o}{\ell} = 0.783 \quad \bar{I}_p^2$	17
Simply-supported beam, bending only	Beam center	$\frac{w}{w_o} = (1 - \frac{4x^2}{\ell^2})$	Rigid plastic	$\frac{w_o}{\ell} = 0.0625 \quad \bar{I}_p^2$	17
Simply-supported beam, bending only	Beam center	$\frac{w}{w_o} = \cos \frac{\pi x}{\ell}$	Elastic	$(\frac{w_o}{\ell})^2 = 0.02053 \quad \bar{I}_e^2$	17
Simply-supported beam, bending only	Beam center	$\frac{w}{w_o} = \cos \frac{\pi x}{\ell}$	Rigid plastic	$\frac{w_o}{\ell} = 0.0796 \quad \bar{I}_p^2$	17
Simply-supported beam, bending only	Beam root	$\frac{w}{w_o} = \frac{16}{5\ell^4} (x^4 - 2\ell x^3 + \ell^3 x)$	Elastic	$(\frac{w_o}{\ell})^2 = 0.02034 \quad \bar{I}_e^2$	17
Simply-supported beam, bending only	Beam root	$\frac{w}{w_o} = \frac{16}{5\ell^4}(x^4 - 2\ell x^3 + \ell^3 x)$	Rigid Plastic	$\frac{w_o}{\ell} = 0.0781 \quad \bar{I}_p^2$	17
Clamped-clamped beam, bending only	Beam center	$\frac{w}{w_o} = 2(1 - \frac{x^2}{\ell^2})$	Rigid plastic	$\frac{w_o}{\ell} = 0.03125 \quad \bar{I}_p^2$	17
Clamped-clamped beam, bending only	Beam center	$\frac{w}{w_o} = \frac{16}{\ell^4}(x^2 - \frac{\ell^2}{4})^2$	Elastic	$(\frac{w_o}{\ell})^2 = 0.00488 \quad \bar{I}_e^2$	17
Clamped-clamped beam, bending only	Beam center	$\frac{w}{w_o} = \frac{16}{\ell^4}(x^2 - \frac{\ell^2}{4})^2$	Rigid plastic	$\frac{w_o}{\ell} = 0.0406 \quad \bar{I}_p^2$	17
Clamped-clamped beam, bending only	Beam root	$\frac{w}{w_o} = \frac{16}{\ell^4}(x^4 - 2\ell x^3 + \ell^2 x^3)$	Elastic	$(\frac{w_o}{\ell})^2 = 0.00488 \quad \bar{I}_e^2$	17
Clamped-clamped beam, bending only	Beam root	$\frac{w}{w_o} = \frac{16}{\ell^4}(x^4 - 2\ell x^3 + \ell^2 x^2)$	Rigid plastic	$\frac{w_o}{\ell} = 0.04165 \quad \bar{I}_p^2$	17

TABLE (Cont'd.)

STRUCTURAL ELEMENT	COORDINATE SYSTEM ORIGIN	DEFORMED SHAPE	STRAIN BEHAVIOR	RESPONSE FORMULA	REFERENCE
Simply-supported beam; bending, membrane & strain hardening	Beam center	$\frac{w}{w_o} = (1 - \frac{4x^2}{\ell^2})$	Rigid plastic with strain hardening	$\frac{i^2 b^2}{P_y \rho A} = \frac{16M_p}{P_y \ell}(\frac{w_o}{\ell}) + \frac{16}{3}(\frac{w_o}{\ell})^2 + \frac{64E_t A}{5P_y}(\frac{w_o}{\ell})^4$	17
Clamped-clamped beam; bending, membrane & strain hardening	Beam center	$\frac{w}{w_o} = 2(1 - \frac{4x^2}{\ell^2})$	Rigid plastic	$\frac{i^2 b^2}{P_y \rho A} = \frac{32M_p}{P_y \ell}(\frac{w_o}{\ell}) + \frac{16}{3}(\frac{w_o}{\ell})^2 + \frac{64E_t A}{5P_y}(\frac{w_o}{\ell})^4$	17
Pinned-clamped beam, bending only	Pinned end	$\frac{w}{w_o} = \frac{3.49}{\ell^5} x (x^2 - \ell^2)^2$	Elastic	$(\frac{w_o}{\ell})^2 = 0.00896 \; \bar{i}_e^2$	17
Pinned-clamped beam, bending only	Pinned end	$\frac{w}{w_o} = \frac{3.49}{\ell^5} x (x^2 - \ell^2)^2$	Rigid plastic	$\frac{w_o}{\ell} = 0.0650 \; \bar{i}_p^2$	17
Pinned-clamp beam, bending only	Pinned end	$\frac{w}{w_o} = \frac{7.7}{\ell^4}(x^4 - \frac{3}{2}\ell x^3 + \frac{1}{2}\ell^3 x)$	Elastic	$(\frac{w_o}{\ell})^2 = 0.00937 \; \bar{i}_e^2$	17
Pinned-clamped beam, bending only	Pinned end	$\frac{w}{w_o} = \frac{7.7}{\ell^4}(x^4 - \frac{3}{2}\ell x^3 + \frac{1}{2}\ell^3 x)$	Rigid plastic	$\frac{w_o}{\ell} = 0.0547 \; \bar{i}_p^2$	17
Clamped rectangular plate; bending membrane & shear	Plate center	$\frac{w}{w_o} = \cos\frac{\pi x}{2X} \cos\frac{\pi y}{2Y}$	Rigid plastic	$\frac{\pi^2 i^2 X^2}{8\rho\sigma_y H^4} = (\frac{w_o}{H})(\frac{\pi^2}{16}[1+\beta^2] + \frac{\pi^3}{\sqrt{3}}[1+\beta]) + (\frac{w_o}{H})^2(\frac{\pi^4}{128}[1+\beta^2] + \frac{\pi^2}{4\sqrt{3}}\beta])$	17
Circular clamped plate bending & membrane	Plate center	$\frac{w}{w_o} = (1 - \frac{r}{R})$	Rigid plastic	$\frac{3i^2 R^2}{2\rho\sigma_y H^4} = 3(\frac{w_o}{H}) + \frac{3}{2}(\frac{w_o}{H})^2$	17

TABLE (Cont'd.)

STRUCTURAL ELEMENT	COORDINATE SYSTEM ORIGIN	DEFORMED SHAPE	STRAIN BEHAVIOR	RESPONSE FORMULA	REFERENCE
Circular simply-supported plate, bending only	Plate center	$\frac{w}{w_o} = \cos\frac{\pi r}{2R}$	Rigid plastic	$\frac{w_o}{H} = 0.637\ i^2R^2/\rho\sigma_y H^4$	17
Thin wall cylinder, no end restraint	Cylinder axis	ΔR = constant	Elastic	$(\frac{\Delta R}{R})^2 = i^2/\rho H^2 E$	17
Thin wall cylinder, no end restraint	Cylinder axis	ΔR = constant	Elastic-plastic, $\frac{\Delta R}{R} > \epsilon_y$	$\frac{\Delta R}{R} = \frac{1}{2}(\frac{i^2}{\rho H^2\sigma_y} + \frac{\sigma_y}{E})$	17
Thin wall cylinder, with radial end restraint, membrane only	Cylinder axis at midplane	$\Delta R = \Delta R_o(1-\frac{4x^2}{L^2})$	Rigid plastic	$\frac{0.75i^2}{\rho H^2\sigma_y} = (\frac{\Delta R}{R})$ $+4(\frac{R}{L})^2(\frac{\Delta R}{R})^2$	17
Thin spherical shell	Center of sphere	ΔR = constant	Elastic	$(\frac{\Delta R}{R})^2 = 0.5\ i^2/\rho H^2(\frac{E}{1-\nu})$	17
Thin spherical shell	Center of sphere	ΔR = constant	Elastic-plastic $[\frac{\Delta R}{R} > \frac{(1-\nu)\sigma_y}{E}]$	$\frac{\Delta R}{R} = \frac{0.25i^2}{\rho\sigma_y H^2} + \frac{0.5(1-\nu)\sigma_y}{E}$	17
Clamped-clamped beam, with end restraint (rectangular section only)	Center of beam	Unknown	Rigid plastic	$\frac{w_o}{H} = \frac{1}{2}[(1-\frac{3i^2\ell^2}{\sigma_y\rho H^4})^{1/2}-1]$	10
Rectangular clamped plate	Center of plate	Unknown	Rigid plastic	$\frac{w_o}{H} = \frac{(3-\xi_o)[(1+\Gamma)^{1/2}-1]}{2[1+(\xi_o-1)(\xi_o-2)]}$	10
Plane space frame, with added mass	Center of frame mass member	See Fig. 1	Rigid plastic	$\frac{w_o}{H} = \frac{3A_1^2 i^2}{4(1+3k)\rho\sigma_y b^2 H^4}$	4
Plane space frame	Center of frame cross member	See Fig. 1	Rigid plastic	$\frac{w_o}{H} = \frac{3\ell^2 i^2}{16\rho\sigma_y H^4}$	4

DEFINITION OF SYMBOLS

ENGLISH

A	beam cross-sectional area
A_i	area loaded by specific impulse
B	peak blast loading pressure
b	loaded width of beam
DIF_m	dynamic increase factor for maximum shear
E	material elastic modulus
E_t	tangent modulus for strain-hardening material
G	mass attached to plane frame
H	thickness of plate, or shell
I	second moment of area of a cross-section; total impulse
i	specific applied impulse
$\bar{i}_e$	$(i^2 b^2 \ell^2/\rho AEI)^{1/2}$, scaled specific impulse for elastic response
$\bar{i}_p$	$(i^2 b^2 \ell/\rho AM_p)^{1/2}$, scaled specific impulse for plastic response
k	ratio of attached mass to frame cross-member mass = $G/\rho \ell bH$
ℓ	length of beam for which the deformation is being determined; length of cylinder
M_p	beam plastic moment
P_y	axial yield force of the beam = $A\sigma_y$
R	mean radius of a sphere or cylinder, radius of a circular plate
r	radius to arbitrary point on a circular plate
r_u	dynamic ultimate flexural resistance
ΔR	radial expansion of a cylinder or a sphere
T	load duration
T_n	natural elastic period
V_o	impulsive velocity
w	lateral deflection of a beam or plate at any point
w_o	center deflection of a beam or plate
X	short semi-span of a plate
x	distance along the beam or plate, normally measured from the center
Y	long semi-span of a plate
y	distance along plate centerline measured from the plate center
Z	plastic section modulus

GREEK

β	X/Y
Γ	$\lambda\beta^2 (3-2\xi_o)[1 - \xi_o + 1/(2-\xi_o)]/6$
ϵ_y	yield stress
λ	$4i^2\ell^2/\sigma_y \rho H^4$
ν	Poisson's ratio
ξ_o	$\beta[(3+\beta^2)^{1/2} - \beta]$
ρ	material density
σ_y	material yield strength
ψ_ϵ	boundary condition factor for strain
ψ_i	boundary condition factor for specific impulse
ψ_p	boundary condition factor for pressure
ψ_{w_o}	boundary condition factor for maximum deflection

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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 articles about spall fracture of solids and optimal vibration reduction over a frequency range.

Professor D. Krajcinovic of University of Illinois at Chicago has written a summary of general features of material fracture and crack propagation. Analytical methods are reviewed. Passive and active models are described and compared.

Dr. W.D. Pilkey, Mr. L. Kitis, and Dr. B.P. Wang of University of Virginia, Charlottesville, Virginia have written a review of optimal vibration reduction techniques for systems subject to harmonic excitation over a frequency range. Only passive means of control are considered. The objective functions used for optimization are restricted to those that relate directly to some measure of frequency response.

SPALL FRACTURE OF SOLIDS

D. Krajcinovic*

Abstract. This article contains a summary of general features of material fracture and crack propagation. Analytical methods are reviewed. Passive and active models are described and compared.

In the most general case the energy imparted to a body by some external source can be: used for rigid body motion, stored as elastic strain energy, and dissipated by a change of phase or some other type of permanent (irreversible) rearrangement of crystalline microstructure.

This review deals with spall fracture of solids in a somewhat restricted sense. The same problem can be studied within the wider context of shock-wave physics or the shock compression of solids [1]. This review focuses on phenomena characterized by stress levels that are typically in the range of rupture or yield stress. The pressures associated with significant shock compressions are commonly 10 to 50 times larger in magnitude.

Among the several ways in which crystalline structure can be changed, the following are discussed in this article: change in the pattern of linear defects (dislocations) resulting in what is commonly perceived as plastic flow and evolution of a population of planar and spherical microcracks (or microdefects) arising typically at impurities or grain boundaries.

Dislocations resulting in plastic flows are typical of ductile metals and rubber-like materials; they occur during slowly applied loads and at high temperatures. A material that undergoes impulsive loads of short duration and high intensity typically develops a large number of small (or micro) cracks; these cracks are distributed in a fairly homogeneous manner over a finite part of the solid. (The crack is usually considered small if its size is less than that of a grain.)

The growth of microcracks under the influence of dynamic loads, now known as spalling or scabbing, was apparently first noticed and examined by Hopkinson during the 1920s. The military applications associated with the design of projectiles and armor has provided impetus for the study of spalling during the past 40 years.

Spalling is defined here as a mode of material fracture associated with the interaction of unloading (tensile) stress waves. It occurs in connection with impacts (collisions), explosive blasts, intense radiation, or electric pulses. The magnitude and duration of the tensile pulse are functions of the load-time history, geometry, and material properties of the structure and the support conditions (boundary conditions).

GENERAL OBSERVATIONS

The main reason for the diffuse pattern of cracks in dynamic loading is a disparity in the velocity of crack propagation (cca 2000 m/sec for metals) and the velocity of stress wave propagation (typically up to 7000 m/sec). A stress level that provides sufficient energy to cause crack growth will change before the crack has a chance to acquire its critical size. Hence, degradation of the material can vary gradually in space and time from complete separation (fragmentation) to a level virtually indistinguishable from the virgin material.

The metallurgical aspects of spalling have been reviewed [1, 2]. The damage in a majority of cases occurs around defects in the material, thus implying that damage is a process of activation rather than nucleation.

In highly pure materials spall damage is associated with either $\{111\}$ (aluminum monocrystals) or

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$\{ 1\ 0\ 0 \}$ planes (brittle materials). In the case of polycrystalline materials damage propagates in both inter- and trans-granular modes. In materials with a large number of impurities and defects the initial distribution of cracks has a random orientation. The deterioration propagates, in all likelihood in a random fashion, until one of the crack systems – typically one perpendicular to the principal tensile strain – becomes dominant and begins to control the subsequent material response. The remainder of the cracks remain dormant until and unless the direction of the tensile stress changes. When a large number of microcracks are activated, the process can be described in a statistically smoothed sense using the methods of continuum mechanics. The cracking of concrete and especially geotechnical materials is also a function of initial damage, and the same principles are valid.

The detection of microdefects such as cracks and voids is a fairly routine task. For example, the volume of spherical voids of a material can be measured simply by weighing a specimen in air and in liquid and comparing the weights with a virgin piece of the same volume of material [3]. It is also possible to count the number of voids per unit area on a micrograph [3]. More exotic methods, such as small angle neutron scattering [4], acoustic emission [5], and ultrasonic testing, were successfully used in the past. It is in principle possible to measure the damage on the surface of a body and associate the surface damage density to the volume damage density in a probabilistic manner.

ANALYTICAL METHODS

Early Work

Most of the early work on spalling has been succinctly summarized [2, 6]. In one review [6] the material is considered to be purely elastic even at the incipient spall. The other paper [2] examines the influence of the pulse shape (i.e., its time history) and its duration on the location and extent of damage. An important and often overlooked conclusion is that damage cannot be satisfactorily predicted unless a complete description of the stress history at a particular cross section is available. The authors also point out that a fracture cannot be instantaneous because it is dependent on the rate at which cracks can be nucleated and propagated.

The analyses in both reviews are based on the propagation of stress waves through an ideally elastic solid. The incident wave produced by collision or explosion is typically compressive. After it is reflected from a free boundary, the wave is transformed into a tensile wave. When the tensile stresses exceed certain threshold values, spalling occurs; i.e., loss of integrity perpendicular to the axis along which the tensile wave propagated.

A series of similar papers has appeared in the last two decades in the Soviet Union. A common characteristic of the papers is an either-or proposition according to which "the transition of the material into a powdery medium takes place instantaneously on a certain (moving) surface dividing the undamaged region from the fragmented region" [7]. In other words a solid body is divided by a moving surface (shock front) into two parts. Part of the volume already traversed by the moving front is pulverized; the remainder of the solid is still in its virgin state. According to this purely mathematical artifice spalling is an instantaneous process in which a solid is transformed from one extremal state into another. Although such a stratagem is convenient analytically, it contradicts both physical intuition and overwhelming experimental evidence to the contrary.

The debate on selecting a fracture criterion ascribed to a moving discontinuity front has been summarized [8]. Various authors have proposed at least six different models. They differ in the definition of the nature of the (crushed) material traversed by the moving front -- definitions range from ideal incompressible and compressible fluids to an ideally plastic solid – and in the selection of the spalling condition on the moving discontinuity front – conditions range from threshold values of stress and energy to velocity of the fracture wave. In view of the fact that experimental evidence does not support any of these assumptions, it is redundant to discuss the purported merits or demerits of the suggested models.

Several other similar models have been discussed [9]. In addition, some empirical and semiempirical design procedures associated with the design of bomb shelters have been summarized [10-12].

Damage Theories

The lack of a variable to define the level of damage locally both qualitatively and quantitatively is the essential shortcoming of the methods mentioned above. In the absence of such a variable, which must be a function of space and time, spalling must indeed be arbitrarily defined as an instantaneous transition between two extremes -- from virgin material to totally fragmented medium. And yet damage during dynamic fracturing, measured for example by the density of microcracks, is obviously a continuous function of time. The site at which total separation occurs is typically embedded in a region where crack density has reached a considerable level. Macroscopically, spalling is a well defined orderly process consisting of a measurable and identifiable sequence of events; i.e., nucleation, growth, and coalescence of microcracks into a macrocrack. The fast is that the time scale is compressed such that the events cannot be seen.

In order to describe a process characterized by a gradual, time- and space-dependent degradation of material it is necessary to introduce a variable that reflects in an acceptable manner the distribution and density of microdefects in the material. Models that suggest a specific interdependence of the stress and strain field on one side and the damage field on the other side can be classified as either passive or *active models* [13].

With passive models the level of damage, or material degradation, is determined on the basis of stresses and strains computed for the virgin material; that is, the unmodified material. With active models the stress and damage fields interact and modify each other. Available experimental evidence strongly supports the results obtained using active models. The stress pulse undergoes significant changes as the microcracks in the material grow. Because the level of damage strongly depends on the pulse shape [2], passive models provide less than reliable prediction whenever damage is substantial.

Passive models. One of the best known passive models is the Tuler-Butcher model [14] according to which damage depends on the entire stress history

$$D = \int_0^t A[\sigma(t) - \sigma_0]^\lambda dt$$

A, σ_0, and λ are the material parameters. The damage variable D is somewhat loosely defined either as the degradation of strength or as a number of observable cracks.

According to a different approach [15] the time to failure can be computed from stress σ as

$$t_R = t_0 \exp[(U_0 - \gamma\sigma)/kT]$$

where k and T are the Boltzmann's constant and temperature; t_0, U_0, and γ are material constants related to the atomic vibration period, *binding* energy of atoms, and the level of lattice disorder respectively.

Active models. Neglecting the influence of damage on such macroscopic parameters of the material as density and elastic moduli simplifies the problem enormously because the stresses and strains can be determined on the basis of the propagation of waves in an elastic medium. This is the major shortcoming of every passive model. The speed at which the waves propagate, the pulse shape, and the energy are substantially altered by the damage-changed properties of the material; i.e., the sharp wave fronts are smoothed, the pulse durations are generally increased, speed of propagation is lowered, and the energy is diminished through dissipation. Experimental observations unambiguously relate the extent of damage to the duration and magnitude of the tensile pulse; *predictions* based on passive models are thus of questionable reliability. A reliable model should consider the interaction of damage level and stress fields; i.e., the redistribution of stresses and strains due to the gradual change of the material properties as damage accumulates. *In view of the gradual and continuous* change of material properties as functions of stresses and strains a solution of the wave propagation problem requires special and complex computer codes.

In the last decade a powerful active model for spalling analyses that utilizes experimental procedures has been developed [16]. The model is applicable to the analysis of dynamic fracturing of both brittle and ductile materials and even the occurrence of shear band instabilities; the model is in the form of a sequence of special computer codes rather than in a conventional continuum mechanics form.

Fracture in the case of ductile materials is assumed to occur by nucleation and viscous growth of nearly spherical voids [16]. The experimentally observed *surface* distribution of voids is by *means* of a special computer program related to the volumetric distribution of voids. Rate laws that govern the nucleation of new voids and the viscous growth of existing voids are formulated on the basis of some passive models in terms of the tensile pressure obtained from the Mie-Gruneisen equation for the material.

A fracture is assumed to be brittle whenever damage consists of penny-shaped cracks. In this case observed surface cracks are organized into groups according to the size and orientation; cracks are then transformed statistically into a volumetric distribution assuming axial symmetry around the axis of tensile wave propagation. Special rate equations have been proposed for crack nucleation and growth. Fragmentation is considered to be the extension of crack growth; i.e., a final stage of interaction and coalescence of microcracks. The computations performed for one- and two-dimensional geometries compare admirably well with experimental data for a wide range of materials, including aluminum, steel, iron, copper, and polycarbonates.

In the early 1970s a conventional analytical model based on thermodynamics with internal variables was developed [17, 18]. Damage was assumed to consist of small, independent (non-interacting) cracks distributed in brittle materials and spheroidal voids in ductile materials. In one case [17] damage was defined by a vector normal to the cracks and of a magnitude equal to the relative void area. With spheroidal cavities the damage variable is a scalar. Damage evolution laws are formulated on the basis of existing material science passive models. The rigorous thermomechanical constitution of this model is conducive for future development.

A modification of this model, which contains the original Kachanov's damage theory as a special case, was proposed by Krajcinovic and Srinivasan [19] during a study of the dynamic fracturing of concrete. Instead of postulating an arbitrary damage law, the damage criterion is derived from the associated flow potential, similar to the yield condition in the theory of plasticity. This approach rests on firmer theoretical grounds and facilitates studies of cyclic loads and rotating stress fields. It is also of interest that the thermodynamic force conjugate to the damage variable is related to the crack resistance force, or the energy release rate - stress intensity factor, used in fracture mechanics.

Some essentially linear cases have been studied in which the inertial effects associated with the fast crack growth was introduced [20]. Other linear cases have been studied [21].

SUMMARY

At present it is probably safe to state that the problem of spalling requires significant further development. Elementary methods based on elastic wave propagation are, in all probability, sufficient for general analyses during design. Future development will probably favor continuum mechanics theories. The establishment of a comprehensive theory, despite recent theoretical advances, is far from complete. A better understanding of damage evolution laws, strain rate influences, crack propagation speed, and establishment of an effective wave propagation code are some aspects of the problem that will demand strong efforts. The importance of the problem is sufficient guarantee that such efforts will be forthcoming.

ACKNOWLEDGMENT

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OPTIMAL VIBRATION REDUCTION OVER A FREQUENCY RANGE

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Abstract. This is a review of optimal vibration reduction techniques for systems subject to harmonic excitation over a frequency range. Only passive means of control are considered. The objective functions used for optimization are restricted to those that relate directly to some measure of frequency response. Other common optimization goals such as weight minimization with response constraints are not included in this survey.

CONVENTIONAL DYNAMIC VIBRATION ABSORBER

The simplest device used to attenuate the steady-state vibration of a mechanical system over a frequency range is the conventional dynamic absorber. In the classical analysis, the main system is modeled as a mass resonating on a spring (Figure 1).

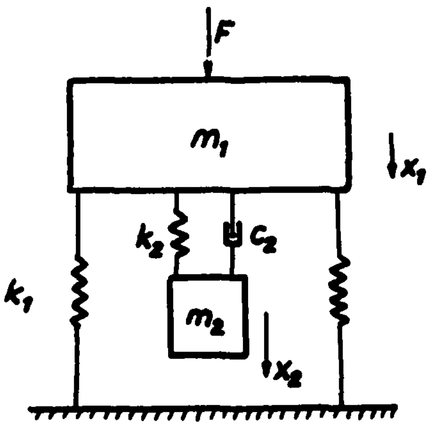

Figure 1. A Mass-Spring System with a Conventional Dynamic Vibration Absorber

The absorber is tuned to resonate such that the motion of its mass m_2 becomes relatively large and the motion of the main mass m_1 is minimized. The first analysis of the absorber is usually attributed to Ormondroyd and Den Hartog [1]. A detailed discussion of optimal tuning and damping parameters is given in Den Hartog's book [2]. The following symbols are used to write the equations of motion in a dimensionless form.

$x_{st} = F/k_1$ = static displacement of main mass produced by a force F

$\mu = m_2/m_1$ = mass ratio = absorber mass/main mass

$\Omega_n = (k_1/m_1)^{1/2}$ = uncoupled natural frequency of main system

$\omega_n = (k_2/m_2)^{1/2}$ = uncoupled natural frequency of damper system

$f = \omega_n/\Omega_n$ = ratio of natural frequencies (1)

$g = \omega/\Omega_n$ = ratio of the exciting frequency to the uncoupled natural frequency of main system

$C_c = 2m_2\Omega_n$ = critical damping

$\xi = c_2/C_c$ = damping ratio

$z_i = x_i/x_{st}$, $(i = 1,2)$ = displacement ratio

With this notation the equations of motion in the frequency domain can be written

$$(1-g^2)z_1 + \mu f^2(z_1 - z_2) + j2\mu\xi g(z_1 - z_2) = 1$$
$$-g^2 z_2 + f^2(z_2 - z_1) + j2g\xi(z_2 - z_1) = 0 \tag{2}$$

which gives

$$z_1 = \frac{A + j\xi B}{C + j\xi D} \tag{3}$$

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where

$$A = f^2 - g^2$$

$$B = 2g$$

$$C = -\mu f^2 g^2 + (g^2 - 1)(g^2 - f^2) \tag{4}$$

$$D = 2g(1 - g^2 - \mu g^2)$$

If $A/C = B/D$, then z_1 becomes equal to A/C, which is independent of damping ξ. For fixed μ and f the condition $A/C = B/D$ yields a quadratic equation in g^2 the two roots of which are the frequencies g_1, g_2 where the amplitude $|z_1|$ of the main mass is independent of damping. The points $(g_1, |z_1(g_1)|)$ and $(g_2, |z_1(g_2)|)$ on the frequency response curve $|z_1(g)|$ are called fixed points or invariant points.

Den Hartog optimizes absorber performance by first choosing $f = \omega_n/\Omega_n$ (tuning) so that the fixed points are adjusted to equal height. He then finds the value of ξ (optimum damping) to make the frequency response curve pass through one of the fixed points with a horizontal tangent. His result for optimum tuning is

$$f = \frac{1}{1+\mu} \tag{5}$$

To find optimum damping for fixed μ, substitute equation (5) into equation (3), find the derivative of $|z_1|$ with respect to g, then evaluate at one of the fixed points, say g_1, and equate the result to zero. From the equation thus obtained the damping ratio may be found as

$$\xi^2 = \frac{\mu(3 - \sqrt{\mu/(\mu+2)}}{8(1+\mu)^3} \tag{6}$$

On the other hand, if the fixed point chosen is the one at g_2, the resulting damping ratio is given by

$$\xi^2 = \frac{\mu(3 + \sqrt{\mu/(\mu+2)}}{8(1+\mu)^3} \tag{7}$$

Den Hartog recommends the use of the average value

$$\xi^2 = \frac{3\mu}{8(1+\mu)^3} \tag{8}$$

EXTENSIONS OF THE CONVENTIONAL DYNAMIC ABSORBER

Lewis [3] extended this optimization procedure to multiple degree-of-freedom, discrete, undamped systems to which a conventional viscous vibration absorber is attached. For such a system with N masses Lewis proves the existence of 2N−2 fixed points. Thus, if the designer selects a resonant peak of primary interest, the adjacent invariant points in the vicinity of this peak can be adjusted as described above to obtain optimum tuning and damping. As a particular case Lewis analyzes the two-mass system shown in Figure 2 and shows that the invariant points occur at the frequencies

$$\omega^2_{a,b} = \frac{K(M_1 + M_2 + m)}{M_1(M_2 + m)} \pm \frac{K\sqrt{2M_1M_2m(M_1 + M_2 + m)}}{2M_1M_2(M_2 + m)} \tag{9}$$

with optimum tuning given by

$$\frac{k}{K} = \frac{m(2M_1M_2 + 2M_2^2 + 2M_2m - M_1m)}{2M_1(M_2 + m)^2} \tag{10}$$

and optimum damping by

$$c^2 = \frac{K(8M_1M_2 + 8M_2^2 + 8M_2m - M_1m)m^3}{4(M_2 + m)^3(M_1 + M_2 + m)} \tag{11}$$

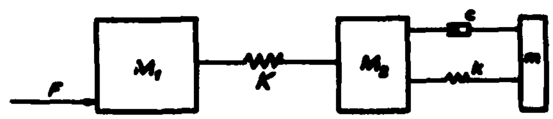


Figure 2. Two-Mass System with Tuned Damper

Snowdon [4] modified the conventional absorber by adding a spring in series with the damper. He showed that the resulting device, called a three-element dynamic absorber, was active through a greater frequency range and reduced transmissibility (absolute value of the ratio of main mass displacement to the prescribed displacement of a foundation attached to the main mass by a spring) more effectively at the center of this range. In the same paper, Snowdon introduced dual absorbers to create a pronounced trough in the transmissibility curve while avoiding the two large compensating resonant peaks that appear in the transmissibility curve of the single absorber. Snowdon attaches these absorbers to an undamped single degree-of-freedom system and provides design information for them in graphical form. Two of his curves have been reproduced to show the changes in transmissibility (Figures 3 and 4).

Randall et al [5] provided optimum absorber design curves for primary systems with damping (Figure 5). They proved that, after damping is introduced into the main system, invariant points no longer exist. Defining a performance measure G by

$$G = \max_{\omega} |x_1(\omega)| \quad (12)$$

they used a numerical search to compute tuning and damping parameters that minimize G.

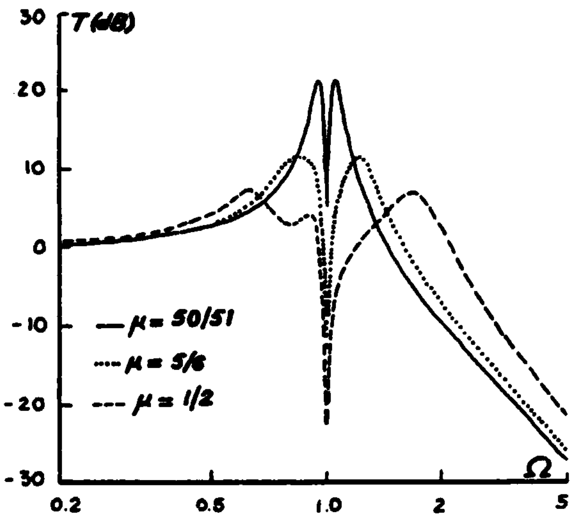
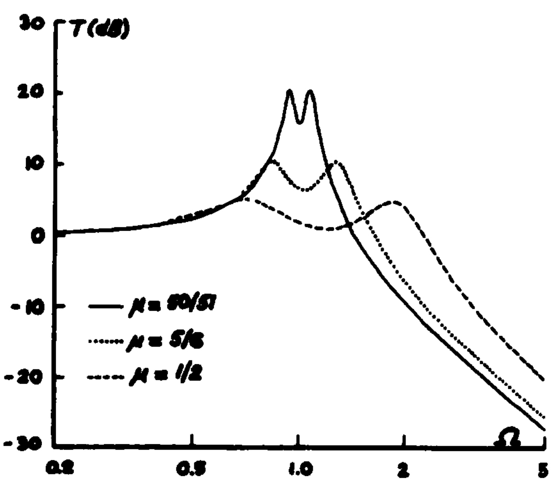


Figure 4. Transmissibility of the Dual Absorber



$\Omega = \dfrac{\omega}{\omega_0}$, $\omega_0^2 = \dfrac{K_1}{M_1+M_2}$, K_1 = spring constant of main system, M_1 = mass of main system, M_2 = mass of absorber, ω = excitation frequency

Figure 3. Transmissibility of the Three-Element Dynamic Absorber

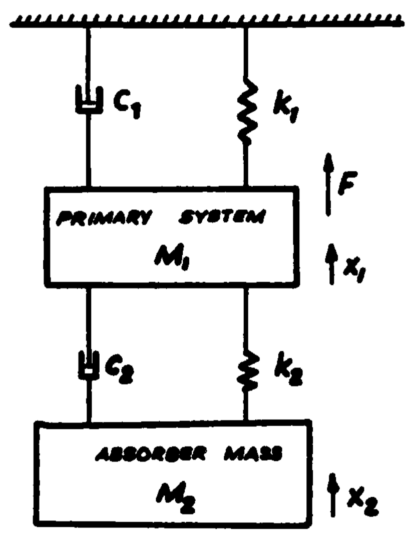


Figure 5. Vibration Absorber for a Damped System

Soom and Lee [6] solved the same problem by nonlinear programming and investigated the possibility of using nonlinear springs to improve broadband response. They also tried several different objective functions, for example

$$G_1 = \sum_{\omega} (|x_1(\omega) - 1|)^2 \text{ for } \omega \text{ such that } |x_1(\omega)| > 1$$

$$G_2 = \max_{\omega} (\omega |x_1(\omega)|)$$

$$G_3 = \sum_{\omega} |x_1(\omega)|^2 \qquad (13)$$

$$G_4 = \sum_{\omega} \omega |x_1(\omega)|^2$$

Nonlinearities have also been treated by Roberson [7] and Arnold [8]. Roberson considered the system shown in Figure 6 in which the spring between the masses M_1 and M_2 is nonlinear. Its load-deflection curve is the sum of a linear and a cubic term. Because the absorber is undamped in this case, its effectiveness is limited to a small frequency range. Roberson's synthesis criterion is the maximization of this suppression band.

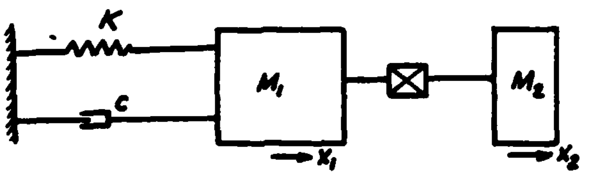


Figure 6. Vibration Absorber with Nonlinear Spring

Arnold [8] studied the same system as Roberson but set c = 0. He provides frequency response curves of the system for hardening and softening coupling springs as well as for a softening spring designed according to Roberson's optimum system-parameter specifications. In both cases [7, 8] the restoring force in the nonlinear spring is taken as a function of spring extension.

$$R(x) = c(x \pm \mu^2 x^3) \qquad (14)$$

The plus sign indicates a hardening spring characteristic and the minus sign indicates a softening one.

Kwak et al [9] and Haug and Arora [10] used a steepest descent algorithm to solve the classical absorber problem over a finite frequency range. Their objective function is

$$G = \max_{a \leq \omega \leq b} |z_1(\omega)| \qquad (15)$$

where z_1 is as defined in equation (1); the frequency interval of interest is [a,b]. They minimize G subject to the constraints

$$\max_{a \leq \omega \leq b} \left| \frac{x_2 - x_1}{x_1} \right| < Q_{max} \qquad (16)$$

$$f_{MIN} < f < f_{MAX} \qquad (17)$$

$$\xi_{MIN} < \xi < \xi_{MAX} \qquad (18)$$

The notation is as in equation (1). They showed that, for certain finite frequency intervals, designs superior to Den Hartog's infinite frequency range optimum can be found.

SYSTEMS WITH CONTINUOUS MEMBERS

Plunkett [11] proved the existence of invariant points for undamped continuous systems to which a single discrete damper has been connected. He exploited this property to determine optimum damping for these systems. His approach is a generalization of the methods of Den Hartog [1, 2] and Lewis [3]. He considers the vibration velocity at one point of a linear system resulting from a sinusoidal force at another point.

Let the force applied at a point 1 be F_1 and v_1 be the velocity at the same point. Suppose a damper with damping constant c is applied across points with relative velocity v_2. Let the unknown vibration velocity at the point of interest be v_3. Plunkett shows that

$$\frac{v_3}{F_1} = jb_1 \frac{1 + jb_2 c}{1 + jb_3 c} \qquad (19)$$

and notes that equation (19) has the same form as Den Hartog's equation (3). Thus when $b_2/b_3 = 1$, the ratio v_3/F_1 is independent of c and has the invariant points property described above in conjunction with the conventional dynamic vibration absorber. The value of c that gives a zero slope of the amplitude $|v_3/F_1|$ with respect to frequency ω at the invariant value of $|v_3/F_1|$ is an optimum value for c. Henney and Raney [12] applied a similar technique to optimize damping for vibrating uniform beams and studied the sensitivity of maximum displacement response to deviation from optimum damping.

Snowdon [13, 14] described the reduction by absorbers of the force transmitted to the terminations of undamped cantilever beams at the resonant frequencies of beam vibration. The systems under consideration are shown in Figure 7. The force transmissibility T across the beam is defined as follows

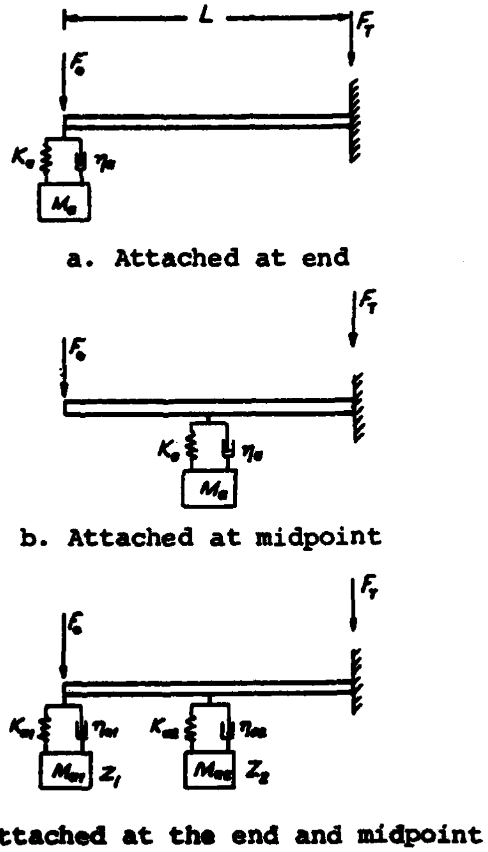
$$T = |F_T/F_0| \tag{20}$$

F_T is the force transmitted to the fixed end and F_0 is the applied force. When a single absorber is used, as in Figures 7a and 7b, essentially the same procedure as that used for the conventional absorber is applicable. The fixed points are located by comparing transmissibility curves obtained for zero and infinite damping. The frequency ratio is then chosen so that the fixed points lie on the transmissibility curve and actually take the equal values of transmissibility at the fixed points.

When two absorbers are applied simultaneously to the beam (Figure 7c), Snowdon's approach is to assign each absorber the values of optimum tuning and damping that were determined when the absorber was attached individually to its present position on the beam. Optimum suppression of both first and second beam resonances results from this procedure.

Jacquot and Foster [15] considered an undamped single-degree-of-freedom system equipped with a damped cantilever beam serving as a vibration absorber. The authors developed an approximate system dynamics by an assumed modes approach. They retained only one mode of the beam. Because the resulting equations were of the form obtained for the conventional absorber problem, the same tuning and damping approach was applicable. Snowdon [16] analyzed platelike absorbers attached either to a lumped mass-spring system or to a plate with small internal damping and presented optimum design parameters in graphical form.

Jacquot [17] appended a discrete absorber with structural or viscous damping to a beam (Figure 8).



K_a = absorber spring constant
η_a = absorber damping constant
M_a = absorber mass
Z = absorber impedance

Figure 7. Dynamic Absorbers Attached to a Cantilever Beam Excited by a Sinusoidally Varying Force at Its Free End

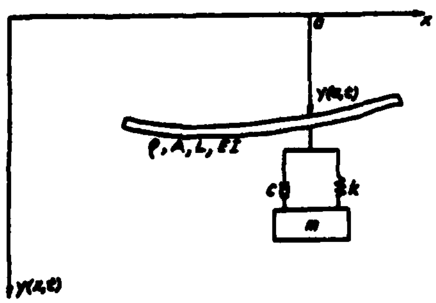


Figure 8. Euler-Bernoulli Beam with Dynamic Vibration Absorber

Using an assumed mode approach as in [15], he derived an approximate frequency response given by

$$y(x,\lambda) = \frac{\epsilon_1 \varphi_1(x)}{EI\beta_1{}^4 L} \frac{T^2 - \lambda^2}{\lambda^4 - \lambda^2(1+T^2(1+\mu\varphi_1{}^2(a))+T^2} \quad (21)$$

where

$$\lambda = (\omega/\beta_1{}^2)\sqrt{\rho A/EI}$$

$$T^2 = (k/m)\,(\rho A/EI\beta_1{}^4) \quad (22)$$

$$\mu = m/\rho AL$$

and β_i, φ_i are the beam mode shapes and eigenvalues satisfying

$$\frac{d^4\varphi_i}{dx^4} = \beta_i\varphi_i \quad (23)$$

Because the form of equation (21) is the same as that found in the conventional absorber problem, with the exception that μ is replaced by $\mu\varphi^2(a)$, Jacquot was able to tune and damp to flatten the fundamental resonance response using Den Hartog's procedure.

Warburton and Ayorinde [18] extended Jacquot's representative mode method to plates and shells by defining appropriate effective mass and stiffness for such elastic bodies. The accuracy of this single-mode approximation was favorably affected if adjacent resonant frequencies were well separated from the natural frequency for which the absorber was being tuned and adversely affected as the absorber size increased. In a companion paper [19], the authors considered cylindrical shells as examples of dynamically complex structures for which the ratio of adjacent natural frequencies tends toward unity. They showed that as dynamic complexity increased optimum absorber parameters deviated from those calculated for an equivalent single-degree-of-freedom system.

MULTIPARAMETER DESIGN BY NONLINEAR PROGRAMMING

McMunn and Plunkett [20] developed a computational method to optimize multiple dampers for large mechanical systems. Damping was defined to be optimum if the maximum response over a range of excitation frequencies was minimized. The response function of interest, for example

$$f(\omega,\underline{c}) = \left|\frac{x_i}{P_j}\right|^2 \quad (24)$$

where x_i is the displacement of the ith mass and P_j is the force on the jth mass, is first maximized with respect to excitation frequency ω using

$$\frac{\partial f}{\partial \omega} = 0 \qquad \frac{\partial^2 f}{\partial \omega^2} < 0 \quad (25)$$

and then minimized with respect to the vector c of damping values

$$\min_{\underline{c}} \quad f(\omega, \underline{c}) \quad (26)$$

In fact, the minimization over c also considers values of f at $\omega = \Omega_1$, and $\omega = \Omega_2$ if a finite frequency interval $[\Omega_1, \Omega_2]$ is being considered. Two multiple-degree-of-freedom, multiple-damper discrete systems and a column with complex modulus damping were studied as examples using this approach. A similar approach was adopted by Ng and Cunniff [21] who designed a three-degree-of-freedom isolation system and verified their results by experimental tests. In their formulation the authors define a primitive function

$$|\underset{\sim}{x}|^2 = (P^{-1}\underline{f})\,(P^{-1}\underline{f})^* \quad (27)$$

where * denotes complex conjugate transpose,

$$P = -\omega^2 M + j\omega C + K \quad (28)$$

and $\underline{f}$ is the force vector. Their first step is to minimize over damping variables the primitive function maximized over frequency

$$\min_{c^1} \; \max_{\omega^1} \; |x^1|^2 \quad (29)$$

They repeat this procedure until an optimum is reached

$$|\underset{\sim}{x}|^2_{opt} = \min_{c^n} \max_{c^n} |\underline{x}^n|^2 \quad (30)$$

Dale and Cohen [22] extended the method of McMunn and Plunkett to continuous systems the steady-state equations of motion of which could be reduced to a set of ordinary differential equations containing spatial coordinates as independent variables. Both dissipative and nondissipative design parameters were included.

Lunden [23] presented a nonlinear programming solution based on a sequential unconstrained minimization technique. The problem was to determine a continuous damping distribution that minimizes the maximum response of a vibrating beam over a specified frequency interval. In a second paper [24] the author applied the same approach to vibrating frames. In these references, the maximum response F in the frequency interval studied is written as

$$F(\eta^d, \eta^s) = \max_{a<\omega<b} f(\eta^d, \eta^s, \omega) \tag{31}$$

where η^d denotes distributed structural damping and η^s denotes the structural damping constants for discrete springs in the system. An exact displacement method is used with hysteretic damping introduced by the loss factor η^d giving a complex bending stiffness $EI(1 + j\eta^d)$. The 4 x 4 stiffness matrix for a beam element then takes the form

$$\underset{\sim}{F} = EI(1 + j\eta^d)K\,\underline{x} \tag{32}$$

where K is a 4 x 4 matrix of transcendental functions of frequency.

Kitis [25] utilizes structural reanalysis and modal techniques with nonlinear programming to make tractable problems in which the systems under consideration contain a large number of degrees of freedom. The repetitive computations of response required in the nonlinear programming portion of the optimal design are carried out using efficient reanalysis methods or condensed eigenproblem solutions; computation time in the structural analysis phase of the design is thus reduced.

IMPEDANCE MATCHING

The progressive wave solution to the wave equation for continuous chain-like systems has been used to minimize vibratory response over a frequency range by means of impedance matching. An illustration of the basic idea of this technique is the rod shown in Figure 9 [14]. Designate the displacement at any point x by ξ and write the wave equation as

$$\frac{\partial^2 \xi}{\partial x^2} + n^2 \xi = 0 \tag{33}$$

where

$$n^2 = \rho \frac{\omega^2}{E} \tag{34}$$

If the end of the rod at x = 0 is subjected to a sinusoidally varying force F_o, then the driving point impedance Z_o is given by

$$Z_o = \frac{F_o}{(\partial \xi/\partial t)_{x=0}} = \frac{F_o}{j\omega\xi_{(x=0)}} \tag{35}$$

Snowdon [14] shows that the impedance Z_o defined in equation (35) can be written as

$$Z_o = A\sqrt{\rho E}\, \frac{1 - Re^{j\varphi}}{1 + Re^{j\varphi}} \tag{36}$$

$Re^{j\varphi}$ describes the relative magnitude of and the phase difference between incident and reflected waves. The characteristic impedance Z_{ch} is defined as the impedance of an infinitely long rod in which reflections do not occur. The value of Z_{ch} is obtained from equation (36) by equating R to zero

$$Z_{ch} = A\sqrt{\rho E} \tag{37}$$

A matched condition will occur if a damper of damping constant Z_{ch} is attached to the rod at x = 0. This attachment causes the ratio R of reflected to incident wave to be zero so that no vibration response buildup due to reflected waves is possible.

This idea has been applied to shafts on supports [26]. Here the dynamic response is expressed in progressive waveform-like electrical response waves in transmission line theory. Waveforms for a uniform shaft flexibly supported on two rotational and translational mass-spring-damper units at the ends and one such unit in the interior are obtained. The terminating impedance is made equal to the characteristic impedance of the shaft to obtain a matched condition.

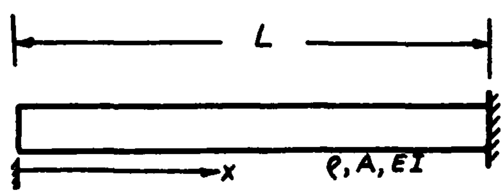


Figure 9. Rod under Longitudinal Vibration

LIMITING PERFORMANCE METHODS

A limiting performance approach has been applied [27, 28] to the optimal design of vibratory systems over a frequency range. In this approach, the design configurations are not fixed at the outset; rather, those parts of the system to be designed are replaced by control forces. For a selected cost function and design constraint the absolute optimal performance of the system can be computed by solving an optimization problem in which the control forces are unknowns. The solution is called the limiting performance of the system.

After the limiting performance characteristics have been found, the designer can choose a prospective configuration for the part of the system to be designed. He can apply parameter identification techniques to find optimum design variable values so that the designed system responds as closely as possible to the limiting performance response. The limiting performance characteristics are found by linear programming; parameter identification can be accomplished by such curve fitting techniques as least squares. This two-stage procedure has been demonstrated for the optimal design of rotor suspension systems [27].

BOOKS AND MONOGRAPHS

The book by Haug and Arora [10] contains considerable material applicable to frequency response shaping; specialized aspects are not treated in detail. Two other useful references are the monograph by Sevin and Pilkey [28] and the book by Snowdon [14]. Sevin and Pilkey present an introduction to the subject and a summary of the state of the art up to 1971. Snowdon's book contains a wealth of information on vibration absorbers and reduction of beam vibrations.

ACKNOWLEDGMENT

This work was supported by the Office of Naval Research, Arlington, Virginia.

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BOOK REVIEWS

FREE VIBRATION ANALYSIS OF RECTANGULAR PLATES

D.J. Gorman
Elsevier-North Holland Pub. Co., New York, NY
1982; 324 pages; $60.00

This work is a summarization and generalization of a number of previously published papers by Professor Gorman dealing with the free vibrations of rectangular plates. It presents the most comprehensive set of published analytical results to date for rectangular plates governed by classical plate theory; that is, the plates are homogeneous, isotropic, and thin and undergo vibrations of amplitude less than thickness and free of in-plane initial stresses. No comparisons are made with the voluminous numerical results found elsewhere in the literature; the results are based on the author's own accurate calculations.

Chapter 2 presents comprehensive eigenfrequencies for six cases of rectangular plates having two opposite sides simply supported and the others simply supported, clamped, or free. These problems have exact solutions in the sense that the eigenfrequencies are obtained from frequency determinants of finite size; in this case the orders are no larger than four, and the well known Voigt-Levy solution of the equation of motion is used. For each of the six cases, 64 frequencies are presented for a/b and b/a = 1, 1.25, 1.5, 2, 2.5, and 3; a and b are the plate dimensions. For plates having free edges (three cases) results are given for two values of Poisson's ratio (0.333 and 0.5).

Chapters 3 through 7 deal with the remaining 15 cases of plates with combinations of clamped, simply supported, and free edges. The method of superimposing infinite series of Voigt-Levy solutions previously developed by the author and others is utilized. Convergence studies were made to establish the accuracy of the frequences to four significant figures. Numerical results for frequencies are typically given for the first ten modes in each case for values of a/b and b/a as listed above. When free edges are involved, Poisson's ratio is set at 0.333.

The last chapter is devoted to a series of problems of rectangular plates either with added point masses or supports or with line supports. Again the superposition procedure is used; results for frequencies are given. Results for frequencies given throughout the book are comprehensive; however, considerably less information is supplied about the corresponding mode shapes.

The reviewer recommends the book to individuals interested in applying the superposition method to the analysis of eigenvalue problems for rectangular regions and those who desire extensive, accurate numerical results for the free vibration of rectangular plates governed by classical theory.

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Columbus, OH

VIBRATIONS OF SHELLS AND PLATES

W. Soedel
Marcel Dekker, Inc., New York, NY
1981; 366 pages; $45.00

This book aims "to give engineering graduate students and practicing engineers an introduction to the vibration behavior of shells and plates." In the opinion of the reviewer the author has succeeded very well. He points out that shell vibrations receive little or no attention in typical vibrations textbooks. The primary emphasis of the book is on shells; plates (and even membranes, straight beams, and rings) are used mainly to provide simple examples when shells would be unduly complicated. Professor Soedel mentions in his Preface that the book evolved from a set of lecture notes developed over a ten-year period.

The chapters are as follows:

1. Historical Development of Vibration Analysis of Continuous Structural Elements
2. Deep Shell Equations
3. Equations of Motion for Commonly Occurring Geometries
4. Non-Shell-Type Structures
5. Natural Frequencies and Modes
6. Simplified Shell Equations
7. Approximate Solution Techniques
8. Forced Vibrations of Shells by Modal Expansion
9. The Dynamic Influence (Green's) Function
10. Moment Loading
11. Vibrations of Shells and Membranes under the Influence of Initial Stresses
12. Shell Equations with Shear Deformation and Rotatory Inertia
13. Combinations of Structures
14. Hysteresis Damping
15. Shells Made of Composite Material

Chapter 1 presents some interesting perspectives of 24 historical figures from Galileo to Love; most of the references were written before 1850. Chapter 2 is a derivation of the equations of Love's theory in curvilinear coordinates. In Chapter 3 these equations are specialized to shells of revolution and to conical, cylindrical, and spherical shells. In Chapter 4 the equations are reduced further to straight and curved beams and plates. Some classical exact, free vibration solutions for straight beams, circular rings, circular plates, simply supported rectangular plates, and circular cylindrical shells are presented in Chapter 5; other sections deal with the orthogonality, superposition, and damping distortions of modes.

Chapters 6 and 7 contain approaches that are useful when exact solutions become untractable. Simplified shell equations include those of membrane, inextensional, and shallow shell theory; they are applied to the free vibrations of several shell configurations. Approximate procedures discussed in Chapter 7 include the interconnected direct variational, Galerkin, and Rayleigh-Ritz methods (with beam functions); finite differences; finite elements; and the Southwell and Dunkerley theorems.

Chapters 8 through 10 deal with forced vibrations. The classical approach for viscously damped systems and an expansion of the displacements and forcing functions in terms of the free vibration eigenfunctions are described. Point and line loads are also discussed. Dynamic influence functions are demonstrated by traveling point loads on shells.

The complicating effects of initial stress, shear deformation, and rotary inertia are discussed in Chapters 11 and 12. The rotating saw blade is used as an example. Beams, plates, and shells are also described. The last three chapters contain introductions to special topics of practical importance.

The book is interestingly written and easy to follow. The reviewer recommends it particularly to the individual who has previously studied vibrations of discrete systems, rods, beams, and plates and wants a beginning understanding of shell vibrations.

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SHORT COURSES

DECEMBER

MODERN COMPUTERS IN MECHANICAL DESIGN

Dates: December 6-7, 1982
Place: Northampton, UK
Objective: The program covers different aspects of CAD and their use in the mechanical engineering environment. It is envisaged that the seminar would be of great interest to managers, technical advisers and any member of a CAD evaluation team in industry. There will be an open forum during the seminar to stimulate discussion on different aspects and related problems which may be of interest to the delegates.

Contact: Dr. M.A. Dorgham, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK - Telephone: Milton Keynes 653945; Telex: 825061.

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

Dates: December 8-12, 1982
Place: Huntsville, Alabama
Dates: February 7-11, 1983
Place: Santa Barbara, California
Dates: March 7-11, 1983
Place: Washington, DC
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 St., Santa Barbara, CA 93105 - (805) 682-7171.

JANUARY

RELIABILITY METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 10-14, 1983
Place: Tucson, Arizona
Objective: The objective of this short course and workshop is to review the elements of probability and statistics and the recent theoretical and practical developments in the application of probability theory and statistics to engineering design. Special emphasis will be given to fatigue and fracture reliability.

Contact: Special Professional Education, Harvill Building No. 76, Room 237, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3054.

FEBRUARY

MACHINERY VIBRATION ANALYSIS

Dates: February 22-25, 1983
Place: Tampa, Florida
Dates: June 14-17, 1983
Place: Nashville, Tennessee
Dates: August 16-19, 1983
Place: New Orleans, Louisiana
Dates: November 15-18, 1983
Place: Chicago, 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 informa-

tion 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, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SYSTEMATIC APPROACH TO IMPROVING MACHINERY RELIABILITY IN PROCESS PLANTS

Dates: February 23-25, 1983

Place: San Francisco, California

Objective: This seminar is intended to guide machinery engineers, plant designers, maintenance administrators, and operating management toward results-oriented specifications, selection, design review, installation, commissioning, and post start-up management of major machinery systems for continued reliable operations. Emphasis will be on pumps, compressors, and drivers.

Contact: Sherry Theriot, Professional Seminars International, P.O. Box 156, Orange, TX 77630 - (713) 746-3506.

MARCH

EXPLOSION HAZARDS EVALUATION

Dates: March 14-18, 1983

Place: San Antonio, Texas

Objective: Fundamentals of combustion and transition to explosion including recent experimentation on large-scale systems, current testing techniques and their utility, accidental explosions, and preventive measures are reviewed. Free-field explosions and their characteristics including definition of an explosion, characteristics of explosions, and the fallacy of "TNT" equivalence are defined. Loading from blast waves such as reflected waves – both normal and oblique, diffraction and diffracted loads, internal blast loading, and effects of venting will be covered. Structural response to blast and non-penetrating impact including approximate methods, the P-i concept, Bigg's methods, numerical methods, and applicable computer codes will be reviewed. Fragmentation and missile effects (trajectories and impact conditions), thermal effects (fireballs from explosions and radiation propagation), damage criteria (buildings, vehicles, and people), and design for blast and impact resistance (general guidelines, design using approximate methods, and computer-aided design) will be reviewed.

Contact: Ms. Deborah Stowitts, Southwest Research Institute, P.O. Drawer 28510, 6220 Culebra Road, San Antonio, TX 78284 - (512) 684-5111.

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

MECHANICAL FAILURES PREVENTION GROUP SYMPOSIUM
Technical Advances and Their Impact on Detection, Diagnosis and Prognosis

The 36th Mechanical Failures Prevention Group (MFPG) Symposium will be held December 6-10, 1982 at the La Posada Hotel, 4949 East Lincoln Drive, Scottsdale, Arizona 85253 - (800) 528-7869. The meeting is sponsored by National Bureau of Standards, Office of Naval Research, Naval Air Systems Command, with participation by the IEEE Reliability Society.

The Symposium will consist of Technical Sessions addressing: Sensors and Instrumentation, New Technologies and Techniques, Applications of Data Processing, Machinery Health Monitoring, Prognosis of Failure, and "Living Papers." The "Living Papers" will consist of visits to local industry and government facilities by those who register in advance. Proceedings will be distributed at the time of registration.

For further information contact: Mr. T.R. Shives, Executive Secretary, MFPG, Materials Building, Room A-113, National Bureau of Standards, Washington, DC 20234.

INTERNATIONAL CONFERENCE ON MODERN VEHICLE DESIGN ANALYSIS
June 21-24, 1983
London, UK

The International Association for Vehicle Design will sponsor a symposium on Modern Vehicle Design Analysis to be held June 21-24, 1983 in London, England. Contributed papers are invited in all areas of vehicle design analysis and especially for applications of structural optimization, graphics as a computational and design tool, vehicle noise and vibration control techniques, nonlinear calculations including crashworthiness studies, and new structural materials for weight and cost savings.

For further information contact: Drs. Mounir M. Kamal and Joseph A. Wolf, Jr., symposium organizers, Engineering Mechanics Department, General Motors Research Laboratories, Warren, MI 48090 - (313) 575-2929; or Dr. M. Dorgham, International Association for Vehicle Design, The Open University, Milton Keynes, MK7 6AA, England.

INFORMATION RESOURCES

SOIL MECHANICS INFORMATION AND ANALYSIS CENTER (SMIAC)

INTRODUCTION

The Soil Mechanics Information and Analysis Center (SMIAC) is located at the U.S. Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi. It is one of four Department of Defense (DOD) information analysis centers at WES and was established in 1966. The Center provides users with information in soil mechanics, engineering geology, rock mechanics, engineering seismology, geophysics, earthquake engineering, and soil dynamics. It primarily serves technical information needs of the Department of the Army, Research and Development community, and the Corps of Engineers' Civil Works and Military activities. Because of the concentration of both civil and military research related to its subject areas at WES, much of the assistance rendered by the Center is provided to WES researchers. A significant number of requests for geotechnical information from other DOD agencies, contractors, and the scientific community are also handled each year.

MISSION AND APPROACH

The mission of the SMIAC is to collect, analyze, evaluate, condense, and disseminate technical information in its subject areas to a broad group of users. The current volume of material being published in its subject area is enormous. A potential user of the Center could undertake his own literature search and review in any good technical library and would eventually find the specific information being sought. Most individuals do not have time to do this; they need a specific answer to a specific question. The SMIAC tries to provide this answer by referring the requestor to a specific reference or to an expert who is knowledgeable about the problem. The Center also performs literature searches in specific subject areas when asked.

ORGANIZATION

The SMIAC is staffed by a director and one other geotechnical engineer. Technical assistance in developing answers to specific questions is provided by the engineers and scientists of the Soil Mechanics, Engineering Geology and Rock Mechanics, and the Earthquake Engineering and Geophysics Divisions of the WES Geotechnical Laboratory. Questions on the response of soils to blast and shock loading are referred to the Geomechanics Division of the WES Structures Laboratory.

Funding to operate the Center is provided by the U.S. Army Materiel and Readiness Command (DARCOM) and the Civil Works Directorate of the Office, Chief of Engineers.

RESOURCES AND OPERATION

The principal resource of the SMIAC is people. Nearly 100 specialists in various aspects of the subject matter covered by this SMIAC are available at WES as resource persons. Their ready knowledge of the field of research in which they work makes possible quick, accurate, and specific answers to many of the queries received by the Center.

The SMIAC draws support from the WES Technical Information Center whose library contains about 80,000 items relating to the field covered by the Center. These items include books, technical journals, reports, periodicals, reprints, and microfilm. In addition to the card catalog, relevant indexes available in the library include Engineering Index, Applied Science and Technology Index, British Technology Index, Monthly Catalog of U.S. Government Publications, and Government Reports Index. In addition, the library has the following other catalogs from libraries or information centers in either card or book form: U.S. Geological Survey Library, Engineering Societies Library, John Crerar Library (Chicago), and the Library of Congress. A remote on-line terminal links SMIAC through the WES library with the Defense Research and Development Test and Evaluation On-Line System's Technical Report and Work Unit Data Banks. The SMIAC also uses the Lockheed Information System DIALOG to access a number of data bases of geotechnical interest. ***Geodex, Geotechnical Abstracts,*** and ***Rock Mechanics Abstracts*** are hands-on data bases which the Center uses regularly in its work.

The SMIAC also serves as the repository for a portion of the personal papers of the late Dr. Arthur Casagrande, a long-time consultant to the Corps of Engineers and an internationally recognized leader in soil mechanics.

The day-to-day operation of the Center involves responses to telephone or written requests for information. These responses take three forms: (a) oral or written advice from a technical expert or the WES staff, (b) specific reference to a particular technical document plus arrangement for loan of that document by the WES library, or (c) a literature search which results in a bibliography and set of abstracts furnished to the requestor.

SERVICES AND PUBLICATIONS

As indicated above, SMIAC serves its user community through personal technical advisory services carried out in close cooperation with the staffs of the Geotechnical Laboratory and the WES Technical Information Center. Most requests for assistance take less than one day for response and no charge is made for these services. Requests for service involving substantial efforts are handled on a cost-reimbursable basis.

Technical inquiries or requests for publications. Quick response is provided through the personal geotechnical expertise of the staff, referral to other WES experts, or the use of the various data bases described earlier. The staff conducts literature searches, reviews documents, and performs analyses where necessary to produce the desired result. In the case of more complex studies, this takes the form of a letter report to the user providing the technical data or information requested. Requests for loan of publications are referred to the WES library. Requests for retention copies of WES reports are usually referred to Defense Technical Information Center (DTIC) or National Technical Information Service (NTIS). However, on occasion, the SMIAC is able to supply a retention copy of a recent WES report.

Current awareness program. Internal to WES, the SMIAC provides a current awareness service to WES researchers. This is accomplished by scanning DTIC current publication lists and selected journals and providing individuals with abstracts which are believed relevant to their current activities.

Special studies. The Center is currently preparing an English, French, German, and Russian language Soil Mechanics Glossary of over 8500 terms. Publication is expected in 1983. In addition, SMIAC has added several thousand entries of abstracts of soil mechanics literature from non-DOD sources into the DTIC technical report data bank for ready access. The Center also published the "Microthesaurus of Soil Mechanics Terms" in 1974.

POINTS OF CONTACT FOR SERVICES

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ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (DA), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, DC 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2365, 2372, 2400, 2436, 2458)

82-2285

On the Stability of Rotating, Axially Loaded, Homogeneous Shafts

J. Wauer
Inst. f. Technische Mechanik, Univ. Karlsruhe, Kaiserstrasse 12, D-7500 Karlsruhe-1, Germany, Intl. J. Solids Struc., 18 (6), pp 459-466 (1982) 4 figs, 10 refs

Key Words: Stability, Shafts, Beams, Rotating structures, Timoshenko theory, Continuous parameter method

Using a rotating Timoshenko-beam subjected to axial pressure load with internal and external damping a general circulatory vibration system with distributed parameters is formulated in which stability behavior is discussed in detail. The effect of gyroscopic stabilization and its influence on the different damping mechanisms is studied. By means of modern operator methods the well-known theorems of Thomson and Tait are generalized for one-dimensional, continuous rotor systems.

82-2286

Acceleration of Torsional Crankshaft Vibrations in a Diesel Engine with a Tuned Vibration Damper (Drehschwingungsbeschleunigung von Kurbelwellen bei Dieselmotoren mit federgekoppelten Drehschwingungsdämpfern)

F. Martinek
MTZ Motortech. Z., 43 (6), pp 269-270 (June 1982) 4 figs, 3 refs
(In German)

Key Words: Shafts, Crankshafts, Torsional vibration, Diesel engines, Dynamic vibration absorbers (equipment)

Vibratory stress from a crankshaft can be controlled by a tuned torsional vibration damper. Vibrations in auxiliary drives are also reduced. Vibratory acceleration of a crankshaft-mounted gear will force a rigidly coupled power take-off to oscillate. For design of directly coupled pump drives, the additional load due to crankshaft vibration must be compensated for to protect gears, bearings and shafts. Serious problems due to lack of space are encountered when engine output is increased.

82-2287

On the Stability of a Rotating Elastic Shaft Supported by Journal Bearings

Y. Tsuda, J. Inoue, H. Tamura, and A. Sueoka
Ohita Univ., 700 Dannoharu, Ohita-shi, Japan, Bull. JSME, 25 (203), pp 856-861 (May 1982) 7 figs, 7 refs

Key Words: Shafts, Flexible shafts, Bearings, Journal bearings, Oil whip phenomena

The theoretical stability characteristics of a rotating elastic shaft are investigated. For a symmetrical rotating shaft model, in which the shaft with a rotor at its midpoint is supported by journal bearings, the limit frequency at which oil whirl of conical mode starts (for both elastic and rigid shafts) can be analytically obtained in addition to the critical conditions which are absolutely stable against that mode of oil whip. A stability chart for the translational mode based on infinitely short bearing approximations and Gumbel's boundary condition is also presented.

82-2288

Closed Form Steady-State Solution for the Unbalance Response of a Rigid Rotor in Squeeze Film Damper

D.L. Taylor and B.R.K. Kumar
Cornell Univ., Ithaca, NY, ASME Paper No. 82-GT-263

Key Words: Rotors, Rigid rotors, Unbalanced mass response, Squeeze film dampers

This paper considers the steady-state response due to unbalance of a planar rigid rotor carried in a short squeeze film damper with linear centering spring. The damper fluid forces are determined from the short bearing, cavitated solution of Reynolds' equation.

82-2289

Influence of Unsteady Aerodynamics on Hingeless Rotor Ground Resonance

W. Johnson

NASA Ames Res. Ctr., Moffett Field, CA, J. Aircraft, 19 (8), pp 668-673 (Aug 1982) 12 figs, 2 tables, 16 refs

Key Words: Rotors, Hingeless rotors, Helicopters, Rotors

Calculations of the modal frequency and damping for a hingeless rotor on a gimballed support in hover are compared with measured results for two configurations (differing in blade flap stiffness). Good correlation is obtained when an inflow dynamics model is used to account for the influence of the unsteady aerodynamics. The effect of the unsteady aerodynamics is significant for this rotor system. The inflow dynamics model introduces additional states corresponding to perturbations of the wake-induced velocity at the rotor disk. The calculations confirm the experimental observation that the inflow mode introduced by these additional states is measurable for one configuration but not for the other.

82-2290

Nonlinear Bearing Effects on Rotor Dynamic Analysis

R. Colsher, I. Anwar, and V. Obeid

The Franklin Inst. Res. Lab., Philadelphia, PA, ASME Paper No. 82-GT-291

Key Words: Rotors, Fluid-film bearings, Transient response

Nonlinear effects due to fluid film bearings become significant when vibratory amplitudes are large. To include these effects in rotor dynamic analysis requires conducting time-transient response analysis, where the fluid film forces are estimated at each time step. This paper describes an approach where a unique treatment of bearing forces results in an efficient computational scheme for performing time transient analysis.

82-2291

Solution to a Bistable Vibration Problem Using a Plain, Uncentralized Squeeze Film Damper Bearing

J.A. Palladino and T.W. Gray

General Electric Co., Lynn, MA, ASME Paper No. 82-GT-281

Key Words: Rotors, Turbines, Vibration control, Critical speeds, Bearings, Squeeze film dampers

This paper demonstrates that the use of a plain, uncentralized, squeeze film damper to support the turbine rotor solves all vibration problems by reducing the turbine critical speed and separating it from the casing mode. Also included are effects of exhaust system weight on engine vibration and cabin noise levels.

82-2292

Control of Self-Excited Flow Oscillations in Vaneless Diffuser of Centrifugal Compression Systems

A.N. Abdelhamid

Carleton Univ., Ottawa, Canada, ASME Paper No. 82-GT-188

Key Words: Compressors, Centrifugal compressors, Fluid-induced excitation

Experiments were conducted to evaluate the effectiveness of axisymmetric diffuser exit throttle in delaying the occurrence of self-excited flow oscillation in vaneless diffusers. Sharp edge rings were installed at diffuser exit in order to change the exit flow area. Tests were carried out with the rings attached to one or both of the diffuser walls. Steady and unsteady flow measurements were used to determine the flow field in the diffuser at the onset of the flow oscillations.

82-2293

Critical Speed in Centrifugal Pumps

S. Gopalakrishnan, R. Fehlau, and J. Lorett

Borg-Warner Corp., Commerce, CA, ASME Paper No. 82-GT-277

Key Words: Pumps, Centrifugal pumps, Critical speeds

Simplified equations are derived for the calculations of fluid gap. The results are verified by measurements on a test pump. Sample calculations for a typical multistage boiler feed pump are included as illustration.

82-2294

Understand Critical Speed of Pumps to Help Predict Service Instability

S. Gopalakrishnan, R. Fehlau, and J. Lorett

Byron Jackson Pump Div., Borg-Warner Corp., Power, 126 (1), pp 37-40 (Jan 1982) 10 figs, 5 refs

Key Words: Pumps, Critical speeds

The influence of fluid gap, either at sealing rings or throttle bushings, can outweigh elastic stiffness and greatly affect service instability of the pump. Simplified equations give aid in preparing specifications.

82-2295

Calculation of Wide-Band Components in the Sound Power Spectrum of Axial-Flow Fans (Vortex Noise) (Zur Berechnung breitbandiger Komponenten im Schalleistungsspektrum von Axialventilatoren (Wirbellärm)

S. Gruhl, K. Biehn, J. Plundrich, and P. Költzsch
Zentralinstitut f. Arbeitsschutz Dresden, Germany,
Maschinenbautechnic, 31 (6), pp 269-272 (1982) 4 figs, 7 refs
(In German)

Key Words: Fans, Sound pressure levels, Vortex noise

Using acoustic models of cascades, equations for the calculation of broadband sound power of axial-flow fans (vortex noise) are derived. The random time-variable blade forces, caused by turbulent flow, are taken as the acoustic excitation forces. From this data sound power levels are deduced and the sound power level of fans is approximated.

RECIPROCATING MACHINES

82-2296

Review of Diesel Engine Noise

M.J.J. Slabber
Atlantis Diesel Engines (Pty) Ltd., Cape Town, South Africa, Presented at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981, 23 pp
PB82-206087

Key Words: Diesel engines, Engine noise, Reviews

The mechanism of noise generation from diesel engines and the associated components and structures is presented. Methods to establish the main sources of noise and the effectiveness of structural redesign together with the influence of encapsulation are reviewed.

MATERIALS HANDLING EQUIPMENT

82-2297

Crane Cab Vibration Damping (Schwingungsdämpfung für Krankabinen)

H. Flaig
Mannesmann-Demag Fordertechnik, Wetter, Ruhr,
VDI Z., 124 (9), pp 341-344 (1982) 10 figs, 4 refs
(In German)

Key Words: Cranes (hoists), Vibration damping

A new type of suspension for a crane cabin reduces the vibration of the cab. The suspension can be used with any cab, regardless of weight and is suitable for any reorganization of crane installation.

82-2298

About the New Method to Regulate the Eccentric Force of Mechanical Vibrators

R. Bansevicius and A. Rovetta
Kaunas Polytechnical Inst., Kaunas, Lithuania, USSR,
Meccanica, 4 (16), pp 181-191 (Dec 1981) 20 figs, 6 refs

Key Words: Vibrators (machine), Vibration control

This paper presents a new method for continuous regulation of a vibratory machine oscillation amplitude, by acting only on the electronic equipment, which can be placed at a distance from the machine. The regulation is obtained by the starting transient, with variation of the angular positions of two unbalanced masses. Experimental tests on the analysis of the dynamics and stability of the motion of the rotating unbalanced masses are reported. The influence of the mechanical configuration of the system is examined.

STRUCTURAL SYSTEMS

BRIDGES

82-2299

Natural Oscillations of Suspension Bridges

F. Van der Woude
Univ. of Tasmania, Hobart, Australia, ASCE J. Struc. Div., 108 (ST8), pp 1815-1829 (Aug 1982) 3 figs, 2 tables, 9 refs

Key Words: Bridges, Suspension bridges, Natural frequencies, Mode shapes

Natural modes and frequencies of a simple span suspension bridge with straight backstays are investigated theoretically and experimentally. Fourier series representations of cable displacements are used in conjunction with the Lagrange method to represent the system with a small number of degrees-of-freedom. Bridge system matrices are derived which take into account cable, gravity, bending, and torsional stiffnesses. Natural modes and frequencies are obtained as the eigensolutions of small order system matrices. A numerical example is given from which approximate frequency formulas are derived. Experimental results in the form of frequency response curves are presented for a laboratory model.

82-2300

Comparison Between Theory and Experiment in the Flutter and Buffeting of Long-Span Suspension Bridges

H.-S.-W. Soo

Ph.D. Thesis, Princeton Univ., 318 pp (1982)

DA8213546

Key Words: Bridges, Suspension bridges, Flutter

A theory for the buffeting of long-spanned suspension bridges is proposed and a numerical computation based on this theory is carried out. The computed results and the experimental measurements are in reasonable agreement in view of the required approximations implicit in two important parameters; namely, the aerodynamic admittance function and the bridge vibration modes, which are taken here as uncoupled in bending, torsion, and sway.

82-2301

Bridge Impact Due to Wheel and Track Irregularities

A. Wiriyachai, K. Chu, and V.K. Garg

Illinois Inst. of Tech., Chicago, IL, ASCE J. Engrg. Mech. Div., 108 (EM4), pp 648-666 (Aug 1982) 15 refs, 8 tables, 27 refs

Key Words: Bridges, Moving loads

The impact factors in bridge members due to flat wheels and track irregularities are investigated. The track roughness spectra for class 6 track was used in the analysis, and only selected members of the 175 ft pinned connections truss bridge were studied.

82-2302

Effects of Traffic-Induced Vibrations on Bridge-Deck Repairs

Transportation Res. Board, Washington, DC, Rept. No. TRB/NCHRP/SYN-86, ISBN-0-309-03304-7, 50 pp (Dec 1981)

PB82-198490

Key Words: Bridges, Traffic-induced vibrations

This synthesis will be of special interest to engineers concerned with placement of concrete for construction or repair of bridge decks. Recommendations are provided for restoring, patching, and widening bridge decks in the presence of traffic. This report concludes that traffic can be maintained on the bridge while concrete is placed in deck repairs, overlays, widenings, or replacements.

82-2303

Seismic Design Guidelines for Highway Bridges

R.L. Mayes and R.L. Sharpe

Applied Technology Council, Berkeley, CA, Rept. No. FHWA/RD-81/081, 216 pp (Oct 1981)

PB82-181611

Key Words: Bridges, Seismic design

This document contains guidelines for the seismic design of highway bridges. The guidelines are the recommendations of a team of nationally recognized experts which included consulting engineers, academicians, state highway, and federal agency representatives from throughout the United States. The guidelines are comprehensive in nature and embody several new concepts which are significant departures from existing design provisions. An extensive commentary documenting the basis for the guidelines and an example demonstrating their use are included.

BUILDINGS

82-2304

The El Asnam Earthquake of 10 October 1980: Characteristics of the Main Shock and Lessons to be Drawn for Earthquake Engineering

J. Despeyroux

SOCOTEC, Seige Social: Tour Maine-Montparnasse, 33 avenue del Maine, 75755 Paris Cedex 15, France, Engrg. Struc. 4 (3), pp 139-146 (July 1982) 14 figs, 10 refs

Key Words: Buildings, Earthquake damage, Seismic response

The main shock of the earthquake at El Asnam on 10 October 1980 was a sudden, vertical impulse with high frequency vibrations of short duration followed by lesser vibrations. Case histories of a number of buildings are given, and the lessons that can be drawn from their failure, for future aseismic design.

82-2305

Dynamic Behavior of Rocking Structures Allowed to Uplift

I.N. Psycharis

Earthquake Engrg. Res. Lab., California Inst. of Tech., Pasadena, CA, Rept. No. EERL-81-02, NSF/CEE-81096, 238 pp (1982)

Ph.D. Thesis

PB82-212945

Key Words: Buildings, Seismic design, Foundations, Springs

This report studies the phenomenon of uplifting, the partial separation of the base of a structure from its foundation, which occurs during the ground-shaking of an earthquake. The cases of both a rigid superstructure and a multistory building are considered. Two foundation models which permit uplift are used: the Winkler foundation model, and the much simpler, two-spring foundation model. Simple approximate methods for calculation of the apparent fundamental period of the rocking systems are developed and simplified methods of analysis are proposed.

82-2306

Identification of Understrength and Overstress Parameters for RC Buildings in Greece

V.C. Kalevras

Dept. of Civil Engrg., Democritus Univ. of Thrace, Xanthi, Greece, Engrg. Struc., 4 (3), pp 161-172 (July 1982) 6 figs, 9 tables, 28 refs

Key Words: Buildings, Reinforced concrete, Seismic response, Seismic design

The need for a simple, rational and instructive model of seismic capacity evaluation of existing buildings is stressed and the advantages of using understrength and overstress coefficients are illustrated. Identification and classification of understrength and overstress parameters of earthquake behavior of RC buildings in Greece is presented, based on extensive surveys after the Volvi (1978), Magnissia (1980) and Alkyonides (1981) earthquakes. These parameters apply equally to RC buildings in other geographical areas. Distribution of frequencies for the different types and degrees of understrength and overstress problems in Greek RC buildings is also given.

82-2307

Evaluation of a Shaking Table Test Program on Response Behavior of a Two Story Reinforced Concrete Frame

J.M. Blondet, R.W. Clough, and S.A. Mahin

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/42, NSF/RA-800547, 244 pp (Dec 1980)

PB82-195644

Key Words: Buildings, Reinforced concrete, Seismic response, Dynamic tests, Shakers

This report presents an evaluation of the different stages involved in an experimental study of the seismic behavior of a reinforced concrete structure, by means of an earthquake simulator (shaking table). The discussion is focused mainly on how representative the test structure and the table input motions are with respect to the actual, real life buildings and seismic ground excitations. The design of the structure is then reviewed from the point of view of a current seismic code, and the experimental results are compared with analytical expectations as well as with the design demand levels.

82-2308

Seismic Design of Steel Buildings

B. Kato and H. Akiyama

Dept. of Architecture, Univ. of Tokyo, 7-3-1, Hongo, Bunkyoku, Tokyo 113, Japan, ASCE J. Struc. Div., 108 (ST8), pp 1709-1720 (Aug 1982) 7 figs, 2 tables, 11 refs

Key Words: Buildings, Steel, Earthquake damage, Seismic excitation

An approach for the ultimate limit state design of steel buildings against the credible severest earthquake is presented on the basis of energy concept. The safety of a structure is judged by comparing structure's energy dissipating capacity with earthquake input energy to the structure. A general safety criterion is first developed for a simple elasto-plastic shear-type system, and then a procedure is analyzed in detail to relate the strength and deformation capacity of steel members to those of the dynamically equivalent elasto-plastic system.

are summarized. A computer program for studying material models is described, and some preliminary examples are given. A study of insitu material behavior is presented in which several two-dimensional simulations of cylindrical insitu test events were performed.

TOWERS

82-2309

The Aerodynamic Behaviour of the Framed Multiflue Chimney Stack of Edinburgh Royal Infirmary

H.Y. Wong and D. Dick
Dept. of Aeronautics & Fluid Mechanics, Glasgow Univ., UK, Struc. Engr., 60A (7), pp 211-216 (July 1982) 6 figs, 1 table, 13 refs

Key Words: Chimneys, Aerodynamic stability, Wind-induced excitation

Steel chimneys have been known to be subject to wind-induced oscillation. As a design procedure, an investigation was carried out on the aerodynamic oscillatory behavior of the proposed Edinburgh Royal Infirmary boilerhouse stack through wind tunnel tests on models fitted with various types of aerodynamic damping device. When the new stack was erected, with the incorporation of a damping device consisting of a system of longitudinal slats, instrumental observation on the behavior of the complete structure in wind was also carried out in situ.

82-2311

Estimating the Flexibility of Offshore Pile Groups

M.F. Randolph and H.G. Poulos
Dept. of Engrg., Cambridge Univ., UK, Rept. No. CUED/D-SOILS/TR-116, 19 pp (Apr 1982)
PB82-181405

Key Words: Foundations, Stiffness coefficients, Pile structures, Offshore structures

The overriding criterion in designing piles to support offshore structures is usually the required axial capacity of the pile. The number of piles, and frequently the diameter of each pile, may be fixed at an early stage of the design, while the final length of each pile is only settled after detailed site investigation and the application of a variety of design procedures for estimating the profile of ultimate skin friction. The stiffness of the final foundation must also be estimated accurately in order that the dynamic performance of the structure may be assessed. Modern methods of calculating the stiffness of a piled foundation involve first estimating the axial and lateral stiffness of a single, isolated, pile, and then using appropriate interaction factors and frame analysis techniques to arrive at a stiffness matrix for the complete pile group.

FOUNDATIONS

(Also see Nos. 2305, 2315)

82-2310

Fundamental Properties of Soils for Complex Dynamic Loadings

W.C. Dass, J.L. Bratton, and C.J. Higgins
Applied Res. Associates, Inc., Albuquerque, NM, Rept. No. AFOSR-TR-82-0101, 177 pp (Sept 30, 1981)
AD-A111 901

Key Words: Interaction: soil-structure, Computer programs

An improved understanding of the fundamental behavior of soils under dynamic loads can lead to better modeling of many important soil and soil-structure phenomena. This report presents the initial results of a research program directed toward this goal. Constitutive modeling requirements are briefly reviewed, and results of a literature survey

82-2312

Reflection of Elastic Waves under Initial Stress at a Free Surface: P and SV Motion

A. Chattopadhyay, S. Bose, and M. Chakraborty
Dept. of Physics and Math., Indian School of Mines, Dhanbad-826004, India, J. Acoust. Soc. Amer., 72 (1), pp 255-263 (July 1982) 17 figs, 6 refs

Key Words: Elastic waves, Wave reflection, Sand

The phenomenon of reflection of elastic waves at a free surface of an initially stressed sandy medium is studied. The reflection coefficients are computed numerically for both P and SV motion. The variations of reflection coefficients for different values of η, initial stress parameter, and angle of incidence are represented graphically. The effects of initial stress and sandiness of the layer on surface waves is also studied.

82-2313

Full-Scale Pile Vibration Tests

C.F. Tsai, R. Scott, and D. Steussy

Ertec Western, Inc., Long Beach, CA, Rept. No. NSF/CEE-81077, 127 pp (Dec 1981)

PB82-192378

Key Words: Interaction: soil-structure, Pile structures, Vibration tests

A test program designed to study the potential phenomenon of liquefaction in soil adjacent to pile lead and to monitor the dynamic response characteristics of the pile-soil system during vibration is summarized. Field tests and analytical studies are summarized and results are presented in terms of pile resonance frequencies, model shapes, damping, bending moments, forces, and displacements.

82-2314

Foundation Engineering: Finite Element Analysis, 1970 - June 1982 (Citations from the Engineering Index Data Base)

NTIS, Springfield, VA, 169 pp (June 1982)

PB82-867805

Key Words: Bibliographies, Finite element technique, Foundations, Interaction: soil-structure, Interaction: structure-foundation

This bibliography contains citations concerning the application of finite element methods to analyze structural foundations. Structural subject matter includes pile foundations, drilled shaft foundations, footing designs, and anchors for towers and earth-retaining walls. In addition to the usual applications to buildings, towers, and walls, the citations include references to caissons, railway ballast, and pipeline foundations. The kinds of analyses include dynamic soil-structure interactions, such as in cyclic loads, seismic loads, and deformations on slopes; behavior of foundations on elastic or flexible soils and interlocked rocks; and, behavior under lateral loads.

UNDERGROUND STRUCTURES

82-2315

Dynamic Response of Framed Underground Structures

G.D. Manolis and D.E. Beskos

Dept. of Civil Engrg., State Univ. of New York, Buffalo, NY 14260, Computers Struc., 15 (5), pp 521-531 (1982) 12 figs, 3 tables, 47 refs

Key Words: Framed structures, Underground structures, Interaction: structure-fluid, Layered materials, Dynamic stiffness, Influence coefficient method, Laplace transformation

The dynamic response of framed underground structures under conditions of plane strain is numerically determined in this work. The soil deposit surrounding such structures is assumed to be horizontally layered and resting on a rigid base from which shear waves originate, and to exhibit linear elastic or viscoelastic material behavior. The methodology consists of applying the Laplace transform with respect to time to the governing equations of motion of the soil and the structure and subsequently constructing dynamic stiffness influence coefficients for typical soil and structure elements. A numerical inversion of the solution obtained by the finite element methodology employing the influence coefficients in the transformed domain yields the response as a function of time. Numerical examples to illustrate the method and demonstrate its advantages are presented.

CONSTRUCTION EQUIPMENT

82-2316

Auger Construction Providing Reduced Noise

T.J. Retka and D.W. Schoen

Dept. of the Interior, Washington, DC, US Patent No. 4 266 830, 5 pp (May 12, 1981)

Key Words: Augers, Noise reduction

An auger construction is provided which reduces the surface noise radiated by the auger and serves to at least partially isolate the auger from the remainder of the machine. The auger construction comprises an inner shaft and outer concentric shafts, the latter carrying the helical cutting blade and generally corresponding to the shaft of a conventional auger. An elongated annulus of noise and vibration dampening material is disposed between the inner and outer shafts. A number of arrangements are disclosed for fixing the two shafts together so as to prevent rotational slippage.

POWER PLANTS

(Also see No. 2485)

82-2317

On-Line Analysis of Reactor Noise Using Time-Series Analysis

V.G. McGevna
Lawrence Livermore Natl. Lab., CA, Rept. No. UCRL-86156, CONF-811012-5, 16 pp (Oct 1981) (Presented at the IEEE Symposium on Nuclear Science, San Francisco, CA, Oct 1981)
DE82001720

Key Words: Nuclear reactors, Noise analyzers, Time domain method, Acoustic response

A method to allow use of time series analysis for on-line noise analysis has been developed. On-line analysis of noise in nuclear power reactors has been limited primarily to spectral analysis and related frequency domain techniques. Time series analysis has many distinct advantages over spectral analysis in the automated processing of reactor noise.

82-2318

Conventional Earthquake Response Estimation Technique for Mechanical Appendage Structure System (Proposition of Floor Response Amplification Factor)

S. Aoki and K. Suzuki
Tokyo Metropolitan Univ., 2-1-1, Fukazawa, Setagaya-ku, Tokyo, Japan, Bull. JSME, 25 (204), pp 969-976 (June 1982) 7 figs, 4 tables, 9 refs

Key Words: Nuclear reactor components, Nuclear power plants, Seismic response, Earthquake response

A practical conventional technique for estimating earthquake response of a mechanical appendage system – pipings, tanks, electrical and mechanical equipment -- supported by the primary supporting system installed on nuclear power plants and other industrial facilities, is proposed and discussed. Basic response properties for the appendage system can be represented by the proposed floor response amplification factor in this technique. This factor depicts the ratio of the maximum response of the appendage system to the response spectrum for the supporting system and can be conventionally drawn upon tripartite diagram for engineering use. Its statistical characteristics are investigated. This technique can be applied to a nonelastic case where the restoring force-deformation relation for the appendage system can be simplified as a perfectly-elastoplastic model.

OFF-SHORE STRUCTURES

(Also see No. 2311)

82-2319

Dynamic Response of Offshore Platforms to Extreme Waves Including Fluid-Structure Interaction

S.A. Anagnostopoulos
Shell Oil Co., Houston, TX, Engrg. Struc., 4 (3), pp 179-185 (July 1982) 8 figs, 17 refs

Key Words: Off-shore structures, Drilling platforms, Interaction: structure-fluid, Wave forces

Basic considerations for dynamic response analyses of offshore platforms under extreme wave loadings are discussed and the main difficulties of the problem are pointed out. These difficulties arise from the random nature of the loading, the nonlinearity of the drag dominated wave forces and the dependence of such forces on the response of the structure. A time domain solution is recommended, using kinematics of a random sea state for the wave force model along with a relative velocity formulation to account for fluid-structure interaction. The proposed solution is based on approximating structural velocities in Morison's equation with their values at the previous time step. This simplification linearizes the equations of motion and permits analyses of detailed structural models by modal techniques. A limited comparison with results from a more accurate solution appears to justify this approximation.

82-2320

Large Scale Service Loading Fatigue Testing with Particular Reference to Offshore Structures

K.J. Marsh
Natl. Engrg. Lab., East Kilbride, Scotland, Rept. No. NEL-672, 28 pp (Dec 1980) (Presented at UK-USSR Select Sem. on Corrosion Fatigue, Lvov, USSR, May 1980)
N82-21622

Key Words: Off-shore structures, Fatigue tests, Drilling platforms

A range of tests on welded steel tubular joints, as used in offshore jacket platforms, and parallel work on simpler cruciform welded joints are described. Testing in a seawater environment and the effect of various random loading stress histories appropriate to off-shore structures are covered. Photographs of test procedures in operation are given. There are three different geometries of tubular joint in the program. Three different modes of loading are investigated: axial loading in the brace member (with the chord free to bend and bulge); in-plane bending of the brace member with respect to the chord; and out-of-plane bending.

VEHICLE SYSTEMS

GROUND VEHICLES

82-2321

Calculation of Handling Characteristics of Passenger Car

F. Vlk
Dept. of Internal Combustion Engines and Motor Vehicles of the High Technical College, Brno, Czechoslovakia, Strojnícky Časopis, 33 (3), pp 367-379 (1982) 8 figs, 4 refs
(In Czech)

Key Words: Automobiles, Equations of motion, Transient response

The paper is concerned with derivation of equations of motions of a passenger car for the calculation of handling characteristics based on the space mathematical model. The method described enables analysis of the influence of car parameters on its handling.

82-2322

General Problems in Load Modelling of Commercial Vehicles

P. Michelberger
Dept. of Mechanics, Faculty of Transportation, Engineering Technical Univ., Budapest, Hungary, Strojnícky Časopis, 33 (3), pp 337-347 (1982) 6 figs, 12 refs

Key Words: Ground vehicles, Dynamic response

In the statistical analysis of the dynamic load of commercial vehicles the real introduction of operation conditions is significant. In the phase of design it is important to make some simplification regarding the modeling of structure and the utilization of the operation information independent of the vehicle to be designed. This paper introduces a possible approximate dimensioning method.

82-2323

Dynamic Behaviour of an Elastic Separating Wall in Vehicle Containers: Part 2

H.F. Bauer
Hochschule der Bundeswehr, Munich, West Germany, Intl. J. Vehicle Des., 3 (3), pp 307-332 (Aug 1982) 10 figs, 26 refs

Key Words: Containers, Tank cars, Fluid-filled containers, Interaction: structure-fluid, Vehicle response

Even in completely filled road-tanker-containers with flexible separating cross-walls, the dynamics of the elastic structure and liquid interaction may result in vehicle handling difficulties, especially since the coupled liquid-structure frequencies are drastically reduced when compared to the uncoupled cross-wall frequencies. In this paper the coupled natural frequencies of the liquid-structure are determined for a completely filled circular and rectangular road-tanker-container with a cross-wall being either a flexible membrane or an elastic thin plate. In addition some modes of excitation are also treated, for which pressure at the cross-wall and the total dynamic force of the system could be determined. Some of the results are evaluated numerically.

82-2324

Advances in Nonlinear Wheel/Rail Force Prediction Methods and Their Validation

J.A. Elkins and B.M. Eickhoff
The Analytic Sciences Corp., Reading, MA 01867, J. Dyn. Syst., Meas. and Control, Trans. ASME, 104 (2), pp 133-142 (June 1982) 16 figs, 12 refs

Key Words: Interaction: rail-wheel

Improvements have been made to the nonlinear wheel/rail force prediction method of Elkins and Gostling. These improvements are described, along with the experimental equipment used in order to provide input data for the predictions, and to validate them. A further series of curving tests, using a laboratory coach equipped with bogies having variable suspension parameters, has been carried out, and shown to give excellent agreement with the improved theory. The prediction method is now used on a regular basis within British Rail, and its use for vehicle design is considered, together with planned extensions to cover calculation of wheel and rail wear and dynamic behavior of railway vehicles on curve and switch entry.

82-2325

Prediction of the Probability of Rail Vehicle Derailment During Grade Crossing Collisions

D.B. Cherchas, G.W. English, N. Ritchie, E.R. McIlveen, and C. Schwier
Dept. of Mech. Engrg., Univ. of Toronto, Toronto, Canada, J. Dyn. Syst., Meas. and Control, Trans. ASME, 104 (2), pp 119-132 (June 1982) 16 figs, 7 tables, 29 refs

Key Words: Railroad cars, Collision research (railroad)

A mathematical model and digital computer simulation are developed to analyze the dynamics of railway and road vehicles during grade crossing collisions. The main objective of the simulation is to relate the probability of derailment to railway vehicle speed; however, a variety of other response characteristics such as railway and road vehicle structure deformation and road vehicle dynamic response can be examined. The criterion for derailment is based on the derailment coefficient; i.e., ratio of wheel flange/railhead lateral force to vertical wheel load. A preliminary investigation is made of the sensitivity of the derailment probability to various collision situations, with the emphasis on increasing rail vehicle speed. Conclusions and recommendations based on this analysis are presented.

SHIPS

(Also see No. 2429)

82-2326

An Investigation of Ship Propeller Fatigue

H.P.E. Helle

Ph.D. Thesis, Technische Hogeschool, Delft, The Netherlands, 211 pp (1982)
N82-18627

Key Words: Marine propellers, Fatigue life

Fatigue is a major failure cause in controllable pitch propellers, and practically the only cause in fixed pitch monobloc propellers. Two different types of causes are responsible for fatigue failure. Incidental causes are usually due to misuse or improper repairs. A systematic failure due to inherent weakness occurs when a number of aggravating fatigue factors coincide, such as an unusually high dynamic blade load and an exceptionally large undetected casting defect in a critical area plus one or two unfavorable production factors (low materials strength, high residual stresses). The fatigue failure risk of a propeller that enters operation, is determined therefore by its design stress and the quality control procedure to which it has been subjected.

AIRCRAFT

(Also see Nos. 2289, 2343, 2345, 2349, 2355, 2367, 2378, 2484)

82-2327

Study of Cabin Noise Control for Twin Engine General Aviation Aircraft

R. Vaicaitis and M. Slazak

Modern Analysis, Inc., Ridgewood, NJ, Rept. No. NASA-CR-165833, MAI-1, 147 pp (Feb 1982)
N82-18995

Key Words: Aircraft, Noise transmission, Noise prediction, Noise reduction

An analytical model based on modal analysis was developed to predict the noise transmission into a twin-engine light aircraft. The model was applied to optimize the interior noise to an A-weighted level of 85 dBA. To achieve the required noise attenuation, add-on treatments in the form of honeycomb panels, damping tapes, acoustic blankets, septum barriers and limp trim panels were added to the existing structure.

82-2328

Active Control Technology in Aircraft

D. McLean

Dept. of Transport Tech., Loughborough Univ. of Tech., Leicester, LE11 3TU, UK, Shock Vib. Dig., 14 (7), pp 11-22 (July 1982) 174 refs

Key Words: Reviews, Aircraft, Active control, Fatigue life, Flutter, Wind-induced excitation

This article describes developments in active control technology on aircraft. The following functions are described: relaxed static stability, maneuver load control, fatigue reduction, ride control, flutter mode control, and gust load alleviation.

82-2329

Flight Trial of the Aircraft Fatigue Data Analysis System (AFDAS) MK 2 Prototype

P.J. Howard

Aeronautical Res. Labs., Melbourne, Australia, Rept.

No. ARL/STRUC-NOTE-466. AR-002-249, 33 pp (1981)
N82-21610

Key Words: Aircraft, Fatigue life, Data processing

A prototype version of the aircraft fatigue data analysis system (AFDAS) was evaluated in flight trials by comparison with continuously recorded data. Over a limited period of tests the range-mean-pairs count of strain cycles was the same for both sets of data, and the gains calculated for the AFDAS are identical to those deduced from the continuous record.

82-2330

Dynamics of Aircraft Antiskid Braking Systems

J.A. Tanner, S.M. Stubbs, R.C. Dreher, and E.G. Smith
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TP-1959, L-14788, 100 pp (Feb 1982)
N82-18204

Key Words: Aircraft, Brakes (motion arresters)

A computer study was performed to assess the accuracy of three brake pressure-torque mathematical models. The investigation utilized one main gear wheel, brake, and tire assembly of a McDonnell Douglas DC-9 series 10 airplane. The investigation indicates that the performance of aircraft antiskid braking systems is strongly influenced by tire characteristics, dynamic response of the antiskid control valve, and pressure-torque response of the brake. The computer study employed an average torque error criterion to assess the accuracy of the models. The results indicate that a variable nonlinear spring with hysteresis memory function models the pressure-torque response of the brake more accurately than currently used models.

82-2331

Airbus Industrie and Community Noise

J. Chausonnet
Airbus Industrie, Blagnac, France (Presented at Intl. Symp. on Transportation Noise, CSIR Conf. Centre, Pretoria, Oct 21-23, 1981), 37 pp (1981)
PB82-206160

Key Words: Aircraft noise, Takeoff, Landing, Noise reduction, Human response

The contributions of the total noise perceived outside an aircraft during take-off and landing by the engine and the aerodynamics of the aircraft are considered. The reduction of engine noise by design, the location of the engine and acoustic treatment of the nacelles is discussed. Aerodynamic noise reduction is considered in terms of aircraft design, operational procedures and aircraft weight. A description is given of the noise measuring facility at Toulouse airport used for checking operational procedures and measuring noise levels. Further reductions in noise levels are treated in the conclusion.

82-2332

Aircraft Noise Reduction

R.E. Russell and J.M. Strechenbach
Natl. Inst. for Transport and Road Res., Pretoria, South Africa (Presented at Intl. Symp. on Transportation Noise, CSIR Conf. Centre, Pretoria, Oct 21-23, 1981), 17 pp (Oct 1981)
PB82-206095

Key Words: Aircraft noise, Noise reduction

A brief introduction of the Boeing commercial airliner family is followed by a discussion of the significant noise reduction accomplishments for turbine-powered aircraft from the 1950's to the 1980's, with projections of further benefits until the year 2000. Definition of the trades to be made between noise reduction and fuel economy, as well as technical problems yet unsolved, lead to a recognition that the greatest advances in aircraft noise reduction are past, and that significant research will be required in the future to lower noise floors that are presently inhibiting further progress. Emphasis is given to precautions that must be taken in the selection of meaningful fleet noise data to avoid costly and irreversible errors in airport and community planning.

82-2333

On the Torsional Modes of a Uniformly Tapered Solid Wing

E.H. Mansfield
Royal Aircraft Establishment, Farnborough, UK, Aeronaut. Quart., 33 (2), pp 154-173 (May 1982) 2 figs, 6 tables, 4 refs

Key Words: Aircraft wings, Variable cross section, Torsional response, Mode shapes

An exact analysis is given, within the spirit of elementary theory, of the torsional modes of a uniformly tapered solid wing whose section shape – as distinct from size – is constant. Numerical results are presented for the first five torsional modes for various values of tip chord/root chord. It is shown that the frequencies are fairly insensitive to the magnitude of the taper and a corollary to this, which is also investigated, is that an analysis based on a partially stepped representation of the taper yields close estimates of the frequencies but can yield massive differences in the higher mode shapes. An analysis is also made of warping restraint and distributed inertia effects.

82-2334

Analysis of Pressure Distributions on a Wing with an Oscillating Trailing Edge Flap in Subsonic and Transonic Flow (Etudes des Effets Instationnaires de Gouvernes en Ecoulement Tridimensonnel Subsonique et Transsonique)

H. Consigny

Association Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-81-25, 42 pp (Nov 1981) (Presented at Colloque d'Aerodynamique Appliquee (18th), Poitiers, Nov 18-20, 1981)

PB82-204785

(In French)

Key Words: Aircraft wings, Fluid-induced excitation

An experimental study was carried out to improve the knowledge of the three-dimensional unsteady effects of an oscillating part-span trailing-edge flap. The experiments were performed on a constant chord (0.3m) and constant thickness (16%) supercritical wing. This study provided extensive information on the influence of various parameters on both steady and unsteady chordwise pressure distributions and aerodynamic coefficients (normal force, pitching moment, hinge moment).

82-2335

Aerodynamics on a Transport Aircraft Type Wing-Body Model (Aerodynamique d'un Ensemble Voilure-Fuselage du Type 'Avion de Transport')

V. Schmitt

Association Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-81-22, 28 pp (Nov 1981) (Presented at Colloque d'Aerodynamiquee Appliquee (18th), Poitiers, Nov 18-20, 1981)

PB82-206855

(In French)

Key Words: Aircraft wings, Aerodynamic loads

This study is based on the DFVLR-F4 wing-body combination. The 1/38 model is formed by a 9.5 aspect ratio transonic wing and an Airbus A 310 fuselage. The purpose of this paper is to survey the work done by ONERA. After a description of the F4 wing geometrical characteristics main experimental results obtained in the S2MA wind tunnel are discussed. Both wing-fuselage interferences and viscous effects, which are important on the wing due to a high rear loading, are investigated. In order to do that, 3D calculations are performed and an attempt is made to find their limitations.

82-2336

Self-Tuning Regulators for Multicyclic Control of Helicopter Vibration

W. Johnson

NASA Ames Res. Ctr., Moffett Field, CA, Rept. No. NASA-TP-1996, 50 pp (Mar 1982)

N82-20188

Key Words: Helicopter vibration, Active vibration control

A class of algorithms for the multicyclic control of helicopter vibration and loads is derived and discussed. This class is characterized by a linear, quasi-static, frequency-domain model of the helicopter response to control; identification of the helicopter model by least-squared-error or Kalman filter methods; and a minimum variance or quadratic performance function controller. Previous research on such controllers is reviewed. The derivations and discussions cover the helicopter model; the identification problem, including both off-line and on-line (recursive) algorithms; the control problem, including both open-loop and closed-loop feedback; and the various regulator configurations possible within this class. Conclusions from analysis and numerical simulations of the regulators provide guidance in the design and selection of algorithms for further development, including wind tunnel and flight tests.

82-2337

Limiting Performance of Nonlinear Systems with Applications to Helicopter Vibraton Control Problems

W.D. Pilkey

Dept. of Mech. and Aerospace Engrg., Univ. of Virginia, Charlottesville, VA, Rept. No. UVA/525098-MAE-82/10, ARO-16091.5-E, 26 pp (1982)
AD-A113 239

Key Words: Helicopter vibration, Vibration control

This report summarizes the accomplishments of a study exploring new methods for the vibration control of helicopters. Reanalysis methodology permits a variety of vibration control problems to be solved efficiently. Both analytical and experimental studies have been conducted.

82-2338

Wide-Band Noise of Helicopter Rotors (Bruit Large Bande des Rotors d'Helicopteres)

A. Damongeot
Association Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-80-58, 18 pp (Nov 1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, November 4-5, 1980)
PB82-204579
(In French)

Key Words: Helicopters, Propeller blades, Noise generation

The study shows it is possible to explain the generation of broad-band noise by considering the fluctuations in wall pressures induced by the turbulent speeds of the helicopter blade's boundary layer. The following characteristics of the source region were generally identified: reduced spectrum of wall pressure, thickness of displacement of the boundary layer, length of correlation, and speed of convection.

MISSILES AND SPACECRAFT

82-2339

Structural Dynamic Analysis of the Space Shuttle Main Engine

L.P. Scott, G.T. Jamison, W.A. Mccutcheon, and J.M. Price
Huntsville Res. and Engrg. Ctr., Lockheed Missiles and Space Co., Inc., Huntsville, AL, Rept. No. NASA-CR-161945, LMSC-HREC-TR-D784490, 166 pp (Dec 1981)
N82-19302

Key Words: Space shuttles, Rocket engines, Dynamic structural analysis

This structural dynamic analysis supports development of the SSME by evaluating components subjected to critical dynamic loads, identifying significant parameters, and evaluating solution methods. Engine operating parameters at both rated and full power levels are considered. Detailed structural dynamic analyses of operationally critical and life limited components support the assessment of engine design modifications and environmental changes. Engine system test results are utilized to verify analytic model simulations. The SSME main chamber injector assembly is an assembly of 600 injector elements which are called LOX posts. The overall LOX post analysis procedure is shown.

82-2340

Methodology of Uniaxial Transient Vibration Test for Satellites

B. Boissin, A. Girard, and J.F. Imbert
Centre National d'Etudes Spatiales, Toulouse, France, Rept. No. CNES-81/CT/PRT/SST/SM/194, ESA-CR(P)-1474, 20 pp (June 10, 1981)
N82-18640

Key Words: Spacecraft, Vibration tests, Testing techniques, Shakers

Realistic data for thrust transient, launch vehicle, and satellite characteristics are defined. Dynamic response analysis is performed based on a survey of current methods. For most of the low frequency dynamic flight environment of a satellite, transient testing minimizes the risk of under or overtesting inherent to conventional sine testing. As feasibility of such tests on uniaxial electrodynamic shakers was recently proved, the problem is now the dependence of the test specification on possible variations of launch vehicle and satellite dynamic characteristics. Possible variations of parameters are discussed and a sensitivity analysis is performed.

BIOLOGICAL SYSTEMS

HUMAN

(Also see No. 2331)

82-2341

Slow Vertex Potentials Evoked by Whole-Body Impulsive Vibrations in Recumbent Men

T. Miwa, Y. Yonekawa, and K. Kanada
Dept. of Human-Environmental Engrg., Natl. Inst. of Industrial Health, 21-1, Nagao 6 chome, Tama-ku, Kawasaki 213, Japan, J. Acoust. Soc. Amer., 72 (1), pp 214-221 (July 1982) 6 figs, 4 tables, 28 refs

Key Words: Vibration excitation, Human response

Characteristics of slow vertex responses evoked by whole-body vertical and horizontal impulsive vibrations of one cycle of a sinusoid were investigated in recumbent men. Fundamental frequencies were varied from 8 to 100 Hz. The p-p amplitudes and latencies of V potentials were determined as a function of vibration amplitude and fundamental frequency. The response patterns are similar to those evoked by optical and acoustic stimuli to human visual and auditory organs. The thresholds of the evoked potentials were determined by a cross-correlation technique and the perceptional thresholds were measured for the same vibration. It is concluded that the perceptional thresholds can be estimated approximately from the thresholds of the evoked potentials, for example, by subtraction of 14.5 dB from the thresholds of the evoked potentials for vertical vibrations and 10 dB from those for horizontal vibrations from 8 to 100 Hz.

82-2342

Human Body Vibration Exposure and Its Measurement

G. Rasmussen
Technical Review, 1, pp 3-31 (1982) 26 figs, 1 table

Key Words: Vibration excitation, Human response, Measurement techniques

Instrumentation requirements for evaluation of the responses of humans to vibration according to criteria specified in ISO Standard 2631 are described, as well as some of the pitfalls to be avoided during these measurements. Exposure limits for vibration transmitted to the hands and arms of operators of vibrating tools have been suggested in Draft Standard ISO/DIS 5349. A special hand adaptor developed for the measurement of hand-arm vibration transmitted from the handle of such tools is described in the article, and measurement results obtained with it on a chip hammer are illustrated.

82-2343

Annoyance Caused by Propeller Airplane Flyover Noise: Preliminary Results

D.A. Mccurdy and C.A. Powell
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83244, 35 pp (Dec 1981)
N82-18996

Key Words: Aircraft noise, Human response

The annoyance response of people to the noise of propeller airplane flyovers was examined. The specific items of interest were the annoyance prediction ability of current noise metrics; the effect of tone corrections on prediction ability; the effect of duration corrections on prediction ability; and the effect of critical band corrections on the prediction ability of perceived noise level. Preliminary analyses of the data obtained from two experiments are presented.

82-2344

Measurement and Prediction of Annoyance Caused by Time-Varying Highway Noise

S.L. Yaniv, W.F. Danner, and J.W. Bauer
Natl. Engrg. Lab., Natl. Bureau of Standards, Washington, DC 20234, J. Acoust. Soc. Amer., 72 (1), pp 200-207 (July 1982) 5 figs, 5 tables, 12 refs

Key Words: Noise measurement, Noise prediction, Traffic noise, Human response

Twenty-eight audiologically normal adult subjects participated in a study designed to assess how well six noise-rating indices would predict the annoyance caused by 3-minute recorded samples of traffic noise obtained from both nominally constant-speed and stop-and-go traffic. The study was performed in a laboratory simulating a home environment. Annoyance judgments were obtained through the use of a magnitude estimation technique involving a 10-point scale. Subjects were also asked if they could accept each of the 24 traffic sounds if heard on a regular basis in their homes. Data obtained indicate that the simpler noise-rating indices, such as the average sound level and the level exceeded 10% of the time, predict annoyance as well as, if not better than, complicated schemes incorporating a measure of either variability or rate-of-change of levels with time. Thus it appears that the measurement and computational burdens associated with these complicated schemes are unwarranted.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 2336, 2487)

82-2345

A Study of the Performance of an Olsen-Type Active Noise Controller and the Possibility of the Reduction of Cabin Noise

S.E. Keith and H.S.B. Scholaert
Inst. for Aerospace Studies, Toronto Univ., Downsview, Ontario, Canada, Rept. No. UTIAS-228, 28 pp (Mar 1981)
PB82-205063

Key Words: Active noise control, Active absorption, Acoustic absorption, Aircraft

In contrast to orthodox sound insulating techniques, the active noise controller is a device designed to reduce sound levels by means of an electronic transducing system. The device is a basic feedback control system composed of a speaker, microphone, amplifier and control unit. The scheme can be effective in reducing low frequency noise. The idea of active noise control pioneered by Olson and May produced an electronic sound absorber which appeared to be successful over small volumes, in a unidirectional sound field. This work has re-examined these accomplishments and more recent developments to test their suitability to the aircraft industry. The results suggest only limited possible use for all systems studied.

82-2346
Broad-band Active Sound Absorption (Absorption Acoustique Active Large Bande)
A. Roure and V. Martin
Association Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-80-57, 21 pp (Nov 1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, Nov 4-5, 1980)
PB82-204504
(In French)

Key Words: Active noise control, Acoustic absorption, Active absorption, Ducts

This study describes work carried out at the Mechanical and Sound Laboratory of Marseille to construct a broad-band stable anti-noise system in a duct with flow. After recalling the theory of sound propagation in ducts, the theoretical method, using a relatively simple electric current to control the sources, is set forth. The system is very sensitive to the effects of various delays and can cause a loss in the attenuation of several dozen decibels. Encouraging results were found in controlling sounds from 20 to 30 decibels over three octaves.

82-2347
Some Observations on the Use of Active Acoustic Absorption in Turbulent Air Ducts (Quelques Remarques a Propos de la Mise en Oeuvre de l'Absorption Active dans les Conduits d'Air avec Ecoulement Turbulent)
M. Jessel
Association Aeronautique et Astronautique de France, Paris, Rept. No. AAAF-NT-80-56, 16 pp (Nov 1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, Nov 4-5, 1980)
PB82-204595
(In French)

Key Words: Active noise control, Acoustic absorption, Active absorption, Ducts

If light superimposed on light could result in darkness, then sound superimposed on sound could give silence. This study outlines the current state of active absorbers in ducts containing still fluids, the methods of access to secondary generating sources of active absorption, the fundamental sound equations in any medium, and general statement of secondary sources.

82-2348
Measurement of the Absorption Properties of Acoustic Materials Used in the Fabrication of Cowlings (Mesure des Proprietes d'Absorption de Materiaux Acoustiques Utilises pour la Realisation de Capotages)
B. Corlay and G. Delalot
Rept. No. CETIM-11-H-285, 164 pp (July 1981)
N82-19002
(In French)

Key Words: Acoustic absorption, Acoustic linings

A wide selection of sound absorbing materials was tested, using the stationary wave tube method, and absorption factors were determined. Results are used to compile a catalog of industrial acoustically absorbent materials which can be employed as interior linings on cowlings for mobile or fixed noisy equipment. Theory that explains the absorptivity of these materials when used alone or in combinations is also presented. Results for low and middle frequency absorption are stressed.

82-2349
Variable Response Load Limiting Device
D.D. McSmith

NASA Langley Res. Ctr., Hampton, VA, U.S. Patent Appl. No. 6-309-291, 18 pp (Oct 1981)

Key Words: Energy absorption, Aircraft seats

An energy absorbing device used as a load limiting member in a structure to control its response to applied loads is described. It functions by utilizing a spool assembly having flanged ends and an interior cavity of sufficiently large diameter to cause it to deform plastically at a prescribed load. In application, the spool is utilized as a pivot point for the legs of an aircraft seat.

82-2350

T-Matrix Formulation to Study the Frequency Dependent Properties of Absorbing Materials

V.K. Varadan and V.V. Varadan

Ohio State Univ. Res. Foundation, Columbus, OH, 76 pp (Jan 15, 1982)

AD-A113 914

Key Words: Absorbers (materials), Wave diffraction, Matrix methods

A scattering matrix theory is presented for studying the multiple scattering of both longitudinal and transverse elastic waves in a medium containing a random distribution of inclusions or voids of arbitrary shape. A statistical analysis with QCA and Percus-Yevick pair correlation function is then employed to obtain expressions for the average amplitudes of the coherent fields which may be solved to yield the bulk or effective properties of the inhomogeneous medium. Suggestions for incorporating CPA in conjunction with QCA so that materials with dense concentration of inclusions can be considered are also given.

82-2351

Development of Nonlinear Analytical Models for Piping System Restraint Devices

M.A. Pickett

Ph.D. Thesis, Univ. of Connecticut, 235 pp (1982)

DA8213911

Key Words: Piping systems, Snubbers, Shock absorbers

Restraint devices, commonly known as snubbers, are installed in piping systems to limit stresses due to potentially damaging transients. Snubber models are developed herein based on the inherent velocity sensitive or acceleration sensitive characteristics of the respective devices. Using these models, system response is predicted for various excitation conditions and for the various hardware design parameters that exist for the two classes of snubbers. For the velocity sensitive snubber, the fluid in the snubber is considered both as incompressible and as compressible. A method is presented for evaluating equivalent snubber parameters for use in piping system analysis.

82-2352

Suppression of Vibration Effects on Piezoelectric Crystal Resonators

V.J. Rosati

Dept. of the Army, Washington, DC, U.S. Patent Appl. No. 6-343 644, 9 pp (Jan 23, 1982)

Key Words: Active vibration control, Oscillators

An active method and apparatus for suppressing or cancelling the effects of vibration on quartz crystal controlled oscillators generates an electrical signal which is a replica of the vibration acting on the crystal resonator. The signal is thereafter properly phased and applied directly to the crystal electrodes, thereby operating to substantially eliminate unwanted vibration-induced sidebands in the signal output of the oscillator.

82-2353

Problems of the Optimal Synthesis of a Vibroisolating System

K.V. Frolov, A.V. Sinev, and V.I. Sergeyev

The A.A. Blagonravov Inst. of Engrg., Academy of Sciences of the USSR, Moscow 101830, Griboyedov Street 4, USSR, Strojnícky Časopis, 33 (3), pp 257-268 (1982) 2 figs, 8 refs

(In Russian)

Key Words: Isolators, Vibration isolators, Optimization

Assignments of optimal synthesis of vibroisolating systems include the formulation of functional constraints tied up with conflicting requirements of the set quality of vibroisolation and the magnitude of relative deflections. On the basis of additive quality criteria with weight coefficients an optimalization task was formulated. The shapes are presented of various quality functionals applied in optimal synthesis. Investigations are made into the methods of solving the task of linear vibroisolation systems synthesis by applying the Wiener-Hopf equation and the method of multi-parameter multi-criterial optimization of nonlinear vibroisolating systems under random loads. The notion of the Paret plane of optimal solutions is introduced and the plotting of Paret curves exemplified.

82-2354
Rigid-Body Response of Base-Isolated Structures
I.G. Tadjbakhsh and J.J. Ma
Dept. of Civil Engrg., Rensselaer Polytechnic Inst., Troy, NY, ASCE J. Struc. Div., 108 (ST8), pp 1806-1813 (Aug 1982) 5 figs, 8 refs

Key Words: Base isolation, Seismic excitation

The problem of control of rigid body response of structural systems such as nuclear islands, which are mounted on a grid of bearings with three dimensional damping and stiffness properties, is analyzed. A parametric study is carried out to show the effects of the dimensionless parameters of the foundation on the transmissibilities of the structure due to harmonic ground motion. The characteristics of an optimal base isolation are discussed and results are presented in a form which may be of use in preliminary designs.

82-2355
Study of Noise Reduction Characteristics of Composite Fiber-Reinforced Panels, Interior Panel Configurations, and the Application of the Tuned Damper Concept
J. Lameris, S. Stevenson, and B. Streeter
Ctr. for Res., Inc., Univ. of Kansas, Lawrence, KS, Rept. No. NASA-CR-168745, 163 pp (Mar 1982) N82-21999

Key Words: Absorbers (equipment), Dynamic vibration absorption (equipment), Noise reduction, Panels, Composite structures, Fiber composites, Aircraft noise

The application of fiber reinforced composite materials, such as graphite epoxy and Kevlar, for secondary or primary structures developing in the commercial airplane industry was investigated. A composite panel program was initiated to study the effects of some of the parameters that affect noise reduction of these panels. The fiber materials and the ply orientation were chosen to be variables in the test program. It was found that increasing the damping characteristics of a structural panel will reduce the vibration amplitudes at resonant frequencies with attendant reductions in sound reduction. Test results for a dynamic absorber, a tuned damper, are presented and evaluated.

TIRES AND WHEELS

82-2356
Test Equipment for Fatigue Evaluation of Automotive Wheels (Versuchseinrichtungen zur Untersuchung der Ermüdungsfestigkeit von Fahrzeugrädern)
G. Fischer and V. Grubišić
Menzelweg 6, 6100 Darmstadt, Automobiltech. Z., 84 (6), pp 307-316 (June 1982) 10 figs, 2 tables, 8 refs
(In German)

Key Words: Wheels, Fatigue life

The complex stresses applied to rolling wheels makes it necessary to use special procedures and test equipment to accomplish both the objectives: weight reduction and safety. For an optimum design it is necessary to know the stresses resulting from different service conditions and the corresponding allowable stresses dictated by the material and manufacturing processes. A method has been developed which makes it possible to determine these stresses in a simple laboratory loading test, in which the wheel with tire fitted is kept rolling under simulated service loading conditions in a roll-test stand. The allowable stresses, which depend on the cumulative frequency distribution and the prestresses resulting from assembly and inflation of the tire, are obtained from tests performed with complete wheels.

82-2357
Theoretical and Experimental Studies on the Dynamic Properties of Tyres. Part 4: Investigations of the Influences of Running Conditions by Calculation and Experiment
H. Sakai
Fourth Dept. of Res., Japan Automobile Inst., Ibaraki, Japan, Intl. J. Vehicle Des., 3 (3), pp 333-375 (Aug 1982) 62 figs, 1 table, 7 refs

Key Words: Tires, Dynamic properties

The results of calculations performed in previous sections of the paper are applied to the study of the influence of running conditions on the six components of force and moment in the case of real tires. An experiment to determine the six components is described, and the experimental values compared with the calculated values. A bibliography containing 100 references is included.

BLADES
(Also see Nos. 2334, 2338)

82-2358
Transonic Blade Flutter: A Survey of New Developments

M.F. Platzer
Dept. of Aeronautics, Naval Postgraduate School, Monterey, CA 93940, Shock Vib. Dig., 14 (7), pp 3-8 (July 1982) 30 refs

Key Words: Reviews, Blades, Flutter

This paper presents a review of current work in transonic blade flutter research. Aerodynamic analyses for the prediction of attached flow flutter, choke flutter, and stall flutter are described. Also reviewed are unsteady aerodynamic measurement and flutter test programs that have recently been completed or are in progress to investigate transonic blade flutter phenomena.

82-2359

Coupled Bending-Bending-Torsion Flutter of a Mistuned Cascade with Nonuniform Blades

K.R.V. Kaza and R.E. Kielb
NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-82813, E-1156, 20 pp (1982)
N82-21604

Key Words: Cascades, Blades, Flutter, Flexural vibration, Torsional vibration

A set of aeroelastic equations describing the motion of an arbitrarily mistuned cascade with flexible, pretwisted, nonuniform blades is developed using an extended Hamilton's principle. The derivation of the equations has its basis in the geometric nonlinear theory of elasticity in which the elongations and shears are negligible compared to unity. A general expression for fore-shortening of a blade is derived and is explicitly used in the formulation. The blade aerodynamic loading in the subsonic and supersonic flow regimes is obtained from two dimensional, unsteady, cascade theories. The aerodynamic, inertial and structural coupling between the bending (in two planes) and torsional motions of the blade is included. The equations are used to investigate the aeroelastic stability and to quantify the effect of frequency mistuning on flutter in turbofans. Results indicate that a moderate amount of intentional mistuning has enough potential to alleviate flutter problems in unshrouded, high aspect ratio turbofans.

82-2360

Flutter and Response of a Mistuned Cascade in Incompressible Flow

K.R.V. Kaza and R.E. Kielb
Univ. of Toledo, Toledo, OH and NASA Lewis Res. Ctr., Cleveland, OH, AIAA J., 20 (8), pp 1120-1127 (Aug 1982) 12 figs, 1 table, 21 refs

Key Words: Cascades, Blades, Flutter, Tuning, Coupled response, Flexural vibration, Torsional vibration, Computer programs

This paper presents an investigation of the effects of blade mistuning on the aeroelastic stability and response of a cascade in incompressible flow. The aerodynamic, inertial, and structural coupling between the bending and torsional motions of each blade and the aerodynamic coupling between the blades are included in the formulation. A digital computer program was developed to conduct parametric studies. Results indicate that the mistuning has a beneficial effect on the coupled bending-torsion and uncoupled torsion flutter. The effect of mistuning on forced response, however, may be either beneficial or adverse, depending on the engine order of the forcing function.

82-2361

An Experimental Investigation of Gapwise Periodicity and Unsteady Aerodynamic Response in an Oscillating Cascade. Volume 2: Data Report. Part 1: Text and Mode 1 Data

F.O. Carta
United Technologies Res. Ctr., East Hartford, CT, Rept. No. NASA-CR-165457-V-2-PT-1, 411 pp (Dec 1981)
N82-18180

Key Words: Blades, Airfoils, Cascades, Aerodynamic stability

Tests were conducted on a linear cascade of airfoils oscillating in pitch to measure the unsteady pressure response on selected blade along the leading edge plane of the cascade, over the chord of the center blade, and on the sidewall in the plane of the leading edge. The pressure data were reduced to Fourier coefficient form for direct comparison, and were also processed to yield integrated loads and particularly, the aerodynamic damping coefficient. Data obtained during the test program, reproduced from the printout of the data reduction program are compiled.

82-2362

An Experimental Investigation of Gapwise Periodicity and Unsteady Aerodynamic Response in an Oscillating Cascade. Volume 2: Data Report. Part 2: Mode 2 Data

F.O. Carta

United Technologies Res. Ctr., East Hartford, CT, Rept. No. NASA-CR-165457-V-2-PT-2, 390 pp (Dec 1981)
N82-18181

Key Words: Blades, Airfoils, Cascades, Aerodynamic stability

Computer data are provided for tests conducted on a linear cascade of airfoils oscillating in pitch to measure the unsteady pressure response on selected blades along the leading edge plane of the cascade, over the chord of the center blade, and on the sidewall in the plane of the leading edge.

82-2363

The Use of Performance-Monitoring to Prevent Compressor and Turbine Blade Failures

R.E. Dundas
Factory Matural Res. Corp., Norwood, MA, ASME Paper No. 82-GT-66

Key Words: Blades, Turbine blades, Compressor blades, Fatigue life, Monitoring techniques

Most failures of compressor and turbine blades in gas turbines and axial-flow compressors are due to high-frequency fatigue (neglecting the rare instances of foreign-object ingestion). Fatigue is the result of vibration of the blade, either in resonance or in flutter. With mature machines, the user can avoid the possibility of most resonant-vibration failures by a program of performance monitoring. Flutter can be avoided only if there is reason (such as experience) to expect it in a certain operating regime. Examples of a simple performance-monitoring procedure are given.

82-2364

Method for Predicting Impulsive Noise Generated by Wind Turbine Rotors

L.A. Viterna
NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-82794, E-1128, 7 pp (1982) (Presented at the Intl. Conf. on Noise Control Engrg., San Francisco, CA, May 17-19, 1982)
N82-21714

Key Words: Blades, Turbine blades, Wind turbines, Noise prediction

Large wind turbines can generate both broad band and impulsive noises. These noises can be controlled by proper choice of rotor design parameters such as rotor location with respect to the supporting tower, tower geometry and tip speed. A method was developed to calculate the impulsive noise generated when the wind turbine blade experiences air forces that are periodic functions of the rotational frequency. This phenomenon can occur when the blades operate in the wake of the support tower and the nonuniform velocity field near the ground due to wind shear. Results from this method were compared with measured sound spectra taken at locations of one to two rotor diameters from the DOE/NASA Mod-1 wind turbine. The calculated spectra generally agreed with the measured data in both the amplitude of the predominant harmonics and the roll of rate with frequency.

82-2365

An Inviscid-Viscous Interaction Treatment to Predict the Blade-to-Blade Performance of Axial Compressors with Leading Edge Normal Shock Waves

W.J. Calvert
Natl. Gas Turbine Establishment, UK, ASME Paper No. 82-GT-135

Key Words: Compressors, Compressor blades, Shock waves

An inviscid-viscous interaction treatment has been developed to predict the blade-to-blade flow in axial compressors operating with supersonic inlet conditions and a normal shock wave at inlet to the blade passage. The treatment uses both direct and inverse modes of operation for the inviscid and viscous calculations, and thus it can model the separation of the suction surface boundary layer produced by the strong interaction with the shock wave.

82-2366

Structural Dynamics of Shroudless, Hollow, Fan Blades with Composite In-Lays

R.A. Aiello, M.S. Hirschbien, and C.C. Chamis
NASA Lewis Res. Ctr., Cleveland, OH, ASME Paper No. 82-GT-284

Key Words: Blades, Fan blades, Aircraft engines, Computer programs, Bird strikes

Structural and dynamic analyses are presented for a shroudless, hollow, titanium fan blade proposed for future use in aircraft turbine engines. The blade was modeled using the Lewis Research Center's Blade Structural Analysis Computer Program (Cobstran). Cobstran is an integrated program consisting of mesh generators, composite mechanics, Nastran, and pre- and post-processors. Vibration and impact analyses are presented.

82-2367

Application of the Finite Element Method to Rotary Wing Aeroelasticity

F.K. Straub and P.P. Friedmann

Univ. of California, Los Angeles, CA, Rept. No. NASA-CR-165854, 232 pp (Feb 1982)

N82-20561

Key Words: Helicopters, Propeller blades, Blades, Aeroelasticity, Finite element technique

A finite element method for the spatial discretization of the dynamic equations of equilibrium governing rotary-wing aeroelastic problems is presented. Formulation of the finite element equations is based on weighted Galerkin residuals. This Galerkin finite element method reduces algebraic manipulative labor significantly, when compared to the application of the global Galerkin method in similar problems. The coupled flap-lag aeroelastic stability boundaries of hingeless helicopter rotor blades in hover are calculated. The linearized dynamic equations are reduced to the standard eigenvalue problem from which the aeroelastic stability boundaries are obtained. The convergence properties of the Galerkin finite element method are studied numerically by refining the discretization process. Results indicate that four or five elements suffice to capture the dynamics of the blade with the same accuracy as the global Galerkin method.

82-2368

A Preliminary Comparison Between the SR-3 Propeller Noise in Flight and in a Wind Tunnel

J.H. Dittmar and P.L. Lasagna

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-82805, E-1144, 14 pp (1982) (Presented at the 103rd Meeting of the Acoustical Society of America, Chicago, IL, Apr 27-30, 1982)

N82-21998

Key Words: Propeller blades, Noise generation, Wind tunnel tests

The noise generated by supersonic-tip-speed propellers is addressed. Models of such propellers were tested for acoustics in a wind tunnel. One of these propeller models, SR-3, was tested in flight on the Jetstar airplane and noise data were obtained. Preliminary comparisons of the maximum blade passing tone variation with helical tip Mach number taken in flight with those taken in the tunnel showed good agreement when corrected to the same test conditions. This indicated that the wind tunnel is a viable location for measuring the noise of these propeller models.

BEARINGS

(Also see No. 2455)

82-2369

Interactive Graphic Simulation of Rolling Element Bearings. Phase 1. Low Frequency Phenomenon and RAPIDREB Development

P.K. Gupta

Mechanical Technology, Inc., Latham, NY, Rept. No. MTI-81TR66, AFWAL-TR-81-4148, 139 pp (Nov 1981)

AD-A112 009

Key Words: Bearings, Rolling contact bearings, Simulation, Computer programs

A selective suppression of the very high frequency content of the generalized motion simulated by the original DREB computer program has led to considerable increase in the maximum permissible time step size and hence performance simulations over relatively large time domains (several shaft revolutions) have been economically possible with the updated version RAPIDREB. Capabilities of RAPIDREB are demonstrated for both light load, low speed DMA (Despun Mechanical Assembly) ball bearings and the heavy load, high speed engine type ball bearings. From the simulations obtained over a shaft revolution it is shown that the race guided cage in the DMA bearings is generally stable while the ball guided cage produces relatively noisy and to some extent unstable cage motion.

82-2370

Elastohydrodynamic Analysis of a Cylindrical Journal Bearing with a Flexible Bearing Shell

S.C. Jain, R. Sinhasan, and D.V. Singh

Dept. of Mech. and Industrial Engrg., Univ. of Roorkee, Roorkee 247672, India, Wear, 78 (3), pp 325-335 (June 1, 1982) 6 figs, 11 refs

Key Words: Bearings, Journal bearings, Finite element technique, Elastohydrodynamic properties

The effect of the elastic deformation of a bearing shell was considered in the determination of the performance characteristics of a hydrodynamic journal bearing. The finite element method with an iteration scheme was employed to solve the Reynolds equation governing flow in the clearance space and the three-dimensional linear elasticity equations representing the displacement vector field in the bearing shell. Performance characteristics were obtained in terms of load-carrying capacity, fluid flow, power loss and attitude angle for an aspect ratio L/D = 1, eccentricity ϵ = 0.6 and for a wide range of deformation coefficients. The results are compared for bearing materials having Poisson's ratio ν equal to 0.3 and 0.4.

GEARS

(Also see No. 2456)

82-2371

Fatigue Resistance and Noise Generation of Gear Materials: Bronze, Nylon, Cast Iron, and Phenolic

J.H. Chen and F.M. Juarbe

The Polymer Corp., Reading, PA, ASME Paper No. 82-DE-3

Key Words: Gears, Fatigue (materials), Noise generation, Failure analysis

High cycle fatigue and sound generation characteristics of selected gear materials were examined under oil-lubricated and initially greased conditions. Failure modes of the gears were investigated and advantages as well as limitations of the gear materials are discussed.

82-2372

The Response of a Geared Compressor Set to Torsional Excitation Accounting for Damping and Flexibility in the Bearings and Damping and Backlash in the Gear

P.E. Simmons

Shell UK Exploration and Production, London, UK, ASME Paper No. 82-GT-246

Key Words: Gears, Compressors, Torsional response, Damping, Backlash effects, Flexibility coefficients

A mathematical model representing the torsional characteristics of a machine train including a gear has been developed incorporating a number of features which are usually neglected; namely, damping and flexibility in the bearings and damping, backlash and pitch error in the gear teeth. This model has been used in conjunction with a computer simulation language to predict the performance of a geared compressor in which there is a torsional resonant frequency close to twice the motor speed.

FASTENERS

82-2373

Fatigue Performance and Fastener Flexibility for Single Shear Aluminum Joint with Different Splice Plates

B. Palmberg

Aeronautical Res. Inst. of Sweden, Stockholm, Sweden, Rept. No. FFA-TN-HU-2165, 80 pp (1981)
N82-19599

Key Words: Joints (junctions), Aircraft, Fatigue life

The influence of bending stiffness on secondary bending single shear double row joints was investigated. Countersunk steel bolts were installed in 6D10 holes. A load spectrum representing a fighter aircraft wing panel was used. It is shown that fatigue life increases with increasing bending stiffness, and that secondary bending is decreased by a splice plate arrangement which has very low bending stiffness. The bolt flexibility is determined from measured values of splice plate elongation and the gap variation between the two base plates. It is found that different splice plates yield almost the same bolt flexibility and additional lubrication when torquing the simloc nuts increases fatigue life significantly.

82-2374

Fatigue of 2024-T351 and 7075-T7351 Al-Alloy Lugs With and Without Interference Fit under Maneuver Spectrum Loading

A. Buch and A. Bercovits

Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Rept. No. TAE-440, 39 pp (Apr 1981)
N82-19568

Key Words: Joints (junctions), Aircraft, Fatigue tests

Aircraft pin-lug joints with and without interference fit were tested under maneuver loading programs with random loading sequence. The effect of design load, lug material and interference fit on the spectrum fatigue life was investigated. The interference fit of 0.3% had a strong beneficial effect on the fatigue life for all loading programs, even when local tensile stress peaks exceeded the material yield stress. Test results are presented and compared with predictions based on Miner's Rule, the Relative Miner Rule, and a notch analysis method.

LINKAGES

82-2375

Dimensional Synthesis of Four Bar Linkage for Function Generation with Velocity and Acceleration Constraints

G. Guj, Z.Y. Dong, and M. Di Giacinto
Istituto di Meccanica Applicata alle Macchine, University di Roma, Meccanica, 4 (16), pp 210-219 (Dec 1981) 8 figs, 2 tables, 13 refs

Key Words: Four bar mechanisms, Dynamic response

The dimensional synthesis of a four bar linkage for function generation, usually performed by considering only kinematic characteristics of the mechanism, may be improved by accounting also for its dynamical behavior. In the present study the maximum values of velocity and acceleration are controlled in order to limit the inertial forces, as required in the design of high-speed mechanisms. For this purpose an optimization technique, based on penalty function method, has been adopted. Several numerical results for different choices for constraints and initial design are presented and discussed.

SEALS

(Also see No. 2432)

82-2376

Developing New Seal Materials through Dynamic Testing

W.E. Berner
Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH 45433, Lubric. Engrg., 38 (6), pp 349-358 (June 1982) 11 figs, 5 tables, 2 refs

Key Words: Seals, Dynamic tests

This paper discusses the development procedures used by the Air Force in determining sealing materials for aircraft hydraulic systems. Where possible, candidate state-of-the-art materials were screened for their physical properties and hydraulic-fluid compatibility. Alternately, the synthesis of a new material may be required to achieve program goals. Upon achieving targeted physical properties and fluid compatibility, materials were evaluated for their dynamic performance and sealability. Three pieces of test apparatus, used to determine a seal material's performance, were developed. Materials were evaluated for low- and high-temperature sealability and endurance.

STRUCTURAL COMPONENTS

CABLES

(Also see No. 2482)

82-2377

Ocean Cable Dynamics Using an Orthogonal Collocation Solution

H. Migliore and E. McReynolds
Portland State Univ., Portland, OR, AIAA J., 20 (8), pp 1084-1091 (Aug 1982) 10 figs, 14 refs

Key Words: Cables, Collocation method

Ocean cable systems are particularly vulnerable to failure during deployment and retrieval operations due to dynamic effects imposed by ship motion and time dependent changes in hydrodynamic forces, cable length, area, and tension. The continuous equations of motion for a cable system undergoing change of length were developed, where hydrodynamic forces were incorporated as added mass and velocity-squared drag. The nonlinear equations were solved using method of weighted residuals, orthogonal collocation. Residual quantities were not treated directly; rather, an approximation procedure for spatial derivatives was developed resulting in broader application for the solution technique. Numerical results were compared with two sets of available experimental data.

82-2378

Large Scale Dynamics of Long Flexible Cables Towed through Air

L.K. Karlsen
Dept. of Aeronautical Engrg., Royal Inst. of Tech., Stockholm, Sweden, Rept. No. KTH-AERO-TN-61, 32 pp (1981)
N82-19567

Key Words: Cables, Towed systems, Aircraft

The full nonlinear equations of motion of a flexible cable in air are formulated together with the appropriate initial and boundary conditions at the cable ends. The properties of transverse waves are studied using a linearized amplitude equation. Numerical computations are carried out on the complete equations for the large scale motion. The longitudinal elastic equation is replaced by an inextensibility

condition and a modified equation for the cable tensile force. Some typical cases of targets towed by an aircraft are considered. The response is computed for aircraft maneuvers such as acceleration-deceleration, climb-descent, and 180 deg. turns with short and long cables.

82-2379

A Model to Predict the Coupled Axial Torsion Properties of ACSR Electrical Conductors

K.G. McConnell and W.P. Zemke
Dept. of Engrg. Sci. and Mech., Iowa State Univ., Ames, IA 50011, Exptl. Mech., 22 (7), pp 237-244 (July 1982) 10 figs, 1 table, 9 refs

Key Words: Cables, Wind-induced excitation, Coupled response, Axial vibration, Torsional vibration

The modeling of ACSR (aluminum-conductor steel-reinforced) electrical conductors for dynamic analysis requires some knowledge of the mechanical properties of the conductor. It was found both experimentally and theoretically, using a simple strength of materials approach, that the axial-torsional behavior of ACSR conductors is highly coupled; i.e., axial motion causes torsional motion and vice versa. Although wind-induced oscillation of ACSR power lines has been observed for years, the importance of axial-torsional coupling has not been generally recognized, nor studied. A simplified mathematical model correlated well with experimental measurements for this type of coupled mechanical behavior. It is hoped that being able to control the amount of coupling through cable design may lead to better control of wind-induced oscillations.

82-2380

Dynamic Analysis of Underwater Cables

A. Lo and J.W. Leonard
Oregon State Univ., Corvallis, OR 97331, ASCE J. Engrg. Mech. Div., 108 (EM4), pp 605-621 (Aug 1982) 11 figs, 24 refs

Key Words: Cables, Underwater structures, Fluid-induced excitation, Finite element technique

A general approach is presented for the finite element analysis of cable systems under hydrodynamic influences. The drag and inertia effects of fluid are included using a Morrison type equation. Curved cable elements are used to improve the geometric approximation of cable segments so that less elements are required than if straight elements are used. The formulation can also handle geometric and material nonlinearities and the effects of any discrete elements can be lumped at nodal points. The principle of virtual work is used to formulate the governing equations and an incremental solution scheme is adopted to simulate the nonlinear effects. The development of the model is presented in a general setting so that further extension or inclusion of other hydrodynamic models is possible. Numerical examples demonstrate the validity and capability of the mathematical formulation. Excellent comparison to experimental results were obtained using a relatively coarse grid of curved cable elements.

82-2381

Dynamic Analysis and Behavior of Electric Transmission Line Systems Subjected to Broken Wires

F.M.A. Siddiqui
Ph.D. Thesis, Univ. of Pittsburgh, 215 pp (1981) DA8214511

Key Words: Transmission lines, Wire, Computer programs

The purpose of the present investigation is to develop an analysis tool to study the behavior of transmission line systems when one or more wires suddenly break. In particular the variation with time of the longitudinal unbalanced loads in the system are considered in order to determine the maximum values for the design of the support structures. The primary emphasis during the investigation has been in the development of a computer program which will perform a dynamic analysis of a general line system after any number of wires are broken. A lumped mass mathematical model is used and the nonlinear equations of motion are solved using four different numerical analysis procedures.

BEAMS

82-2382

Vibration and Stability of a Two-Layered Beam with Imperfect Bonding

S. Chonan
Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Acoust. Soc. Amer., 72 (1), pp 208-213 (July 1982) 6 figs, 11 refs

Key Words: Beams, Layered materials, Timoshenko theory, Vibration response

This paper is a study of the vibration and stability of a two-layered beam with imperfect bonding subjected to axial and

tangential loads. The beam consists of two identical layers joined together by a bonding agent. The normal and shear bond stresses at the interface of the layers are taken to depend on the respective relative vertical and horizontal displacements of the layers. Each layer is assumed to bend according to the Timoshenko beam theory. It is found that the modes of vibration are divided into three classes – the bending mode, the thickness-stretch mode, and the longitudinal mode. The flutter and divergence instability loads are obtained for clamped-free beams and are shown graphically as functions of the shear and normal stiffnesses of the bond. Numerical results are compared with those from the classical Euler beam theory.

82-2383

Effect of Support Conditions on Beam Vibrations Subjected to Moving Loads

J.J. Wu

Large Caliber Weapon Systems Lab., Army Armament Res. and Dev. Command, Watervliet, NY,
Rept. No. ARLCB-TR-82002, 23 pp (Jan 1982) (Presented at the Conf. of Army Mathematicians (27th), West Point, NY, June 10-12, 1981)
AD-A111 937

Key Words: Beams, Moving loads, Vibration response, Supports

Solutions of beam vibrations under moving loads are presented with a variety of support conditions. The purpose is to demonstrate how the support conditions will effect such beam motions. The solution method and mathematical background will be reviewed including the introduction of various support parameters. By slightly modifying an existing computational scheme, the desired results have been obtained and presented in several tables and plots showing the effect of support stiffness on beam motions.

82-2384

Natural Vibrations of a Tapered Beam

M. Kuroda, S. Hatano, and S. Sato

Seikei Univ., Musashino-shi, Tokyo, Japan,
Bull. JSME, 25 (204), pp 952-958 (June 1982) 6 figs, 4 refs

Key Words: Beams, Variable cross section, Natural vibrations, Flexural vibration

A theoretical and experimental study of natural frequencies of bending vibrations of a beam with non-uniform cross section is presented. General solution of the differential equation of the eigenvalue problem is obtained by making use of power series solutions. This solution is applied to a uni-tapered cantilever with I-type cross section, and the nondimensional frequency equation is introduced, yielding a good coincidence of the numerical computations with experimental values concerning the natural frequencies.

82-2385

Super Summed and Differential Harmonic Oscillations in a Slender Beam

T. Yamamoto, K. Yasuda, and N. Tei

Nagoya Univ., Chikusaku, Nagoya, Japan,
Bull. JSME, 25 (204), pp 959-968 (June 1982) 12 figs, 15 refs

Key Words: Beams, Harmonic excitation, Sum and difference frequencies

Various types of nonlinear forced oscillations are expected to occur in a beam subjected to harmonic excitation. This paper is concerned with super summed and differential harmonic oscillations. Theoretical analysis shows that only the summed type can occur in the beam. It also reveals that the transition to the state in which the super summed and differential harmonic oscillation occurs from the state in which only the harmonic oscillation occurs, is made continuously by increasing the excitation frequency. The experimental analysis confirms the results of the theoretical analysis.

82-2386

Analytical and Experimental Investigations of Bimodular Composite Beams

C.W. Bert, C.A. Rebello, and C.J. Rebello

School of Aerospace, Mech. and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73019,
Rept. No. OU-AMNE-82-2, 80 pp (July 1982)

Key Words: Beams, Composite structures, Sandwich structures, Vibration tests

Part I of this report treats analytical and experimental vibration investigations of a sandwich beam with a core of polyurethane foam and facings of unidirectional cord-rubber. The latter material is bimodular; i.e., it has drastically different behavior in compression as compared to tension. This work is believed to be the first devoted to vibration of bimodular material in a sandwich configuration. Two different analyses are presented: one is an unsymmetric sandwich

version of the well-known Timoshenko beam theory, which results in a fourth-order flexural differential equation. The other is a refinement of the DiTaranto-Mead-Markus sixth-order theory with the addition of rotatory inertia. Theoretical and experimental results are presented for the frequencies of the first three modes of vibration of a pin-ended beam without axial restraint. Part II is an analytical investigation of static bending of thick beams laminated of two different unidirectional bimodular materials. Closed-form solutions are presented for two different loading/boundary condition cases, and laminates containing up to six layers are considered. Particular attention is devoted to the effect of the stacking sequence of the layers.

82-2387
Asymptotic Matrix Integration Methods Applied to Rotating Beams
K.E. Barry
Ph.D. Thesis, Stanford Univ., 155 pp (1982)
DA8214552

Key Words: Beams, Rotating structures, Vibration analysis

Asymptotic matrix integration methods are studied in the analysis of the vibrational characteristics of a rotating beam. The differential equations of motion are formulated in state vector and matrix notation for a uniform beam subjected to either compressive or tensile forces arising from steady rotation. The capabilities and advantages of three asymptotic matrix integration methods are explored in dealing with the problems posed by these equations. These methods – the WKB one-term approximation, the Keller-Keller two-term expansion, and an iterative integration procedure – are all derived from WKB theory.

COLUMNS

82-2388
Experimental and Theoretical Studies of Columns under Axial Impact
J. Ari-Gur, T. Weller, and J. Singer
Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Intl. J. Solids Struc., 18 (7), pp 619-641 (1982)

Key Words: Columns, Dynamic buckling

The dynamic response of columns loaded by an impulsive axial compression was studied experimentally and theoretically. Approximate criteria for determination of dynamic buckling are discussed and applied. The investigation was carried out on clamped specimens, made of metals and composite materials, loaded impulsively by a striking mass. In the theoretical study Rayleigh-type beam equations are assumed for a geometrically imperfect column of a linear-elastic anisotropic material. A numerical solution, by a finite-difference approach, yields buckling behavior which correlates well with the experimental results. It is shown that initial geometrical imperfection, duration of impulse and effective slenderness have a major influence on the buckling loads whereas the effect of the material is secondary. The major effects are presented in a form that can guide the designer.

82-2389
On the Dynamic Stability of Viscoelastic Perfect Columns
S. Dost and P.G. Glockner
Dept. of Mech. Engrg., Univ. of Calgary, 2400 University Dr., N.W. Calgary, Alberta, Canada T2N 1N4,
Intl. J. Solids Struc., 18 (7), pp 587-596 (1982)

Key Words: Columns, Viscoelastic properties, Dynamic stability

The dynamic stability of simple supported perfect columns made of a linearly viscoelastic material and subjected to an axial compressive load, P, smaller than the classical Euler elastic buckling load, P_e, is examined. The solution to the integro-differential equation is obtained by means of Laplace transforms. In addition, an approximate solution is also derived by adopting the approximation technique. The results are applied to a simple three-element model viscoelastic column.

FRAMES AND ARCHES

82-2390
Studies on Evaluation of Shaking Table Response Analysis Procedures
J.M. Blondet
Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-81/18, NSF/CEE-81047, 219 pp (Nov 1981)
PB82-197278

Key Words: Frames, Reinforced concrete, Seismic excitation, Shakers

The evolution of the response of reinforced concrete frames to seismic ground motions is studied using experimental data from shaking table tests of reinforced concrete model structure. The structural response during shaking is analyzed and correlated with the input table motion. The response is characterized by means of the average vibration period and the effective acceleration; the ground motion by its pseudoacceleration response surface. The distribution of the energy supplied to the structure by the shaking table is also described. Numerical methods for filtering shaking table and seismic signals are studied. Two widely used techniques, namely the window method and the Ormsby filter, are examined and combined into a numerical scheme with greater flexibility in the specification of the filter parameters and in the numerical performance.

PANELS

(See No. 2355)

PLATES

82-2391

Dynamic Response of Frameworks by Fast Fourier Transform

C.C. Spyrakos and D.E. Beskos

Dept. Civil and Mineral Engrg., Univ. of Minnesota, Minneapolis, MN 55455, Computers Struc., 15 (5), pp 495-505 (1982) 8 figs, 32 refs

Key Words: Framed structures, Fast Fourier transform, Shock response, Wind-induced excitation, Seismic excitation

A general numerical method for determining the dynamic response of linear elastic plane frameworks to dynamic shocks, wind forces or earthquake excitations is presented. The method consists of formulating and solving the dynamic problem in the frequency domain by the finite element method and of obtaining the response by a numerical inversion of the transformed solution with the aid of the fast Fourier transform algorithm. The formulation is based on the exact solution of the transformed governing equation of motion of a beam element and it consequently leads to the exact solution of the problem.

82-2392

The Dynamic Stability of Circular Arches Taking into Account the Flexibility of the Supported Ends and the Behaviour of the Load

Y. Wasserman

Dept. of Mech. Engrg., Ben Gurion Univ. of the Negev, Beer Sheva, Israel, Israel J. Tech., 19 (4), pp 173-180 (1981) 2 figs, 2 tables, 10 refs

Key Words: Arches, Dynamic stability

This paper investigates the problem of dynamic stability of circular arches which are loaded by a uniformly distributed radial load consisting of constant and time-varying portions. The degree of flexibility of the end supports, and three cases of load behavior in the process of deformation, are taken into account. A common equation of dynamic stability of a circular arch with flexibly supported ends, and the equations of the boundary frequencies for the three cases of load behavior, are obtained.

82-2393

Geometrically Nonlinear Transient Analysis of Laminated Composite Plates

J.N. Reddy

Dept. of Engrg. Science and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. VPI-E-82.8, AFOSR-TR-81-3, 37 pp (Mar 1982) AD-A113 852

Key Words: Plates, Composite structures, Layered materials, Transient response, Transverse shear deformation effects, Rotatory inertia effects

Forced motions of laminated composite plates are investigated using a finite element that accounts for the transverse shear strains, rotary inertia, and large rotations (in the von Karman sense). The present results when specialized for isotropic plates are found to be in good agreement with those available in the literature. Numerical results of the nonlinear analysis are presented showing the effects of plate thickness, lamination scheme, boundary conditions, and loading on the deflections and stresses.

82-2394

The Effect of Non-Stationary Random Vibrations on Plates of Complex Form

A. Waberski

Dept. of Math. and Physics, Inst. of Theoretical Mech., Silesian Technical Univ., Ulkatowicka 7, Gilwice, Poland, Appl. Acoust., 15 (3), pp 171-189 (May 1982) 23 figs, 6 refs

Key Words: Plates, Random vibration

Such thin-walled structures as thin plates and shells have been widely used in the devices and structures involved in

aircraft and rocket engineering. These elements are very often affected by random loadings which are characterized as non-stationary random fields. This occurs, in particular, at the moment of starting and also in the transient working conditions of the structure. Random non-stationary vibrations of plates are especially affected by their complex form, as well as by the way in which the edge is fixed, the latter being described by boundary conditions. In this paper only thin elastic plates of complex form clamped along the edge are considered. In particular, the statistical characteristics of plate vibration are analyzed. The plates are subjected to non-stationary random loadings which are of a harmonic character with random amplitude and phase, their frequency changing linearly.

82-2395

Anomaly Observed in the Approximate Analysis of Vibrating Rectangular Plates with Edges Elastically Restrained against Rotation and Translation

R.O. Grossi and P.A.A. Laura

Inst. of Appl. Mech., Puerto Belgrano Naval Base, Argentina, Appl. Acoust., 15 (3), pp 223-229 (May 1982) 1 fig, 3 tables, 6 refs

Key Words: Plates, Rectangular plates, Fundamental frequency, Rayleigh-Ritz method, Spring constants

This paper deals with the solution of the title problem in the case of an orthotropic plate with three edges elastically restrained against rotation while transverse displacement is prevented. It is assumed that the fourth edge is elastically restrained against rotation and translation. The natural boundary conditions are satisfied approximately at the fourth edge. The Rayleigh-Ritz method is used to drive an approximate fundamental frequency equation and a rather curious anomaly is shown to exist in the frequency values for a certain range of values of the rotational and translational spring parameters which govern the motion of the fourth edge.

82-2396

Flexible Vibrations and Instabilities of a Rotating Disk Carrying a Heavy Pin

J.J. Blech and Y. Kovari

Faculty of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 19 (4), pp 127-134 (1981) 15 figs, 7 refs

Key Words: Disks (shapes), Rotating structures, Natural frequencies, Mode shapes

The dynamic behavior is investigated of a rotating thin circular disk which carries a rigid pin at its inner radius and is fully or partially clamped at its outer radius. Natural frequencies and instability onset speeds are calculated for the symmetric and the anti-symmetric modes of vibration.

SHELLS

(Also see No. 2323)

82-2397

Elasto/Visco-Plastic Dynamic Response of General Thin Shells to Blast Loads

S. Takezono and K. Tao

Kumamoto Univ., Kumamoto, Japan, Bull. JSME, 25 (203), pp 728-735 (May 1982) 12 figs, 15 refs

Key Words: Shells, Blast loads, Viscoelastoplastic properties

The authors study an elasto/visco-plastic dynamic response of thin shells to strong blast loads, where a consideration is given to the viscosity of the material in the plastic range. The equations of motion and the relations between the strain and the displacement are derived from the Sanders nonlinear theory for thin shells. The constitutive relation for shell response is linear elastic, visco-plastic. In the linear elastic range Hooke's law is used. In the plastic range the elasto/visco-plastic equations by Fyfe based on the model developed by Perzyna are employed. The criterion for yielding used in this analysis is the von Mises yield theory. The fundamental equations are numerically solved by a method using finite difference in both space and time. As a numerical example an elliptical, cylindrical shell subjected to external impulsive loads is analyzed.

82-2398

Dynamic Buckling of Orthotropic Shallow Spherical Shells

M. Ganapathi and T.K. Varadan

Dept. of Aeronautics, Indian Inst. of Tech., Madras 600 036, India, Computers Struc., 15 (5), pp 517-520 (1982) 5 figs, 2 tables, 12 refs

Key Words: Shells, Spherical shells, Dynamic buckling, Damping effects

The dynamic axisymmetric behavior of clamped orthotropic shallow spherical shell subjected to instantaneously applied uniform step-pressure load of infinite duration, is investigated. The available modal equations, based on an assumed

two-term mode shape for the lateral displacement, for the free flexural vibrations of an orthotropic shallow spherical shell is extended for the forced oscillations. The resulting -ial equations are numerically integrated using Runge-Kutta method, and hence the load-deflection curves are plotted. The pressure corresponding to a sudden jump in the maximum deflection (at the apex) is considered as the dynamic buckling pressure, and these values are found for various values of geometric parameters and one value of orthotropic parameter. The numerical results are also determined for the isotropic case and they agree very well with the previous available results.

82-2399

A Seismic Response Analysis of a Cylindrical Liquid Storage Tank Including the Effect of Sloshing (2nd Report, Analysis Based on Energy Method)

K. Fujita

Takasago Technical Inst., Technical Headquarters, Mitsubishi Heavy Industries, Ltd., Takasago, Hyogo Pref., 676, Japan, Bull. JSME, 25 (204), pp 977-985 (June 1982) 4 figs, 4 tables, 12 refs

Key Words: Containers (tanks), Storage tanks, Shells, Cylindrical shells, Sloshing, Seismic response, Energy methods

A seismic response analysis method for a cylindrical liquid storage tank subjected to a horizontal earthquake is presented, based on an energy method, taking into consideration the coupling effect between sloshing and bulging. The kinetic energy and the strain energy of an empty tank shell are estimated by the axisymmetric shell finite element method. The kinetic energy and the potential energy of the liquid in the tank are estimated analytically by superposition of two types of velocity potential -- one obtained by assuming the tank wall as rigid and the other considering the liquid to be coupled with the tank shell, neglecting the oscillation of liquid free surface.

PIPES AND TUBES

(See Nos. 2351, 2454)

DUCTS

(Also see Nos. 2346, 2347, 2415)

82-2400

Duct Sound Power Measurement in the Presence of Flow (Mesure de la Puissance, Acoustique Rayonnee en Conduit en Presence d'Ecoulement)

J. Roland

Association Aeronautique et Astronautique de France, Paris, Rept. No. AAAF-NT-80-60, 27 pp (Nov 1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, Nov 4-5, 1980)
PB82-204553
(In French)

Key Words: Sound level meters, Fan noise, Ducts

The power of sound radiated by a fan in one or more ducts connected with it is a given element in calculating the performance of an air distribution system. This study sets forth the difficulties of measurement in a duct in the presence of flow and examines three possible methods, comparing the results of two of the methods used.

82-2401

Sound Field Near the Edge of a Liner in Uniform Flow

W. Mohring and W. Eversman

Association Aeronautique et Astronautique de France, Paris, Rept. No. AAAF-NT-80-62, 32 pp (1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, Nov 4-5, 1980)
PB82-203852

Key Words: Ducts, Acoustic linings

An example which contains only a constant velocity mean flow is discussed. It is assumed that a two-dimensional duct with constant cross-section carries a uniform mean flow and contains a liner of finite length. It is found that the amount of acoustic energy entering a part of the duct which contains the lining differs from the acoustic energy leaving that part even if the liner is assumed to be without losses.

BUILDING COMPONENTS

82-2402

A Linearization Technique for the Dynamic Response of Nonlinear Continua

C.M. Krousgrill, Jr.

Earthquake Engrg. Res. Lab., California Inst. of Tech., Pasadena, CA, Rept. No. EERL-80-08, NSF/RA-800640, 150 pp (1981)
PB82-201823

Key Words: Structural members, Dynamic response, Equivalent linearization method

A technique for understanding the dynamic response of structural elements is developed. The technique is based on the concept of the equivalent linearization method which relies on obtaining an optimal linear set of equations to model the original nonlinear set. The linearization is performed at the continuum level, because the equivalent linear stiffness and damping parameters are physically realizable and are defined in such a way that the method could be easily incorporated into finite element computer codes. Three different approaches, each based on the minimization of a distinct difference between the nonlinear system and its linear replacement, are taken. Existence and uniqueness properties of the minimization solutions are established and procedures for solving the equivalent linearization are discussed. The method is applied to three specific examples: one dimensional, hysteretic shear beams; thin plates governed by nonlinear equations of motion; and the same nonlinear plates but with cutouts.

82-2403
Variations in Sound Transmission on Steel Studded, Gypsum Walls
J.W. Kopec
Riverbank Acoustical Labs., Geneva, IL, Sound Vib., 16 (6), pp 10-15 (June 1982) 7 figs, 2 tables, 7 refs

Key Words: Walls, Sound transmission loss

A comprehensive data analysis indicates variations in sound transmission loss and class of thirty-seven different configurations involving steel studded gypsum board walls.

82-2404
Dynamic Response of Coupled Wall Systems
J.D. Aristizabal-Ochoa
Vanderbilt Univ., Nashville, TN, ASCE J. Struc. Div., 108 (ST8), pp 1846-1857 (Aug 1982) 10 figs, 2 tables, 6 refs

Key Words: Walls, Reinforced concrete, Seismic excitation

Results of an experimental investigation to determine the inelastic dynamic behavior of reinforced concrete coupled wall systems under severe earthquake motions are reported. These tests show that the natural frequencies of reinforced concrete structures are reduced to as much as 50% of the initial uncracked values during the first few seconds of a strong earthquake. Additional reductions in the natural frequencies are not as significant as those caused by the first shock even if the aftershocks are significantly stronger than the first one. The size, strength, and ductility of the coupling beams are the controlling factors in the mode of failure of coupled wall systems, and, although the test structures were subjected to severe inelastic behavior, some characteristics, such as modal shapes, nodal points, and amplification (filtering) along the height of the structure were similar to those of linear elastic systems.

ELECTRIC COMPONENTS

CONTROLS (SWITCHES, CIRCUIT BREAKERS)

(See No. 2431)

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2345, 2346, 2347, 2417, 2449, 2459)

82-2405
Computation of Steady-State Scattered Sound from Submerged Infinite Cylinders by a Structural Analog Method
F.M. Henderson
David W. Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD, Rept. No. DTNSRDC-82/012, 61 pp (Feb 1982)
AD-A111 820

Key Words: Interaction: structure-fluid, Acoustic scattering, Cylinders, Structural analog method

Finite-element formulations of fluid-structure interaction problems based on the use of structural analogies have been used in a wide variety of applications. The formulations originate from analogies that can be derived between the equations of dynamic elastic motion and generalized forms of the scalar wave equation. The analogies prescribe that the fluid can be modeled with structural finite elements to which special material properties have been assigned. A particular advantage of this approach is the requirement for only a single degree-of-freedom at each field grid point to represent the scalar field variable. In this report the analog formulations are extended to steady-state plane wave scattering by infinite cylinders. Details of implementation of the formulations via the NASTRAN computer program are presented along with calculations of acoustic pressure scattered by submerged rigid cylinders, empty elastic cylinders, and elastic cylinders containing fluids bounded by interior cylinders which may be eccentric with respect to the outer cylinder.

82-2406

YF 102 In-Duct Combustor Noise Measurements with a Turbine Nozzle, Volume 3

C.A. Wilson and J.M. Oconnell

Stratford Div., Avco Lycoming Engine Group, Stratford, CT, Rept. No. NASA-CR-165562-V-3, 244 pp (Sept 1981)

N82-21033

Key Words: Combustion engines, Combustion noise, Noise measurement

The internal noise generated by an Avco Lycoming YF-102 engine combustor installed in a test rig was recorded. The narrow band pressure level spectra is presented.

82-2407

Apparatus and Method for Jet Noise Suppression

L. Maestrello

NASA Langley Res. Ctr., Hampton, VA, U.S. Patent Appl. No. 6-238-791, 25 pp (June 3, 1981)

Key Words: Jet noise, Noise reduction

A method and apparatus for jet noise suppression through control of the static pressure of the jet and control of the rate of entrainment of ambient fluid into the jet downstream o' the exhaust nozzle is discussed. In addition, the momentum flux over an extended region of the jet is regulated.

82-2408

The Effect of Barriers on Wave Propagation Phenomena: With Application for Aircraft Noise Shielding

C.V.M. Mgana

Ph.D. Thesis, Stanford Univ., 144 pp (1982)

DA8214595

Key Words: Noise barriers, Aircraft noise, Wave propagation, Low frequencies, High frequencies

In recent years the subject of suppressing aerodynamic noise by shielding has actively been pursued both analytically and experimentally. Although there is a reasonably good agreement between the experimental results obtained under laboratory conditions and analytical results, the comparison is far from being satisfactory under flight conditions where several physical factors come into play in this problem. In order to make a reasonable study of the problem, the whole range of the frequency spectrum has to be studied. In the present study the frequency spectrum has conveniently been divided into two regimes: the low frequency and high frequency regimes. Two separate methods have been developed for application to each regime.

82-2409

A Summary of Recent Research on Acoustic Bottom Interaction

P.J. Vidmar and R.A. Koch

Applied Res. Labs., Univ. of Texas at Austin, TX, Rept. No. ARL-TR-82-14, 136 pp (Mar 10, 1982)

AD-A114 034

Key Words: Underwater sound

This report summarizes research on the acoustic interaction with the sea floor. Major topics considered are bottom structures having near-surface layering and propagation over slopes. Other topics include bottom interaction in shallow water, the effects of bottom roughness, and the bottom interaction phase shift.

82-2410

A Prony Measuring System for Underwater Acoustical Measurements

C.K. Brown and R.W. Luckey

Naval Res. Lab., Washington, DC, Rept. No. NRL-MR-4735, 23 pp (Jan 31, 1982)

AD-A112 008

Key Words: Underwater sound, Sound measurement, Digital techniques, Measuring instruments

A new digital system, the Prony Measuring System, for underwater acoustical measurements from 1 Hz to approximately 2 MHz has been developed. The heart of the system is a stable signal and sampling source and 12-bit, 5-MHz, analog-to-digital converter with a 4K buffer memory. A PDP-11/23 serves as a controller as well as a signal processor for averaging, and amplitude and phase estimation.

82-2411

Mean Multipath Intensity Relation for Sound Propagation through a Random Ocean Front

J.A. Neubert

Naval Ocean Systems Ctr., San Diego, CA 92152, J. Acoust. Soc. Amer., 72 (1), pp 222-225 (July 1982) 1 fig, 9 refs

Key Words: Underwater sound

By considering the stochastic nature of the phase fluctuations in the ocean, the conventional ray theory intensity relaxation was extended in an earlier paper to permit consideration of partial coherence in multipath problems. Although this relation worked well in the open ocean, it proves to be incomplete for sound propagation through a random ocean front. By also considering the amplitude fluctuations, a mean multipath intensity relation is found that takes into consideration the strong horizontal sound-speed gradients that occur in certain important ocean frontal regions.

82-2412

T-Matrix Analysis of Acoustic Wave Scattering from Thin Elastic Shells

V.V. Varadan and V.K. Varadan

Ohio State Univ. Res. Foundation, Columbus, OH, Final Rept. May 1, 1980 - Apr 30, 1982, 15 pp (Oct 1981)

AD-A111 980

Key Words: Sound waves, Wave scattering, Shells, Underwater sound

Progress has been made in the study of acoustic wave scattering by elastic obstacles immersed in water using the T-matrix approach. It is understood that scattered field data is required for long, thin bodies of revolution whose wall thickness is very small compared to the wavelength of the incident wave but whose overall dimensions are comparable and often larger than the wavelength of the incident wave. This project was begun to precisely address such problems, taking into account and exploiting the thinness of the shell. Shell theory equations are used rather than the full elasticity equations in region I in order to avoid some of the complications.

82-2413

Scattering of Transient Acoustic Waves in Fluid and Solids

G.C. Herman

Technische Hogeschool, Delft, The Netherlands, 190 pp (Dec 22, 1981)

N82-22000

Key Words: Sound waves, Elastic waves, Wave diffraction

The linearized theory of the three-dimensional scattering of transient acoustic waves in fluids and solids by obstacles of finite interest is discussed. Special attention is devoted to the direct time-domain analysis and its implementation, although Fourier inversion of analytically obtained frequency-domain results is occasionally used as a check on the numerically obtained time-domain results.

82-2414

Instability and Acoustic Emission of Overexpanded Supersonic Jets (Instabilite et Emission Acoustique de Jets Supersoniques Surdetendus (Simulation en Analogie Hydraulique)

E. Brocher and J.P. Gondran

Association Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-80-51, 18 pp (Nov 1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, Nov 4-5, 1980)

PB82-203845

(In French)

Key Words: Acoustic emission

The analogy existing between the two-dimensional flow of a free surface liquid and the two dimensional flow of a compressible gas is used to investigate the phenomenon of instability occurring in overexpanded supersonic jets. One finds in the hydraulic case the characteristics of the instability observed on gaseous jets; namely: the instability occurs only over a certain range of the surrounding counter-pressure; the emitted sound has a marked discrete frequency of very high intensity; the wavelength of the emitted sound is coupled to the cell length of the structured jet. A theoretical model which takes into account the jet structure is elaborated.

82-2415

Action of a Helmholtz Resonator Placed in the Wall of a Permanent Flow Duct (Comportement d'un

Resonateur d'Helmholtz Place en Parol d'un Conduit Parcouru par un Ecoulement Permanent)
M. Cubaud
Association Aeronautique et Astronautique de France, Paris, Rept. No. AAAF-NT-80-63, 19 pp (Nov 1980) (Presented at Colloque d'Acoustique Aeronautique (7th), Lyon, Nov 4-5, 1980)
PB82-203381
(In French)

Key Words: Helmholtz resonators, Noise reduction, Ducts

The action of a Helmholtz resonator placed in the wall of a duct with or without a permanent flow is studied. Such a device is commonly used in industrial soundproofing. Its field of application is on monochromatic plane waves or with narrow bands. The experiment involved establishing a model representing the acoustical system constituted by the resonator and the duct in a closed circuit form. The study shows that contrary to commonly accepted ideas, a flow does not necessarily exercise an unfavorable influence in the attenuation brought about by a Helmholtz resonator placed in the wall of a duct.

SHOCK EXCITATION

(Also see Nos. 2486, 2489)

82-2416
A Manual for the Prediction of Blast and Fragment Loadings on Structures
W.E. Baker, J.J. Kulesz, P.S. Westine, P.A. Cox, and J.S. Wilbeck
Southwest Res. Inst., San Antonio, TX, Rept. No. SWRI-02-5594, DOE/TIC-11268, 779 pp (Aug 1981)
AD-A111 849

Key Words: Blast response, Blast resistant structures

The purpose of this manual is to provide architect-engineer firms guidance for the prediction of air blast, ground shock and fragment loadings on structures as a result of accidental explosions in or near these structures. Information in this manual is the result of an extensive literature survey and data gathering effort, supplemented by some original analytical studies on various aspects of blast phenomena. Many prediction equations and graphs appear in the manual, accompanied by numerous example problems illustrating their use.

82-2417
Techniques for Reducing Gun Blast Noise Levels: An Experimental Study
L.L. Pater and J.W. Shea
Naval Surface Weapons Ctr., Dahlgren, VA, Rept. No. NSWC-TR-81-120, 60 pp (Apr 1981)
AD-A112 290

Key Words: Gunfire effects, Noise reduction

Several techniques for reducing gun muzzle blast noise levels were investigated experimentally to determine potential effectiveness and utility for existing major-caliber guns. Techniques explored included muzzle brakes, conical muzzle devices, baffle-type silencers, water spray, and aqueous foam.

82-2418
Prediction of Seismic Response of Long-Period Structures
Y. Fujino and A.O.H.-s Ang
Univ. of Tokyo, Bunkyo-ku, Tokyo, Japan 113, ASCE J. Struc. Div., 108 (7), pp 1575-1588 (July 1982) 6 figs, 2 tables, 25 refs

Key Words: Seismic response, Natural frequencies, Low frequencies

This paper describes the application of an analytical method for estimating the seismic response of long-period structures at an intermediate distance from a fault; the method is based on fault dislocation and surface wave theory. Long-period ground motions due to Love waves and their response spectra are calculated for various fault rupture and crustal models. Sloshing wave heights in a large tank during the earthquake are also estimated.

82-2419
Response of Intermediate Scale Submarine Models to Simulated Nuclear Underwater Explosions. Volume 1. Development of Computational Procedures
A.S. Kushner and D.E. Ranta
Pacifica Technology, Del Mar, CA, Rept. No. PT-U81-0015-Vol-1, DNA-5799F-1, 41 pp (June 12, 1981)
AD-A113 869

Key Words: Underwater explosions, Nuclear explosions, Doubly Asymptotic Approximation

The physical significance of the terms in the double asymptotic approximation (DAA) are evaluated. Additionally, the computational aspects of the terms are discussed. Two simplified versions of the DAA are proposed. These versions are referred to as the plane wave-added mass (PWAM) cylinder approximation and the PWAM plate approximation. Both approaches are evaluated via comparison to exact solutions and full DAA solutions. The PWAM plate approximation is shown to give results almost identical to the full DAA for problems dominated by structural deformation. Both methods appear to do a good job of picking up shell translation response.

82-2420

Interaction of a Weak Wave with a Characteristic Shock in a Hyperelastic Medium

S. Pluchino
Seminario Matematico, Universita di Catania, Meccanica, 4 (16), pp 192-195 (Dec 1981) 18 refs

Key Words: Shock waves

The transmission and reflection of plane one-dimensional waves across a shock wave in a nonlinear isotropic and isothermal hyperelastic medium is investigated. The amplitudes of both the transmitted and the reflected waves and the jump of the shock acceleration are determined explicitly for a particular class of thermodynamical potentials. It is shown that in the case of Tolotti's potential, the interaction does not affect the propagation of either kind of wave.

82-2421

Generalized Sharp-Blow Waves Containing a Trailing Finite-Amplitude Discontinuity in the Domain Interior

T.S. Lee
Elect. Engrg. Dept., Univ. of Minnesota, Minneapolis, MN 55455, Intl. J. Nonlin. Mech., 17 (2), pp 105-118 (1982) 6 figs, 2 tables, 9 refs

Key Words: Shock wave propagation, Wave propagation

The classical sharp-blow wave in one-dimensional gas dynamics portraying disturbances following a surface impact or explosion forecasts the severest possible power-law decay in the strength of a leading shock wave entering a uniform medium. In a Lagrangian formulation, the present work establishes, for the same decay law, a new class of solutions for which the existence of an interior trailing shock discontinuity in response to a boundary back-pressure presence is a central thesis. It is determined that if the back pressure lies below a certain critical level relative to the frontal pressure, the strength of the trailing discontinuity is invariant but is inversely related to the magnitude of the relative back pressure. At the critical pressure level, the solution is at its weak-interior-shock limit, recognizable as the continuous wave previously discovered by Adamskii and Popov.

82-2422

Resonant Scattering by Fluid-Filled Cavities

G.A. McMechan
Earth Physics Branch, Dept. of Energy, Mines and Resources, Pacific Geoscience, Sidney, BC, V8L 4B2, Canada, Bull. Seismol. Soc. Amer., 72 (4), pp 1143-1153 (Aug 1982) 7 figs, 1 table, 9 refs

Key Words: Cavities, Fluid-filled containers, Seismic excitation, Wave diffraction

Interaction of seismic energy with a fluid-filled cavity results both in scattering by the cavity and in excitation of its normal modes. The normal modes contain information about the properties of the fluid that fills the cavity and its size. In the frequency domain, each mode in the cavity response can be decomposed into a sum of two spectra: the background scattering from an empty cavity and the resonant coupling between the fluid cavity filler and the surrounding matrix. Synthetic seismograms are computed by Fourier transformation and summing modes. The theory is applied to a water-filled crack in granite, a model for the core of Mars, and a magma chamber.

82-2423

Stationary and Transient Response Statistics

P.H. Madsen and S. Krenk
Riso National Lab., 4000 Roskilde, Denmark, ASCE J. Engrg. Mech. Div., 108 (EM4), pp 622-635 (Aug 1982) 12 figs, 3 tables, 15 refs

Key Words: Transient response, Multidegree of freedom systems, Spectral densities, Covariance function

The covariance functions for the transient response of a linear MDOF-system due to stationary time limited excitation with an arbitrary frequency content are related directly to the covariance functions of the stationary response. For rational spectral density functions closed form expressions for the covariance functions are obtained. In case of white noise excitation the expressions simplify considerably, and an approximative method for including the main effects of an actual spectral density function is derived based on a white noise analogy. The theory is applied to a multistory frame structure, and it is demonstrated that it offers an efficient way to calculate the time-dependent second-order moments.

82-2424

Dynamics of Cloth Subject to Ballistic Impact Velocities

C.M. Leech and B.A. Adeyefa
Univ. of Manchester, Inst. of Science and Tech., P.O. Box 88, Manchester M60 1QD, UK, Computers Struc., 15 (4), pp 423-432 (1982) 11 figs, 6 refs

Key Words: Textiles, Impact response

The method of characteristics is employed for the numerical simulation of the dynamics of textile structures subject to ballistic impact velocities. The characteristic equations are applied at each node and then, naturally, lead to an iterative solution in a similar manner to that evolving from finite element modeling. This method is much better at predicting the peculiar signal fronts than other competing techniques.

VIBRATION EXCITATION

82-2425

Wind Excited Behaviour of Structures III

D.J. Johns
Dept. of Transport Tech., The Univ. of Tech., Loughborough, Leicestershire, LE11 3TU, UK, Shock Vib. Dig., 14 (7), pp 23-28 (July 1982) 2 tables, 178 refs

Key Words: Reviews, Wind-induced excitation, Vortex shedding, Galloping, Flutter, Turbulence

This article reviews recent literature on wind-excited behavior of structures. Among the phenomena considered are those due to vortex shedding, galloping, flutter, divergence, and turbulence. Theoretical and experimental (model and full scale) studies are included as are techniques to alleviate wind excited behavior.

82-2426

A Fundamental Study on Frictional Noise (5th Report, The Influence of Random Surface Roughness on Frictional Noise)

M. Yokoi and M. Nakai
Osaka Industrial Univ., 3-1-1 Nakagaido Daito-city, Osaka, Japan, Bull. JSME, 25 (203), pp 827-833 (May 1982) 11 figs, 1 table, 13 refs

Key Words: Friction excitation, Surface roughness

Frictional noises which occur when a steel rod is pressed in the radial direction on a rotating thick steel disk with various random surfaces without lubrication are studied experimentally and theoretically. When the surface roughness becomes larger, loss of contact occurs. The results calculated by considering the random surface roughness as an external force agree with the experimental results. Assuming a rod as a sound radiator of cylindrical waves, the calculated conversion ratio from acceleration of a rod to sound pressure is coincident with the experimental results. Additionally, sound pressure level is proportional to the differentiation of lateral acceleration of the rod. This conversion ratio makes it possible to predict the sound pressure level from the easily measured acceleration.

82-2427

Vortex-Induced Vibrations of Structures

S.A. Hall
Earthquake Engrg. Res. Lab., California Inst. of Tech., Pasadena, CA, Rept. No. EERL-81-01, NSF/CEE-81094, 241 pp (Jan 1982)
PB82-201849

Key Words: Vortex-induced vibration

Vortex-induced oscillations, which are often of concern when a bluff structure is exposed to fluid cross-flow, are studied. A semi-empirical model is developed based on the fluid momentum theorem. The model involves a highly simplified abstraction of the complex flow field, as well as assumptions concerning the nature of the coupling between the fluid and the oscillating structure. Three prototype problems are examined, including harmonically forced cylinders, spring-mounted cylinders, and taut elastic cables. In each case, the structure is assumed to be of circular cross-section and situated in a uniform cross-flow. Only oscillations transverse to the flow are considered. The problem of modal interaction for elastic cables is stressed.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 2286, 2291, 2487)

82-2428

Apparatus for Damping Operator Induced Oscillations of a Controlled System

J.W. Edwards and J.W. Smith

NASA Hugh L. Dryden Flight Res. Ctr., Edwards, CA, U.S. Patent No. 4 298 833, 13 pp (Nov 3, 1981)

Key Words: Vibration dampers

Flight control-related apparatus for damping operator induced oscillations of a controlled system responding to an operator controlled signal is described. The device utilizes a lag-lead filter for frequency and amplitude estimation of the control input, and a rectification and smoothing filter for producing a signal proportional to the absolute value of the frequency and amplitude estimate for use in suppression of the control system output signal.

82-2429

Prediction of Ship Roll Damping. A State of the Art

Y. Himeno
Dept. of Naval Architecture and Marine Engrg., Univ. of Michigan, Ann Arbor, MI, Rept. No. 239, 86 pp (Sept 1981)
AD-A112 282

Key Words: Damping, Ship rolling

Various methods for predicting the roll damping of a ship at forward speed are discussed. In particular, a simple method and a component analysis are described. The component analysis assumes that the damping is composed of friction damping, eddy damping, lift damping, wave damping, normal-force damping of bilge, keel, hull pressure damping due to bilge keels, and wave damping of bilge keels. Formulas for these components are derived from theoretical and experimental considerations. A listing of a computer program used to compute roll damping is included.

82-2430

Measurement of Large Damping

H. Sekiguchi and T. Asami
Himeji Inst. of Tech., 2167, Shosha, Himeji, Hyogo, 671-11 Japan, Bull. JSME, 25 (204), pp 986-993 (June 1982) 9 figs, 1 table, 9 refs

Key Words: Damping coefficients, Measurement techniques, Phase method, Gravity method

Damping is an elementary factor to be considered in designing vibration isolators. Measurement of damping coefficient or damping ratio is of great importance. Usually these values are calculated by logarithmic decrement or resonance method. These are convenient methods if a system possesses light damping; however, the accuracy of these methods is not satisfactory in a large damping system. In this paper two new methods to calculate large damping with high accuracies are proposed: a method utilizing a phase angle between input and output, called phase method, and a method utilizing the gravitational acceleration, called gravity method. It is shown that the measured values obtained by the phase method and the gravity method show a higher degree of accuracy than those obtained by the resonance method.

82-2431

Damping Characteristics of Solid Brush Current Collection Systems

C.A. Broniarek
Mech. Engrg. Dept., Tuskegee Inst., AL 36088, Wear, 78 (1, 2), pp 233-242 (May 1982) 5 figs, 6 refs

Key Words: Current collectors, Damping coefficients

The damping characteristics of a current collection system were examined. The following three categories of damping were selected: damping in the brush material due to rheological properties of the brush material (called internal friction); damping in the interface between the brush and the holder or between the brush and the rotor (called interface damping); and fluidic damping, or viscous damping, due to interaction with the ambient fluid, such as air, vapor etc. The theoretical analysis of several types of mechanisms and models is postulated. The experimental tests for measurements of the damping parameters are suggested. The analytical methods of calculation of the equivalent of damping constants to be used in the standard stability analysis are presented.

82-2432

Damping Seals for Turbomachinery

G.L. Vonpragenau
NASA George C. Marshall Space Flight Ctr., Huntsville, AL, Rept. No. NASA-TP-198, 28 pp (Mar 1982)
N82-20183

Key Words: Turbomachinery, Seals, Dampers

A rotor seal is proposed that restricts leakage like a labyrinth seal, but extends the stabilizing speed range beyond twice the first critical speed. The dynamic parameters were derived from bulk flow equations without requiring a dominant axial flow. The flow is considered incompressible and turbulent. Damping seals are shown to be feasible for extending the speed range of high performance turbomachinery beyond the limit imposed by conventional seals.

FATIGUE

(Also see Nos. 2320, 2329, 2374)

82-2433

A Comparison of the Fatigue Strength of Machined and As-Cast Surfaces of SG Iron

M.S. Starkey and P.E. Irving

Group Tech. Ctr., GKN Technology Ltd., Birmingham New Rd., Wolverhampton WV4 6BW, UK, Intl. J. Fatigue, 4 (3), pp 129-136 (Apr 1982) 15 figs, 23 refs

Key Words: Fatigue (materials)

The fatigue strength of machined specimens of ferritic SG iron has been compared with the strength of specimens having an as-cast surface. Micropores, exposed by machining, initiated failure in the machined specimens, whereas surface irregularities or dross defects initiated failure from the as-cast surface. While the endurance of specimens in which failures initiated at surface irregularities was only marginally less than that of machined specimens, dross defects reduced fatigue life by a factor of ten. It is demonstrated that the fatigue life of SG irons is dominated by micro-crack growth and that the effect of all types of SG-iron defects on fatigue endurance is related to defect size. Specimen endurances of less than 10^5 cycles can be predicted using a fracture mechanics approach and integrating the Paris Law from the appropriate defect size.

82-2434

Fatigue Behaviour and Mean Effects in Grey Cast Iron

J. Fash and D.F. Socie

Design Div., Dept. of Mech. and Industrial Engrg., Univ. of Illinois at Urbana-Champaign, Urbana, IL 61801, Intl. J. Fatigue, 4 (3), pp 137-142 (Apr 1982) 12 figs, 2 tables, 12 refs

Key Words: Fatigue (materials), Fatigue tests

Strain cycle fatigue concepts are well integrated into fatigue life prediction methodology for wrought components. Concepts developed for wrought materials cannot be directly extended to cast materials because of differences in the fatigue mechanisms, but the framework of a life prediction method for cast iron components will be similar. Observations and results of constant-amplitude completely reversed fatigue tests performed in strain and load control are reported for a pearlitic grey cast iron. Mean amplitude tests in both control modes have been conducted to evaluate the effects of mean stresses and strains.

82-2435

Structure-Property Relationships in Graphitic Cast Irons

P.A. Blackmore and K. Morton

British Cast Iron Res. Assn., Alvechurch, Birmingham B48 7QB, UK, Intl. J. Fatigue, 4 (3), pp 149-155 (Apr 1982) 12 figs, 5 tables, 13 refs

Key Words: Fatigue (materials)

Some techniques used to study fatigue of cast irons are discussed and used to study the structure-property relationships in graphitic cast irons. A wide range of cast irons have been assessed to give a better understanding of the effects of metallurgical structure and graphite morphology on the fatigue behavior of these materials. It is concluded that the true fatigue strength reduction factor is one of the most significant parameters by which to consider improvements in fatigue properties. Increasing the amount of spheroidal graphite is suggested as a method of improving the fatigue properties of CG cast irons and yielding alloys with great potential importance.

82-2436

Service Life of a 60 MW Turbine Rotor with Frequent Starts (Lebensdauerbetrachtungen für den Turbinenläufer eines 60-MW-Turbosatzes mit häufigen Starts)

A.D. Truchnij and K.-F. Schröder

Energetisches Inst. Moscow, USSR, Maschinenbautechnik, 31 (5), pp 227-230 (May 1982) 9 figs, 2 tables, 9 refs

(In German)

Key Words: Fatigue life, Steel, Turbines

The results of fatigue tests on 21 Cr Mo V steel are used in the prediction of fatiuge life of turborotors under different starting conditions.

82-2437

The Fatigue Properties of Some Cast Steels

K. Selby

Metallurgy and Mech. Performance, Steel Castings Res. and Trade Assn., 5 E. Bank Rd., Sheffield S2 3PT, UK, Intl. J. Fatigue, 4 (3), pp 124-128 (Apr 1982) 11 figs, 10 refs

Key Words: Fatigue (materials), Steel

Fatigue properties of some cast steels are presented with the aim of highlighting both the need and areas for future work on these materials. Possible explanations for the lack of acceptance by design engineers of cast steels are given. Specific areas in which further research is required are indicated. The biggest problem is predicted as being the characterization and mathematical modeling of real defects. Discontinuities worthy of investigation are listed.

82-2438

Crack Closure – Is It Just a Surface Phenomenon?

N.A. Fleck and R.A. Smith

Engrg. Dept., Cambridge Univ., Trumpington St., Cambridge CB2 1PZ, UK, Intl. J. Fatigue, 4 (3), pp 157-160 (July 1982) 3 figs, 1 table, 12 refs

Key Words: Fatigue (materials), Steel, Crack propagation, Prediction techniques

The fatigue crack closure response in the plane strain regions of a steel specimen is evaluated. Compliance measurements using a new type of closure gauge, crack-mouth clip gauge and back face strain gauge show that the fatigue crack is closed for a significant portion (20%) of the load cycle. A sectioning technique is used to confirm that the fatigue crack is closed along the whole crack front, at zero load.

82-2439

A Model for Fatigue Crack Growth in a Threshold Region

J.C. Radon

Mech. Engrg. Dept., Imperial College of Sci. and Tech., Exhibition Rd., London SW7 2BX, UK, Intl. J. Fatigue, 4 (3), pp 161-166 (July 1982) 4 figs, 18 refs

Key Words: Fatigue (materials), Steel, Crack propagation, Prediction techniques

The prediction of fatigue crack growth at very low ΔK values, and in particular for the threshold region, is important in design and in many engineering applications. A simple model for cyclic crack propagation in ductile materials is discussed and an expression is developed. The model is successfully used in the analysis of fatigue data of BS 4360-50D steel.

82-2440

Research Study to Define the Critical Failure Mechanisms in Notched Composites under Compression Fatigue Loading

B.W. Rosen, A.P. Nagarkar, R.B. Pipes, and R. Walsh

Materials Sciences Corp., Spring House, PA, Rept. No. MSC/TFR/1201/1801, 105 pp (Mar 1981) AD-A113 645

Key Words: Fatigue life, Composite structures, Layered materials

Analytical and experimental studies to identify the dominant failure mechanisms for compression fatigue of notched composite laminates have been conducted. The effects of stacking sequence and matrix material on damage growth as well as failure mechanisms under compression fatigue loading are reported. Two types of resin materials and four kinds of laminate layups have been considered.

82-2441

FRP Composite Designs Involve Special Fatigue Considerations

Auto Engr. (SAE), 90 (5), pp 51-57 (May 1982) 11 figs (Based on SAE Paper No. 820698, "Fatigue Considerations for FRP Composites," by D.A. Riegner and J.C. Hau, General Motors Manufacturing Development)

Key Words: Fatigue life, Fiber composites

Preventing fatigue failure of FRP composite parts requires design considerations which are considerably different from those of metal materials.

82-2442

Experimental Verification of a Fatigue Wear Equation

V.K. Jain and S. Bahadur

Mech. Engrg. Dept., Univ. of Dayton, Dayton, OH 45469, Wear, 79 (2), pp 241-253 (July 1, 1982) 5 figs, 4 tables, 18 refs

Key Words: Fatigue life, Wear

It is demonstrated that the wear equation based on the concept of repetitive loading of surface asperities in sliding can be used to estimate the wear of polymeric materials. Wear and surface topography data for poly(methyl methacrylate), poly(vinyl chloride) and high density polyethylene pins sliding against a hardened and ground AISI 4340 steel disk are reported.

82-2443

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

O. Buxbaum and H. Lowak
Lab. fuer Betriebsfestigkeit, Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung e.V., Darmstadt, Germany, Rept. No. LBF-S-159 (1981), 214 pp (1981)
N82-21619

Key Words: Fatigue life, Aircraft

Results of investigations by industry and research organizations in the field of fatigue are summarized. Most reports concern fatigue test results from specimens and components under constant amplitude, programmed and random loading. Others concern the measurement and analysis of loading in service. Investigations on cyclic stress-strain behavior, crack propagation, fracture mechanics, and residual strength are included.

82-2444

Fatigue Crack Propagation from Fillet Weld Toes

K. Yamada and M.A. Hirt
Dept. of Civil Engrg., Nagoya Univ., Nagoya, Japan, ASCE J. Struc. Div., 108 (7), pp 1526-1540 (July 1982) 18 figs, 20 refs

Key Words: Welded joints, Fatigue life, Crack propagation

The fatigue crack propagation behavior of two types of fillet welded specimens is investigated and the application of fracture mechanics for the prediction of fatigue life is discussed. Small scale fillet welded stiffener and gusset specimens were tested under constant amplitude stress cycles. The crack propagation behavior is estimated from dye-markings on the fatigue fracture surface.

ELASTICITY AND PLASTICITY

82-2445

Hybrid State Vector Methods for Structural Dynamic and Aeroelastic Boundary Value Problems

L.L. Lehman
Ph.D. Thesis, Stanford Univ., 200 pp (1982)
DA8214590

Key Words: Boundary value problems, Aeroelasticity

A computational technique is developed that is suitable for performing preliminary design aeroelastic and structural dynamic analyses of large aspect ratio lifting surfaces. The method proves to be quite general and can be adapted to solving various two-point boundary value problems. The solution method, which is applicable to both fixed and rotating wing configurations, is based upon a formulation of the structural equilibrium equations in terms of a hybrid state vector containing generalized force and displacement variables. A mixed variational formulation is presented that conveniently yields a useful form for these state vector differential equations. Solutions to these equations are obtained by employing an integrating matrix method.

82-2446

On the Dynamic Elastic Limit

J.F. Bell
Dept. of Mech., The Johns Hopkins Univ., Baltimore, MD 21211, Exptl. Mech., 22 (7), pp 270-276 (July 1982) 6 figs, 14 refs

Key Words: Metals, Elastic properties, Impact response

A simple method is described for accurately measuring the dynamic elastic limit in any solid which has a linear-elastic domain at small strain, including high-strength structural metal alloys. This method has the advantages of laboratory simplicity, a minimum of complex assumptions, and a close parallel with the manner in which the quasistatic elastic limit generally is determined.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see No. 2430)

82-2447

User's Guide to Noise Data Acquisition and Analysis Programs for HP9845: Nicolet Analyzers

M.C. Mcgary

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83256, 40 pp (Feb 1982)
N82-19943

Key Words: Computer programs, Noise analyzers

A software interface package was written for use with a desktop computer and two models of single channel Fast Fourier analyzers. This software features a portable measurement and analysis system with several options. Two types of interface hardware can alternately be used in conjunction with the software. Two types of storage medium, either tape cartridge or floppy disc can be used with the software. Five types of data may be stored, plotted, and/or printed.

82-2448

Automated Torsion Pendulum: Control and Data Collection/Reduction Using a Desktop Computer

J.B. Enns and J.K. Gillham
Dept. of Chemical Engrg., Princeton Univ., NJ, Rept. No. TR-24, 36 pp (Apr 1982)
AD-A113 038

Key Words: Measuring instruments, Computer-aided techniques, Data processing

A torsion pendulum interfaced with a desktop computer form an automated instrument for dynamic mechanical characterization of polymeric materials. The computer controls the initiation of the oscillation, collects the digitized data and calculates the shear modulus and loss modulus from the damped oscillations, utilizing one of four methods of analysis.

82-2449

Impulse Duration: A New Instrument for Its Measurement

R. Cook
Advanced Measurement Technology Section, Natl. Acoustic Labs., 5 Hickson Rd., Millers Point, Sydney, Australia, Appl. Acoust., 15 (3), pp 205-222 (May 1982) 16 figs, 1 table, 4 refs

Key Words: Measuring instruments, Noise measurement

An instrument is described which, when used with a peak hold reading sound level meter, will measure the durations of acoustic impulses in accordance with the Atherley and Martin and CHABA criteria for hearing damage risk to impulsive noise. The instrument is small, lightweight, can be battery powered and is designed for field use. Comparison tests show that the impulse duration meter gives more accurate and repeatable results than the oscilloscope trace photograph method or the digital waveform recorder method of impulse duration assessment. By using the instrument with a suitable impulse source reverberation time, measurements may be conducted.

82-2450

A New Method of Non-Contact Measurement of Linear Displacement

M.P. Cooke and A. de Sa
School of Physics, The Univ., Newcastle-upon-Tyne, NE1 7RU, UK, J. Phys.: E Sci. Instrum., 15 (8), pp 843-847 (Aug 1982) 5 figs, 5 refs

Key Words: Displacement measurement, Proximity probes, Magnetic properties

The new method of non-contact measurement of linear displacement described in this paper utilizes the large changes in the field of a permanent magnet with distance. The output of a magnetic field detector is fed to a microprocessor programmed to display the distance between the magnet and the detector directly. The maximum measurable displacement is limited by the size of the permanent magnet and the noise level of the detector.

82-2451

Mechanism of Damage in the Vibratory Test with Stationary Specimen

M. Matsumura, S. Okumoto, and Y. Saga
Hiroshima Univ., Sendamachi-3, Naka-ku, Hiroshima, 730, Japan, Bull. JSME, 25 (204), pp 898-905 (June 1982) 15 figs, 14 refs

Key Words: Cavitation, Vibration probes

The vibratory cavitation device with a vibratory probe oscillating in close proximity to a specimen surface was improved. By recirculation of the testing liquid through a bore in the horn and the gap between the stationary specimen and the vibrating probe, the temperature distribution on the stationary specimen came within ±0.5°C, and the errors in the experimental results were able to be kept below ±3%. It was confirmed that the stationary specimen is damaged by cavitation with a more ductile mode than the vibrating specimen. This is attributed to absence of stress of longitudinal vibrations.

82-2452

Application of a Computerized Vibroacoustic Data Bank for Random Vibration Criteria Development

R.C. Ferebee

NASA George C. Marshall Flight Ctr., Huntsville, AL, Rept. No. NASA-TP-1998, 32 pp (Mar 1982) N82-20238

Key Words: Data processing, Experimental test data, Vibration measurement, Acoustic measurement, Computer-aided techniques

A computerized data bank system was developed for utilization of large amounts of vibration and acoustic data to formulate component random vibration design and test criteria. This system consists of a computer, graphics tablets, and a dry silver hard copier. The vibration and acoustic data are stored in the form of power spectral density and one third octave band plots over the frequency range from 20 to 2000 Hz. Standard extrapolation procedures were programmed for prediction of component random vibration test criteria for new launch vehicle and payload configurations. A user's manual is included to guide potential users through the programs.

82-2453

Digital Processing of Signals Using Statistical and Fourier Techniques for Identification of Systems

R. Ramaswami

Santa Maria, Brazil, Microtecnic, No. 2, pp 49-52 (1982) 12 figs, 8 refs

Key Words: Signal processing techniques, Digital techniques, Statistical analysis, Fast Fourier transform

The emergence of modern instruments coupled with fast Fourier transform system, minicomputer and other features, has revolutionized the signal processing. The article presents digital processing of signals using statistical and Fourier techniques. The techniques such as autocorrelation, autopower spectrum, crosspower spectrum, transfer function anc coherence function are discussed.

DYNAMIC TESTS

82-2454

Acoustic Emission Tests Assure Gas Pipeline Integrity

P.W. LaRocca

PSE&G Research Corp., Maplewood, NJ, Oil Gas J., 80 (13), pp 129-132 (Mar 29, 1982) 7 figs

Key Words: Acoustic emission, Nondestructive tests, Testing techniques, Pipelines, Bridges

A case history is presented de[illegible]ing the use of acoustic emission technique for nondestruct.ve testing of a gas pipeline mounted through bridge cantilevers under a bridge which was damaged by ice jams.

DIAGNOSTICS

82-2455

Studies on the Vibration and Sound of Defective Rolling Bearings (First Report: Vibration of Ball Bearings with One Defect)

T. Igarashi and H. Hamada

Technological Univ. of Nagaoka, Kamitomioka-cho, Japan, Bull. JSME, 25 (204), pp 994-1001 (June 1982) 10 figs, 7 tables, 9 refs

Key Words: Bearings, Ball bearings, Diagnostic techniques

An investigation was undertaken to establish a procedure for diagnosing rolling bearings for defects from their vibration and sound. The vibration and sound of a rolling bearing with one dent on the race surface of the inner or outer ring or on the ball surface were studied. When the inner ring was caused to rotate at a constant speed under a given thrust load applied to the outer ring, the outer ring radial vibration velocity was determined by a moving coil type converter. Using the data obtained, vibration waveforms were observed, peak vibration pulses measured, and real time frequencies of the vibration analyzed by fast Fourier transform analyzer. The fundamental characteristics of ball bearings having one defect were clarified, and a method by which to locate the defect and determine its size was established.

82-2456

On a Prognosis of Gear Surface Failure Using Sound of Gears

K. Umezawa, K. Handa, H. Kawarada, and H. Kamei

Res. Lab. of Precision Machinery and Electronics, Tokyo Inst. of Tech., Nagatsuta, Midori-ku, Yokohama, Japan, Bull. JSME, 25 (203), pp 834-841 (May 1982) 17 figs, 10 refs

Key Words: Diagnostic techniques, Gears, Gear teeth

The faults on a gear surface are usually noticed by a change in characteristics of gear sound; however, it is difficult to discriminate the symptoms on the surface of gear teeth using the sound of gears in operation. By observing the frequency fluctuation of gear sound, a measuring system was developed. Pitting tests were performed and the sounds of gears were measured at several numbers of load cycles. Scoring tests were also performed. Results of this new analyzing method revealed that much information can be obtained about running conditions of gears, and a new field may be forthcoming in detecting gear surface failure.

BALANCING

82-2457

The Identification and Elimination of Non-Independent Balance Planes in Influence Coefficient Balancing

M.S. Darlow

Rensselaer Polytechnic Inst., Troy, NY, ASME Paper No. 82-GT-269

Key Words: Influence coefficient method, Balancing techniques

This paper discusses the origin and symptoms of the non-independent balance plane problem and thus alerts the balancing engineer to its existence and provides a systematic method for identifying and eliminating this problem which is consistent with the general influence coefficient balancing procedure.

82-2458

Modal Balancing of a Multi-Mass Flexible Rotor Without Trial Weights

A.B. Palazzolo and E.J. Gunter

Univ. of Virginia, Charlottesville, VA, ASME Paper No. 82-GT-267

Key Words: Rotors, Flexible rotors, Modal balancing technique

A procedure is presented to determine the unbalance distribution in a multi-mass flexible rotor system without requiring that trial weights be placed upon the shaft to first determine the influence coefficient matrix of the various balance planes. A modified Nyquist plotting procedure is presented to generate a polar plot of proximity probe measurements for determination of the 90-deg phase shift position of the modal eccentricity.

MONITORING

82-2459

Monitoring Combustion Chamber Pulsations with Anechoic Pressure Probes

C.W. Rodman

Columbus Labs., Battelle, Columbus, OH, InTech, pp 51-53 (Apr 1982) 1 fig, 6 refs

Key Words: Combustion noise, Combustion excitation, Monitoring techniques

Industrial combustion systems often show a tendency to generate sustained pulsations of enough intensity to cause structural damage. The pulsations can usually be prevented by changes in system configuration or operating mode, but measurement data are needed if the modifications are to be implemented systematically. Conventional pressure instrumentation is unsuitable because of problems with high pressure ratios, excessive temperatures, and long probe lengths. Gas-purged probes with anechoic terminations can be used in these applications. The instruments minimize acoustic signal distortion while protecting the sensing elements from the combustion products.

ANALYSIS AND DESIGN

ANALOGS AND ANALOG COMPUTATION

(See No. 2483)

ANALYTICAL METHODS

82-2460

A Procedure for Improving Discrete Substructure Representation in Dynamic Synthesis

A.L. Hale and L. Meirovitch

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, AIAA J., 20 (8), pp 1128-1136 (Aug 1982) 2 figs, 1 table, 21 refs

Key Words: Substructuring methods, Dynamic synthesis, Natural frequencies, Mode shapes

In a discrete substructure synthesis method, the motion of each substructure is represented by a given number of shape vectors called admissible vectors. To force the individual substructures to act together so as to form a whole structure, approximate geometric compatibility conditions are imposed by means of an approach based on weighted residuals. A structure defined by the approximate compatibility conditions is referred to as an intermediate structure. This paper develops a general iterative procedure for improving the admissible vectors representing each discrete substructure in the synthesis. The procedure permits the computation of an improved eigensolution for the intermediate structure, without increasing the number of degrees of freedom used to represent each substructure.

82-2461

Applications of the Method of Complex Functions to Dynamic Stress Concentrations

D. Liu, B. Gai, and G. Tao

Inst. of Engrg. Mech., Academia Sinica, Harbin, China, Wave Motion, 4 (3), pp 293-304 (July 1982) 10 figs, 8 refs

Key Words: Complex function method, Dynamic stress concentration

The complex function method used in the solution of static stress concentration around an irregularly shaped cavity in an infinite elastic plane is generalized to the case of dynamic loading. This paper presents the solutions of two dimensional elastic wave equations in terms of complex wave functions, and general expressions for boundary conditions for steady state incident waves. Dynamic stresses around a cavity of arbitrary shape are then expressed in series of complex domain functions; the coefficient of the series can be determined by truncating a set of infinite algebraic equations. Results of dynamic stress concentration factors for circular and elliptical cavities are given.

82-2462

Modal and Laplace Transformation of Linear Non-Self-Adjoint Problems of Dynamics

F. Pochylý and H. Netuka

Res. Inst. SIGMA, Olomouc, Czechoslovakia, Strojnický Časopis, 33 (3), pp 269-280 (1982) 7 refs (In Czech)

Key Words: Linear systems, Modal analysis, Laplace transformation

For the solution of linear dynamical systems described by the system of linear differential equations there are essentially applied two methods such as modal and Laplace transformation. The first method is preferred while Laplace transformation is applied mainly in connection with the determination of transient curve and frequency response in the theory of control and electric circuits. The purpose of this article is to present a connection between these methods which could be a stimulation for the more detailed qualitative analysis of dynamical systems.

82-2463

The Transient Heaving Motion of Floating Cylinders

R.W. Yeung

Dept. of Ocean Engrg., Massachusetts Inst. of Tech., Cambridge, MA, J. Engrg. Math., 16 (2), pp 97-119 (May 1982) 11 figs, 18 refs

Key Words: Cylinders, Floating structures, Transient response, Time domain method

The transient heave response of a freely floating cylinder with given initial conditions is obtained by a simultaneous time-domain solution of the fluid-motion and rigid-body dynamics problems. Volterra's method is used to derive the integral equation associated with the fluid motion. It is shown that the unit initial-velocity response is simply the time-derivative of the unit initial-displacement response multiplied by one half of the infinite-fluid virtual mass of the cylinder. Numerical evaluation of integrals related to the unsteady water-wave Green function is facilitated by expressing them in terms of the complex error function. Results for the transient motion of semi-circular, triangular, and rectangular cylinders are presented.

82-2464

Finite-Element Technique for Solving Problems Formulated by Hamilton's Principle

S. Sorek and J.J. Blech

Faculty of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Computers Struc., 15 (5), pp 533-541 (1982) 6 figs, 14 refs

Key Words: Finite element technique, Hamiltonian principle, Time dependent excitation

The finite element technique is applied to functionals which govern dynamical problems where time is an independent variable. This paper demonstrates improved accuracy in mass-spring-damper systems and exemplifies rendevous problems of a travelling particle in a medium. The motion is governed by Hamilton's principle. The time interval is fixed.

82-2465

Results Arising Through the Matrix Formulation of Random Vibration Analysis

J.D. Robson

Univ. of Glasgow, UK, Intl. J. Vehicle Des., 3 (3), pp 297-306 (Aug 1982) 7 refs

Key Words: Vibration analysis, Random vibration, Matrix methods

This paper presents a number of examples in which results of considerable practical importance have arisen as an immediate consequence of the apparently trivial circumstance of the matrix formulation of random vibration analysis. These examples are all concerned with the description of multivariate random vibration, but the results derived are various in their nature concerning the formulation of response relationships, restrictions on spectral densities, relationships between the various spectral densities -- direct and cross -- of multivariate responses, and limits to the repeated conditioning of recorded signals.

82-2466

Integral Equation Methods for Eigenvalue Estimation in Systems with Discontinuous Coefficients

J.P. Spence

Ph.D. Thesis, Michigan State Univ., 107 pp (1981) DA8212460

Key Words: Eigenvalue problems

The advantages of taking an integral equation approach to problems in eigenvalue estimation in discontinuous systems are investigated. The inherent smoothing properties of integrals suggest that methods based on integral equations should be quite effective in handling systems with discontinuous material properties. It is found that the integral equation formulation of the Galerkin method leads to upper bounds for the eigenvalues which are superior to those obtained from the traditional differential equation formulation.

82-2467

Complex Experimental and Theoretical Method for Solution of Dynamical State of Stress

J. Beneš and H. Šebková

Inst. of Thermomechanics, Czechoslovak Academy of Sciences, Prague, Czechoslovakia, Strojnícky Časopis, 33 (3), pp 291-307 (1982) 14 figs, 6 refs (In Czech)

Key Words: Stress waves, Wave propagation, Finite difference method, Dynamic photoelasticity

An efficient method for the solution of non-stationary state of stress of two-dimensional configurations using the experimentally-theoretic approach consisting of dynamical photoelasticity combined with finite-difference-method calculations is described. The proposed method is illustrated by the solution of the transversal impact on a thin strip.

82-2468

Reflection and Transmission by a Random Medium

U. Bahr

Wissenschaftsbereich Theoretische Physik der Technischen Universität Dresden, German Democratic Republic, J. Mech. Phys. Solids, 30 (3), pp 155-175 (1982) 6 figs, 8 refs

Key Words: Wave propagation, Wave reflection, Wave transmission, Random parameters

From ultrasonic inspections of heterogeneous materials the ultrasonic velocity in a test specimen and the ultrasonic reflection and transmission coefficients can be found over a certain range of frequencies. This paper presents a theoretical analysis of the frequency dependence of the reflection and transmission coefficients caused by random fluctuations of the material parameters.

82-2469

Mean Field Attenuation and Amplitude Attenuation Due to Wave Scattering

R.-S. Wu

Dept. of Earth and Planetary Sciences, Massachusetts Inst. of Tech., Cambridge, MA 02139, Wave Motion, 4 (3), pp 305-316 (July 1982) 2 figs, 1 table, 37 refs

Key Words: Seismic waves, Wave diffraction, Amplitude attenuation

The inadequacy of two widely used approaches for formulating the amplitude attenuation of seismic waves -- the formulation of mean-field attenuation and that of scattering coefficient under the single scattering approximation -- is discussed. Using a one-dimensional layered slab it is shown that the attenuation of the mean field is merely a statistical effect caused by phase interference among different realizations of the random wave ensemble, and does not represent the amplitude attenuation.

82-2470

Invariant Imbedding Method for Wave Problems

G.I. Babkin and V.I. Klyatskin
The Pacific Oceanological Inst., Academy of Sciences of the USSR, Vladivostok, USSR, Wave Motion, 4 (3), pp 195-207 (July 1982) 24 refs

Key Words: Wave equation, Boundary value problems

A new method which reduces various boundary value problems for a wave equation to initial value problems is developed. The scalar Helmholtz equation for the one- and three-dimensional cases is considered. The method is extended to the case of nonlinear media. Its applications to the wave equation for different dimensions and various media are described.

82-2471

Two-Dimensional Bifurcations of Stokes Waves

D.U. Martin
TRW Defense and Space Systems Group, Redondo Beach, CA 90278, Wave Motion, 4 (3), pp 209-219 (July 1982) 5 figs, 5 refs

Key Words: Water waves, Wave propagation, Bifurcation theory

Bifurcation techniques are used to obtain a new class of small amplitude water waves of permanent form. This calculation illustrates an approach which can be applied to nonlinear waves of various types to generate new steady solutions from old. Stokes waves are used as a starting point, and the critical value of steepness at which bifurcation can occur is computed for various choices of modulation wavelength and angular orientation. It is found that, for two-dimensional surfaces, bifurcation can occur at small values of wave steepness.

82-2472

One-Dimensional Pulse Propagation in Composite Materials Modelled as Interpenetrating Solid Continua

M.F. McCarthy
Natl. Univ. of Ireland, Univ. College, Galway, Ireland, Wave Motion, 4 (3), pp 221-242 (July 1982) 24 refs

Key Words: Wave propagation, Composites

Modulated simple wave theory is used to study the propagation of one dimensional, finite amplitude, high frequency pulses in composites which are modeled as interpenetrating solid continua with two identifiable constituents. The equations which govern the propagation of high frequency pulses are derived and their properties are studied in detail. Particular attention is paid to small amplitude high frequency pulses and results for pulses propagating into composites of a rather general nature are presented.

82-2473

Scattering of SH Waves by Embedded Cavities

S.K. Datta and A.H. Shah
Dept. of Mech. Engrg., Univ. of Colorado, Boulder, CA 80309, Wave Motion, 4 (3), pp 265-283 (July 1982) 15 figs, 1 table, 22 refs

Key Words: Wave diffraction, Cavity-containing media, Matched asymptotic expansion technique, Finite element technique

Scattering of plane SH waves by sub-surface circular cavities and thin slits in a semi-infinite elastic medium is analyzed. Two methods of solution are used to obtain the displacements on the free-surface. One is a method of matched asymptotic expansion that is very effective when the wavelength is long compared to the dimensions of the cavity (or the crack). The other is a combined finite element and analytical technique, which is useful in the long to intermediate wavelength range. The results obtained by these two techniques are shown to agree quite well for long wavelengths.

82-2474

Propagation in a Randomly Perturbed Multimode Matched Waveguide

W.E. Kohler
Dept. of Math., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Wave Motion, 4 (3), pp 243-263 (July 1982) 11 figs, 1 table, 14 refs

Key Words: Wave propagation, Wave diffraction, Boundary value problems, Waveguide analysis

A stochastic two-point boundary value problem, modeling propagation in a randomly perturbed two-mode waveguide, is studied in the diffusion limit. A lowpass spectral approximation is introduced, from which the forward scattering approximation emerges as the leading order description. First order corrections are explicitly computed. The results are compared with two-mode radiative transfer theory and computer simulations.

82-2475

On Rayleigh Scattering by a Grating

J.W. Miles

Inst. of Geophysics and Planetary Physics, Univ. of California, La Jolla, CA 92093, Wave Motion, 4 (3), pp 285-292 (July 1982) 2 figs, 6 refs

Key Words: Wave diffraction, Cylinders

The acoustic diffraction of a plane wave by a periodic row of identical cylinders of arbitrary cross section and characteristic dimension a is calculated for $ka \ll kd < \pi$, where k is the wave number and d is the wavelength of the array. The reflection and transmission coefficients depend only on d, k, the angle of incidence, and the area and virtual mass of the cross section. The general results are applied to a grating of inclined flat plates.

MODELING TECHNIQUES

82-2476

Mathematical Foundations for Normal Mode Modeling in Waveguides

T.B. Gabrielson

Sensors and Avionics Technology Directorate, Naval Air Dev. Ctr., Warminster, PA, Rept. No. NADC-81284-30, 81 pp (1982)

AD-A111 941

Key Words: Mathematical models, Waveguide analysis, Normal modes, Sound waves

The mathematical foundation for wave theory modeling of acoustic propagation in leaky waveguides is presented. The development of the normal mode solution for the field in a fluid layer overlying a fluid half-space is summarized in order to provide the basis for advanced modeling work. The three types of propagation supported by a leaky duct – trapped modes, leaky modes and interface waves – are developed along with several approximation techniques. The concepts are illustrated by means of a practical problem in shallow water acoustic transmission.

NUMERICAL METHODS

82-2477

Application of Point Least Squares Method with B-Splines in Solid Mechanics Problems

T. Mizusawa and T. Kajita

Dept. of Construction Engrg., Daido Inst. of Tech., Hakusuicho-40, Minami-ku, Nagoya, Japan, Intl. J. Numer. Methods Engrg., 18 (6), pp 897-907 (June 1982) 1 fig, 6 tables, 24 refs

Key Words: Least squares method, Beams, Plates

A discrete approach using the B-spline functions and the concept of the point least square is presented. The general procedure, in which trial functions satisfy neither governing differential equations nor boundary conditions, is used in solving solid mechanics problems. No numerical integration is required in the formulation and the resulting matrix has the advantage of always being symmetrical. To demonstrate the accuracy and versatility of the present method, vibration of beams, skew plate problems, thick plates and a non-self-adjoint problem are analyzed. A good accuracy is obtained with increase in the number of fitting points and of knots of B-spline functions.

PARAMETER IDENTIFICATION

82-2478

Identification of Multivariable High Performance Turbofan Engine Dynamics from Closed Loop Data

W. Merrill

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-82785, E-1120, 16 pp (1982) (Presented at the 6th IFAC Symp. on Identification and System Parameter Estimation, Washington, DC, June 7-11, 1982)

N82-20339

Key Words: Turbofan engines, Aircraft engines, Parameter identification technique

The multivariable instrumental variable/approximate maximum likelihood (IV/AML) method or recursive time-series analysis is used to identify the multivariable (four inputs-three outputs) dynamics of the Pratt and Whitney F100 engine. A detailed nonlinear engine simulation is used to determine linear engine model structures and parameters at an operating point using open loop data. The IV/AML method is used in a direct identification mode to identify models from actual closed loop engine test data. Models identified from simulated and test data are compared to determine a final model structure and parameterization that can predict engine response for a wide class of inputs. The ability of the IV/AML algorithm to identify useful dynamic models from engine test data is assessed.

82-2479

The Evaluation of the Frequency Transfer Function from Experimental Data

J. Kozánek

Inst. of Thermomechanics, Czechoslovak Academy of Sciences, Prague, Czechoslovakia, Strojnícky Časopis, 33 (3), pp 281-289 (1982) 2 figs, 1 table, 6 refs

(In Czech)

Key Words: Parameter identification technique, Frequency transfer function

This paper deals with the forced harmonic response of a nonconservative vibration system measured for a number of suitable frequencies. The least square method, useful for identification methods, is used to obtain the frequency transfer function from the measured data in the complex plane.

OPTIMIZATION TECHNIQUES

(See No. 2480)

DESIGN TECHNIQUES

82-2480

Structural Optimization on Geometrical Configuration and Element Sizing with Statical and Dynamical Constraints

J.H. Lin, W.Y. Che, and Y.S. Yu

Dept. of Civil Engrg., Princeton Univ., Princeton, NJ 08540, Computers Struc., 15 (5), pp 507-515 (1982) 6 figs, 4 tables, 18 refs

Key Words: Optimization, Design techniques, Minimum weight design

A bi-factor α-β algorithm based on the Kuhn-Tucker criteria about the minimal weight design of a structure under statical and dynamical constraints is presented. The design variables may cover sizes of the elements and/or coordinates of the nodes. The upper and lower bounds of each variable are specified, and the stress constraints based on full-stress criteria are also taken into account.

COMPUTER PROGRAMS

(Also see Nos. 2366, 2369, 2447, 2488)

82-2481

Recent Improvements of the Non-Linear Transient Dynamic Structural Computer Programs EURDYN

J. Donea, S. Giuliani, and J.P. Halleux

Joint Res. Ctr., Commission of the European Communities, Ispra, Italy, 38 pp (1980)

EUR-6694

Key Words: Computer programs, Finite element technique, Transient response

This report describes a new version of the finite element computer programs EURDYN for elasto-plastic transient dynamic analysis of 2- and 3-D structures. A convected coordinate description (coordinates rotate but do not deform with the elements) accounts for large displacements and rotations. A lumped explicit scheme is used for marching in time. User's manual updates are included and a sample problem is treated.

82-2482

Description of Computer Program CAB3DYN for the Time Domain Analysis of the Three-Dimensional Long-Time Deployment Behavior of General Ocean Cable Systems

H.T. Wang and R.S. Cheng

Ship Performance Dept., David W. Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD, Rept. No. DTNSRDC/SPD-0633-03, 58 pp (Dec 1981)

AD-A111 989

Key Words: Computer programs, Cables, Towed systems, Time domain method

The report describes in detail Program CAB3DYN, which analyzes in the time domain the three-dimensional long-time deployment behavior of free-floating and towing ocean cable systems. The report describes the coordinate systems used, the modeling of the time-varying current profile, and the formulations for the surface buoy or prescribed surface motion, intermediate bodies, and the connecting cable.

82-2483

Response of a Structure Solicited by Displacements Imposed on a Part of Its Edge Response (d'Une Structure Excitee Par des Deplacements Impose sur Une Partie de sa Frontiere)

C. Seon

Centre Technique des Industries Mecaniques, Senlis, France, Rept. No. CETIM-11-L-182, 60 pp (June 1981)

N82-18644

(In French)

Key Words: Computer programs, Modal analysis, Beams, Undamped structures

A computation method is presented which allows for the introduction of nonstationary displacements in the calculation of modal response. The method is adapted to the existing structural analysis computer programs PASD and BASMOD. Calculation simulations for an undamped beam were run. Results are satisfactory and a user manual for the program is given.

82-2484

Application of an Airfoil Stall Flutter Computer Prediction Program to a Three-Dimensional Wing: Prediction Versus Experiment

A.J. Muffoletto

Dept. of Aerospace Engrg., Pennsylvania State Univ., University Park, PA, Rept. No. NASA-CR-168586, 136 pp (Mar 1982)

N82-19169

Key Words: Computer programs, Aircraft wings, Flutter

An aerodynamic computer code, capable of predicting unsteady and C sub m values for an airfoil undergoing dynamic stall, is used to predict the amplitudes and frequencies of a wing undergoing torsional stall flutter. The code is an empirical prediction method designed to yield unsteady values of normal force and moment given the airfoil's static coefficient characteristics and the unsteady aerodynamic values, alpha, A and B.

82-2485

SONATINA-1: A Computer Program for Seismic Response Analysis of Column in HTGR Core

T. Ikushima

Japan Atomic Energy Res. Inst., Tokyo, Japan, Rept. No. JAERI-M-9165, 72 pp (Nov 1980)

DE81700375

Key Words: Computer programs, Nuclear reactors, Seismic response

A computer program SONATINA-1 for predicting the behavior of a prismatic high-temperature gas-cooled reactor (HTGR) core under seismic excitation has been developed. The computer program can be used to predict the behavior of the HTGR core under seismic excitation.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

(Also see Nos. 2328, 2358, 2425)

82-2486

World Conference on Earthquake Engineering, Proceedings, Seventh

Turkish National Committee on Earthquake Engineering et al., Istanbul, Sept 1980, 9 vols

Key Words: Proceedings, Earthquakes

Following are the conference proceedings volume titles and the topics covered in each volume. Volume 1: Geoscience Aspects, Part I - Seismic Wave Propagation, Seismic Source Studies, Seismic Micro- and Macro-Regionalization, Seismic Risk Analysis; Volume 2: Geoscience Aspects, Part II - Strong Motion Instrumentation and Data Collection, Influence of Local Conditions on Ground Motion, Simulated and Artificially Generated Ground Motions, Spectral Analysis and Interpretation of Ground Motion; Volume 3: Geotechnical Aspects - Dynamic Properties and Behaviour of Soils and Rocks, Dynamic Properties and Behavior of Soil and Rock Structures, Geotechnical Experimental Investigations, Dynamic Properties and Behaviour of Foundations, Piles and Retaining Walls; Volume 4: Structural Aspects, Part I - Earthquake Resistant Design of Buildings, Earthquake Resistant Design of Rural Housing, Repair and Strengthening of Structures; Volume 5: Structural Aspects, Part II - Methods of Dynamic Analysis; Volume 6: Structural Aspects, Part III - System Identification, Interaction Problems, Experimental Facilities and Investigation of Structures and Models, Non-Deterministic Properties and Behaviour of Structures; Volume 7: Structural Aspects, Part IV - Experimental Facilities and Investigation of Structures and Models, Deterministic Dynamic Properties and Behaviour of Structures, Vibration Measurement of Full Scale Structures, Dynamic Behaviour of Structural Materials and Components; Volume 8: Civil Engineering Aspects - Nuclear Power Plants, Dams and Other Hydraulic Structures, Buried Structures, Lifeline Structures (Pipelines, Bridges), Miscellaneous Civil Engineering Facilities, Base Isolation; Volume 9: Socio-Economic Aspects, Studies of Specific Earthquakes, Progress Reports.

TUTORIALS AND REVIEWS

82-2487

Materials for Noise and Vibration Control

W.E. Purcell

S/V, Sound Vib., 16 (7), pp 6-31 (July 1982) 16 figs, 1 table

Key Words: Reviews, Noise reduction, Vibration control, Acoustic absorption, Noise barriers, Vibration damping, Vibration isolation, Material damping, Absorbers (materials), Isolators

A comprehensive mini-handbook for the selection and application of commonly available noise and vibration control materials. Basic information is provided on the characteristics of sound absorptive, sound barrier, vibration damping, and vibration isolation materials.

BIBLIOGRAPHIES

(Also see No. 2314)

82-2488

Vibrational Analysis of Structures: Computer Applications. 1972 - May, 1982 (Citations from the International Aerospace Abstracts Data Base)

NTIS Rept. for 1972 - May 1982, 269 pp (May 1982) PB82-867185

Key Words: Vibration analysis, Computer programs, Bibliographies

This bibliography contains citations concerning structural engineering analyses of various shapes and bodies. Topics discuss various problems confronting engineers in the fields of design, elasticity, and structural limitations, along with the use of computer technology to provide solutions and optimization. Mathematical models and available computer programs are included in the cited reports.

82-2489

Abstract Journal in Earthquake Engineering

Volume 10, Dec 1981

Key Words: Earthquakes, Bibliographies

This journal is a comprehensive annual collection of abstracts and citations of current literature pertinent to the field of earthquake hazard mitigation. The present volume contains more than 1,800 abstracts and citations of technical papers, research reports, books, codes, and conference proceedings. The abstracts are obtained from 96 technical journals, and from the publications of academic, professional, and governmental organizations in 24 countries.

AUTHOR INDEX

CALENDAR

DECEMBER 1982

14-16 11th Turbomachinery Symposium [Texas A&M University] Houston, TX *(Peter E. Jenkins, Turbomachinery Labs., Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX 77843 - (713) 845-7417)*

FEBRUARY 1983

28 - Mar 4 SAE Congress & Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1983

21-23 NOISE-CON 83 [Institute of Noise Control Engineering] Cambridge, MA *(NOISE-CON 83, Massachusetts Inst. of Tech., Inst. Information Services, 77 Massachusetts Ave., Cambridge, MA 02139 - (617) 253-1703)*

28-31 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hqs.)*

APRIL 1983

18-20 Materials Conference [ASME] Albany, NY *(ASME Hqs.)*

18-21 Institute of Environmental Sciences' 29th Annual Technical Meeting [IES] Los Angeles, CA *(IES, 940 E. Northwest Highway, Mount Prospect, IL 60056 - (312) 255-1561)*

21-22 14th Annual Modeling and Simulation Conference [Univ. of Pittsburgh] Pittsburgh, PA *(William G. Vogt, Modeling and Simulation Conf., 348 Benedum Engineering Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261)*

MAY 1983

9-13 Acoustical Society of America, Spring Meeting [ASA] Cincinnati, OH *(ASA Hqs.)*

9-13 Symposium on Interaction of Non-Nuclear Munitions with Structures [U.S. Air Force] Colorado Springs, CO *(Dr. C.A. Ross, P.O. Box 1918, Eglin AFB, Florida 32542 - (904) 882-5614)*

17-19 Fifth Metal Matrix Composites Technology Conference [Office of the Undersecretary of Defense for Research and Engineering] Naval Surface Weapons Center, Silver Spring, MD *(MMCIAC - Kaman Tempo, P.O. Drawer QQ, Santa Barbara, CA 93102 - (805) 963-6455/6497)*

JUNE 1983

6-10 Passenger Car Meeting [SAE] Dearborn, MI *(SAE Hqs.)*

20-22 Applied Mechanics, Bioengineering & Fluids Engineering Conference [ASME] Houston, TX *(ASME Hqs.)*

JULY 1983

11-13 13th Intersociety Conference on Environmental Systems [SAE] San Francisco, CA *(SAE Hqs.)*

AUGUST 1983

8-11 Computer Engineering Conference and Exhibit [ASME] Chicago, IL *(ASME Hqs.)*

8-11 West Coast International Meeting [SAE] Vancouver, B.C. *(SAE Hqs.)*

SEPTEMBER 1983

11-13 Petroleum Workshop and Conference [ASME] Tulsa, OK *(ASME Hqs.)*

11-14 Design Engineering Technical Conference [ASME] Dearborn, MI *(ASME Hqs.)*

12-15 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

14-16 International Symposium on Structural Crashworthiness [University of Liverpool] Liverpool, UK *(Prof. Norman Jones, Dept. of Mech. Engrg., The Univ. of Liverpool, P.O. Box 147, Liverpool L69 3BX, England)*

25-29 Power Generation Conference [ASME] Indianapolis, IN *(ASME Hqs.)*

OCTOBER 1983

17-19 Stapp Car Crash Conference [SAE] San Diego, CA *(SAE Hqs.)*

17-20 Lubrication Conference [ASME] Hartford, CT *(ASME Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

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
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

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 Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

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PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

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> **Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].**

> **Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .**

The format and style for the list of References at the end of the article are as follows:

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- titles of articles within quotations, titles of books underlined
- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addision-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).
5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).
7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

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EDITORIAL

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CALENDAR