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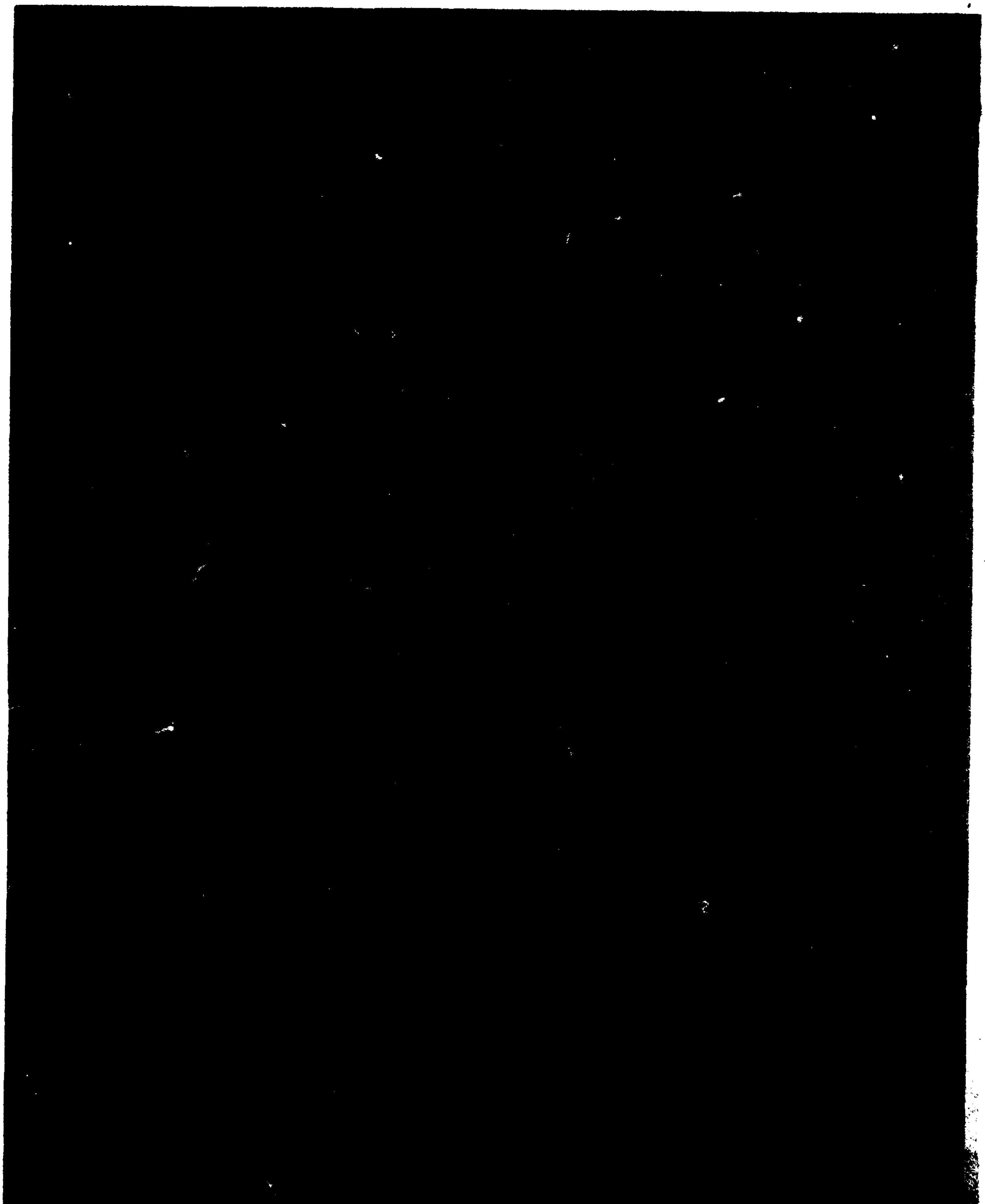

SVIC NOTES

During the week following Labor Day, I had the privilege of participating in a DoD IAC (Information Analysis Center) Conference and Workshop. As a matter of fact, I had a part in the planning and organization of this conference. This was a family affair in the sense that it only involved the IACs in the United States Department of Defense. As many readers probably know, information analysis centers are abundant throughout the federal government and, indeed, in the private sector. But why should I mention such a conference in this Digest at all? Certainly this particular conference had nothing to do with shock and vibration. It did, however, have to do with technical information and the results of the conference have some implications that are of general interest.

The IAC managers met for the broad purpose of increasing their effectivenss in information analysis and dissemination. In the keynote address, Dr. George Gamote of the Department of Defense applauded this effort and called for IAC operations that are strongly oriented toward user needs. This is very encouraging, but even more encouraging is the spirit of cooperation with respect to the sharing of resources that emerged from the conference. Those who stand to profit most from such a cooperative effort are the scientists and engineers who must seek the most recent information in their discipline, those who must keep abreast of the latest developments in their technology.

Consider the average investigator concerned with problems related to shock and vibration. Frequently, he needs to know the latest developments in materials such as metals, ceramics or plastics. Because of their special structural properties, he might wish to learn about special combinations of materials or composites. In addition to dynamic considerations, he might need to be aware of other mechanical properties or even the thermophysical properties of the materials with which he works. He might select a material with superior dynamic properties, but be faced with a difficult machinability problem for production. Where does he learn about this? Information in all of the above areas, as well as in concrete, soils, trafficability, reliability and other areas, may be obtained from the IACs represented at this conference. If each of these tells about the rest of these, will that not be most helpful to all?

The cooperation that I wrote about includes an agreement that each IAC, including this Center, publish information about the capabilities of other IACs. I think this action will be in the best interest of all IACs but, more importantly, it will allow them to serve their users better. Therefore, early in 1981, there will be a section in this Digest on other information sources. I look forward to this new thrust with enthusiasm.

H.C.P.

EDITORS RATTLE SPACE

VIBRATION ANALYSIS - A USEFUL TECHNIQUE

Vibration analysis -- defined as the analysis of vibration test data to evaluate machine condition -- has been in existence for many years. However, recent developments in instrumentation as well as measurement and analysis techniques have made vibration analysis a powerful practical engineering tool for avoiding machine failures and production losses. The techniques and applications of vibration analysis were described by Volin* in a recent issue of the DIGEST.

The increased use of expensive high-speed machinery in continuous operation to produce petrochemicals and other petroleum products, food, paper, steel, power, and drugs has made it a necessity to develop a method for avoiding costly machine failures and the losses of production associated with them. In many instances unwanted mechanical vibration, which has always been considered undesirable, has proven to be a primary indication of machine condition. Not only are failures avoided but production downtime can also be scheduled through continuous vibration monitoring and analysis. Unnecessary repairs can be avoided because the condition of the machine is indicated by its mechanical vibration signature.

The successful application of vibration analysis to machine condition evaluation has been made possible by advances in electronics and signal analysis techniques. The theory of mechanical vibrations in which vibration response (measured effect) is related to excitation (cause of problem) has been known for a long time. But only in the past few years have sensors that detect mechanical vibration and convert it into electrical signals been perfected. Similarly the advent of practical signal analyzers to condition and analyze these signals has made it possible to obtain information directly related to machine condition.

Today engineers are improving the process by which an analyzed vibration signal is associated with a specific characteristic of machine condition. Progress has been made, but the existing techniques are far from being automatic and therefore require experience and sound engineering judgment. Vibration analysis promises to be a challenging and interesting technical area for engineers in the next few years.

R.L.E.

* Volin, R., "Techniques and Applications of Mechanical Signature Analysis," SVD, 11 (9), pp 17-33 (Sept 1979).

HISTORICAL ASPECTS OF THE SEISMIC ANALYSIS OF LARGE DAMS

R. Dungar*

Abstract - This paper is divided into three main sections. The generalities of the aseismic design of dams are reviewed in one section. The remaining two sections deal with specific details related to concrete dams and to embankment structures.

"The great dams constructed during the past five decades are being viewed by the present generation of people with wonderment and awe. They are remarkable structures, and visitors acquire a lasting impression very similar to that gained from a first viewing of the great pyramids in Egypt. But the majority of such visitors recognize a great dam only as a massive formation of concrete, or of earth, or of rock, and have little comprehension of the massive human effort which went into its creation. This effort represents the cumulative work of many thousands of men, all directed towards achieving the same objective - the building of a great dam. Furthermore, the dam stands as a symbol of useful human endeavor, in contrast with the dormant pyramids which were built by subjugated slaves" [1].

The massive human effort referred to by Ackerman [1] includes the planning, design, and construction phases of a dam project. The majority of designs for large dams (over 50 meters in height) often include evaluations of prescribed seismic loading. Ackerman also refers to various materials from which a dam can be constructed; each material can be used to produce a specific type of structure. Thus the details needed to analyze one type of dam for both static and dynamic conditions might be completely different from those of a different type.

GENERAL CONSIDERATIONS

As recently as the mid 1960s, the analysis of large dams for seismic loading conditions generally followed concepts used in many building codes: a seismic coefficient is used to define lateral loading, for which the displacements and stresses are calculated by a static analysis of the structure. The lateral loading of a given section is defined by the product of its weight and the seismic coefficient. This coefficient is related to the expected value of the maximum acceleration; in many cases it is taken in the range of 0.05 - 0.10.

It was realized at least as far back as 1931 that, in addition to the weight of a dam, hydrodynamic pressure on its face contributes significantly to the inertial properties of the structure-fluid system. Westergaard [2] developed an expression for this pressure for a rigid structure with a vertical upstream face and infinite length in the cross-canyon direction; it was a function of the period of harmonic excitation. This so-called Westergaard pressure and the seismic coefficient have been used to analyze a number of the large dams in the world. Zanger [3] later assumed that the reservoir fluid is incompressible and showed that the hydrodynamic pressure obeys the Laplace equation; the pressure is thus easy to calculate for irregular shaped reservoirs by either analog methods [4] or numerical methods [5]. Much work has recently been concerned with calculating the hydrodynamic pressure [6-10], including the interaction of the structure and the fluid, with and without fluid compressibility [11]. Although the effects of compressibility can be demonstrated mathematically, compressibility has not yet been conclusively proved; theoretical resonance of a fluid system due to fluid compressibility is possibly not obtainable due to such effects as reservoir sediment damping [12]. However, it is expected that uncertainties will eventually be clarified by accurate prototype dynamic testing and measurement of hydrodynamic pressure and its phase relation with respect to the acceleration of the structure.

*Motor-Columbus Consulting Engineers Inc., Parkstrasse 27, CH-5400 Baden, Switzerland

The seismic coefficient method provides a simple tool for analyzing a structure. However, depending on the degree of accuracy required, the coefficient must be adjusted according to the period of the structure to reflect the quasi resonance that will occur when earthquake effects are within the structural frequency range. Resonance and other dynamic calculations are dealt with below.

The recording and analysis of earthquake ground motions have played a significant role in the history of seismic analysis. For many years it was widely believed that the golden rule for a state-of-the-art analysis was to use the El Centro acceleration time record as the input for a structural-response analysis. However, much literature is now available on seismic-hazard analysis, which can be conducted on by both probabilistic and deterministic means [13]. Such analyses are used to establish both the expected peak acceleration and the frequency content and time duration.

Housner [14] realized the importance of estimating the frequency content of earthquake motions. His curves showed the peak velocity response of a structure for given earthquakes plotted as a function of structural frequency and damping, which he called spectral velocity. He also averaged and scaled these curves for five Californian bedrock records. He chose the area under the response spectra between given limits of structural period -- termed spectral intensity – and did not scale according to peak acceleration values of individual records. Much work has also been completed on fitting artificial records to given response spectra so that the acceleration time envelope function is representative of actual recorded events [15]. Such fitting assures that a broad band of frequency is covered by the design acceleration time history and avoids the sharp peaks in spectral curves that can occur with a single recording from a particular site [16].

The dynamic response of an elastic structure can be accurately obtained from spectral curves only if one mode of vibration is contributing to the response; this is assumed when the curve is derived. If the contribution is from more than one mode, the maximum response from the peaks associated with the individual modes must be estimated [6]; modal superposition is used. Response spectra have been developed for building structures that exhibit both elastic and plastic deformation, but there has been no serious attempt to apply these spectra to dam design.

Other methods of dynamic computation include those that consider full dynamic response using step by step computation; in this case response is calculated for a large number of time increments for a given acceleration time design motion. The finite element method [17, 18] has been used both for linear elastic computation, in which modal summation is made at each time step [19, 20] and for inelastic dynamic computation, mainly for embankment structures [21].

THE ANALYSIS OF CONCRETE DAMS

The finite element method has allowed complicated geometries and boundary conditions to be represented with relative ease. Progress with this method was stimulated in the U.K. by a committee of the Institution of Civil Engineers established in 1958 to investigate the design of arch dams. The findings of this committee have been summarized [22].

To date, arch, gravity, and buttress concrete dams have been dynamically analyzed by the finite element method; both two- and three-dimensional representations have been used. Several programs are also available for automatic finite element mesh generation [23-25]. Outstanding problems that remain to be solved include nonlinearities within the structure [13], correct representation of the reservoir fluid as discussed above, and correct representation of boundary motion. Boundary conditions are generally assumed to be fixed at some distance from the dam, particularly in three-dimensional analyses. Such a finite volume calculation does not represent the energy that would actually radiate from the structure through the foundation, however; waves would be reflected from the assumed fixed boundary. This problem is perhaps not serious for a flexible structure, such as an arch dam, but, for more rigid structures such as gravity and buttress dams, the effect of energy radiation is important. It is therefore useful that these stiff structures can usually be represented by a two-dimensional idealization for which it is relatively easy to introduce appropriate boundary conditions to represent the effects of radiation [26].

Future developments in the field of concrete dam design will undoubtedly focus on aseismic design, as opposed to simply performing a dynamic analysis. For example, the shape of an arch dam can be influenced by dynamic as well as static loading, and the strength of the concrete can be established for all loading conditions [13]. The problem of correct shape for dynamic loading has not yet received much attention in the literature, mainly because few options are open to the design engineer after the shape has been established to meet static requirements and other geometrical constraints.

EMBANKMENT DAMS

The analysis of both earth and rockfill embankment dams can be handled by simple methods and hand calculation or very complicated numerical computation requiring the latest state-of-the-art techniques to represent the structure and the constituent material.

The seismic coefficient method, sometimes called the pseudostatic method [27], can be applied to an assumed potential slide mass of embankment material. The wedge is checked for sliding stability by calculating the driving forces on the potential slide plane, for both self weight and earthquake action; the forces are compared with the shear resistance of the material on this plane. Terzaghi [28] appears to have been the first proponent of this method; he recommended a seismic coefficient of up to 0.5. The method has been modified, first by Newmark [29], who calculated permanent deformation of the plane by assuming that the slide mass behaved as a rigid body. These calculations can also include the effects of embankment pore water pressure and the effects of the variation of acceleration throughout the embankment [30, 31].

Most other attempts to estimate the response of embankments relied on the assumption that the material is a linear elastic continuum. The first model assumed that only shear motion was occurring from one horizontal layer to the next. This solution, called the shear beam model [32], eliminates those modes of vibration associated with embankment rocking; these were later demonstrated to be important components of total motion [33].

Dynamic tests for all types of cohesionless embankment materials in a drained condition indicate a nonlinear stress-strain response under medium to large cyclical strain amplitudes. Hysteresis loops for cyclical strain have often been described by an equivalent secant modulus. Equivalent critical damping factors and test results show that the modulus decreases and damping increases as cyclical strain amplitude increases [34]. In an undrained condition the pore water pressure generally increases due to the tendency of the material to exhibit cyclical densification [35].

Attempts to model numerically an embankment in terms of its true dynamic response have included the correct inertial and time-dependent damping and stiffness properties of the material [36]. Certain computing procedures [37] were applied to a large number of embankment structures following a notable study of slides in the San Fernando Dams during the earthquake of February 9, 1971 [38]. The method involves assigning an equivalent shear modulus and damping value to various locations within the embankment considered by the finite element idealization. These values are initially estimated but are refined in an iterative way; each new value is selected as a function of the strains calculated during the previous iteration cycle. The main criticism of this method is that stiffness and damping change at each instant of elapsed time during the earthquake; these changes are not incorporated in the average values used for the complete response history. Furthermore, no reference is made to pore water pressures generated during the response history when the stiffness and damping properties are established. These values change with both the time-dependent shear strain amplitude and the time-dependent pore water pressure.

Attempts have recently been made to correct the deficiencies in the original equivalent linear method [39-41], but many workers would prefer a more fundamental approach to the problem of establishing the dynamic response of an embankment. Work has already been completed on modeling a soil in terms of its stress-strain response [42, 43] for both static and dynamic loading conditions. In addition, these models have been incorporated into nonlinear response calculations for continuum solutions using both solid and fluid components of the continuum [44]. Such solutions are undoubtedly more promising from a fundamental point of view than those of the equivalent linear type.

It is the author's opinion however, that much work remains before the problems of analyzing embankment dams for seismic excitation will be resolved. These solutions will have to include an estimate of the permanent deformation of the embankment due to the distortion of the material body as a whole and to sliding on given planes of rupture; the effects of pore pressure generated by the dynamic motion of the material will be included in the calculation. Such calculations will allow safety checks of existing dams and the execution of dynamic designs of future dams. It will be possible to have adequate allowance for the required freeboard to prevent overtopping during an earthquake.

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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 techniques for measurement of wheel/rail forces and damping of mechanical vibrations and acoustic waves.

Mr. D.R. Ahlbeck and Mr. H.D. Harrison of Battelle, Columbus Laboratories, Columbus, Ohio have written a paper which examines the basic phenomena of wheel/rail loads and summarizes the historical development of force measurement techniques.

Mr. J.R. Birchak and Mr. D. Rader, of NL Petroleum Services, Houston, Texas have written an article which surveys recent literature on phenomenological damping providing an overview of the mechanisms underlying the damping of mechanical vibrations and acoustic waves.

DAMPING OF MECHANICAL VIBRATIONS AND ACOUSTIC WAVES

J.R. Birchak* and D. Rader**

Abstract - The references cited in this survey of recent literature on phenomenological damping provide an overview of the mechanisms underlying the damping of mechanical vibrations and acoustic waves. The references are grouped according to damping parameters, gases, liquids, solids (metals, nonmetals, and geological materials), and surface losses at interfaces. Practical implications are summarized to show engineering applications and directions for future investigations of energy dissipation.

In the analysis of vibrating systems, functional representations of the damping mechanisms must be established for the relevant ranges of stress amplitude, frequency, vibrational mode, temperature, and other parameters [1-3]. Both internal and external mechanisms of dissipation play a role, namely, material damping (internal friction, internal scattering, and bulk thermodynamic losses) and dissipation at surfaces (interactions at interfaces). Material damping is defined as the loss of energy per cycle per unit volume (uniform strain amplitude) inherent in a bulk medium experiencing cyclic mechanical vibrations or acoustic wave motion [2]. Structural damping includes both intrinsic material damping and interface damping at joints and boundaries [1]. For highly damped structures, the energy loss per cycle can depend on vibrational stress amplitude and therefore be nonlinear [1]. Conventional damping parameters defined for linear behavior have been modified and used to estimate nonlinear damping by introducing a mathematical term that accounts for the effects of test specimen geometry [1, 4].

In this article, the problem of identifying dissipation parameters is considered first. The references cited provide a broad overview of material damping in gases, liquids, and solids. Interface and boundary effects are reviewed separately. The implications of damping research are summarized by surveying practical applications of damping studies.

PARAMETERS

Equations of motion. The equation of motion for mechanical vibrations generally follows the form of the equation for a damped harmonic oscillator.

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = F(t) \qquad (1)$$

In the equation m=mass, x=displacement, b=damping coefficient, k=spring constant, and F(t)= driving force [2]. The homogeneous solution of equation (1) - i.e., F(t) = 0) -- describes transients decaying from an initial force, motion, or displacement condition. Development of conceptual descriptions of damping phenomena requires expansion of the harmonic oscillator approach in Maxwell, Kelvin-Voigt, Biot, or some other mathematical model. For linear materials, the constant b can be incorporated in a complex stiffness parameter

$$k^* = k + i\omega b \qquad (2)$$

where $i = \sqrt{-1}$ and ω= angular frequency. This formulation is equivalent to using complex moduli to describe linear polymeric and elastomeric materials subject to time varying displacements or stresses [2].

For nonhomogeneous, nonlinear materials, b and k can vary with displacement amplitude, frequency, and spatial position within the body [2]. Nonlinear models improve agreement between theory and experiment but are difficult to apply in structural analyses [2, 5, 6]. Rasmussen [7] obtained the dissipation parameter as a function of arbitrary nonlinear restoring forces and arbitrary but small non-

* *Task Leader, Acoustic Sensors, NL Petroleum Services, Houston, Texas*
** *Manager, Sensor Development, NL Petroleum Services, Houston, Texas*

linear damping forces. General relations are obtained for both amplitude and rate-dependent damping.

The effects of amplitude dependence have been examined for random amplitude excitation in narrow-band frequency ranges and for random loads on internally damped beams [8, 9]. Lateral and cantilever beam motions have also been investigated [10, 11]. For metals, nonlinear damping has been modeled using small plastic strains below the elastic limit [5]. In a recent survey article, linear and nonlinear vibration problems in thermomechanics were reviewed; the effects of elasticity, viscoelasticity, plasticity, and magnetoelasticity were described for thermally-induced vibrations [12].

The mechanisms that cause damping of mechanical vibrations also affect acoustic wave attenuation. In the case of homogeneous linear viscoelastic materials, a functional relation between acoustic attenuation and vibrational damping can be conveniently deduced. In particular, both wave motion and cyclic stress-strain behavior in linear viscoelastic materials can be described in terms of a complex modulus that is conceptually analogous to the complex stiffness in equation (2).

When such wave phenomena as beam spread, scattering in multiphase materials, and dispersion contribute significantly to acoustic attenuation, additional terms have been introduced in attempts to account for these effects [13, 14]. Still other effects can arise in multiphase media. In geological materials, for example, the frequency dependence and amplitude dependence of attenuation are influenced by grain interface and pore fluid effects as well as scattering [15]. Acoustic wave attenuation can result from mode conversion, in which energy is lost to another mode or to boundary radiation and is not directly dissipated as heat [16].

An overview of linear elastic wave propagation has been given by Scott [17]; he reviewed the literature on homogeneous, nonhomogeneous, and anisotropic materials. The behavior of waves in anelastic solids has been surveyed [18], and overviews of losses in fluids are available [18-21]. Analysis of engineering structures requires that both the intrinsic dissipation within the components and the damping at interfaces be accounted for. Eigenvalue methods that use the matrix form of equation (1) to describe structural damping have been reviewed [22].

Loss mechanisms. The bulk mechanisms in fluids are typically relaxation of vibrational modes, thermal relaxation, viscosity, and phase transformations [19-21]. Scattering, diffusion, viscous, resonance, and evaporation effects occur at interfaces or nonhomogeneities in a fluid [23]. For small, uniformly distributed, nonhomogeneities, the mechanism is classed as material damping.

In a previous survey [3], the material damping capacity was reviewed for solids. Internal friction is typically either (a) frequency and temperature dependent but amplitude independent (e.g., viscoelastic materials to moderate stress levels), or (b) amplitude dependent having residual strains [1]. Bulk mechanisms include such dislocation motions as resonance, relaxation, and breakaway; viscoelasticity; molecular curling in polymers; such electronic motions as thermal, eddy current, and superconducting pairs; microscopic interface slip (e.g., graphite flakes in gray iron); energy transfer to a second phase (e.g., fluids in porous rock); magnetic domain wall motion; diffusion of point defects; grain boundary motion; thermal anelasticity; and such phase related phenomena as stress-induced transformations and wave scattering [1, 3, 15, 20].

The mechanisms at interfaces include: coulomb friction, microslip, adhesive bond damping, and coating damping [1, 24, 25]. Thin coatings or liners of elastomers, porcelains, enamels, and plastics produce dissipation related to the area of the interface [26-28]. Surface roughness increases the attenuation of waves propagating along or reflected by an interface [29, 30].

Damping measurements. In general, damping measurements should be made over a broad range of frequencies, temperatures, and stress amplitudes [1, 3, 31]. Ideally, the measurements should be compatible with potential analytical techniques for calculating damped structural vibrations. It has been recommended that material damping should be characterized by the specific damping energy U_{dv}, which is defined as the damping energy per cycle per unit volume, and that uniform dynamic stress amplitude distribution throughout the unit volume should be assumed [1, 2]. Similarly, specific damping energy

U_{da} at the interface can be defined as a loss per unit area. These representations are particularly desirable for nonlinear damping. Typically, conventional damping parameters implicitly contain a stored strain energy term that is poorly defined for materials exhibiting permanent deformations [2].

On the other hand, materials that exhibit linear damping can be described with conventional parameters. These include magnification factor, bandwidth, quality factor Q, loss tangent, logarithmic decrement, specific damping capacity, and plane wave attenuation -- i.e., exponential decay constant. The relationships among damping parameters have been discussed [2, 19, 31]. These relationships require similar test conditions [32-34]. For example, damping capacity can depend on bias stress or vibrational mode, either shear or longitudinal [4]. In addition, wave propagation can include such loss mechanisms as scattering, which are not included in conventional damping representations [13, 15, 19, 35, 36].

GASES

Loss mechanisms. Classic monatomic gases exhibit absorption due to shear and bulk viscosities, heat conduction, and heat radiation [20]. Polyatomic gases exhibit additional losses from relaxation among molecular, vibrational, and rotational states. In mixtures, catalytic interactions (e.g., water in air) can increase acoustic attenuation [19, 37].

The relationships among molecular relaxation, viscosity, thermal conduction, and diffusion have been used to predict the pressure and frequency dependence of sound in air at elevated temperatures [38]. Broadband propagation and attenuation constants have been derived for a nonuniform atmosphere in which altitude, temperature, and humidity vary along the propagation path [39]. Nonuniform potential flows in compressible gases produce dispersion and attenuation [40]. Turbulence broadening, however, has been found to depend on beam width and orientation [41]. The attenuation coefficients can be measured in highly attenuative gases using a reflectivity technique [42].

Two phase losses. Clouds of small liquid droplets in gases significantly attenuate acoustic pure tones and duct modes. The role of liquid properties, droplet size, and mass fraction on attenuation has been studied [43]. The acoustic losses are attributed to exchange processes and to condensation of vapor on droplets that produce temperature and density gradients [44, 45]. Attenuation from gas-solid suspensions is calculated from mass, momentum, and energy balances [46]. Particle diameter, thermal properties, and frequency also affect attenuation [47].

Losses from constraints. The flow of gases along constraining surfaces also affects acoustic energy loss within the bulk of the gas. Acoustic losses in turbulent gases are greater than those in quasi-steady gases [48]. Axial gradients in ducts having sheared flow; varying cross sections also increase attenuation [49, 50]. Nozzle damping is a major acoustic loss mechanism in solid propellant motors [51]. Losses occurring solely at boundaries are discussed below (see Interfaces and Layers).

LIQUIDS

Loss mechanisms. General descriptions of wave phenomena in liquids are available [19-21, 37, 52, 53]. Even simple monatomic liquids are found to have substantial differences between bulk and shear viscosities. The resulting relaxation times are related to damping that corresponds to bulk and shear strains [54].

The attenuation of ultrasonic shear waves in viscous fluids has been measured using various pulse widths [55]. Significant corrections to the simple exponential decay constant are required to account for the observed attenuation. In pneumatic liquid crystals, an intramolecular mechanism has been shown to account for anisotropic acoustic attenuation [56]. In ocean water, a number of attenuation mechanisms are relevant [57]. The loss of acoustic spatial coherence in oceans has been derived from fluctuating temperature fields caused by internal waves and ocean turbulence [58].

Two phase losses. Liquids can contain gaseous, liquid, or solid nonhomogeneities. In this section only finely dispersed nonhomogeneities are considered. Extended boundaries are treated in the section on interfaces. Gaseous nonhomogeneities are detected using backscatter, attenuation, and dispersion measurements;

they are influenced primarily by resonance characteristics [59]. Under certain conditions, however, vapor in the bubbles and viscoelastic properties of the host liquid can affect losses [23, 60]. For a limited frequency range, the attenuation of acoustic tone burst correlates with bubble size distributions due to resonance effects [61, 62].

For liquid and solid nonhomogeneities (emulsions and suspensions), attenuation arises from four factors: material damping in the constituents, interface viscous processes, interface thermal processes, and scattering including wave motion and particle collisions [63, 64]. The theory of compressional wave attenuation has been extended to cover high concentration suspensions for a wide range of frequencies [65]. Apparatus has been developed to rapidly measure the frequency spectra of ultrasonic attenuation in suspensions [66].

A wide variety of suspensions have been studied. For example, during the suspension polymerization of vinyl chloride, attenuation is related to cavitation boiling and polymer formation [67]. In ferrofluids, the acoustic losses are very sensitive to the strength of the applied magnetic field [68]. The physical properties of paper stock suspensions are estimated using a viscoelastic operator to calculate attenuation and velocity [69]. Ultrasonic attenuation has also been used to diagnose and monitor the flow of coal-water and coal-toluene slurries [70-73]. In molten metals, particulates (oxides, carbides, and nitrides) have been evaluated by ultrasonic techniques [74].

SOLIDS

Metals and alloys. Damping characteristics of metals and alloys have been studied as a function of temperature, frequency, and strain amplitude [75-81]. Mason and McSkimin [82, 83] made some of the early identifications of ultrasonic loss mechanisms. Dislocation motion can give both relaxation and nonlinear damping [84-86]. Antiferromagnetic and ferromagnetic processes can dissipate vibrational stress energy [3, 4, 87-89]. At high frequencies, various electronic and phonon losses also contribute to acoustic attenuation [90, 91]. In solid state physics, electronic band theory and lattice models are evaluated using the thermal, frequency, and orientation dependence of attenuation.

The polycrystalline grain structure of single phase metals and alloys affects ultrasonic scattering and attenuation measurements in polycrystalline media [92-95]. This loss mechanism is so large in some materials that the reflections from small defects are obscured, thereby reducing the reliability of nondestructive test procedures [96-98]. The orientation dependence of ultrasonic properties within single crystals is used to determine rolling direction in grain-oriented materials [99, 100]. In cemented tungsten carbides, microcracks at grain boundaries can be detected by attenuation measurements [101].

Finely dispersed nonhomogeneities (a second phase in the host) produce volumetric damping. For example, cast irons have graphite precipitates in a matrix of iron alloy. Gray irons contain flake graphite that cause larger stress intensity factors and therefore more damping than malleable or spheroidal irons [102-105]. The pearlitic intermetallic spacing of cementite and ferrite, on the other hand, has much less contrast between phases and produces less damping than graphite [106].

Damping and attenuation measurements have been used for estimating various properties of metals and alloys [107-110]. Continuous ultrasonic attenuation measurements have revealed rapid increases just prior to fracture [111]. Fracture toughness can also be detected ultrasonically [112]. During the application of stress, acoustic emissions (deformation energy lost by stress wave generation) correlate with mechanical deformation and fatigue damage [113-115].

Nonmetallic solids. Nonmetallic solids have less electronic conduction than metals and hence a different electronic contribution to energy losses. Various methods are used to derive the damping of nonmetallic solids. The pressure dependence of ultrasonic attenuation and thermal conduction can be calculated for crystalline nonmetallic solids [116]. For viscoelastic materials, nonlinear static and dynamic behavior have been calculated using finite element techniques [117]. The effects of temperature and biaxial stresses on viscoelastic damping have also been studied [118, 119]. In addition, stiffness and damping of elastomers under rotating loads have been calculated [120].

The damping mechanisms in polymers generally produce larger losses than those in metals. The dynamics of molecular chain relaxation processes are deduced from ultrasonic attenuation measurements on monosubstituted polystyrenes [121]. Shear relaxation functions have been derived for polymethyl methacrylate [122]. Mixing polymeric materials having damping maxima at different frequencies and temperatures allows optimum damping layers to be composed [123]. The commonly used techniques for measuring an interpreting the acoustic properties of solid polymers have been surveyed to identify relative advantages and limitations [124].

Near the softening temperature, glasses exhibit high damping, but at low temperatures damping phenomena in glasses are similar to those of crystalline materials [125]. At very low temperatures, however, special corrections must be made to calculate specific heat from ultrasonic attenuation [126].

Another factor influencing the damping of nonmetals is gamma irradiation; it shifts the temperature relaxation curve of glass, indicating density changes of tunneling and nontunneling defects [127]. Irradiation with fast neutrons has been observed to decrease the attenuation of carbon [128]. Ultrasonic attenuation has also been measured for a range of ceramic polycrystals. The scattering cross sections correlate with microstructure [129].

The following examples show the diversity of multiphase nonmetallic materials being investigated. The dynamic stiffness of fiber-reinforced composite materials has recently been reviewed in a survey of experimental and analytical investigations [130]. The shear strength of graphite-polymide composites correlates with ultrasonic attenuation [131]. Shock-excited multi-layer structures in shear or longitudinal strains have been described by a four-element viscoelastic model [132]. In layered composites, spectral analysis of ultrasonic waves has been used for nondestructive testing [133]. In asphaltic-aggregate mixtures, damping depends on composition; the more stable the mixture, the greater the damping [134]. For living tissue, an iterative technique for high-resolution pulse-echo interrogation is used [135]; bone has been characterized using ultrasonic attenuation [136]. Voids in carbon fiber-reinforced plastics and in porous ceramics have been detected ultrasonically [137, 138].

Geological applications. Geological studies are reviewed separately because the sizes and types of nonhomogeneities in rock formations of the earth differ from those of conventional engineering materials. Metals, for example, can often be regarded as single phase materials for engineering purposes, whereas earth formations consist of a matrix structure of one or more solid grain species and a fluid-filled pore volume [139, 140]. Variations of mechanical properties from grain to grain and macroscopic matrix anisotropy can significantly affect acoustic scattering in formations [141-143]. Through transmission, pulsed ultrasonic techniques have been used to demonstrate correlation between attenuation and grain size [15, 144, 145].

A recent theoretical approach considers porous rocks as two phase media [146]. The inclusions, which can be filled with liquid-gas mixtures, are modeled as oblate spheroids, permitting consideration of shapes ranging from spheres to fine cracks [147, 148]. Wave motion in fluid saturated porous rock, described by two dilatational and one shear wave, has been experimentally verified [149, 150]. One simple model for sedimentary rock is based on transverse isotropy, in which one axis of symmetry is normal to the bedding plane [151]. Constitutive equations have been derived, and five elastic constants are used to describe the anisotropy [152, 153].

The three major physical mechanisms for energy loss in rocks are viscosity, solid friction, and, at great depths, plastic deformation [15]. Coulomb friction between grains yields the observed velocity and attenuation characteristics for the frequency range from a few hertz to a few hundred kilohertz [154-158]. Internal friction in rocks can also be associated with dislocations and plastic deformation at contact points between grains [157, 158], but a viscoelastic model is probably more appropriate to upper mantle than to crustal rock [15, 159]. For fluid-filled rocks, viscous damping and fluid flow contribute to losses [160, 161]. The classical coulomb criterion for shear failure on a plane has been applied to rock [152].

Losses have been studied theoretically and experimentally for various geological materials [162, 163]. In granite, the internal friction has been related to dislocation theory [156, 157]. In rock, seismic wave attenuation due to friction has been investigated [164, 165]. Grain boundary friction is not an important seismic loss mechanism for in situ rocks because of high ambient stress [166]. The damping characteristics of geological surface layers (soils) affect the vibrations of buildings. A mathematical model has been derived for multilevel structures on layered soils [167].

The seismic characteristics of two phase media are used in exploring for oil and gas bearing formations. Seismic velocity, acoustic impedance, and attenuation of porous rocks and sandstone beds that might contain hydrocarbons have been investigated for various degrees of fluid saturation [168-172]. The effects of fluid saturation on dynamic elasticity of sedimentary rocks, on mechanical relaxation spectra of crystalline rock, and on velocity in low porosity rocks and granular aggregates have also been measured [173-176]. Temperature, pressure, and fluid compressibility also affect acoustic properties of rocks [177-179].

Pressure, partial fluid saturation, and brine-gas mixtures have been found to affect acoustic velocity and attenuation in sandstones [180-182]. In stratigraphic mapping, seismic data is analyzed to identify beds reflecting waves [183, 184]. The diagnostic basics for evaluating stratigraphic traps, porous boundaries, and rock beds are also applicable to seismic interpretation [185-187].

The fracture characteristics of formations affect drilling and production operations for oil and gas. The effects of cracks on velocity and on Poisson's ratio have been measured for dry and saturated cracked rocks [188-190]. The frequency dependence of attenuation, boundary waves, and interface patterns has been used for detecting cracks [191-193].

Seismic and acoustic techniques are also being applied to remote monitoring of in situ coal gasification [194]. Dynamic mechanical properties, attenuation, and acoustic emission techniques are used to evaluate soils [195-197]. Bottom roughness and ocean sediments have been monitored and characterized using acoustic techniques [198-202].

INTERFACES AND LAYERS

In contract to the slip damping of graphite flakes, in which losses are distributed throughout the volume of cast iron, the damping energy in certain structural components is related to surface effects. Component surface roughness, for example, causes scattering that attenuates longitudinal, flexural, and surface waves progressing along the surface [203, 204]. Underwater sound is attenuated by bottom losses [205]. Stoneley waves propagating along the interface between two media are also affected by roughness [206]. Nonparallelism of layer surfaces and Brillouin scattering from amorphous polymers also influence attenuation of wave motion [207, 208].

In bonded layers, wave motion has been studied using time domain analysis and broadband ultrasonic spectroscopy [209, 210]. Impedance matched wearface layers and shaped backing layers can improve ultrasonic transducer performance [211, 212]. The strength of ultrasonic waves entering a material can be optimized by selecting appropriate transducer size and frequency for the surface curvature [213].

For mechanical vibrations, frictional losses in structures have been calculated for a simple overlapping joint and for built up joints containing polyethylene gaskets [214, 215]. The combination of added dampers and dry friction at joints effectively limits self-excited vibrations [216]. The effect of metallic interfaces in bolted joints has been studied for oscillating tangential loads [217]. A model has been developed to describe assembly dispersion and interfilament coulomb friction in yarns [218].

For bonded joints, the losses in the thin adhesive layer are proportional to the contact area. Ultrasonic spectroscopy and attenuation have been investigated for nondestructive evaluation of the adhesive bond strength of joints [219-221]. The dynamic stiffness of a nonlinear viscoelastic block bonded between two plates has been analyzed [222]. Elastomeric shear dampers have been used to damp small deflections in spacecraft [223]. Turbine blades have been damped with bonded enamel coatings [28].

In ducts, the losses in liners are related to surface area and add to the bulk fluid losses discussed in the section on gases. Liner attenuation can be nonlinear [224]. Duct losses have been increased by using soft-walled two-sectional liners and by producing variable liner impedance by flowing air through a multilayer resonant cavity [225, 226].

IMPLICATIONS

Structural damping. In many of the foregoing citations, the damping of materials and structures is dependent on stress amplitude, temperature, and frequency. Typical problems and models for dynamic structural damping have been reviewed and applied to obtain low cost solutions to vibration problems [27, 227]. For example, bolted plates increase damping in high temperature structures [228]. Simple beams with viscoelastic dampers have long been of interest [229]. Mode dependence of damping has now been calculated for high order normal modes [230-232]. For systems having multi-degrees of freedom, techniques are being developed to select damper materials and locations [233].

The damping associated with joints, viscoelastic layers, and discrete dampers has been reviewed for steel and concrete structures [234]. An empirical relation has been used to predict damping for steel framed structures [235]. Structural joint and localized dampers have been incorporated in a NASTRAN finite element program [236]. Damages in structures can be detected using a random decrement technique [237].

When such damped structures as aircraft are analyzed, the matrix form of equation (1) applies, and the damping matrix must include terms that accommodate coupling among modes [22, 238]. For floating platforms, such as for offshore drilling rigs, dynamic damping has been evaluated [239]. For reducing machinery vibrations, a combined system made of two impact dampers has been investigated [240]. An adaptation of the finite element technique has also been used to calculate the coupled hydrodynamic response for concrete gravity dams [241].

Damping can reduce vibrations in rotating joints and other components of rotating systems [242]. The damping coefficients have been calculated for oil lubricated journal bearings [243]. A pressurized gas squeeze film has also been used as a journal damper [244]. For gas turbines, the effect of linear and nonlinear dampers has been calculated [245].

Typical structural applications are being used to reduce helicopter rotor vibrations with elastomeric dampers [246] and to predict space shuttle modal damping [247]. Simplified methods have also been developed to identify vehicle suspension parameters and vibration testing on a road simulator [248]. Hull vibrations and structure-borne sound in ship structures have been reviewed [249-251].

Material characterization. Material characterization has been improved by computer processing of ultrasonic attenuation; processing provides estimates of fracture toughness and mechanical strength [252-254]. Additives for reducing radiation damage in zirconium have been evaluated using internal friction measurements [255]. The dynamic properties of cushions have been related to acoustic impedance measurements [256]. These few examples illustrate that a range of material problems can be addressed using internal friction and acoustic measurements.

Imaging. One of the fastest growing areas of characterization is the imaging of interiors of structures. In a manner similar to sonar imaging methods, ultrasonic waves are now being used extensively to produce images of impedance discontinuities in materials [257, 258]. Synthetic aperture techniques that correct for refraction and attenuation are being applied to seismic and medical studies [259]. Anomalies in the amplitude of seismic data -- so-called bright and dim spots -- have recently been used to improve seismic imaging of geological reservoirs [260]. Ultrasonic tomography techniques have been developed to produce images of the variations of ultrasonic attenuation within a specimen [261]. As electronic signal processing becomes faster and memory capacity becomes larger, image quality and resolution will improve.

Summary. The citations reviewed exhibit a broad range of advances in the understanding and applications of damping phenomena. Theoretical investigations have improved models describing the mechanisms causing damping, the modal dependence of damping, and the vibrations of damped structures. Experimental investigations have led to the development of improved techniques for reducing noise in flowing gases and liquids, improved materials and methods for damping structural vibrations, better stratigraphic interpretations of geological structures, and better techniques for identifying material properties.

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TECHNIQUES FOR MEASUREMENT OF WHEEL-RAIL FORCES

D.R. Ahlbeck and H.D. Harrison*

Abstract - Measurement of dynamic forces at the wheel/rail interface has long been of interest to railroad administrations, rail vehicle designers, and track designers. An accurate assessment of these forces is essential to the safe operation of trains, as well as to the design of vehicle and track structural components. Techniques employed to measure wheel/rail forces fall into one of two categories: loads measured at a specific location in the track (wayside measurements) and loads measured by a specific vehicle (on-board measurements). In this paper, the basic phenomena of wheel/rail loads are examined briefly, the historical development of force measurement techniques is reviewed, and the current state-of-the art in measurement techniques is summarized.

Recent trends in rail transportation have made the direct measurement of dynamic loads at the wheel/rail interface a necessity. Freight cars of 100-ton and even 125-ton capacity are operated in increasing numbers in North America and on the mineral-hauling railroads of Australia, South America, and Africa. The high static wheel loads of these heavy cars have taxed the metallurgical capabilities of rail steels, and such dynamic response as rock and roll on bolted-rail track has imposed loads beyond the strength limits of some structural components of track. High-speed operation of lightly-loaded freight cars, on the other hand, has been found to result in occasional hunting instabilities; high lateral loads cause track, vehicle, and cargo damage, as well as the danger of derailment. Measurements of wheel/rail loads under specific test trains and revenue traffic have been fundamental in investigating these problems. Large-scale experiments such as those conducted at the Facility for Accelerated Service Testing at the Transportation Test Center (TTC) near Pueblo, Colorado, have been undertaken to study vehicle-track interaction under more controlled conditions. Such experiments require the measurement of wheel/rail loads to provide a direct correlation with track degradation and component damage.

The introduction of high-speed passenger equipment by railway administrations in Europe and North America has also been instrumental in the development of improved load measurement techniques. Wheel loads and lateral-to-vertical load ratios are recognized as key factors in evaluating locomotives and cars for safety in operation. Following the derailment of the prototype E60CP electric locomotive at 105 mph (170 km/hr) during an acceptance run on the Northeast Corridor of the United States, an extensive test program was undertaken by the National Railroad Passenger Corporation (AMTRAK) and the Federal Railroad Administration (DOT/FRA) to determine the dynamic wheel loads on the locomotive. Techniques used in this program were refined in subsequent tests of the AMTRAK SDP40F and E8 passenger locomotives. Wheel/rail load measurements from both instrumented wheelset and wayside transducers are now used routinely in qualification tests of such new equipment as the AEM-7 electric locomotive and the Canadian-built LRC (Light-Rapid-Comfortable) trainset.

LOADING MECHANISMS

Loads at the wheel/rail interface are transmitted across a small contact patch on the running surface except when the wheel flange contacts the rail, in which case a two-point load path exists. The forces at the wheel/rail interface include:

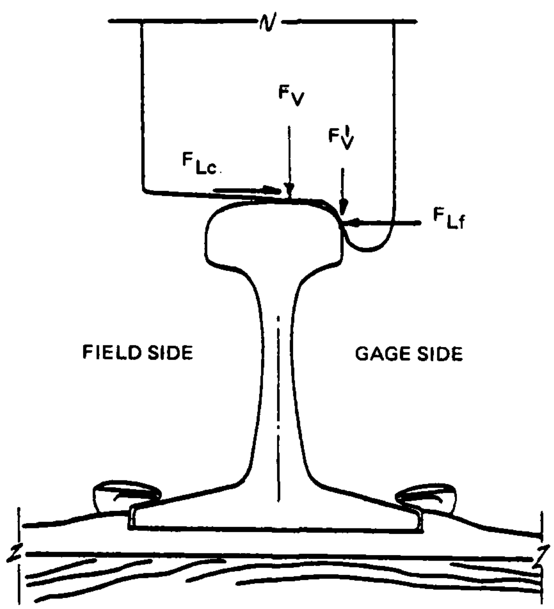
- Vertical forces due to the static weight of the vehicle, dynamic forces due to wheel and rail irregularities on the running surface -- wheel flats and rail joints, for example -- the response of the vehicle to track geometry errors, and components of longitudinal train-action forces
- Lateral forces from the vehicle response to track geometry irregularities, components of

Battelle, Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201

longitudinal train-action forces, such external disturbances as wind, self-excited hunting motions, and the creep and flanging forces necessary to guide the vehicle through curves

- Longitudinal forces due to wheel/rail creep, traction (with powered wheelsets), and braking

The force vectors at the wheel/rail interface are illustrated in Figure 1 for a typical loading situation: that of the lead outer wheel of a rail vehicle negotiating a sharp curve; the radius of curvature is less than 1,000 ft. Wheel/rail loads have been characterized under typical revenue freight traffic [1]. Maximum expected load amplitudes from this source and from other experimental programs, summarized in Table 1, show the full-scale range required of wheel/rail load transducers.



F_V = VERTICAL LOAD AT TREAD CONTACT

F'_V = VERTICAL LOAD AT FLANGE CONTACT

F_{Lc} = LATERAL LOAD DUE TO CREEP FORCE (SHOWN FOR HIGH RAIL ON CURVE)

F_{lf} = LATERAL LOAD DUE TO FLANGE FORCE

(LOADS SHOWN ACTING ON THE RAIL)

Figure 1. Schematic Diagram of Wheel/Rail Interface Region

HISTORICAL BACKGROUND

Two different, yet fundamentally similar methods, are used to measure wheel/rail loads: with the instrumented wheelset or with the instrumented rail. Strain gages, either on the wheel plate or spokes or on the rail web or base, are used to transduce strains resulting from the wheel/rail loads into proportional electrical signals. Other methods have in the past been employed to measure wheel loads: combinations of load cells and strain gages on the rail vehicle truck and load-cell base plates beneath the rail [2]. These methods are subject to substantial error when the measured laods are projected back to the actual wheel/rail loads. The current trend is toward direct measurement of loads at the wheel or rail.

Instrumented wheelsets. All instrumented wheelsets used as load-measuring transducers measure load-induced strains within the wheelset structure. The basic component in these measurements is the resistance strain gage, which was developed during the 1930s and introduced into the U.S. in 1939. One of the first references to the possible use of strain gages on the wheel to meausre vertical and lateral loads was in 1946 by M.F. Verigo of the Soviet Union [3]. The Japanese National Railways (JNR) began developing and improving wheelset load-measuring techniques in 1952. They employed instrumented wheelsets on prototype New Tokaido equipment during operating safety studies in the early 1960s [4]. Other early tests of instrumented wheelsets were conducted by the Swedish State Railways (SJ) in the late 1950s [5].

Work on instrumented wheelsets was first undertaken in the U.S. in 1963 by the Electro-Motive Division (EMD) of General Motors Corporation [6]. This wheelset provided a lateral force signal proportional to the average strain in the wheelplate; vertical load information was obtained from gages mounted in a hole drilled through the wheelplate. The vertical signal provided a single spike load sample for each revolution of the wheel. A more refined wheelset prepared in 1973 to overcome some of the shortcomings of the original design included four wheelplate holes to increase vertical load samples to once each 90° of rotation. This wheelset was used in tests of the SDP40F locomotive [7, 8]. A similar wheelset was employed by General Electric (GE)

Table 1. Maximum Expected Loads at the Wheel-Rail Interface

	Wheel-Rail Loads - 1b (kN)		
	Vertical	Lateral	Longitudinal
Good Tangent Track (CWR)			
Mixed Freight Traffic, ⩾60 mph (0.1% Probability Level)	49,000 (218)	12,000 (53)	
Mixed Freight Traffic, <40 mph (0.1% Probability Level)	48,000 (214)	3,500 (16)	
Extreme Value (Maximum Recorded)	104,000 (463)	22,000 (98)	
Poor Tangent Track (BJR)			
100-ton Freight Car, Roll Resonance on Staggered Joints	80,000 (356)	30,000 (133)	
Joint Impact	80,000 (356)		
Good Curved Track (CWR), R = 1000 ft			
Locomotive (6-axle), Sanded Rail	45,000 (200)	15,000 (67)	8,000 (36)
Locomotive (6-axle), Sanded Rail, High Dynamic Braking Load	45,000 (200)	22,000 (98)	12,000 (53)
100-ton Freight Car	50,000 (222)	12,000 (53)	4,000 (18)
Good Curved Track (CWR), R = 573 ft			
Locomotive (6-axle), Sanded Rail	45,000 (200)	18,000 (80)	8,000 (36)
Locomotive (6-axle), Sanded Rail, High Dynamic Braking Load	45,000 (200)	27,000 (120)	12,000 (53)
Poor Curved Track (Line and Cross Level Errors)			
Locomotive (6-axle)	50,000 (222)	45,000 (200)	

in tests of a U30C locomotive in 1974 [9]. Further development of the EMD wheelset during 1977-1978 resulted in gage patterns and circuit designs that produce continuous lateral and vertical load measurements as the wheel rotates [10].

Although European administrations in general have preferred to instrument spoked wheels, a strain-gaged S-shaped disc wheel was utilized by the Swedish locomotive builder Allmana Svenska Elektriska Aktiebolaget (ASEA) and SJ on the Rc-4A electric locomotive tested by AMTRAK on the Northeast Corridor during 1976. Two wheelsets provided continuous lateral and vertical wheel forces during tests; the forces were processed into individual wheel and total-truck loads and lateral-to-vertical (L/V) load ratios. AMTRAK and DOT/FRA procured three similar wheelsets from ASEA/SJ in 1977 for use on the SDP40F locomotive. These wheelsets were utilized in perturbed track tests [11] at the Transportation Test Center. Detailed descriptions of these wheelsets are available in technical reports [12, 13]. Wheelsets similar to the EMD design were used on an E8 locomotive during these tests and have been described [11, 14].

Several wheelsets have been instrumented to measure loads under 100-ton freight cars. The Association of American Railroads (AAR) under contract to the DOT/FRA during 1974 instrumented both wheelsets of a Barber S2 truck to measure vertical and lateral loads [15]. Strain gages were applied to standard CK-36 cast steel wheels, and the wheelsets have since been utilized for measurements in the FAST track experiments. As part of the recent wheel/rail load characterization program conducted by Battelle for DOT/TSC, a wheel of a 100-ton open-top hopper car, also equipped with a Barber S2 truck, was fitted with strain-gages for measuring vertical and lateral loads [1]. Data from this wheelset were analyzed to determine the limitations of a strain-gaged wheel as a transducer, as well as to statistically characterize the load on tangent and curved tracks.

Considerable development of spoked-wheel transducers has been sponsored by British Rail (BR) in recent years for evaluation of track loads and operating safety under such high-speed trains as the HST and APT [17]. British Rail has emphasized the need for longitudinal load measurements in understanding curving phenomena. They have included measurement of longitudinal loads from traction and curving from their instrumented spoked wheelset design. Considerable effort has been concentrated on processing the signals to minimize cross-modulation by the orthogonal load components, as well as providing an accurate continuous signal from each load [18].

Instrumented rail. A variety of strain gage patterns have been applied to rail measurements of wheel/rail loads. Perhaps the most successful pattern has been the vertical load measurement circuit adapted from strain gage patterns reported by the ORE [19, 20]. This pattern, illustrated in Figure 2, measures the net shear force differential between the two gaged regions, a-b and c-d. With the gage pattern placed between the rail support points (in the crib, the space between crossties), the circuit output is directly proportional to the vertical load P as it passes between the gages. The influence zone of the pattern is very short, a few inches either side of the midpoint between a-b and c-d, so that only a sample of short time duration is provided from each passing wheel. This pattern has shown excellent linearity and minimal sensitivity to lateral load (cross talk) or to the lateral position of the vertical load in laboratory and field tests.

Other methods have been employed to extend the vertical measurement zone and provide a longer time duration of the load sample. Russian experimenters [21] have developed a system utilizing web compression strains at the neutral axis of the rail. Laboratory strain search techniques indicated that this location provided the best compromise between sensitivity, cross talk, and influence length. The influence length to the 50 percent amplitude points for one gage at the neutral axis was found to be about 4 in. (10 cm). Bridges were wired with six gage pairs spanning 20 in. (51 cm); six adjacent circuits provided were

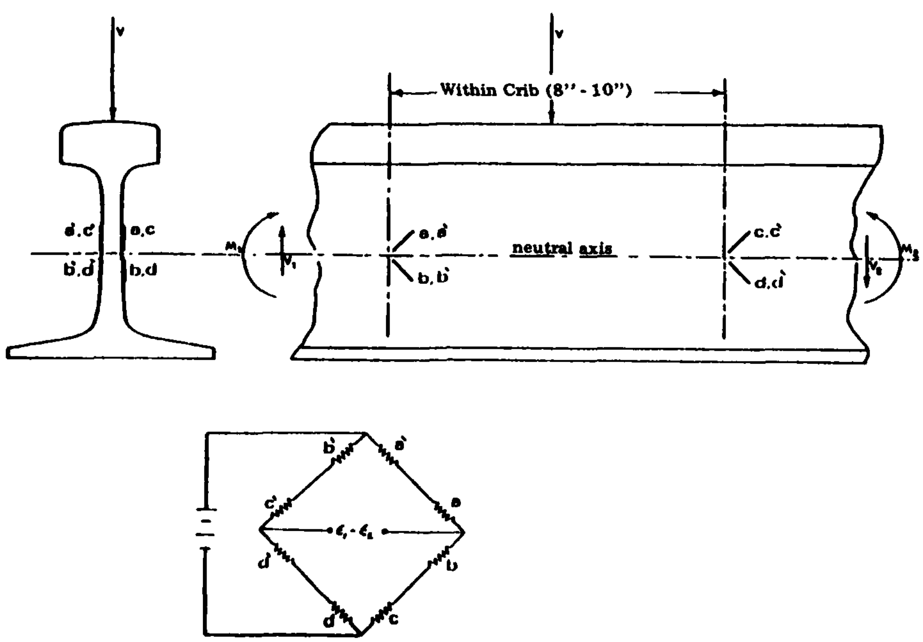
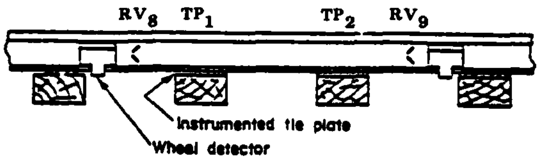


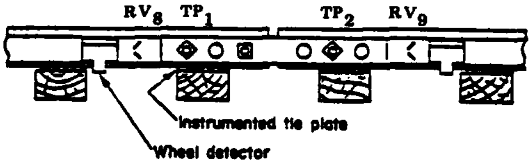
Figure 2. Strain Gage Circuit for Measuring Vertical Wheel/Rail Loads

sufficient to capture one complete wheel revolution. Recent experiments sponsored by DOT/FRA [1] employed rail web chevon gage patterns in combination with load-cell tie plates, as shown in Figure 3, to extend the vertical load measurement zone to 35 in. (89 cm), approximately one-third of a wheel revolution. This method was used to study flat wheel and rail joint impact loads.

Measurements of lateral wheel/rail loads have been somewhat less successful. A circuit for measuring lateral load through the bending strains in the rail web was reported by the ORE [22]. Swiss experimenters used special 8-in. (20 cm) wide gages connected in series to increase the length of the measurement zone; they measured bending strains along the upper region of the rail web between ties and along the lower region over a tie. A variant of this circuit consisting of four vertically-oriented strain gages, one above and one below the neutral axis on either side of the web and directly over the tie, was used by Battelle in test programs during 1976. During tests of the SDP40F locomotive on the Chessie System in 1977 [8], substantial discrepancies were discovered between apparent lateral loads measured simultaneously by instrumented wheelsets and the rail circuits. This led to extensive laboratory tests by Battelle to evaluate this circuit and other possible



EXTENDED VERTICAL WHEEL/RAIL LOAD MEASUREMENT ON CWR TRACK



EXTENDED VERTICAL WHEEL/RAIL LOAD MEASUREMENT ZONE AT RAIL JOINT

Figure 3. Examples of Extended Vertical Wheel/Rail Load Measurement Zone (35-Inch Length)

strain gage configurations. The vertically-oriented gage pattern was found to be quite sensitive to cross talk from the lateral position of the vertical load and resulted in apparent lateral loads as much as 50 percent higher than the actual laod. Two other gage patterns reported by the ORE [23] were evaluated; both used longitudinally-oriented gages on the rail base or base plus head, and the gages were located midway between ties. These patterns, used by German (DB) and French (SNCF) experimenters, proved to have poor linearity and were sensitive to support conditions, an important criterion for typical North American track with spikes and wood tie construction. A base chevron pattern suggested by Harrison was also evaluated in these laboratory tests. It proved to have the best combination of characteristics. Comparative results from these tests are given in Table 2.

In the past two years, the base chevron gage pattern, shown in Figure 4, has been evaluated in several major field experiments employing both wheelset and rail instrumentation [1, 11, 16]. Still another gage pattern consisting of vertically-oriented gages applied within the base fillet radius on either side of the rail, centered within the crib, is being evaluated by DOT's Transportation Test Center. Comparative analyses of wheelset and rail-measured lateral load data and error analyses of both transducer systems have been made to define problem areas with these patterns [11] and to allow improvements in their application.

PRINCIPLES OF OPERATION

Wheel/rail forces are applied at small contact interface patches on the wheel tread and under some conditions on the wheel flange, as shown in Figure 1. Strains near these contact patches in both the wheel and rail are short-duration pulses. As the loads are distributed into the wheel or track structure, however, these strains become more diffuse and longer in duration. Measuring these strains to obtain a signal proportional to a given load creates sometimes-conflicting requirements

- To maximize sensitivity and signal-to-noise ratio
- To minimize distortion due to orthogonal loads and changes in load position on the wheel or rail running surface

- To measure close to the contact interface, minimizing the mass attenuation
- To prodice a continuous signal unmodulated by rotation

Track instrumentation cannot, of course, meet this last criterion; the maximum sampling rate of the continuous passing load by rail transducers is limited by the crosstie spacing. With an instrumented wheelset, however, several strain gage patterns can be used on equally-spaced diametral lines around the wheel; the signals from each gage pattern are appropriately processed and combined to produce a continuous load signal. Strain search techniques employing both finite-element computer modeling and laboratory experiments [1, 13, 14] have been used to determine the optimum locations for wheelset strain gages to meet the above criteria. Gage placement for the ASEA/SJ wheelset for the SDP40F locomotive is sketched in Figure 5 as a typical example. Gages on diametral lines across the wheel are wired into individual bridges to reduce unwanted strain signals. This results in a raw bridge signal for vertical loads of alternating polarity, ranging from pulses to a more-or-less triangular shape (Figure 5). The combined signals must then be processed by analog or digital techniques to reconstruct a continuous signal with no loss in fidelity. A similar process is used for lateral load signals from the wheelset.

Signal processing from wayside transducers is more straightforward: in current practice, frequency-division multiplexing is used -- up to 104 data channels were recorded during the perturbed track tests -- to record the signals on magnetic tape in analog form. On-site data processing is controlled by a microprocessor, which determines the peak lateral and vertical loads for each passing wheel at each measurement site, stores these values on digital cassette tape, and prints out the tabulated values after the train has passed.

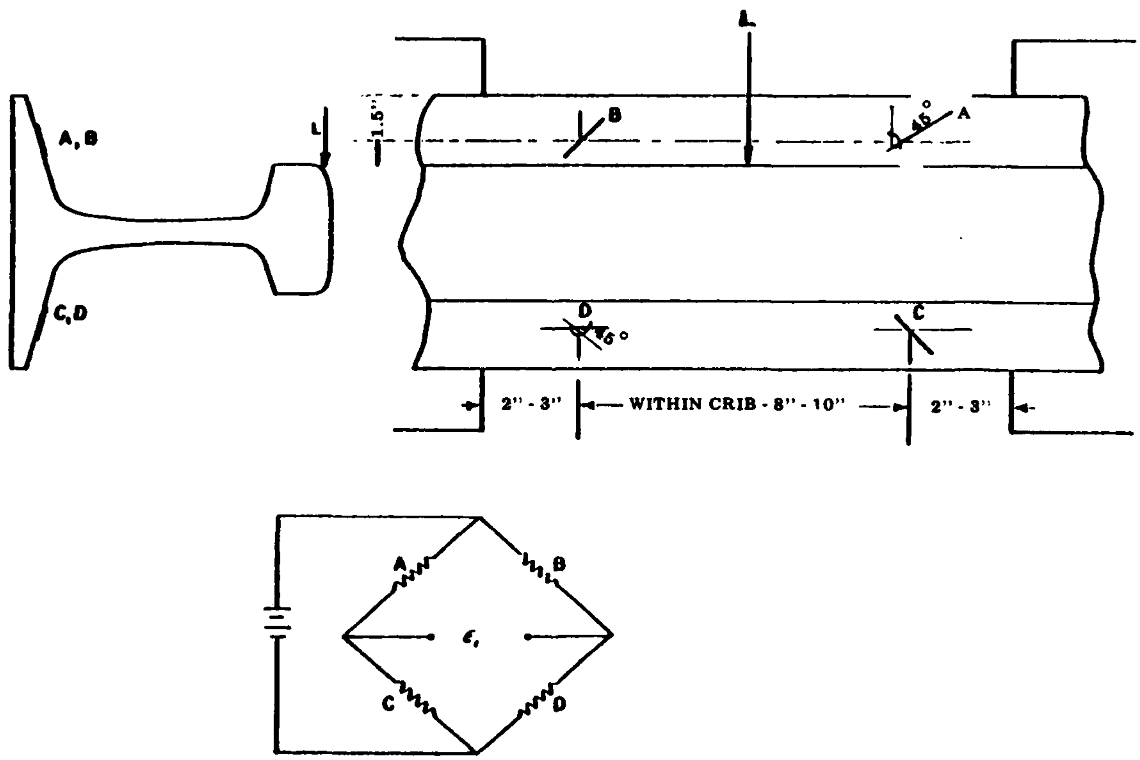


Figure 4. Strain Gage Circuit for Measuring Lateral Wheel/Rail Loads

TABLE 2. Comparative Evaluation of Lateral Wheel/Rail Load Measuring Circuits on Rail

Criteria	Web Vertical Over Tie (Fully-Supported)	Web Vertical Between Ties	Base Chevron	Base Longitudinal	Head and Base Longitudinal
Sensitivity #	Good	Good	Good	Good	Excellent
Microvolts / volt per kip	21	19	17	31 (½ bridge)	74
Linearity (0 to 10 Kips)	Fair	Excellent	Good	Poor	Poor
at 5 kips, Error =	+9%	−1%	−5%	+61%	+32%
Crosstalk*	Poor	Poor	Good	Fair	Good
Lb per 1000 lb V at Flange Contact Point	580	780	−56/−132[a]	133	−13/−179[b]
Sensitivity to Support	Fair	Poor	Good	Poor	Poor
Clips off, field -		−7%	−11%	+89%	+46%
Clips snugged -		−49%	+10%	−46%	−32%
Sensitivity to Vertical Position of Lateral Load	Fair	Fair	Good	Fair	Good
Z = −.44" to −.81" below rail running surface	+18%	+19%	+8%	−12%	−10%
Change in Sensitivity under Vertical Load (0 to 30 kips)	Good	Poor	Good	Fair	Good
30 Kip V, Y = 0	−4%	−49%	−3%	+19%	+3%[c]

Clips loose on adjacent ties (nominal condition)
* Sensitivity for lateral load applied at Z = −.44" below rail running surface
a Near edge of chevron pattern
b Due to localized head bending strains
c Disregarding localized effects in head (gages centered on head at X = 1.75")

CALIBRATION

An important aspect of wheel/rail load measurements is the calibration technique used to determine transducer gains and scaling factors. This has been addressed by Vanstone [11] *with regard to the perturbed track tests* and the comparison between rail transducers and both SDP40F and E8 instrumented wheelsets.

Rail circuits are calibrated by means of a rail head fixture, orthogonal precision load cells simulate the contact shape of a new AAR wheel. Veritcal loads are applied hydraulically and reacted against the underside of a car or locomotive, the lateral load is then applied hydraulically between the rail heads. Induced moments as the rail head moves laterally outward are minimized by clevis pin load cells in the vertical load path. Signals from the strain gage circuits are

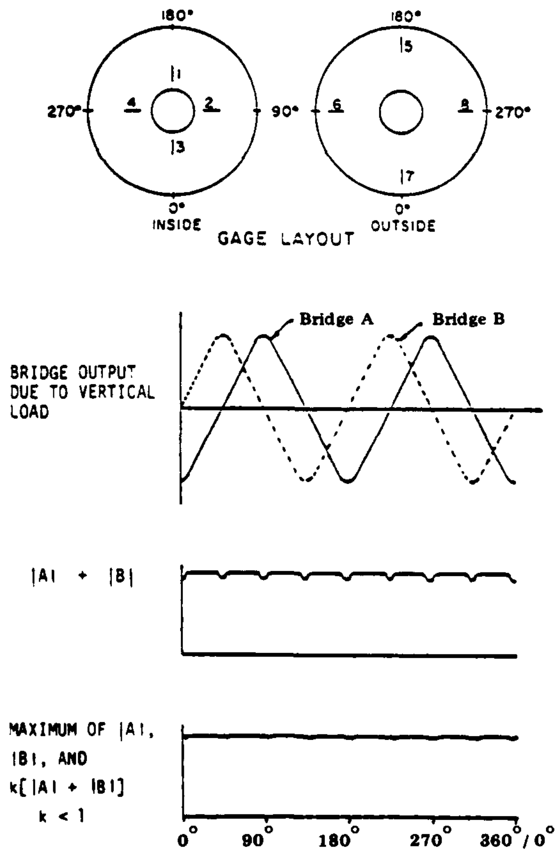


Figure 5. Vertical Force Measurement From ASEA/SJ-Type Wheelset

plotted on an X-Y plotter against the precision load cell outputs. The gain of the circuit is established in engineering units by the resulting slope of the plot. Resistor shunt calibrations are used throughout tests to provide a check on this physical calibration. Errors *introduced in the calibration process primarily affect* the lateral load circuit; errors include moments in the rail head due to the lateral position of the vertical load, irregularities in rail support at the ties, and rotation of the rail at higher L/V ratios.

Wheelsets are generally calibrated in special static loading fixtures that apply known veritcal loads to the journal bearing adapters and a lateral load at one wheel rim, reacted at the other. Errors can arise during simultaneous loading of both wheels due to differences in elastic deformations of the wheelset and the fixture; such differences result in unknown lateral friction force components through the wheel/rail interface. British Rail applies vertical loads through a pivoted beam to a pad representing the rail and then superimpose lateral or longitudinal forces through these pads. In their calibration rig, the pads are fully floated on orthogonal linear bearings to compensate for distortions of the wheelset under load. ASEA/SJ wheelsets are both statically and dynamically calibrated. In the dynamic calibration, the fixture rotates the wheelset while loads are applied at the wheel/rail interface through disc-shaped rollers. This provides a more realistic application of the known loads.

ERROR ANALYSIS

Load measurements from strain-gaged wheelsets or rails are subject to errors from several sources. Wheelset errors have been discussed [10-14], and errors at the rail -- some of which are analogous to those at the wheel -- have also been examined [1, 11, 16]. The important characteristics and error sources of wheel/rail load measurement transducers are

- Sensitivity and resolution -- sensitivity has a direct bearing on the signal-to-noise ratio; resolution depends on the full range of the transducer (maximum expected load) and data processing errors over this range
- Ripple -- the modulation in signal gain or scale factor due to wheel rotation (analogous to the influence zone at the rail)

Table 3. Comparison of Instrumented Wheelset and Instrumented Rail Load Measurement Characteristics [11-13, 16]

Criteria	ASEA/SJ Wheelsets Vertical	ASEA/SJ Wheelsets Lateral	Rail Circuits Vertical	Rail Circuits Lateral
Sensitivity (μ in./in./kip)	4.1	15	9.5*	19*
Linearity error (maximum deviation from straight line, kips)	unk	unk	<0.6* (<0.8)*	0.5* (0.8)*
Ripple (change in sensitivity with wheel roation, %)	±5	±2	na	na
Hysteresis (kips)	unk	unk	<0.5* (<0.6)*	0.6* (0.9)*
Vertical to lateral crosstalk (kips per kip V) -- at nominal contact position		-.040		-0.067 -0.035* (-0.060)*
at flange contact point		unk		-0.070**
Vertical to lateral crosstalk (sensitivity to lateral position of load moving toward flange, kips/kip V/in.)		+0.011		-0.033
Lateral to vertical cross talk (% per kip L)	<0.7		0.07	
Sensitivity change with load position (L moving down rail, V moving toward flange, %/in.)	+3.8	+5.0	-1.5	+21.6
Centrifugal error	negligible	negligible	na	na
Thermal error	a.c. coupled	zero adj.	na	na

* Evaluation of 14 rail circuits [16]; values in parenthesis at one standard deviation
** Laboratory Tests

- Cross talk -- outputs in the strain gage bridge induced by orthogonal loads; for example, apparent lateral load due to changing vertical load position across the wheel tread or the rail running surface
- Centrifugal effects -- output signals due to strains induced by wheel rotation (affects wheelsets only)
- Thermal effects -- strains induced by changes in temperature
- Linearity and hysteresis -- deviations during load cycles from the ideal strain gage bridge output versus load input relationship
- Longitudinal cross talk -- apparent load due specifically to traction or creep torque-induced loads

Typical values for these different sources of error are summarized in Table 3. Simultaneously-measured lateral loads from wheel and rail transducers have been evaluated [11, 16]. Results showed close agreement on the average (within about 500 lb), but the standard deviation of differences between wheel and rail for different test sections typically ranged from 2,000 to 3,000 lb (9 to 13 kN), with the wheel sometimes high and the rail sometimes high. This phenomenon is under further investigation.

A final consideration is system bandwidth – the maximum frequency range in which the transducer will measure loads at the wheel/rail interface without serious distortion or attenuation. Because of the mass of the wheel rim and the tendency toward wheel plate bending modes above 400 to 500 Hz, wheelset strain signals have customarily been low-pass filtered at 80 to 100 Hz. British Rail has noted a ringing upon impact at about 400 Hz with their spoked wheelset. The small effective mass of the rail head within the short influence zone of the rail circuit, on the other hand, allows a bandwidth well over 1 kHz. Wayside data, however, is normally filtered at 300 Hz before digital data processing.

CONCLUSIONS

Loads from an instrumented wheelset can be used to evaluate the dynamic response of a specific vehicle to a broad spectrum of track conditions over a given track route. Loads from an instrumented track site can provide an evaluation of all passing wheels (not just the instrumented wheelset) and can therefore encompass a full range of rail vehicles, speeds, and operating conditions for that specific location for comparison with the test vehicle. A judicious combination of both on-board and wayside measurements can most cost-effectively provide an evaluation of new equipment and a comparison with the existing load environment.

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BOOK REVIEWS

NOISE, BUILDINGS AND PEOPLE

D.J. Croome
Pergamon Press, Oxford, England, 1977

This book emphasizes building acoustics and the complex interrelationships among the attitudes of the inhabitants, the requirements for adequate mechanical services (air conditioning, plumbing, etc.), and other factors. It is one in a series of ten volumes dealing with heating, ventilating, and refrigeration.

The book contains two major sections: fundamentals of acoustics (including characteristics of sound sources and sound propagation), and noise control (including subjective response and designing for optimum sound conditioning). Eleven chapters deal with various aspects of these topics.

The divisions and layout of this book are extremely well thought out and practical. Chapter one is a scientific and philosophical discussion and introduces concepts in environmental engineering of buildings. The second chapter begins the section on noise control. Various acoustical comfort criteria and the predicted responses of people based on those criteria are given. Included are the acoustical conditions that bring about sleep disturbance, some criteria on tolerance for low-frequency vibration, and the concepts of landscaped offices. Noise sources in buildings, including mechanical and hydraulic noise, are discussed in the third chapter. Chapter four deals with the control of noise, including the techniques for sound insulation of party walls and facades, the control of H.V.A.C. system noise, and the concepts of building siting for noise control. In addition, vibration of equipment and the resulting structure-borne sound are discussed; the several illustrated case studies are very informative. The last chapter of the section is devoted to design techniques, including those for office landscaping, auditoria, and other architectural spaces; and to designing noise out of air conditioning systems. An interesting and somewhat unique presentation of the results of major research to date is given in several chapters in the form of tables that summarize recent work.

The remaining five chapters deal with fundamentals of acoustics: paths of vibrations, wave motion, sound propagation, structure-borne sound (including nonlinear vibrations, multi-degree-of-freedom systems, and viscoelastic damping), sound in rooms, and sound transmission.

Very brief appendices contain a listing of titles of British Standards, titles of booklets available on workplace health and safety, a selected reference bibliography, and a listing of 12 publications from the British Noise Advisory Council. Except for the reference bibliography (dating as late as 1976 with most entries from respected English language publications), these appendices are of marginal utility. An author index and a rather complete subject index are more notable features of this book.

Overall, this volume is a more-than-adequate treatment of a many-faceted subject. By necessity, it often omits many details in derivations of formulae and skims over material that could be given exhaustive treatment. Hence, this volume is not for the self-learner but for the knowledgeable scientist, architect, or engineer who needs a good text in the area of building acoustics.

This book is the work of high quality professionals: well written with clear figures and illustrative photographs and sensible organization. The 611 pages are densely packed with an enormous amount of information. Croome combines science, sociology, and philosophy to present a very readable book. I recommend it highly.

R.J. Peppin
5012 Macon Road
Rockville, MD 20852

STRUCTURAL INTEGRITY TECHNOLOGY

J.P. Gallagher and T.W. Crooker, Editors
ASME, New York, NY, 1979

This publication contains papers presented at the Conference on Structural Integrity Technology, Washington, D.C., May 9-11, 1979. This conference was sponsored by the Materials Division of ASME.

The published proceedings are unsatisfying – the variety of topics and approaches are presented in a helter-skelter fashion with little, if any, attempt at correlation or comparison. Each author describes his problem and his approach as if the rest of the world did not exist. This reader would be much more interested in papers that compare approaches and techniques as used in different applications. Some of this flavor might have been included in the discussions at the conference. It is unfortunate that those discussions were not included in the proceedings.

The publication contains 23 papers in 228 pages. Presumably every reader will find one or more papers of specific interest. Those interested in structural integrity would likely want to have this publication as a reference source. The reader desiring an overview understanding and/or education in structural integrity technology will be disappointed; this publication is not recommended for this purpose.

Should ASME decide to repeat this conference, this reviewer would urge that the organization and emphasis be placed on approaches, rather than applications. For example, several papers could be devoted to probabilistic design, several to brittle failure, and several to the role of inspection. Each series of papers could be tied together with an overview paper.

This is the type of publication that belongs in a library for occasional reference, but it is not suggested for personal libraries.

K.E. McKee
IIT Research Institute
Chicago, Illinois 60616

COMPUTATIONAL METHODS FOR SOLUTIONS OF ENGINEERING PROBLEMS

C.A. Brebbia and A.J. Ferrante
Crane Russak & Co., New York, NY, 1978

Most engineering and physics problems now employ computational methods. The book by Brebbia and and Ferrante discusses the impacts of computers and their applications to problems in solid mechanics, simple structures, fluid mechanics, and heat transfer. The seven chapters are well illustrated; numerous computer programs illustrate the principles involved.

Chapter I is s general discussion of computers and programming. Flow charts are introduced.

Chapters II and III are concerned with the fundamentals of matrix operations and their utilization in computational methods. Linear equations are solved using Gauss elimination, the cholesky method, and iterative methods. Eigenvalues and eigenvectors are considered, including the Veanello-Stodola method and Jacob's method. Simple beam and truss analyses are considered. A number of programs are used for illustrative purposes.

Chapter IV discusses behavior of linear solids. The author considers virtual displacement and the principle of minimum potential energy with respect to stress and elasticity theory. A short selection describes the use of matrix methods in dynamics.

Chapter V describes such approximate methods as the Rayleigh-Ritz method and the Galerkin method. Examples illustrate beams and two-dimensional plates. Collocation methods are not described.

Chapter VI is concerned with finite element techniques. Mesh generation is explained in simple terms. Triangular elements are considered with methods for assembling the stiffness matrix. Various types of shape functions for triangular elements are also considered. Higher elements are briefly discussed. The chapter contains a large number of computer programs. The reviewer would have preferred a more descriptive section on isoparametric elements.

Chapter VII discusses fluid mechanics and the governing equations. Examples of the use of finite elements are given for hydraulics, flow-through porous media, and seepage problems. No computer programs are given.

The reviewer was impressed with the large number of computer programs given for the various computational methods. The authors are to be commended for collecting the programs.

H. Saunders
General Electric Company
Schenectady, New York 12345

SHORT COURSES

OCTOBER

VIBRATION DAMPING
Dates: October 6-9, 1980
Place: Dayton, Ohio
Objective: This course is designed to teach vibration damping fundamentals, analytical methods and experimental techniques required to design and apply damping treatments which will solve vibration problems. The course is comprised of lectures, workshops, and laboratory demonstrations of methods used to measure damping material properties, to apply damping materials to structures, and to test damped and undamped structures. Computerized approaches for incorporating damping into new and existing structures and techniques for using viscoelastic materials for reducing noise will be discussed. The practical approach to problem solutions will be emphasized. The design techniques presented will be applicable to the design of viscoelasticity damped structures and will include use of newly established approaches which make use of both specialized and routine finite element analysis. The course content of this course is up-dated annually to reflect the latest developments of vibration damping technology.

Contact: Mr. Dale H. Whitford, Research Institute - KL 501, University of Dayton, Dayton, OH 45469 - (513) 229-4235.

VIBRATION TESTING
Dates: October 6-9, 1980
Place: San Diego, California
Objective: Topics to be covered are: exciters, fixtures, transducers, test specifications and the latest computerized techniques for equalization, control, and protection. Subjects covered include dynamics and dynamic measurements of mechanical systems, vibration and shock specifications and data generation. Demonstrations are given of sine random and shock testing and of how test specifications are met.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

SENSORS, INSTRUMENTATION AND MEASUREMENTS
Dates: October 7-10, 1980
Place: Dalls, Texas
Dates: October 14-17, 1980
Place: Chicago, Illinois
Dates: October 21-24, 1980
Place: Salt Lake City, Utah
Dates: October 28-31, 1980
Place: Boston, Massachusetts
Objective: A course for individuals involved in the selection and calibration of sensors and measurement instrumentation, the taking of dynamic measurements, performing modal or signature analysis, etc. Course includes laboratories on sensors and signal conditioning, data archiving, IEEE Bus, calculators, computers and analyzers. Instructional laboratories and equipment demonstrations by manufacturer.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

BLASTING AND EXPLOSIVES SAFETY TRAINING
Dates: October 8-10, 1980
Place: Nashville, Tennessee
Dates: October 22-24, 1980
Place: Casper, Wyoming
Dates: November 5-7, 1980
Place: Hershey, Pennsylvania
Dates: November 19-21, 1980
Place: Lexington, Kentucky
Dates: December 3-5, 1980
Place: Kansas City, Missouri
Dates: December 10-12, 1980
Place: Williamsburg, Virginia
Objective: This course is a basic course that teaches safe methods for handling and using commercial explosives. We approach the problems by getting at the reasons for safety rules and regulations. Helps provide blasters and supervisors with a practical understanding of explosives and their use - stressing importance of safety leadership. Familiarizes risk management

and safety personnel with safety considerations of explosives products and blasting methods.

Contact: E.I. du Pont de Nemours & Co. (Inc.), Applied Technology Division, Wilmington, DE 19898 - (302) 772-5982/774-6406.

MODAL VIBRATION TESTING IBRAHIM TECHNIQUE

Dates: October 9-10, 1980
Place: Boston, Massachusetts
Objective: Theory and use of the ITD method. Determining modal vibration parameters through a computational procedure utilizing a structure's free decay response or random response data, without the need for measuring the input forces. Free software.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

SCALE MODELING IN ENGINEERING DYNAMICS

Dates: October 20-24, 1980
Place: San Antonio, Texas
Objective: The course will begin with a drop test demonstration of damage to model and prototype cantilever beams made from different materials. These tests help to introduce the concepts of similarity and of physical dimensions which are preliminary to any model analysis. Formal mathematical techniques of modeling will then be presented including the development of scaling laws from both differential equations and the Buckingham Pi Theorem. A number of sessions then follow wherein the instructors present specific analyses relating to a variety of dynamic vibrations and transient response problems. The problems are selected to illustrate the use of models as an analysis tool and to give examples of variations on different modeling techniques. Types of problems presented include impact, blast, fragmentation, and thermal pulses on ground, air and floating structures.

Contact Wilfred E. Baker, Southwest Research Institute, 6220 Culebra Road, P.O. Box 28510, San Antonio, Texas 78284 - (512) 684-5111, Ext. 2303.

MACHINERY VIBRATION

Dates: October 21-24, 1980
Place: Albany, New York
Objective: Stressing the basic aspects of rotor-bearing system dynamics, the course will provide a fundamental understanding of rotating machinery vibrations, an awareness of available tools and techniques for the experimental and mathematical analysis and diagnosis of rotor vibrations problems, and an appreciation of how these techniques are applied to correct vibration problems. Economic evaluation and failure analysis techniques, including metallurgical considerations will also be presented.

Contact: Paul E. Babson, Mechanical Technology Incorporated, 968 Albany-Shaker Road, Latham, NY 12110 - (518) 785-2371.

DIGITAL SIGNAL PROCESSING

Dates: October 28-30, 1980
Place: Atlanta, Georgia
Objective: The mathematical basis for the fast Fourier transform calculation is presented, including frequency response, impulse response, transfer functions, mode shapes and optimized signal detection. Convolution, correlation functions and probability characteristics are described mathematically and each is demonstrated on the Digital Signal Processor. Other demonstrations include spectrum and power spectrum measurements; relative phase measurements between two signals; and signal source location.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

NOVEMBER

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

Dates: November 3-7, 1980
Place: Huntsville, Alabama
Dates: December 8-12, 1980
Place: Anaheim, California
Dates: February 2-6, 1981
Place: Santa Barbara, California
Dates: March 2-6, 1981
Place: Washington, D.C.
Dates: April 6-10, 1981
Place: Boston, Massachusetts

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 - (815) 682-7171.

FINITE ELEMENTS: BASIC PRINCIPLES AND PRACTICAL ASPECTS

Dates: November 10-14, 1980

Place: Tucson, Arizona

Objective: The purpose of this course is to provide structural engineering practitioners with an understanding of the fundamental principles of finite element analysis, to describe applications of the method, and to present guidelines for the proper use of the method and interpretation of the results obtained through it. Emphasis will be placed upon the linear analysis of frameworks, plates, shells and solids; dynamic analysis will also be treated. Daily workshop sessions will utilize the GIFTS interactive graphics finite element system, which is a popular stand along analysis capability and which also serves as a pre- and post-processor for such widely used programs as SAP and NASTRAN.

Contact: Dr. Hussein Kamel, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-1650/626-3054.

18TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 10-14, 1980

Place: Tucson, Arizona

Objective: This course will cover the following subjects: reliability engineering theory and practice; mechanical reliability; risk analysis; reliability testing and demonstration; maintainability engineering; product liability; and reliability and maintainability management.

Contact: Dr. Dimitri Kececioglu, Aeronautical Engineering, Bldg. 16, University of Arizona, Tucson, AZ 85721 - (602) 626-2495/626-3901/626-3054.

MACHINERY VIBRATION IV

Dates: November 11-13, 1980

Place: Cherry Hill, New Jersey

Objective: Lectures and demonstrations on vibration measurement rotor dynamics and torsional vibration are scheduled. General sessions will serve as a review of the technology; included are the topics of machine measurements, modal vibration analysis, and vibration and nosie. The rotor dynamics sessions will include: .using finite element, transfer matrix, and nonlinear models; vibration control including isolation, damping, and balancing. The sessions on torsional vibration feature fundamentals, modeling measurement and data analysis, self-excited vibrations, isolation and damping, transient analysis, and design of machine systems.

MODAL ANALYSIS, SUBSTRUCTURING AND TESTING

Dates: November 11-14, 1980

Place: Chicago, Illinois

Dates: November 18-21, 1980

Place: Dalls, Texas

Dates: December 2-5, 1980

Place: Salt Lake City, Utah

Dates: December 9-12, 1980

Place: Boston, Massachusetts

Objective: A state-of-the-art presentation on structural analysis techniques combined with laboratory demonstrations. Covers mechanical structures, modes of vibration, modal analysis, structural testing, finite element modeling and substructuring including structural dynamics modification techniques. Instructional laboratories and equipment demonstrations by manufacturer.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

DECEMBER

MACHINERY VIBRATION ANALYSIS

Dates: December 10-12, 1980

Place: New Orleans, Louisiana

Objective: The course covers causes, effects, detection, and solutions of problems relating to rotating machines. Vibration sources, such as oil and resonant whirl, beats, assembly errors, rotor flexibility, whip, damping, eccentricity, etc. will be discussed. The effect on the overall vibration level due to the interaction of a machine's structure, foundation, and components will be illustrated.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 5-9, 1981

Place: Tucson, Arizona

Objective: The objective of this short course and workshop is to provide practical information on engineering applications of probabilistic and statistical methods, and design under random vibration environments. Modern methods of structural and mechanical reliability analysis will be presented. Special emphasis will be given to fatigue and fracture reliability.

Contact: Dr. Paul H. Wirsching, Associate Professor of Aerospace and Mechanical Engineering, The University of Arizona, College of Engineering, Tucson, AZ 85721 - (602) 626-3159/626-3054.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 9-13, 1981

Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 16-20, 1981

Place: Phoenix, Arizona

Objective: Program emphasis is on how to increase productivity, cost-effectiveness and data-validity of data acquisition groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

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

NOISE-CON 81
June 8-10, 1981
Raleigh, North Carolina

NOISE-Con 81, the 1981 National Conference on Noise Control Engineering, will be held at North Carolina State University in Raleigh, North Carolina, on June 8-10, 1981 at the McKimmon Continuing Education Center.

The conference will be sponsored by the Institute of Noise Control Engineering and the School of Engineering, North Carolina State University; Dr. Frank Hart is the General Chairman, Dr. Larry Royster is the Program Chairman, and Mr. Butch Stewart is the Publicity Chairman.

The theme of NOISE-CON 81 is "Applied Noise Control Technology." Ten sessions are presently planned and each session will consist of invited and contributed papers. The ten sessions planned are as follows:

- Textiles and Fibers
- Furniture and Sawmill
- Noise Source Identification
- Barriers and Enclosures
- Tobacco and Packaging
- Mufflers
- Metal Working
- Hearing Protection Devices
- Community Noise
- Miscellaneous Topics

Contributed papers will be selected by a review of the submitted abstracts (a maximum of 1000 words, one figure, and up to five equations may be included). The deadline for receipt of the abstracts is January 14, 1981.

A special seminar on fundamentals and applications of noise control technology, the NOISE-CON SEMINAR, will be held prior to NOISE-CON 81 on June 4-6, 1981.

Those wishing to submit abstracts of contributed papers or desiring further information on the conference or seminar should contact either: Dr. Larry Royster, Program Chairman or Ms. Candace Sumner, Secretary, Center for Acoustical Studies, Dept. of Mechanical & Aerospace Engr., North Carolina State University, Raleigh, NC 27650 - (919) 737-3366/737-2373.

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 (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the C‚ nmissioner of Patents, Washington, D.C. 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. 2194, 2232, 2251, 2252)

80-2178

Calculation of a Shaft-Bearing System of an O-Frame Press with a Two-Point Drive (Berechnung der Baugruppe Welle-Lager einer O-Gestellpresse mit Zweipunktrantrieb)

H. Blum

Institut f. Umformtechnik, Universität Stuttgart, Germany, Konstruktion, 32 (5), pp 185-189 (May 1980) 7 figs, 10 refs

(In German)

Key Words: Shafts (machine elements), Bearings, Presses

A shaft-bearing system is analyzed by means of a finite element technique. A three-dimensional model is developed which considers the entire cross bar region. Contact effects between shaft and bearing are included in the calculation. The elastic response of the system during symmetric and eccentric operating loads is described.

80-2179

Prediction of Dynamic Properties of a Rotor Supported by Hydrodynamic Bearings Using the Finite Element Method

J. Peigney

Centre Technique des Industries Mecaniques, Senlis, France, Rept. No. CETIM-1-4A-29-0, 30 pp (Sept 1979)

N80-17482

Key Words: Rotor-bearing systems, Finite element technique, Perturbation theory, Computer programs

General programs for rotor bearing analysis using the finite element method are presented. A consistent representation of both mass and stiffness is used for the rotor shaft while hydrodynamic bearings are calculated by solving a Reynolds equation. Dynamic characteristics of these bearings are then obtained with a perturbation method. These programs agree well with both numerical and experimental results described in literature. The influence of bearing characteristics on the stability threshold and the unsteady response of a rotor are also studied.

80-2180

Transformation of Rotary Vibratory Motion into a Rotary Motion Due to Base Vibration

K. Ragulskis and A. Slavėnas

Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 143-148 (1977), 2 figs, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Rotors (machine elements), Unbalanced mass response

A case of a solid body on which several unbalanced rotors were mounted is investigated. The body itself can move on a plane along two rectilinear coordinates. The conditions for the transfer of motion as well as the validity of approximation method for the determination of motion in a self-adjusting condition are determined.

80-2181

Rotors in Forward Flight and Dynamic Stall (Pale Reculante et Decrochage Dynamique)

J. Renaud

Helicopters Div., Aerospatiale Usines de Toulouse, France, Rept. No. AAAF-NT-79-20, 26 pp (1979)

N80-18050

(In French)

Key Words: Rotors, Helicopter rotors, Stalling

Dynamic stall of rotors in forward flight is studied in terms of the limiting on helicopter performance. The lift of the rotor, forward velocity, engine speed, and the interaction of vortices with the blade surface all contribute to the development of stall. Experiments demonstrating the unsteady nature of the phenomena are reported. Simulation of dynamic stall phenomena on an oscillating model shows that the delay in unsteady stalling is associated with the development of a system of vortices along the leading edge. A two dimensional analysis is used in modeling dynamic stall.

80-2182

Angular Displacement of the Rotor in a Vibro-Bearing Taking into Account the Rotation Resistance Change Rate

R.-M. Kanapėnas and R. Statkevičius

Kaunas A. Sniečkus Polytechnic Institute, Kaunas,

Lithuania, Vibrotechnika, 3 (27), pp 115-121 (1977), 5 figs, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Rotors (machine elements), Rotor-bearing systems, Angular displacement

The rotor angular displacement analysis of a vibro-bearing with mechanical elastic contact is presented, taking into account the rotation-resistance power moment and the rate of its change as a function of high-frequency oscillation parameters. The constant relationships characterizing the relaxation rate and the rigidity of vibro-bearings from the rotation resistance power moments are given when high-frequency oscillations are present.

80-2183

Experimental Evaluation of Active and Passive Means of Alleviating Rotor Impulsive Noise in Descent Flight

D.S. Janakiram

Systems Research Labs., Inc., RADA Div., Newport News, VA, Rept. No. NASA-CR-159188, 86 pp (Nov 1979)
N80-16839

Key Words: Rotors (machine elements), Flight vehicles, Noise reduction, Active control

A controlled wind tunnel test program was conducted on a model 2.14 m (7 ft) diameter teetering rotor to determine the effectiveness of blade tips such as the Ogee tip and the TAMI (Tip Air Mass Injection) tip in reducing the impulsive noise due to blade-vortex interaction in descent flight. In addition, a full rectangular tip which has the same span as the Ogee tip and an effective rectangular tip which has the same lifting area as the Ogee tip were also considered. The tests were conducted at two advance ratios with various descent rates. A comparison of the performance of different rotors showed that for the same tip Mach number and thrust, the Ogee tip rotor absorbed more power than the full rectangular tip rotor, while the TAMI tip rotor absorbed more power than the effective tip rotor.

80-2184

In-Plane Vibration and Buckling of a Rotating Beam Clamped Off the Axis of Rotation

D.A. Peters and D.H. Hodges

Dept. of Mech. Engrg., Washington Univ., Box 1185, St. Louis, MO 63130, J. Appl. Mech., Trans. ASME, 47 (2), pp 398-402 (June 1980) 4 figs, 11 refs

Key Words: Beams, Rotating structures, Asymptotic approximation

Asymptotic expansion formulas for rotating beams clamped off the axis of rotation are developed for both small and large values of stiffness and off-clamping parameters. A composite expansion formula is also introduced as an engineering approximation to the buckling curve for all values of parameters. The present results agree quite well with an exact numerical solution and indicate the buckling can occur for arbitrarily small stiffness and off-clamping.

80-2185

Flutter Analysis of Small Windturbine, Designed for Manufacture and Use in Developing Countries

P.C. Hensing

Dept. of Aerospace Engrg., Technische Hogeschool, Delft, Netherlands, Rept. No. UTH-LR-272, 29 pp (Aug 1978)
N80-18415

Key Words: Wind turbines, Turbines, Flutter

The flutter behavior of a wind turborotor designed for manufacture and use in developing countries was investigated. Possible improvements are discussed. The effect of scaling is considered. Results show that the addition of small tip-masses has a curative influence on flutter sensitive rotor designs.

80-2186

Operational Experience with VAWT Blades

W.N. Sullivan

Sandia Labs., Albuquerque, NM, In Large Wind Turbine Design Characteristics and R and D Requirements, pp 205-210 (Dec 1979)
N80-16468

Key Words: Turbines, Wind turbines, Turbine blades, Vibration measurement, Finite element technique

The structural performance of 17 meter diameter wind turbine rotors is discussed. Test results for typical steady and vibratory stress measurements are summarized along with predicted values of stress based on a quasi-static finite element model.

80-2187

Core Noise Investigation of the CF6-50 Turbofan Engine

V.L. Doyle and M.T. Moore

Aircraft Engine Group, General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-159749, 520 pp (Jan 1980)

N80-16062

Key Words: Turbofan engines, Noise generation, Motor vehicle noise

The contribution of the standard production annular combustor to the far-field noise signature of the CF6-50 engine was investigated. Internal source locations were studied. Transfer functions were determined for selected pairs of combustor sensors and from two internal sensors to the air field. The coherent ouput power was determined in the far-field measurements, and comparisons of measured overall power level were made with component and engine correlating parameters.

80-2188

Core Noise Investigation of the CF6-50 Turbofan Engine: Data Report 1978-1979

V.L. Doyle

Aircraft Engine Group, General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-159598, 357 pp (Jan 1980)

N80-16061

Key Words: Turbofan engines, Noise measurement, Experimental data

Acoustic data obtained during the running of the CF6-50 turbofan engine on an outdoor test stand are presented. The test was conducted to acquire simultaneous internal and far-field measurements to determine the influence of internally generated noise on the far-field measurements. The data includes internal and far-field narrowband and one-third octave band pressure spectra.

80-2189

Fan Noise Reduction by Single- and Double-Wall Barriers

D. Lohmann

DFVLR, Selbständige Abteilung Technische Akustik, Bienroderweg 53, 3300 Braunschweig, Germany, J. Acoust. Soc. Amer., 67 (6), pp 1974-1979 (June 1980) 8 figs, 7 refs

Key Words: Fan noise, Noise reduction, Noise barriers

It is shown mathematically that in some cases the turbo-jet engine fan noise behind a barrier is amplified instead of being reduced. The amplification effect occurs when the rim of the barrier is located in areas of high or rather maximum sound levels. It was found that double-wall barriers prevent sound amplification. This additional abatement of sound in the shadow zone of the screen is partially caused by absorption of diffracted waves within the open double-wall "cavity." A semi-empirical formula was developed to estimate this absorption. As basic configuration for experimental studies a DC-10 half model with a CF6-turbo fan engine was selected to be tested in model scale of 1 :10. The agreement between theory and experiment is satisfactory.

80-2190

Application of Coherence in Fan Noise Studies

J.R. Balombin

Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TP-1630; E-157, 26 pp (Feb 1980)

N80-18882

Key Words: Fans, Noise generation, Coherence function technique

A study of fan noise was made by using the coherence function to obtain far field spectra that were coherent with the fan rotational rate. Choosing fan rotational rate as one of the two variables yielded new information about the far field noise generated during static fan testing.

RECIPROCATING MACHINES

80-2191

Noise Control for Diesel Engine Generator Sets

N. Schultz and W.A. Summerson

Industrial Acoustics Co., Inc., Bronx, NY, S/V, Sound Vib., 14 (5), pp 30-34 (May 1980) 10 figs, 2 tables, 3 refs

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

Techniques employed in reducing the noise and thermal infrared signatures of Department of Defense diesel engine driven mobile generator sets are presented. The object of the program was to evaluate noise contributing sources of the generator sets and apply noise control techniques to demonstrate that a noise level of less than 80 dBA at 25 ft. (7.6 m) could be achieved by a kit approach. A second criterion was to reduce the thermal signature emitted by the engine. The best acoustical configuration reduces noise levels 13 dBA. The basic design of the generator sets was not altered and their performance was not penalized.

POWER TRANSMISSION SYSTEMS

80-2192

Constrained Fatigue Life Optimization of a Nasvytis Multiroller Traction Drive

J.J. Coy, D.A. Rohn, and S.H. Loewenthal
Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-81447, 20 pp (1980)
N80-18407

Key Words: Mechanical drives, Roller bearings, Fatigue life

A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palmgren analysis method for rolling element bearing life prediction, and also uses life adjustment factors for materials, processing, lubrication, and effect of traction. The analysis method is applied in an optimization study to the multiroller traction drive, consisting of a single-stage planetary configuration with two rows of stepped planet rollers of five rollers per row.

METAL WORKING AND FORMING

(Also see No. 2247)

80-2193

Machine Tool System Identification and Forecasting Control of Chatter

K.F. Eman
Ph.D. Thesis, Univ. of Wisconsin, Madison, WI, 189 pp (1979)
UM 8007547

Key Words: Machine tools, Chatter, System identification techniques

Anticipating the stochastic nature of the machining process, a suitable chosen variable has been used for online identification and prediction of the stability of machine tools. Discrete Autoregressive Moving Average models and their Autoregressive approximations have been implemented, featuring the modal decomposition of the system's dynamic along with the modal contributions yielding the modes susceptible to chatter. Subsequently using the inherent ability of the stochastic models to forecast future values, the modal damping ratio has been chosen for prediction to ascertain the future stability of the system.

ELECTROMECHANICAL SYSTEMS

80-2194

On the Problem of Operational Condition Selection for a Device Coupled with a Slow-Speed Electric Drive

R. Jonušas, G. Kenstavičienė, and M. Rondomanskas
Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 59-64 (1977) 3 figs, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Mechanical systems, Power transmission systems, Angular vibration, Vibration control

The determination of optimal parameters of a device coupled to a slow-speed electric drive for the reduction of angular vibration and duration of transitional processes is described.

MATERIALS HANDLING EQUIPMENT

80-2195

The Study of Regularities Bulk Cargo Transportation of the Working Member of Shaking Conveyor

S. Aseinov and I. Goncharevich
Institut gornogo dela im. A. Skochinskogo, USSR, Vibrotechnika, 3 (27), pp 101-108 (1977), 3 figs, 3 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Materials handling equipment, Conveyors

The motion of bulk cargo on a conveyor is investigated by means of photography and slow-motion cameras. For solution of the differential equations by digital computer, the visco-elastic-plastic model of the bulk cargo is represented by a block diagram. From the theoretical and experimental results a procedure for the design of vibratory conveyors is developed.

80-2196
Limiting Dip Angle of a Vibrator Tray to the Horizon When a Detail is Transporting
S. Aseinov, I. Goncharevich, and R. Aseinov
Institut gornogo dela im. A. Skochinskogo, USSR, Vibrotechnika, 3 (27), pp 109-113 (1977) 2 refs, Kaunas A. Sniečkus, Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Materials handling equipment, Conveyors

An elasto-visco-plastic model of a vibrator tray detail is developed and solutions of differential equations are presented. A limiting dip angle of a vibrator tray to the horizon required for the design of vibrator trays is obtained analytically.

STRUCTURAL SYSTEMS

BUILDINGS

(Also see Nos. 2246, 2295)

80-2197
Response of Simple Structural Systems in Traveling Seismic Waves
J.R. Morgan, W.H. Hall, and N.M. Newmark
Dept. of Civil Engrg., Univ. of Illinois at Urbana-Champaign, IL, Rept. No. UILU-ENG-2015, 127 pp (Sept 1979)
PB80-13400

Key Words: Buildings, Seismic response, Earthquake response, Translational response, Rotational response, Standards and codes

The possibility of using a traveling seismic wave procedure to study the translational and rotational responses of a building is investigated in order to assess current building code procedures and to establish bounds for the interrelationship between torsional and translational response. The theory and procedure for both superposition and coupled reaction models used in the study are described. Three assumptions were made throughout the investigation; only systematic motions over the base were taken into account; only horizontally propagated plane waves with vertical wave fronts of motions were considered; and only rigid foundation systems were considered.

80-2198
Seismic Resistance of Existing Buildings
R.V. Whitman, F.J. Heger, R.W. Luft, and F. Krimgold
Massachusetts Inst. of Tech., Cambridge, MA, ASCE J. Struc. Div., 106 (ST7), pp 1573-1592 (July 1980) 6 figs, 9 tables, 20 refs

Key Words: Buildings, Seismic response, Earthquake damage, Damage prediction

A procedure for strengthening buildings undergoing renovations in zones where intensity of expected seismic shaking is low is recommended. Two buildings, one a masonry bearing wall and heavy timber floor warehouse and the other a reinforced concrete flat slab factory, are studied to determine the existence of weak links in seismic resistance and the cost of upgrading such resistance during major renovations. The expected damage from three levels of earthquake for the two buildings is summarized in damage probability matrices; these matrices are then used to compute mean damage ratios (MDR). Each MDR is shown as a function of strengthening cost, providing a means for estimating the reduction in seismic risk of these buildings from their present condition when they are either strengthened to a recommended practical level or replaced with new construction.

80-2199
Reliability of Existing Buildings in Earthquake Zones
J.T.P. Yao
School of Civil Engrg., Purdue Univ., Lafayette, IN, Rept. No. CE-STR-79-6, 55 pp (Dec 1979)
PB80-153067

Key Words: Buildings, Earthquake damage, System identification technique, Bibliographies

A literature review on safety evaluation of complex structures was conducted in three areas: (1) system identification involving techniques developed to obtain a mathematical representation of a specific physical system when both input and output are known, (2) damage assessment of existing structures, and (3) structural identification with respect to damage and reliability functions and equations of motion. Formulation of reliability evaluation is discussed with respect to damage function, application of pattern recognition, and application of fuzzy sets. Preliminary analysis of available test data is described.

80-2200

Measurement of Traffic Noise Shielding Provided by Buildings

A. Lawrence and M. Burgess

Acoustics Research Unit, Graduate School of the Built Environment, Univ. of New South Wales, New South Wales, Australia, Appl. Acoust., 13 (3), pp 211-225 (May/June 1980) 6 figs, 8 refs

Key Words: Buildings, Noise barriers, Traffic noise

A comparison between some current prediction methods for traffic noise shielding provided by buildings and the actual measured attenuations in typical residential areas is presented. The attenuations measured for individual noise events under nominally identical conditions are shown to have large variations in attenuation.

UNDERGROUND STRUCTURES

80-2201

The Effects of Ground Vibration During Bentonite Shield Tunneling at Warrington

B.M. New

Transport and Road Research Lab., Crowthorne, UK, Rept. No. TRRL-LR-860, 38 pp (1978)

PB80-132087

Key Words: Tunneling, Ground vibration, Vibration measurement, Soil compacting

The environmental effects of the ground vibration caused by the excavation process during a bentonite shield tunnel drive were investigated with particular regard to ground settlement by compaction. Vibration data were recorded from transducers located in boreholes, on the surface, on the tunneling machine and on the concrete tunnel lining. These records were processed to characterize the vibrations in terms of peak particle velocities, frequency spectra and spatial attenuation.

CONSTRUCTION EQUIPMENT

80-2202

A Comparison Between Road Construction Noise in Rural and Urban Areas

D.J. Martin

Transport and Road Research Lab., Crowthorne, UK, Rept. No. TRRL-LR-858, 31 pp (1978)

PB80-132103

Key Words: Construction equipment, Noise generation

A study of the noise from construction activities at six road schemes is described, chosen to represent several types of road design in rural and urban areas. It was found that the earthworks plant used at the urban schemes was generally less powerful and better silenced than the equivalent plant used at the rural sites.

80-2203

Effect of Vibration on Shearing Characteristics of Soil Engaging Machinery

H.M.S. Keira

Ph.D. Thesis, Carleton Univ., Canada (1979)

Key Words: Construction equipment, Vibratory techniques

A theoretical model for predicting the shearing characteristics of soil engaging elements of soil working machines subject to vertical vibration was developed. To validate the mathematical model, a vibratory linear shear apparatus was also developed. A series of tests have been carried out for determining the effects of the amplitude of exciting force, the drawbar speed, the frequency of excitation and the static normal force on the shearing force developed on the plate-soil interface. The experimental results are in close agreement with the theoretical predictions, thus confirming the validity of the theoretical model.

PRESSURE VESSELS

(Also see No. 2206)

80-2204

Fatigue Behavior of High-Pressure Vessels (Festigkeit von Hochdruckbehaeltern f. neuartige Fertigungsverfahren)

V. Grubisic and C.M. Sonsino

Laboratorium f. Betriebsfestigkeit, Darmstadt, West Germany, Rept. No. LBF-FB-148, 250 pp (1979)
N80-18441
(In German)

Key Words: Pressure vessels, Cylindrical shells, Fatigue life

Fatigue experiments on plain and cylindrical specimens with high strain concentration prove that low cycle material properties determined on unnotched specimens can be applied for the dimensioning of these vessels to a defined initial crack. Dimensioning including the stage of crack-propagation is not recommended because of very high strain-intensities and resulting small critical crack-depths, as several damage cases show.

80-2205

Finite Element Formation for Fluid-Structure Interaction in Three Dimensional Space

R.F. Kulak

Reactor Analysis and Safety Div., Argonne National Lab., Argonne, IL, Rept. No. CONF-790615-26, 32 pp (1979)
N80-17410

Key Words: Interaction: structure-fluid, Pressure vessels, Fluid induced excitation, Finite element technique

A three-dimension hexahedral hydrodynamic finite-element is developed. Using trilinear shape functions and assuming a constant pressure field in each element, simple relations were obtained for internal nodal forces. Because the formulation was based upon a rate approach it was applicable to problems involving large displacements. This element was incorporated into an existing plate-shell finite element code. Diagonal mass matrices were used and the resulting discrete equations of motion were solved using explicit temporal integrator. Results for several problems are presented which compare numerical predictions to closed form analytical solutions. In addition, the fluid-structure interaction problem of a fluid-filled, cylindrical vessel containing internal cylinders was studied.

80-2206

Vibration of PWR Internals Considering Their Edge Conditions and Holes

V. Kuželka

Natl'l. Research Inst. for Machine Design, SVÚSS, 250 97 Prague 9 - Běchovice, Czechoslovakia, Nucl. Engr. Des., 57 (1), pp 125-132 (Apr 1980) 6 figs, 4 tables, 15 refs

Key Words: Pressure vessels, Nuclear reactor containment, Fluid-induced excitation, Modal analysis

The frequency modal characteristics of PWR core barrel models with or without holes, under various edge conditions, in air and in water, are presented. The influence of the holes on the frequency spectra, on the values of damping in mentioned environments, and on the end-seating behavior was investigated experimentally. Hydroelastic response of the internals due to random excitation of a coolant flow is analyzed and the design of hydrodynamic equipment, which contains the gravitational channel of 36 m water column is described.

POWER PLANTS

(Also see Nos. 2271, 2286)

80-2207

Dynamic Pressure Inside a PWR - A Study Based on Laboratory and Field Test Data

M.K. Au-Yang and K.B. Jordan

Nuclear Power Generation Div., The Babcock and Wilcox Co., Lynchburg, VA 24505, Nucl. Engr. Des., 58 (1), pp 113-125 (May 1980) 12 figs, 1 table, 8 refs

Key Words: Nuclear reactors, Fluid-induced excitation, Forcing function

The dynamic pressure in the downcomer of a pressurized water reactor (PWR) was measured in a dynamic scale flow model and also in a commercial plant during preoperational tests. It was found that by proper choice of nondimensional parameters, it was possible to collapse the random pressure data from widely different operating conditions to within narrow bands of data scatter and to scale the random pressure forcing function to that of its prototype for the same mode of coolant pump combination.

80-2208

A Critical Reappraisal of Nuclear Power Plant Safety Against Accidental Aircraft Impact

J.D. Riera

Universidada Federal do Rio Grande do Sul, Porto

Alegre-RS, Brazil, Nucl. Engr. Des., 57 (1), pp 193-206 (Apr 1980) 13 figs, 2 tables, 58 refs

Key Words: Nuclear power plants, Crash research (aircraft)

The overall problem of nuclear power plant safety against an accidental aircraft impact is discussed in relation with its structural analysis and design. In part I different approaches used for determining the reaction-time curve are discussed and the influence on the results of target motions is examined. In part II, available solutions for the resulting structural dynamic problem are reviewed.

OFF-SHORE STRUCTURES

(Also see No. 2231)

80-2209

Structural Design of Production Risers and Offshore Production Terminals

W.R. Wolfram, Jr. and R.H. Gunderson

Exxon Production Research Co., Houston, TX, J. Energy Resources Tech., Trans. ASME, 102 (2), pp 106-111 (June 1980) 10 figs, 1 table, 19 refs

Key Words: Off-shore structures, Fatigue life, Model testing

A procedure for predicting design loads and fatigue histories for production risers and offshore terminals is presented. The emphasis is on systems wherein a dedicated vessel is connected to the riser by a rigid mooring arm. A number of structural design configurations are surveyed and techniques for preliminary sizing, dynamic analysis, model testing and fatigue analysis are discussed. The application of this procedure to several specific design cases is summarized.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 2187, 2188, 2245)

80-2210

Determination of Design Load (Stress) Spectra for Truck Components (Ermittlung von Bemessungskollektiven für Nutzfahrzeug Bauteile)

V. Grubišić

Zum Stetteritz 1, 6107 Reinheim 4, Germany, Automobiltech. Z., 82 (4), pp 229-231 (Apr 1980) 5 figs, 1 ref

(In German)

Key Words: Ground vehicles, Fatigue life

A procedure for the measurement and analysis of frequency distribution of service loads (load spectra) or the corresponding stress spectra for various areas of vehicle components under different service conditions is described. In an example, the measurements of the side forces acting on a truck front axle are discussed. From these results and the power density spectra, the design load or stress spectra necessary for laboratory fatigue testing and the prediction of component service life can be estimated.

80-2211

Dynamic Response of a Six-Axle Locomotive to Random Track Inputs

D.S. Garivaltis, V.K. Garg, and A.F. D'Souza

Dynamics Research Div., Association of American Railroads, Chicago, IL, Vehicle Syst. Dyn., 9 (3), pp 117-147 (May 1980) 11 figs, 2 tables, 18 refs

Key Words: Locomotives, Interaction: rail-wheel, Spectrum analysis, Probability density function, Ride dynamics, Fatigue life

Spectral analysis techniques are employed to analyze the dynamic response of a six-axle locomotive on tangent track to vertical and lateral random track irregularities. The locomotive is represented by a thirty-nine degrees of freedom model. A linear model is employed by considering small displacements, linear suspension elements and a linear theory for the wheel-rail interaction. Power spectral densities of displacements, velocities and accelerations and the statistical average frequencies of the system are obtained for each degree of freedom. Comparison of the calculated dominating frequencies with existing experimental values shows good agreement.

80-2212

The Directional Behaviour During Braking of a Tractor/Semi-Trailer Fitted with Anti-Locking Devices

V.S. Verma, R.R. Guntur, and J.Y. Wong

Transport Tech. Research Lab., Dept. of Mech. and Aeronautical Engrg., Carleton Univ., Ottawa, Canada, Intl. J. Vehicle Des., 1 (3), pp 195-220 (May 1980) 23 figs, 1 table, 10 refs

Key Words: Tractors, Articulated vehicles, Braking effects

The directional behavior of a tractor/semi-trailer equipped with anti-locking devices on one or more of its axles was studied using digital simulation. This study was limited to the examination of the behavior of the vehicle during braking in a turning maneuver. The suitability of various anti-locking arrangements was examined from the standpoints of directional control and stability, and braking effectiveness. The results of the study indicated that the control arrangements of current anti-locking devices on a tractor/semi-trailer should be improved.

80-2213

New Rear Axle Suspension on Three-Axled Semi-Trailers

F. Bauchiero

RIV-SKF Turin, Ball Bearing J., 203, pp 24-25 (May 1980) 3 figs

Key Words: Articulated vehicles, Suspension systems (vehicles), Design techniques

A unique design of a three-axle semitrailer and its suspension system are described. Its axle is simply made up of two equalizers suspended from the frame and each carrying a wheel unit at one end. Since the conventional beam axle has been eliminated, this arrangement has relatively light mass and payloads can be increased. The attachments of the equalizers to the frame are equipped with steel-on-steel spherical plain bearings.

SHIPS

(Also see Nos. 2369, 2370)

80-2214

Airborne Noise Levels on Merchant Ships. A Compilation of Data

D.R. Lambert

Naval Ocean Systems Center, San Diego, CA, Rept. No. NOSC/TD-243, 35 pp (Apr 1979)
AD-A079 356/2

Key Words: Ships, Noise measurement, Standards and codes

This document provides general guidance in the development of noise standards for US merchant ships. It is one of several dealing with various aspects of noise as related to the safety of personnel and habitability aboard merchant ships. It summarizes selected A- and C-weighted sound pressure level data for each type of space aboard merchant ships of US flag and non-US flag. The data were extracted or derived from available literature and from recent NOSC measurements.

80-2215

A Linear Theory of Springing

S.O. Skjørdal and O.M. Faltinsen

Div. of Ship Hydrodynamics, The Norwegian Inst. of Tech., Trondheim, Norway, J. Ship Res., 24 (2), pp 74-84 (June 1980) 11 figs, 2 tables, 30 refs

Key Words: Ship hulls, Resonant response, Water waves, Fluid-induced excitation

A linear slender-body theory for the resonant ship hull girder response to the unsteady pressure field in the fluid, usually denoted as springing, is derived. The wave excitation loads are calculated by a generalization of the short-wavelength theory of Faltinsen. A Green's function approach is used to find the pressure distribution. Numerical results are compared with experimental results of Wereldsma and Moeyes. The "forced-motion loads" are obtained by a generalization of the Ogilvie and Tuck approach for forced heave and pitch motions. Discrepancies with other methods are discussed. Numerical results of springing are presented.

80-2216

A Design Procedure for Minimizing Propeller-Induced Vibration in Hull Structural Elements

O.H. Burnside, D.D. Kana, and F.E. Reed

Southwest Research Inst., San Antonio, TX, Rept. No. SSC-281, 178 pp (Sept 1979)
AD-A079 443/8

Key Words: Ship hulls, Propeller-induced excitation, Vibration control

A design procedure for minimizing propeller-induced vibration in hull structural elements is recommended. This procedure begins when the ship's vibration specifications are defined and continues through the design and construction process until the vibration levels measured during sea trials are compared with the specifications. Consideration is given to the hydrodynamic excitation and structural response of the propeller-induced vibration problem, with both analytical and experimental techniques being used in the design process. The recommended procedure is presented and discussed in the form of a flow diagram with 27 separate design steps. The process also contains five evaluation milestones. At these points, the design is assessed, and, if deficiencies are found, corrective action can be taken before the design proceeds. The recommended complete procedure is presented in this report for the first time.

AIRCRAFT

(Also see Nos. 2183, 2240, 2241, 2242, 2244, 2373, 2376, 2378)

80-2217

Finite Element Subvolume Technique for Structural-Borne Interior Noise Prediction

J.F. Unruh

Southwest Research Inst., San Antonio, TX, J. Aircraft, 17 (6), pp 434-441 (June 1980) 9 figs, 1 table, 24 refs

Key Words: Aircraft noise, Noise prediction, Finite element technique

Finite element structural and acoustic representations of a vibrating structure and enclosed acoustic volume are used in a study of structural-borne interior nosie. An acoustic subvolume analysis technique is presented which reduces the degrees of freedom of the interior volume to modal form prior to the coupled system dynamic analysis. Analytical predictions are compared to results from an experimental program to verify the analysis procedures. From these comparisons, the acoustic subvolume technique is shown to be a reliable method to reduce the computational requirements for finite element acoustic analysis.

80-2218

An Improved Prediction Method for the Noise Generated in Flight by Circular Jets

J.R. Stone and F.J. Montegani

Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-81470; E-403, 33 pp (1980)

N80-22048

Key Words: Aircraft noise, Noise prediction

A semi-empirical model for predicting the noise generated by jets exhausting from circular nozzles is presented and compared with small-scale static and simulated-flight data. The present method is an updated version of that part of the original NASA aircraft noise prediction program relating to circular jet noise. The earlier purely empirical supersonic convection formulation is replaced by one based on theoretical considerations. Other improvements were based on model-jet/free-jet simulated-flight tests. The effects of nozzle size, jet velocity, jet temperature, and flight are also included.

80-2219

Noise Suppression Due to Annulus Shaping of Conventional Coaxial Nozzle

U. vonGlahn and J. Goodykoontz

Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-81461; E-390, 19 pp (1980)

N80-22047

Key Words: Aircraft noise, Noise reduction, Nozzles

A method which shows that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocity will lower the noise level is described. The method entails modifying a concentric coaxial nozzle to provide an eccentric outer stream annulus while maintaining approximately the same through flow as that for the original concentric bypass nozzle. Acoustical tests to determine the noise generating characteristics of the nozzle over a range of flow conditions are described. The tests involved sequentially analyzing the noise signals and digitally recording the 1/3 octave band sound pressure levels. Representative spectra for several engine cycles are presented for both the eccentric and concentric nozzles at engine size.

80-2220

Noise Suppression Due to Annulus Shaping of an Inverted-Velocity-Profile Coaxial Nozzle

J. Goodykoontz and U. vonGlahn

Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-81461; E-389, 27 pp (Apr 1980)

N80-22046

Key Words: Aircraft noise, Noise reduction, Nozzles

An inverted velocity profile coaxial nozzle for use with supersonic cruise aircraft produces less jet noise than an equivalent conical nozzle. Furthermore, decreasing the annulus height (increasing radius ratio with constant flow) results in further noise reduction benefits. The annulus shape (height) was varied by an eccentric mounting of the annular nozzle with respect to a conical core nozzle. Implications of the acoustic benefits derived with the eccentric nozzle to practical applications are discussed.

80-2221

Collection and Analysis of In-Service Flight Histories of the Initiation of Fatigue Damage (Sammlung und Analyse von im Betrieb von Luftfahrzeugen aufgetretenen Ermuedungsschaeden)

H. Huth and D. Schuetz

Technische Hochschule, Aachen, West Germany, Rept. No. BMVG-FBWT-79-10, 36 pp (Apr 1979)

N80-17518

(In German)

Key Words: Aircraft, Fatigue life, Crack propagation

In-service aircraft failure histories are evaluated in order to show weak points of design and causes of early fatigue initiation. The distribution and frequency of fatigue cracks in the different structural components show that the main problem is in the joints. The crack lengths of service and test failures at the time of detection are also evaluated. The principal causes of damage are found to be excessive load transfer, double stress concentration, design stress, induced deflections, secondary bending, sharp edge, open hole, and production defects. These causes are explained using examples taken from the collection of cracks.

80-2222

Initial Study of the Response of an Aircraft to Lateral Gusts (Response de L'Avion aux Rafales Laterales. Etudes Exploratoire)

J.L. Cocquerez and R.A. Verbrugge

Universites des Sciences et Techniques de Lille, France, Rept. No. AAAF-NT-79-03, 37 pp (1979)

N80-17084

(In French)

Key Words: Aircraft, Wind-induced excitation

Aircraft performance in turbulence, especially the response to lateral gusts, is studied to optimize the use of automatic flight control systems. Those flight conditions emphasized include low altitude approach, landing with wind composed of transversal gusts, and stability at steep angles of attack at low speeds. The preponderant effects of gust loads vis-a-vis degrees of freedom, the roles of the various control surfaces of the aircraft, and the responses of different aircraft planforms are shown, leading to the modelization of these phenomena.

80-2223

On the Fatigue Life Evaluation of Jointed Specimens Undergoing Load Transfer with Regard to Stress Concentration (Zur lebensdauerabschaetzung von Fuegungen mit schubbeanspruchten Befestigungselementen unter Beruecksichtigung der Lastuebertragung)

J. Franz and D. Schuetz

Laboratorium fuer Betriebsfestigkeit, Darmstadt, West Germany, Rept. No. BMVG-FBWT-79-11, 96 pp (Apr 1979)

N80-17519

(In German)

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

The effect of load transfer and secondary bending stresses on the fatigue life of jointed parts of aircraft structures were investigated during the design phase.

80-2224

Average Gust Frequencies Subsonic Transport Aircraft

Engineering Sciences Data Unit, London, UK, Rept. No. ESDU-69023-A-B-C, 43 pp (1979)

N80-16029

Key Words: Aircraft, Wind-induced excitation, Fatigue life

Data is provided for compilation of the cumulative frequency gust spectrum experienced by an aircraft structure. An estimation of fatigue loading encountered by aircraft wing structures in flight is presented.

80-2225

Study on the Dynamics of Small Flight Vehicles (Zur Dynamik kleiner Fluggerate)

R. Staufenbiel

Institut f. Luft- und Raumfahrt der Technischen Hochschule, Wullnerstrasse 7, 5100 Aachen, Zeitschrift f. Flugwissenschafter u. Weltraumforschung, 4 (2), pp 81-92 (1980) 3 figs, 4 tables, 21 refs

(In German)

Key Words: Aircraft, Flight vehicles, Wind-induced excitation, Landing

The dynamic similarity of flight vehicles, in particular, the influence of vehicle size on stability, loads and disturbances as well as on performance, is examined. Gust sensitivity and landing techniques of small flight vehicles are discussed in some detail considering only the longitudinal motion.

80-2226

Gust Load Alleviation

H. Hitch

British Aerospace Aircraft Group, Warton, UK, In Von Karman Inst. for Fluid Dyn. Active Control Technol., Vol. 2, 12 pp (1978)

N80-21346

Key Words: Aircraft wings, Wind-induced excitation, Vibration control

Mathematical modeling of gust loads on wings is discussed with emphasis on gust load alleviation. Aircraft dynamic models are included. Load reduction achievable with an ACT load alleviation system is discussed.

80-2227

Application of MIL-STD-810C Dynamic Requirements of USAF Avionics Procurements

J.H. Waftord

Aeron. Systems Div., Wright-Patterson AFB, OH, In AGARD Dyn. Environ. Qualification Tech., 11 pp (Nov 1979)

N80-19091

Key Words: Aircraft equipment, Noise measurement, Vibration measurement

The vibration requirements and the application of these requirements to the procurement of avionics equipment are discussed. Data obtained from external noise measurements and aerodynamically induced vibration are reported.

80-2228

Unified Aerodynamic-Acoustic Theory for a Thin Rectangular Wing Encountering a Gust

R. Martinez and S.E. Widnall

Massachusetts Inst. of Tech., Cambridge, MA, AIAA J., 18 (6), pp 636-645 (June 1980) 7 figs, 17 refs

Key Words: Aircraft wings, Wind-induced excitation

A linear aerodynamic-acoustic theory is developed for the prediction of the surface pressure distribution and three-dimensional acoustic far-field for a flat plate rectangular wing encountering a stationary short-wavelength oblique gust. Spanwise Fourier superposition of two-dimensional solutions to the infinite-span wing problem is used to approximate the three-dimensional acoustic field due to the interaction of a stationary oblique gust with a flat-plate rectangular wing traveling at a subsonic speed.

80-2229

Wing/Store Flutter with Nonlinear Pylon Stiffness

R.N. Desmarais and W.H. Reed, III

Langley Research Center, NASA, Langley Station, VA, Rept. No. NASA-TM-81789, 8 pp (Apr 1980)

N80-20280

Key Words: Flutter, Wing stores, Aircraft wings

The influence of pylon stiffness nonlinearities on the flutter characteristics of wing mounted external stores is examined.

80-2230

Some Recent Measurements of Structural Dynamic Damping in Aircraft Structures

E.J. Phillips

British Aerospace Aircraft Group, Brough, UK, In AGARD Damping Effects in Aerospace Struct., 15 pp (Oct 1979)

N80-19576

Key Words: Aircraft wings, Wing stores, Vibration tests, Damping values

Values of structural damping obtained during a flutter investigation of a strike aircraft in several wing store configurations, in which the wings were excited by impulses at the wing tips are presented. A vibration test on a large underwing pylon mounted pod during which three suspensions were represented, and a vibration test on a box section shelf mounted on antivibration mounts are described. During the flutter investigation the structural damping was determined from the time decay of filtered accelerometer signals. In the vibration tests, the test items were excited sinusoidally and damping was obtained from accelerometer response curves at resonance.

80-2231

Analyses and Tests of the B-1 Aircraft Structural Mode Control System

J.H. Wykes, T.R. Byar, C.J. Macmiller, and D.C. Greek

Rockwell Intl. Corp., El Segundo, CA, Rept. No. NASA-CR-144887; H-1109, 268 pp (Jan 1980)
N80-15073

Key Words: Aircraft, Vibration damping

Analyses and flight tests of the B-1 structural mode control system (SMCS) are presented. Improvements in the total dynamic response of a flexible aircraft and the benefits to ride qualities, handling qualities, crew efficiency, and reduced dynamic loads on the primary structures, were investigated. The effectiveness and the performance of the SMCS, which uses small aerodynamic surfaces at the vehicle nose to provide damping to the structural modes, were evaluated.

80-2232

Experimental Study of the Aerodynamics of a Helicopter Rotor Blade Model in an Unsteady Flow Regime During Wind Tunnel Tests

P. Philippe, P. Lafon, and J.C. Bohl

Office National d'Etudes et de Rechercher Aerospatiales, Paris, France, Rept. No. AAAF-NT-79-21, 13 pp (1979)
N80-17036
(In French)

Key Words: Helicopter rotors, Rotary wings, Aerodynamic loads, Wind tunnel tests

Test tools and facilities were developed to understand and analyze flows encountered on helicopter rotor blades. The measurements performed on straight or 30 degree swept blade tips reveal unsteady and tridimensional effects on absolute pressure distributions. The experimental data are also compared with calculations, thus summing up the state of the art of available prediction methods.

80-2233

Design Study of Prestressed Rotor Spar Concept

D. Gleich

Arde, Inc., Mahwah, NJ, Rept. No. NASA-CR-159086, 101 pp (Jan 1980)
N80-17062

Key Words: Helicopter rotors, Design techniques, Rotary wings, Composite structures, Fatigue life, Crack propagation

Studies on the Bell Helicopter 540 Rotor System of the AH-1G helicopter were performed. The stiffness, mass and geometric configurations on the Bell blade were matched to give a dynamically similar prestressed composite blade. A multi-tube, prestressed composite spar blade configuration was designed for superior ballistic survivability at low life cycle cost.

80-2234

Effects of Primary Rotor Parameters on Flapping Dynamics

R.T.N. Chen

Ames Research Center, NASA, Moffett Field, CA, Rept. No. NASA-TP-1431; A-7777, 63 pp (Jan 1980)
N80-15138

Key Words: Helicopter rotors, Dynamic response

The effects of flapping dynamics of four main rotor design features that influence the agility, stability, and operational safety of helicopters are studied. The parameters include flapping hinge offset, flapping hinge restraint, pitch-flap coupling, and blade lock number.

MISSILES AND SPACECRAFT

(Also see No. 2371)

80-2235

Spacecraft Structural Acoustic Studies: The Development of a Practical Prediction Technique for Noise Induced Structural Vibration and Sound Transmission

R.J. Cummins and W. Cooper

British Aerospace Aircraft Group, Bristol, UK, Rept. No. ESA/B44-7/0712; ESA-CR(P)-1264, 200 pp (June 1979)
N80-22052

Key Words: Spacecraft, Noise-induced excitation, Sound transmission, Statistical energy methods, Computer programs

A prediction method was developed for noise induced structural vibration and sound transmission based on the concepts of statistical energy analysis (SEA). An experimental program was also performed in order to establish necessary SEA parameters for a range of typical spacecraft structural components. The computer predictions show a good agreement with the measured response of simple structures exposed to broad band reverberant noise. The limitations of the current method are defined together with suggestions for future development.

80-2236
Spacecraft Damping Considerations in Structural Design
B.K. Wada and D.T. DesForges
Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, In AGARD Damping Effects in Aerospace Struct., 18 pp (Oct 1979)
N80-19578

Key Words: Spacecraft, Damping, Modal tests

The role of damping in the prediction of spacecraft structural responses and loads, and in the structural design of spacecrafts is discussed. The methods used to incorporate damping in the structural analysis are summarized and some experiences and procedures relating to damping in recent spacecraft design are discussed. Methods for modal testing and the experimental determination of damping, the use of discrete dampers, and the estimation of payload response are studied. A collection of damping data for recent spacecraft and related hardware is provided in the appendix.

80-2237
Vibration Damping on San Marco Satellites: Results and Comments
C. Arduini and A. Agneni
Scuola d'Ingegneria Aerospaziale, Rome Univ., Italy, In AGARD Damping Effects in Aerospace Struct., 15 pp (Oct 1979)
N80-19579

Key Words: Spacecraft, Damping values

The damping data from dynamic tests of the San Marco structures is surveyed. The typical trend of the damping coefficient to decrease with frequency is confirmed; however, there is no clear evidence of significant variations with the input level. This feature is discussed in terms of the limits of the half power method.

80-2238
Effect of Structural Damping on the Dynamic Response of Spacecraft
M. Degener
Inst. fuer Aeroelastik, Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, West Germany, In AGARD Damping Effects in Aerospace Struct., 19 pp (Oct 1979)
N80-19577

Key Words: Spacecraft, Damping effects

The effect of structural damping on the dynamic response of spacecraft structures, especially satellites, is investigated. Special regard is given to the influence of intermodal damping coupling and of a nonlinear damping behavior. Results of dynamic tests on satellite structures are studied. A method is presented to determine the dynamic response of a spacecraft structure, taking into account the nonlinear damping behavior by means of a numerical, iterative procedure based on modal data.

BIOLOGICAL SYSTEMS

HUMAN

80-2239
Temporary Threshold Shifts Induced by Vibratory Stimulation
J.E. Kile and W.F. Wurzbach
Univ. of Wisconsin, Oshkosh, WI, S/V, Sound Vib., 14 (5), pp 26-29 (May 1980) 6 figs, 1 table, 16 refs

Key Words: Vibratory tools, Human response, Vibration excitation

Ten normal-hearing subjects were exposed to an electronically-driven vibratory source simulating a hand-held tool. The source had a fundamental frequency of 10 Hz, and RMS acceleration level of 1000 cm/sec^2, and a noise level of 36 dBA. Temporary threshold shifts using Bekesy tracking procedures were measured for the auditory, vibratory, and vibratory-auditory conditions. The results suggested that vibration sources producing low noise levels can elicit temporary threshold shifts.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 2328, 2329, 2350)

80-2240
Active Control Technology, Volume 2

Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium, Rept. No. VKI-Lec-Ser-1979-1-Vol-2, 411 pp (1978)
N80-21344

Key Words: Aircraft vibration, Wind-induced excitation, Vibration control, Active control

The technology of actively employing control to achieve aircraft design objectives is considered. Specific topics covered include gust alleviation, direct lift control, flutter suppression, and improved riding quality.

80-2241
Active Control Technology
M.A. Ostgaard
Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH, In Von Karman Inst. for Fluid Dyn. Active Control Technol., Vol. 1, 59 pp (1978)
N80-21338

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

Active control technology, defined as an extension of conventional feedback control systems which provide a multiple input, multiple output capability is assessed. Active control permits uncoupling of the aircraft equations for motion to allow full exploitation of the complete six degrees of control freedom as compared to the conventional four degrees of control freedom. Active control design considerations are discussed in which a B-52 aircraft was used as the test vehicle for the analysis, development, and flight demonstration of the load alleviation and mode stabilization concepts. Significant performance improvements in the areas of augmented stability, gust load alleviation, fatigue reduction, maneuver load control, ride control, and flutter mode control are reported. The historical background and the future potential of active control are discussed.

80-2242
Investigations of an Active Vibration Isolation System for Helicopters
G. Reichert and H. Strehlow
Royal Aircraft Establishment, Farnborough, UK, Rept. No. RAE-Lib-Trans-1993; BR73047, 58 pp (Nov 1979) (Engl. transl. from Luftfahrtforschung und Luftfahrttechnologie Statusseminar, Bonn, 1978)
N80-21315

Key Words: Vibration isolation, Active isolation, Passive isolation, Helicopter vibration, Rotor-induced vibration

Active and passive methods of minimizing the effects of rotor induced excitation forces on the fuselage vibration characteristics by isolating the rotor/transmission system from the fuselage are described. Attention is focused on an active control system which was developed for eventual use on the BO 105 research helicopter. The advantages of active control systems over passive systems for isolating the helicopter fuselage from rotor induced excitation are discussed.

80-2243
Analytical Tools for Active Flutter Suppression
M. Geradin
Liege Univ., Belgium, In Von Karman Inst. for Fluid Dyn. Active Control Technol., Vol. 2, 47 pp (1978)
N80-21350

Key Words: Active control, Vibration control, Flutter

Two analytical aspects of flutter mode control systems are discussed: the unsteady aerodynamics of the lifting surface, and the synthesis of the control law using modern control theory. Aerodynamic modeling via mathematical modeling is described for two dimensional incompressible flow.

80-2244
Are Locally Reacting Acoustic Liners Always Behaving as They Should?
R. Zandbergen
Fluid Dynamics Div., National Aerospace Lab., Amsterdam, Netherlands, Rept. No. NLR-MP-79002-U, 8 pp (Sept 1, 1979)
N80-22053

Key Words: Acoustic linings, Aircraft engines, Helmholtz resonators

The properties of a Helmholtz resonator type acoustic lining material may be seriously affected by intercellular water drain holes as shown by experiments on an actual aircraft engine liner where drain holes caused a considerable shift in the frequency for maximum attenuation. The drain holes invalidate the assumption of local reaction which is usually made for this type of lining material in duct acoustics. This was confirmed by the phase differences measured between the signals of two microphones at the bottom wall of a cell of the material. Some remarks are made concerning problems associated with the application of the two microphone technique for in situ impedance measurements on a rather large cell material.

80-2245

Frequency Locus Construction for the Bounce and Roll Motions of a Simple Trailer

A.G. Thompson

Mech. Engrg. Dept., Univ. of Adelaide, South Australia, Intl. J. Vehicle Des., 1 (3), pp 221-230 (May 1980) 6 figs, 4 refs

Key Words: Trailers, Suspension systems (vehicles), Automobiles

The body of a two-wheeled trailer with a swing-axle suspension exhibits steady-state bounce and roll motions when excited periodically by vertical inputs at the wheels. Graphical constructions are presented for the determination of the frequency-response amplitudes of the body support points, and the effect of roll stiffness on roll amplitudes. Damping of the anti-roll torsion bars is favored by the results of the studies. The theory may be applied to motor car suspensions if the coupling of the front and rear suspensions through the body is neglected.

80 2246

Vibration Control with Natural Rubber: Building Mounts

I.G. Rose

Malaysian Rubber Producers Research Association, Noise Vib. Control, 11 (4), pp 117-121 (Apr 1980) 8 figs

Key Words: Isolators, Elastomers, Vibration control, Traffic induced vibrations, Buildings

The use of natural rubber as a vibration isolating material in the design of transportation systems is reviewed. This use of rubber ensures optimum utilization of available land, minimizes building costs and allows an efficient, if noisy, transport system.

80 2247

Pneumatic Isolation Systems Control Forging Hammer Vibration

D.E. Baxa and R.A. Dykstra

Univ. of Wisconsin-Extension, Madison, WI, S/V, Sound Vib., 14 (5), pp 22-25 (May 1980) 7 figs, 1 table, 8 refs

Key Words: Isolators, Pneumatic isolators, Forging machinery, Hammers, Vibration isolation

Pneumatic vibration isolation within forging systems is examined for its ability to minimize transmission of vibration from the system to the surrounding environment. Vibration isolation techniques are traced from the pre-World War II period to such present-day approaches as the use of pneumatic isolators in dry-friction damping systems; and the advantages of pneumatic isolators over other primary isolators, such as steel springs, are described. Pneumatic spring isolation for an 8,000 pound steam drop hammer is depicted as a typical application.

SPRINGS

80-2248

A Study of Some Aspects of the Mechanical Behavior of Cross-Spring Pivots and Plate Spring Mechanisms with Negative Stiffness

J.F. Dijksman

Lab. of Fine Mechanics, Technische Hogeschool, Delft, Netherlands, Rept. No. WTHD-116, 121 pp (May 1979)

N80-18416

Key Words: Mechanisms, Plates, Springs

Several aspects of mechanical and kinematical behavior involving a guiding composed of a cross-spring pivot are investigated. Formulas are given for determining the radial flexibility of a cross-spring pivot as a function of the angle of rotation. The mechanical properties of mechanisms composed of flat thin plate springs are also calculated. These mechanisms are suitable for reducing positive stiffness of an elastic guiding for translation.

BLADES

(Also see No. 2186)

80-2249

Vibrations of a Marine Propeller Operating in a Nonuniform Inflow

J.E. Brooks

Ph.D. Thesis, The Catholic Univ. of America, 133 pp (1980)
UM 8013222

Key Words: Marine propellers, Propeller blades, Blades

The effect of blade vibration on the unsteady forces developed by an elastic marine propeller is investigated for a controlled laboratory situation. The study involves the development of a theory for a flexible propeller operating in a spatially nonuniform inflow velocity field and a series of experimental tests. Measurements of unsteady propeller forces in a 24-inch water tunnel are presented for two model propellers whose fundamental resonance frequencies are excited by a nonuniform inflow field.

80-2250

Aeroelastic Equations of Motion of a Darrieus Vertical-Axis Wind-Turbine Blade

K.R.V. Kaza and R.G. Kvaternik

Langley Research Center, NASA, Langley Station, VA, Rept. No. NASA-TM-79295, 57 pp (Dec 1979)
N80-18446

Key Words: Wind turbines, Turbine blades, Blades, Hamiltonian principle

The second-degree nonlinear aeroelastic equations of motion for a slender, flexible, nonuniform, Darrieus vertical-axis wind turbine blade which is undergoing combined flatwise bending, edgewise bending, torsion, and extension are developed using Hamilton's principle. The blade aerodynamic loading is obtained from strip theory based on a quasi-steady approximation of two-dimensional incompressible unsteady airfoil theory. The derivation of the equations has its basis in the geometric nonlinear theory of elasticity and the resulting equations are consistent with the small deformation approximation in which the elongations and shears are negligible compared to unity. These equations are suitable for studying vibrations, static and dynamic aeroelastic instabilities, and dynamic response.

80-2251

Torsional Oscillations of the Rotor Disc for Horizontal Axis Wind Turbines with Hinged or Teetered Blades Part 2

L.S. Hultgren

Aerodynamics Dept., Aeronautical Research Inst. of Sweden, Stockholm, Sweden, Rept. No. FFA-TN-AU-1499-PT-12, 39 pp (Aug 1979)
N80-21881

Key Words: Rotary wings, Disks, Wind turbines, Torsional vibration

The coupling of torsional oscillations of the rotor disc and the blade motions was analyzed for horizontal axis wind turbine hinged or teetered blades. The blades and the tower were assumed to be perfectly rigid. The vibrational analysis was linear and the antisymmetric blade flapping motion was found to be decoupled. Expressions for the eigenfrequencies of the system were obtained. Analytical solutions were constructed for forced vibrations due to gravity, wind shear and tower shadow.

80-2252

Structural Analysis Considerations for Wind Turbine Blades

D.A. Spera

Lewis Research Center, NASA, Cleveland, OH, In Large Wind Turbine Design Characteristics and R and D Requirements, pp 211-224 (Dec 1979)
N80-16469

Key Words: Wind turbines, Turbine blades, Dynamic response

Approaches to the structural analysis of wind turbine blade designs are reviewed. Specifications and materials data are discussed along with the analysis of vibrations, loads, stresses, and failure modes.

BEARINGS

(Also see No. 2178)

80-2253

Influence of the Gas-Film Inertia Forces on the Dynamic Characteristics of Externally Pressurized, Gas Lubricated Journal Bearings

A. Mori, K. Aoyama, and H. Mori

Kyoto Univ., Kyoto, Japan, Bull. JSME, 23 (178), pp 582-586 (Apr 1980) 3 figs, 7 refs

Key Words: Bearings, Gas bearings, Journal bearings, Whirling, Squeeze-film dampers

Modified Reynolds equations are proposed for the determination of the influence of inertia forces on such dynamic characteristics of externally pressurized gas bearings, as whirl instability and squeeze damping. The equations are derived by averaging out the inertia forces in Navier-Stokes equations across the film thickness. Adequate boundary conditions are also given.

80-2254
Gas Static Bearings as Dampers and Generators of Mechanical Vibrations
A. Byelousov, I. Tokorev, and D. Tchegodajev
Kuibishevskii ordena Trudovgo Krasnogo Znameni aviatsionii institut im. akad. S.P. Koroleva, USSR, Vibrotechnika, 3 (27), pp 94-100 (1977) 7 figs, 8 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Dampers, Hydrostatic bearings, Self-excited vibrations, Amplitude data, Frequencies

The nature and the dynamic process as well as self-excited vibrations of hydrostatic bearings were investigated and means for the control of self-excited vibration frequency and amplitude are discussed. A model describing the dynamics of the type of bearing under investigation is presented.

GEARS

80-2255
Endurance and Failure Characteristics of Modified Vasco X-2, CBS 600 and AISI 9310 Spur Gears
D.P. Townsend and E.V. Zaretsky
Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-81421; E-344, 28 pp (1980)
N80-18405

Key Words: Gears, Spur gears, Fatigue tests

Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2, and to compare the pitting fatigue lives of these three materials.

80 2256
Thermal Elastohydrodynamic Lubrication of Spur Gears
K.L. Wang and H.S. Cheng
Northwester·ı Univ., Evanston, IL, Rept. No. NASA-CR-3241, ı37 pp (Feb 1980)
N80-16337

Key Words: Spur gears, Gears, Elastohydrodynamic properties, Computer programs

An analysis and computer program called TELSGE were developed to predict the variations of dynamic load, surface temperature, and lubricant film thickness along the contacting path during the engagement of a pair of involute spur gears. The analysis of dynamic load includes the effect of gear inertia, the effect of load sharing of adjacent teeth, and the effect of variable tooth stiffness which are obtained by a finite-element method. Results obtained from TELSGE for the dynamic load distributions along the contacting path for various speeds of a pair of test gears show patterns similar to that observed experimentally. Effects of damping ratio, contact ratio, tip relief, and tooth error on the dynamic load were examined.

80-2257
Noise and Vibration of Spur Gears. Investigations of Highly Loaded Teeth and High Speeds (Geräusche und Schwingungen an Stirnradgetrieben. Untersuchungen im Bereich hoher Zahnbelastungen und Drehzahlen)
H. Rettig and W. Knabel
VDI Bericht, No. 332, pp 273-282 (1979) 15 figs, 6 refs
(In German)

Key Words: Gears, Spur gears, Geometric effects, Noise generation, Vibration generation

The effect of tooth geometry on noise and vibration generation in single step spur gears at speeds of about 1000 - 2500 rpm was investigated. The variation of the tooth modulus, tooth width, angle of skew, degree of overlap, and profile correction was considered.

80-2258
Gear Noise and Methods for Noise Reduction. Measurement Problems, Elimination of Extraneous Noises, Modal Analysis, and Noise Reduction Methods (Geräuschuntersuchungen und geräuschmindernde Massnahmen an Getrieben. Problematik der Messung, Fremdgeräusch-Eliminierung; Modalanalyse; geräuschmindernde Massnahmen)
M. Weck, P. Gold, and S. Lachenmaier
VDI Bericht, No. 332, pp 263-271 (1979) 16 figs, 8 refs
(In German)

Key Words: Gears, Gear noise, Noise reduction, Coherence function technique

Gear noise measurement techniques, described in DIN 45635, were recently supplemented by coherence methods, which enables filtering out extraneous noise. The methods helped to revise the VDI Guideline 2159 "Gear Noises" which, in turn, lead to further noise reduction studies, with an emphasis on noise reduction at the tooth mesh and on an improved housing design.

80-2259

The State of the Art of the Calculation of Gear Drives (Stand der Berechnungsmöglichkeiten im Zahnradgetriebebau)

M. Weck and P. Gold

VDI Bericht, No. 332, pp 13-24 (1979) 25 figs, 19 refs

(In German)

Key Words: Gears, Bevel gears, Fatigue life

The calculation of the effective loads of teeth and the resulting stresses of gears under repeated loads is presented. The method, which goes beyond the calculations presented in ISO standards and DIN guidelines, is illustrated by examples.

80-2260

Actual Gear Teeth Stresses and Permissible Loads (Tatsächliche Zahnfussspannungen und zulässige Beanspruchungen)

O.R. Lang

VDI Bericht, No. 332, pp 25-32 (1979) 7 figs, 2 tables, 2 refs

(In German)

Key Words: Gears, Fatigue life

A large quantity of data was investigated and approximate methods for the evaluation of the title problem were developed. The results agree well with the data presented in DIN 3990.

FASTENERS

(Also see No. 2223)

80-2261

Estimation of the Fatigue Strength of Welded Joints Based on Non-Destructive Test Results

K. Satoh and K. Seo

Osaka Univ., Japan, Rept. No. ICAF-1125, 17 pp (Mar 1979)

N80-18432

Key Words: Fatigue life, Joints (junctions), Welded joints, *Nondestructive tests, Porous materials*

The relationship between the fatigue strength of welded joints and the results of nondestructive tests was investigated experimentally. Furthermore, statistical data of stress concentration factor caused by porosities were obtained by finite element method. It was found that the fatigue strength of welded joints with porosities could be estimated theoretically by using these statistical data and the fatigue strength reduction factor.

80-2262

Rubber Expansion Joints Reduce Risk of Damage to Piping Systems

R.R. O'Toole

Uniroyal Engineered Products Co., Middlebury, CT, Des. News, 36 (12), pp 48, 50, 52, 55 (June 23, 1980)

Key Words: Joints (junctions), Elastomeric dampers, Piping systems

Different types of rubber expansion joints for different piping configurations are briefly reviewed. Recommendations for the installation and maintenance are given.

80-2263

Damping Effects in Joints and Experimental Tests on Riveted Specimens

L.B. Crema, A. Castellani, and A. Nappi

Istituto di Tecnologia Aerospaziale, Rome, Italy, In AGARD Damping Effects in Aerospace Struct., 17 pp (Oct 1979)

N80-19584

Key Words: Joints (junctions), Damping effects

The importance of dynamic damping is highlighted with emphasis on the effect of riveted joints on energy dissipation. The state of the art in the field of joint damping is illustrated with reference to several theories on damping mechanisms. Results of tests carried out on specimens with riveted joints are discussed.

LINKAGES

80-2264

Kineto-Elastodynamic Analysis of Mechanisms by Finite Element Method

P.K. Nath and A. Ghosh
Jalpaiguri Government Engrg. College, West Bengal, India, Mech. Mach. Theory, 15 (3), pp 179-197 (1980) 15 figs, 1 table, 16 refs

Key Words: Mechanisms, Linkages, Elastodynamic response, Flexural vibration, Finite element technique

A systematic finite element method for kineto-elastodynamic analysis of high speed mechanisms is presented. Effects of number of divisions are investigated and it is found that a certain minimum number of divisions of links is necessary to yield accurate results. A new approach for eliminating the singularity in the stiffness matrices of mechanisms is developed which yields improved results with negligible additional effort. Finite element expressions for the coriolis, tangential and normal components of elastic accelerations is derived for a moving link and a new geometric stiffness matrix is developed to include the effects of the rigid body pinforces and the distributed axial rigid body inertia forces on the transverse vibrations of the links. The method has been further extended to take into account the nonlinear elastic axial forces.

80-2265

Steady State Response of Mechanisms with Elastic Links by Finite Elements

P.K. Nath and A. Ghosh
Jalpaiguri Government Engrg. College, West Bengal, India, Mech. Mach. Theory, 15 (3), pp 199-211 (1980) 6 figs, 18 refs

Key Words: Linkages, Periodic response, Harmonic analysis, Finite element technique

A new analysis procedure for directly obtaining the steady state displacements and stresses within the elastic links of a mechanism is described. The method combines the rigid body harmonic analysis of a mechanism with a novel application of the finite element methods. The analysis includes the higher order elastic acceleration terms and the effects of the axial rigid body forces on the transverse vibrations of the links. The harmonic series expressions for the element displacements are obtained in terms of the crank angle by solving a set of linear algebraic equations. The method also possesses a high computational efficiency.

CAMS

80-2266

The Dynamic Analysis of High-Speed Flexible Cam Mechanisms

S.-S.D. Young
Ph.D. Thesis, Univ. of Houston, TX, 177 pp (1979) UM 8012532

Key Words: Cams, Cam followers, Parameter identification technique

The dynamic behavior of high-speed, flexible cam mechanisms is studied. Various dynamic models are compared to establish conditions for the validity or regions of validity of these models. A parametric modeling error analysis for studying the effect of modeling errors on the system responses is given and some easily used rules of thumb for the cam design are generated. In an effort to model more accurately the cam and follower system by a single degree of freedom system, a parameter identification technique utilizing an optimization algorithm is developed. A new sensitivity analysis method using the eigenvector and eigenvalue derivatives with respect to system parameters is also presented and the presentation of cam mechanism separation using a retaining spring is thoroughly analyzed.

STRUCTURAL COMPONENTS

CABLES

80-2267

Mooring with Multicomponent Cable Systems

K.A. Ansari
Marine Div., Brown & Root, Inc., Houston, TX, J. Energy Resources Tech., Trans. ASME, 102 (2), pp 62-69 (June 1980) 11 figs, 11 refs

Key Words: Cables (ropes), Stiffness coefficients, Moorings

Various mooring line components available for use in offshore operations are discussed and a method for the determination of the stiffness characteristics of a multicomponent cable including the effect of line stretch is presented. The use of these stiffness coefficients in the dynamic analysis of an offshore construction vessel moored by a multileg anchoring system is demonstrated. The maximum limiting tension of

the mooring line considered, which is a combination of anchors, clump weights, chains and cables is determined from the several breaking strengths and anchor capacities associated with the various cable configurations that can occur. To illustrate a practical application, the dynamic response of a moored production barge subjected to external environmental forces is examined.

80-2268

Dynamics of a Moving Mass Being Abruptly Stopped by a Cable

R.W. Buecher

Naval Ocean Systems Center, San Diego, CA, Rept. No. NOSC/TR-489, 12 pp (Dec 1979)
AD-A081 158/8

Key Words: Cables (ropes), Tensile strength

The one-dimensional wave equation is used to determine the propagation of tension in a cable that abruptly stops a moving mass. A simple simulation is used to determine tension propagation when the end of the cable opposite the moving mass is fixed and tension reflections occur. Predicted tensions compare favorably with those determined by experiment.

BARS AND RODS

80-2269

Three Dimensional Vibrations in a Rectangular Bar

T.G. Ryall

Aeronautical Research Labs., Melbourne, Australia, Rept. No. ARL/Struc-Rept-373; AR-001-306, 19 pp (Oct 1978)
N80-17507

Key Words: Bars, Rectangular bars, Three-dimensional problems, Free vibration

An analysis of the free vibrations of a rectangular bar which is semi-infinite in all directions is presented. It is shown that there are six possible types of vibration which allow three adjacent surfaces to be free from normal stress. Three of these vibrations correspond to a corner rotating and the remaining three correspond to a corner translating. The vibration of a rubber block is discussed, and the results illustrate how these fundamental solutions combine to give a free vibration.

BEAMS

80-2270

Influence of an Elastic End Support on the Stability of a Nonuniform Cantilever Subjected to Dissipative and Nonconservative Forces

K.C. Kar

Dept. of Mechanical Engrg., Indian Institute of Tech., Kharagpur-721302, India, Computers Struc., 11 (4), pp 337-341 (Apr 1980) 5 figs, 7 refs

Key Words: Beams, Cantilever beams, Rectangular beams, Follower forces

The influence of an elastic end support on the stability of a damped, linearly tapered cantilever of rectangular cross section subjected to a follower-end-load is studied. The equation of motion is formulated within the Euler-Bernoulli theory for the case of a Kelvin model viscoelastic beam. The effect of external damping is also included in the partial differential equation of motion. The associated adjoint boundary value problem is derived and appropriate adjoint variational principle is introduced. This variational principle is used as the basis for determining approximately the values of the critical load of the system as it depends upon the taper parameters and the stiffness of the elastic end support.

80-2271

Fluid Forces on Rods Vibrating in Finite Length Annular Regions

T.M. Mulcahy

Components Tech. Div., Argonne National Lab., Argonne, IL 60439, J. Appl. Mech., Trans. ASME, 47 (2), pp 234-240 (June 1980) 10 figs, 2 tables, 12 refs

Key Words: Beams, Rods, Fluid-induced excitation, Viscous damping, Nuclear reactor components

Approximate expressions for the fluid forces acting on a central, rigid rod translating periodically in a finite length annular region of confined fluid are derived from the Navier-Stokes equations for a range of geometric and fluid parameters where viscous damping is significant. Based on the derived forces, lumped added mass, and linear dashpot modeling of an annular gap support typically found in nuclear reactors is employed to predict the fundamental frequency and modal damping of a single beam. Test methods and results for the same beam are presented which indicate the force expressions are applicable for small fluid motions.

CYLINDERS

80-2272

Fluctuating Response of Circular Cylinders in Small Groups in Fluid Flow: Discussion and Guide to Data Available

Engineering Sciences Data Unit, London, UK, Rept. No. ESDU-79025, 41 pp (1979)
N80-20510

Key Words: Cylinders, Circular cylinders, Fluid induced excitation, Chimneys, Pipes (tubes)

The response of cylinders in small groups and methods of alleviating oscillation problems are examined. A brief description of the content of currently available sources of data is provided. The derived information can be used to assess the possibility of flow induced oscillation problems of, for example, a group of chimney stacks or a multiple pipe run in a chemical plant.

80-2273

Experimental Study of Cap and Thickness Influence on the Vibration Response and Damping of Flexible Fluid-Coupled Coaxial Cylinders

M. Chu, S. Brown, B. Lieb, and J. Lestingi
Akron Univ., OH, Rept. No. CONF-790615-14, 52 pp (1979)
N80-10633

Key Words: Cylinders, Vibration response, Vibration damping, Viscous damping, Resonant frequencies, Mode shapes

The response of a set of coaxial cylinders with water in the annulus is studied. The effects of cylinder thickness and the fluid filled annulus gap size on the resonant frequencies and mode shapes of the cylinders are presented; also included is *an evaluation of damping for selected gaps and cylinder* thicknesses.

FRAMES AND ARCHES

80-2274

Cyclic Response Prediction for Braced Steel Frames

B.F. Maison and E.P. Popov
Univ. of California, Berkeley, CA, ASCE J. Struc. Div., 106 (ST7), pp 1401-1416 (July 1980) 14 figs, 1 table, 14 refs

Key Words: Frames, Seismic response, Cyclic loading

An experimental and analytical investigation of the behavior of structural steel frames with K-braces subjected to severe cyclic loadings simulating seismic effects is described. The hysteretic behavior of a one-half scale three-story test frame is modeled analytically. Good agreement between the experimental and calculated results is shown to be possible provided the cyclic behavior of individual braces is accurately formulated. A development of a refined empirical brace model for this purpose is outlined.

80-2275

In-Plane Vibration of a Free-Clamped Slender Arc of Varying Cross-Section

T. Irie, G. Yamada, and I. Takahashi
Hokkaido Univ., Sapporo, Japan, Bull. JSME, 23 (178), pp 567-573 (Apr 1980) 8 figs, 2 tables, 12 refs

Key Words: Arches, Variable cross section, Natural frequencies, Mode shapes, Spline technique

The free in-plane vibration of a slender arc of varying cross-section is analyzed by use of the spline interpolation technique. For this purpose, with the arc divided into small elements, the in-plane displacement of each element is expressed by a spline function of 7 degrees with unknown coefficients. The displacement is obtained by determining these coefficients such that the spline function satisfied the equation of motion of the arc at each dividing point and also satisfied the boundary conditions at both ends. In this paper, the tangential displacement of the arc is chosen as the variable to be solved from a sixth-order differential equation, from which the frequency equation is derived. The method is applied to free-clamped arcs with linearly, parabolically and exponentially varying cross-sections; the natural frequencies and the mode shapes of the arcs are *calculated numerically and the effects of the varying cross-*section on them are studied.

MEMBRANES, FILMS, AND WEBS

80-2276

Nonlinear Vibration Phenomena in Films of Solar Arrays

M.A. Zak

Jet Propulsion Lab., Pasadena, CA, AIAA J., 18 (6), pp 678-683 (June 1980) 3 figs, 8 refs

Key Words: Solar arrays, Membranes (structural members), Longitudinal vibration, Transverse vibration

Analytical investigations of nonlinear vibration phenomena in films caused by local compression are presented. The equations of motion for a moving wrinkle are investigated and exact solutions for the longitudinal and transverse vibrations of a wrinkling film are derived.

PANELS

80-2277

Damping Problems in Acoustic Fatigue

V. Giavotto, M. Borri, and G. Cavallini

Istituto de Ingegneria Aerospaziale, Politecnico de Milano, Italy, In AGARD Damping Effects in Aerospace Struct., 11 pp (Oct 1979)
N80-19580

Key Words: Panels, Stiffened panels, Fatigue life, Damping effects, Spacecraft, Aircraft

Damping information necessary for the fatigue design of wideband noise excited structures is identified. Damping mechanisms are considered and damping test results are presented for stiffened panels typical of aerospace structures. The need for models capable of accurately estimating damping effects is emphasized.

PLATES

(Also see Nos. 2248, 2320)

80-2278

Prediction of the Structural Damping of a Vibrating Stiffened Plate

D.J. Mead

Dept. of Aeronautics and Astronautics, Southampton Univ., UK, In AGARD Damping Effects in Aerospace Struct., 15 pp (Oct 1979)
N80-19574

Key Words: Plates, Stiffened plates, Skin-stringer method, Joints (junctions), Damping effects, Aircraft

The sources of energy dissipation in a vibrating stiffened plate, typical of a fuselage stringer skin structure are outlined. For a particular specimen, the principal source was identified as the riveted joints attaching the skin to the stringer. These undergo oscillating tension/compression loads (in the direction of the rivet axis) when the plate vibrates. An experiment to measure the basic damping characteristic of a single riveted joint loaded harmonically is described. The non-linearity of the damping was demonstrated, as was the effect of an air pumping mechanism in the joint.

80-2279

Method for Solving Vibration Problems of a Plate with Arbitrary Shape

K. Nagaya

Dept. of Mech. Engrg., Yamagata Univ., Yonezawa, Japan, J. Acoust. Soc. Amer., 67 (6), pp 2029-2033 (June 1980) 3 figs, 4 tables, 21 refs

Key Words: Plates, Boundary value problems

This paper is concerned with a method for solving vibration problems of a thin elastic plate with arbitrary shape. The exact solution of an equation of motion is utilized and the boundary conditions along both arbitrarily shaped curved and straight line boundaries are satisfied by means of the Fourier expansion method. Numerical calculations are carried out for the clamped or simply supported elliptical and parabolic plates.

80-2280

Dynamic Responses of a Multi-Layered Rectangular Plate on Viscoelastic Foundation due to Moving Loads

C.-J. Lin

Ph.D. Thesis, West Virginia Univ., WV, 168 pp (1979)
UM 8012930

Key Words: Plates, Rectangular plates, Moving loads, Viscoelastic foundations

A general equation of motion and its analytic and numerical solution for the determination of the dynamic deflections and stresses of a multi-layered rectangular plate on viscoelastic foundation subject to a constant force traveling at a constant velocity is presented. Various combinations of simply-supported, clamped, and free edge conditions of the plate are studied. Newly developed computer programs, together with commercially available subroutines are used, and the effects of some parameters are illustrated and briefly discussed.

80-2281

Transverse Vibrations of Circular Plates of Varying Thickness with Non-Uniform Edge Constraints

P.A.A. Laura and G.M. Ficcadenti

Inst. of Applied Mechanics, Puerto Belgrano Naval Base, Argentina, Appl. Acoust., 13 (3), pp 227-236 (May/June 1980) 5 figs, 4 refs

Key Words: Plates, Circular plates, Variable cross section, Variable material properties, Flexural vibration

An approximate method for the study of free vibrations of circular plates varying in thickness and a rotational flexibility which varies arbitrarily around the boundary is presented. The method consists in representing the varying stiffness in terms of a Fourier expansion in the polar angle and approximately expressing the displacement function using a summation of polynomial co-ordinate functions which exactly satisfies only the essential boundary condition. The Ritz method is then applied in order to obtain the frequency determinant. The method can be easily extended to the forced vibrations case.

80-2282

The Investigation of Compensation Method for Decreasing the Sound Field of Large-Size Plate

A. Vyalishev, B. Tartakovskij, and M. Efrussi

Akusticheskii institut, Moscow, USSR, Vibrotechnika, 3 (27), pp 37-41 (1977) 6 figs, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Plates, Noise reduction

The experimental investigation of compensation method for the reduction of the sound field or large rib-reinforced plates is described. The weakening of sound field was obtained within 10, 12 and 15 rigidity rib pitches from 5 to 20 decibels at four compensating vibrators at different adjustment variants of the compensation system.

80-2283

The Compensation of the Radiation Field of the Bent Vibrations into Semifinite Plate

A. Vyalishev, A. Gavrilov, G. Liubashevskij, B. Tartakovskij, and J. Tchony

Akusticheskii institut, Moscow, USSR, Vibrotechnika, 3 (27), pp 31-35 (1977) 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Plates, Flexural vibrations

The calculation methods for potentials and coordinate selection of sources for the compensation of semi-finite plate in remote zone are presented. When selecting the source position two algorithms are discussed: in one of them a more simple criterion of maximum energetical effectiveness from the calculation point has been chosen, in another – a minimum criterion of mean square error. The results of digital calculations indicating both methods of source coordinate selection are presented.

SHELLS

(Also see No. 2357)

80-2284

Stability of Circular Cylindrical Shells under Transient Axial Impulsive Loading

D.G. Zimcik and R.C. Tennyson

Canadian FRAM Ltd., Chatham, Canada, AIAA J., 18 (6), pp 691-699 (June 1980) 18 figs, 2 tables, 16 refs

Key Words: Shells, Cylindrical shells, Dynamic buckling

A study was made of the buckling response of thin-walled circular cylindrical shells subjected to dynamic, transient, axial square-wave (stress) loading of varying time duration. Photoelastic plastic test models were investigated including both geometrically "near-perfect" and imperfect configurations. Using a nonlinear dynamic buckling analysis based upon the Donnell-Mushtari type shell equations, strains and radial deflections were obtained by means of a Galerkin procedure.

80-2285

Hydroelastic Vibration Analysis of Partially Liquid-Filled Shells Using a Series Representation of the Liquid

J.M. Housner, R.W. Herr, and J.L. Sewall

Langley Research Center, Langley Station, VA, Rept. No. NASA-TP-1558; L-13279, 68 pp (Mar 1980)

N80-19563

Key Words: Fluid-filled containers, Tanks (containers), Cylindrical shells, Shells, Vibration response

A series representation of the oscillatory behavior of incompressible nonviscous liquids contained in partially filled elastic tanks is presented. Each term is selected on the basis of hydroelastic vibrations in circular cylindrical tanks. Using a complementary energy principle, the superposition of terms is made to approximately satisfy the liquid-tank interface compatibility. This analysis is applied to the gravity sloshing and hydroelastic vibrations of liquids in hemispherical tanks and in a typical elastic aerospace propellant tank.

PIPES AND TUBES

(Also see Nos. 2262, 2301)

80-2286

Probability of Failure of Piping Designed to Seismically Induced Upset, Emergency and Faulted Condition (Service Conditions B, C and D) ASME Code Limits

M.R. Gorman, L.A. Bergman, and J.D. Stevenson

Dept. of Civil Engrg., Case Western Univ., Cleveland, OH, Nucl. Engr. Des., 57 (1), pp 215-220 (Apr 1980) 2 figs, 5 tables, 8 refs

Key Words: Piping systems, Nuclear power plants, Fracture properties, Standards and codes

The probability of nuclear power plant pipe rupture as a result of earthquake loads is explored, when such piping is designed according to the various behavior stress limits of the ASME code.

80-2287

Opening and Extension of Circumferential Cracks in a Pipe Subject to Dynamic Loads

T.J. Griesbach and D.J. Ayres

Plant Engrg. Dept., Nuclear Power Plant Systems, Combustion Engrg. Inc., Windsor, CT 06095, Nucl. Engr. Des., 57 (1), pp 141-152 (Apr 1980) 15 figs, 14 refs

Key Words: Fracture properties, Piping systems, Nuclear reactor components

Rupture criteria based on the consideration of how cracks which might exist in the primary piping of a pressurized water reactor (PWR) would open and extend is presented. The plastic dynamic analysis of the crack opening effects in the discharge leg pipe is performed using the MARC program until the maximum opening occurs. The *J*-integral plastic crack extension criterion is computed for all times during one transient. The results indicate that none of the cracks will extend significantly and that the opening areas are small fractions of the flow area of the pipe.

80-2288

Dynamics of Suspended Marine Pipelines

J.E. Hall and A.J. Healey

Amoco International Inc., Houston, TX, J. Energy Resources Tech., Trans. ASME, 102 (2), pp 112-119 (June 1980) 11 figs, 11 refs

Key Words: Pipelines, Underwater pipelines, Finite element technique

Finite-element modeling of the dynamics of a large pipeline where nonlinear bottom reactions and ocean fluid drag are included is considered. A time domain simulation procedure is described for computing the dynamic motion and stress response for arbitrary time history inputs at the surface. Also, a method of linearizing the seaway fluid drag terms and of handling the nonlinear bottom reactions is shown for harmonic seaway inputs. The two methods are compared and illustrate the reasonable accuracy of the linearized method.

80-2289

Transition of an Oscillating Incompressible Flow in a Pipe or in a Boundary Layer (Transition d'un Ecoulement Oscillatoire Incompressible dans une Conduite ou dans une Couche Limite)

J. Fauchas and C. Clarion

Institut de Mecanique des Fluides de Marseille, France, Rept. No. AAAF-NT-79-09, 20 pp (1979) N80-17412

(In French)

Key Words: Pipes (tubes), Fluid-induced excitation

A mathematical description of a parallel, or quasi-parallel, incompressible unsteady flow is given as the starting point for a prediction of the transition from laminar to turbulent flow using an energy method. A critical value is determined for the analytic expression of the velocity field as a function of space-time coordinates. Similitude parameters are considered. Calculations are shown to be in good agreement with reported experimental results where it has been observed the beginning of the transition corresponds with the development of point instabilities in the laminar flow regime of a pulsating sinusoidal flow in a cylindrical horizontal tube.

80-2290

Report on the Acoustic Emission Examination of Glass-Fiber Reinforced Plastic Pipes

W. Brockmann and K. Wolitz

Inst. fuer Angewandte Materialforschung, Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung e. V., Bremen, West Germany, Rept. No. UCRL-Trans-11520, 18 pp (Oct 1979)
N80-20604

Key Words: Pipes (tubes), Fiber composites, Acoustic emission

From the results reported, it can be concluded that acoustic emission analysis is suitable as a technique for quality control of high-pressure pipes, because it permits critical processes (fiber breaks) to be distinguished from noncritical processes (delamination, breaks between fibers) at pressure loads up to the rated load. If further tests with a larger number of test specimens can establish a statistically significant correlation between the proportion of fiber breaks below the rated pressure and the bursting pressure which actually occurs, it will be possible, by using acoustic emission analysis and test loads up to the rated pressure, to dispense with an individual test at double rated load, which in its own right can damage, beyond the critical point, a system designed for a load. The use of acoustic emission analysis thus leads to increased safety of the pipes.

80-2291

Mode Selective Transfer of Energy from Sound Propagation Inside Circular Pipes to Pipe Wall Vibration

E.J. Kerschen and J.P. Johnston

Stanford Univ., Stanford, CA, J. Acoust. Soc. Amer., 67 (6), pp 1931-1934 (June 1980) 4 figs, 12 refs

Key Words: Pipes (tubes), Ducts, Sound propagation

Experimental results are presented which show a mode selective transfer of energy from sound propagating inside a circular pipe to pipe wall vibration. The experiments utilize broadband noise generated by flow through a restriction in the plastic (PVC) pipe. For each higher acoustic duct mode, the energy transfer occurs in a narrow frequency band located slightly above the higher-mode cut-on frequency. A match in axial phase velocity between the higher acoustic duct mode and a compatible pipe wall vibrational mode is proposed as the mechanism for the energy transfer. Theoretical predictions for the frequency at which the axial phase velocity match occurs show good agreement with the experimental results.

80-2292

Axisymmetric Buckling of Buried Pipelines by Seismic Excitation

L.H.N. Lee, T. Airman, and C.C. Chen

Solid Mechanics Group, Notre Dame Univ., IN, Rept. No. UND-ERADUPS-TR-5; NSF/RA-790356, 25 pp (Dec 1979)
PB80-151954

Key Words: Pipelines, Underground structures, Dynamic buckling, Seismic excitation

A quasi-bifurcation theory of dynamic buckling and a simple flow theory of plasticity are employed to analyze the axisymmetric, elastic-plastic buckling behavior of buried pipelines subject to seismic excitations. Using the seismic records of the 1971 San Fernando earthquake, a series of numerical results have been obtained, which show that, at strain rates prevalent in earthquakes, the dynamic buckling axial stress or strain of a buried pipe is only slightly higher than that of static buckling.

80-2293

Finite Element Analysis of Pipe Elbows

M.S. Marcus and G.C. Everstine

Computation Mathematics/Logistics Dept., David W. Taylor Naval Ship Research and Development Center, Bethesda, MD, Rept. No. DTNSRDC/CMLD-79/15, 96 pp (Feb 1980)
AD-A081 077/0

Key Words: Pipes (tubes), Computer programs, Finite element technique

NASTRAN analyses were performed with three different finite element models on a 90-degree pipe elbow to determine principal stresses due to internal pressure, inplane bending, out-of-plane bending, and torsion moment loadings. Comparison with stresses experimentally obtained under the four loading conditions demonstrates the adequacy of a finite element model with ideal geometry assumptions and an economical mesh spacing. Implementation of the NASTRAN modeling is described in detail.

DUCTS

80-2294
Acoustic Propagation in Rigid Sharp Bends and Branches
M. El-Raheb and P. Wagner
Jet Propulsion Lab., Applied Mechanics, California Inst. of Tech., Pasadena, CA, J. Acoust. Soc. Amer., 67 (6), pp 1914-1923 (June 1980) 10 figs, 5 tables, 7 refs

Key Words: Ducts, Sound propagation, Noise reduction, Branches systems

The linear acoustic propagation in rigid planar sharp bends and bifurcation ducts is analyzed using a Green's-function integral technique often known as the surface element method. The acoustic characteristics of the sharp bend differ substantially from those of a circular bend with identical turning angle, width, and centerline length. The acoustic loading resulting from a duct bifurcation is highly two dimensional beyond the first cutoff frequency.

BUILDING COMPONENTS

80-2295
Earthquake Resistant Structural Walls. Tests of Isolated Walls. Phase II
R.G. Oesterle, J.D. Aristizabal-Ochoa, A.E. Fiorato, H.G. Russell, and W.G. Corley
Construction Tech. Labs., Portland Cement Assoc., Skokie, IL, Rept. No. PCA-R/D-SER-1629, 335 pp (Oct 1979)
PB80-132418

Key Words: Buildings, Walls, Seismic design, Dynamic tests

Behavior of structural walls for use in earthquake resistant buildings is studied. Included is a presentation of results from sixteen tests on isolated walls. The tests were conducted in an attempt to develop design criteria for reinforced concrete structural walls in earthquake resistant buildings. The objective is to determine ductility, energy dissipation capacity, and strength of a wide variety of walls. Isolated walls representing those found in structural wall systems were tested. Controlled variables included shape of the wall cross-section, amount of main flexural reinforcement, amount of hoop reinforcement around the main flexural reinforcement, amount of horizontal shear reinforcement, axial compressive load, concrete strength, and load history. Two walls were repaired and retested. Observations based on test results are given.

80-2296
Sound Insulation of Windows
B. Hern
Glass and Glazing Federation, Noise Vib. Control, 11 (4), pp 123-126 (Apr 1980) 10 figs

Key Words: Windows, Glass, Noise reduction

Sound insulation values of a variety of possible window glass configurations at the dominant frequencies are described. The effects of thickness, glazing, lamination and mounting are discussed.

ELECTRIC COMPONENTS

MOTORS

80-2297
Analysis of Induction Machine Dynamics During Power System Unbalances
T.H. Ortmeyer
Ph.D. Thesis, Iowa State Univ., IA, 195 pp (1980)
UM 8012980

Key Words: Induction motors, Unbalanced mass response, Skin (structural members)

The effects of power system unbalances on dynamic induction motor operation taking into account rotor bar skin effect are investigated. Two mathematical models of the induction machine are introduced. One model predicts both the electrical and motional transients while the other ignores the electrical transients and predicts only the motional transient. The developed models were used to study three important practical cases of power system imbalance: open delta motor feed, shunt, and series single phase faults on the power system. The necessity of evaluating the skin effect in the rotor representation is clearly established in each case, and the need to account for the electrical transients is evaluated.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2187, 2188, 2189, 2190, 2200, 2217, 2218, 2235, 2239, 2374, 2379)

80-2298

Oil and Petrochemical Plant Noise Control Design - The Data Crisis

J. Norrie

Noise Vib. Control, 11 (3), pp 79-82 (Mar 1980) 1 fig

Key Words: Noise generation, Industrial facilities, Noise reduction

The main features of the type of noise control design process generally followed in Western Europe today are outlined. Some of the pitfalls often found by the inexperienced are also highlighted.

80-2299

Estimation of Noise Shielding by Barriers

Engrg. Sciences Data Unit, London, UK, Rept. No. ESDU-79011, 41 pp (1979)

N80-16835

Key Words: Noise barriers, Acoustic scattering

A method is provided for estimating the shielding effect of a noise barrier in terms of the difference in sound level received at a given location on the side of the barrier remote from the noise source and the sound level received at the same location without the barrier. In the procedure used in this item for estimating the loss due to diffraction it is assumed that the noise is emitted by a point source and that both the source and observer are at large distances from the diffracting edge relative to the wavelengths of the sound considered. Also it is assumed that barriers are rigid, wedge-shaped (as described below) and have hard surfaces and sharp edges.

80-2300

Spherical Harmonic Analysis and Some Applications to Surround Sound

P.S. Gaskell

British Broadcasting Corp., Kingswood, UK, Rept. No. BBC-RD-1979/25, 19 pp (Nov 1979)

N80-16831

Key Words: Harmonic analysis, Sound transmission

Spherical harmonic analysis in three dimensions and azimuthal harmonic analysis in two dimensions are used in studying the problems associated with transmitting surround sound. Some of the fundamental factors and limitations of surround sound transmission are highlighted. A number of specific examples are presented.

80-2301

A Theoretical and Experimental Investigation of the Effects of the Interaction between an Acoustic Field and Cylindrical Structure on Sound Transmission Loss

A.C. Fagerlund

Ph.D. Thesis, Univ. of Iowa, IA, 118 pp (1979)

UM 8012365

Key Words: Sound transmission loss, Cylindrical shells, Piping systems

A theoretical and experimental investigation of the transmission of sound through the walls of a hollow cylinder is pursued by analyzing the interaction between the sound field and structural vibrations. The method used to investigate the problem is based on an energy balance between the internal acoustic field and the vibrational field of the cylinder wall. After the energy balance is established to determine the parameters to be analyzed, each parameter is then examined separately to determine its effect on the overall solution.

80-2302

A Field Investigation of Noise Barrier Performance and Wind Dependent Noise Propagation

P.M. Nelson and P.G. Abbott

Transport and Road Research Lab., Crowthorne, UK, Rept. No. TRRL-SUPPLEMENTARY-338, 36 pp (1978)

PB80-151715

Key Words: Traffic noise, Noise reduction, Noise barriers

This report gives the results of measurements made of the acoustic performance of a noise barrier erected alongside the M40 at a point where the motor passes to within 150 meters of a residential estate.

80-2303

Scattering of Elastic Waves by an Elastic Sphere

D.L. Jain and R.P. Kanwal
Dept. of Mathematics, Delhi Univ., Delhi 110007, India, Intl. J. Engr. Sci., 18 (6), pp 829-839 (1980) 1 fig, 3 refs

Key Words: Elastic waves, Compression waves, Wave diffraction, Discontinuity-containing media

The problem of scattering of plane compressional wave by an elastic sphere embedded in an isotropic elastic medium of different material properties is solved. Approximate formulas are derived for the displacement field, stress tensor, stress intensity factors, far-field amplitudes and the scattering cross section. It is assumed that the wave length is large compared to the radius of the scatter. Various elastostatic limits are also presented.

80-2304

The Project Methods of the Sound Absorption in Pile Carpet Coverings

S. Simaitis
Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 51-58 (1977) 2 figs, 6 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Floor coverings, Acoustic absorption, Noise reduction

To obtain the necessary sound absorption with floor coverings, a procedure for the selection and calculation of structural parameters of various types of one-layer and two-layer carpets is described.

SHOCK EXCITATION

(Also see Nos. 2197, 2198, 2199, 2274, 2292, 2311, 2372)

80-2305

Normal and Shear Impact of Layered Composite with a Crack: Dynamic Stress Intensification

G.C. Sih and E.P. Chen
Inst. of Fracture and Solid Mechanics, Lehigh Univ., Bethlehem, PA, J. Appl. Mech., Trans. ASME, 47 (2), pp 351-358 (June 1980) 13 figs, 10 refs

Key Words: Composite materials, Cracked media, Discontinuity-containing media, Layered materials, Impact response (mechanical)

The dynamic response of a layered composite under normal and shear impact is analyzed by assuming that the composite contains an initial flaw in the matrix material. The analysis method utilizes Fourier transform for the space variable and Laplace transform for the time variable. The time inversion is carried out numerically for various combinations of the material properties of the composite and the results are displayed graphically.

80-2306

On the Pulsation of a Normal Shock Wave Contained in an Aerodynamic Inlet (Pulsation d'un Choc Droit en Aerodynamique Interne)

A. Agnes, E. Brocher, and H. Miton
Institut de Mecanique des Fluides de Marseille, France, Rept. No. AAAF-NT-79-17, 21 pp (1979)
N80-18006
(In French)

Key Words: Shock wave propagation, Nozzles

The response of a normal shock wave, located in a nozzle to down stream pressure perturbation was determined. The system for generating pulsations is described. Initial results are presented showing the two frequencies at which the shock wave oscillations are particularly intense. The computation method for the shock wave oscillation amplitude is also discussed.

80-2307

The Calculation of Shock Interaction of the Surfaces in Contact

P. Lebedev, V. Rodin, and S. Urushev
Leningradskii institute inzheverov zhelesnodorozhnogo transporta im. akademika V.N. Obraztsova, USSR, Vibrotechnika, 3 (27), pp 123-130 (1977), 4 figs, 1 table, 4 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Shock response, Magnetic properties

The shock interaction model of reeds of magnetic contacts is discussed. It is assumed that the characters of contact surfaces have probable distributions. The magnetic contacts are considered to be vibroshock mechanisms. A mathematical model for the calculation of shock process when working magnetic contacts during the interaction is presented.

80-2308

Dynamic Stress-Strain Measurements on Misers Bluff

R.A. Shunk

Electromechanical Systems of New Mexico Inc., Alburquerque, NM, Rept. No. ESI-79-002-TR, 37 pp (May 1979)

AD-A079 308/3

Key Words: Explosion effects, Ground shock

MISERS BLUFF, Phase II, Test 2 was the near simultaneous explosion of six 120 ton ANFO charges on the corner of a hexagon 100 m on a side. Soil stress and strain measurements at several depths were made 6 mm from the array center and between two charges. During the compressive loading by the air blast, dynamic stress-strain curves were plotted where data are available. Comparing the two loctions shows different material behavior.

80-2309

Seismic Behavior of Structural Subassemblages

E.P. Popov

Dept. of Civil Engrg., Univ. of California, Berkeley, CA, ASCE J. Struc. Div., 106 (ST7), pp 1451-1474 (July 1980) 24 figs, 38 refs

Key Words: Seismic response, Cyclic loading, Steel, Reinforced concrete

The behavior of both structural steel and reinforced concrete specimens subjected to quasi-static cyclic loadings simulating severe seismic effects are examined. A large number of experimentally determined hysteretic loops for different structural arrangements serve as illustrations. The important distinction among the material, the member and the subassemblage ductilities is emphasized. The significance of the different character of the hysteretic behavior on the overall seismic structural performance is discussed by relating it to the widely-used response spectrum approach for seismic analysis. The relationship of the latter approach to the conventional code design procedures is also given.

80-2310

Dynamic Seismic Analysis: Economic Considerations

C.K. McDonald

McDonald Engrg. Analysis Co., Inc., Birmingham, AL, ASCE J. Struc. Div., 106 (ST7), pp 1531-1541 (July 1980) 8 figs, 2 tables, 3 refs

Key Words: Seismic analysis

The performance of dynamic seismic analysis from an economic viewpoint is presented. Dynamic models are discussed and several illustrations of economically developed models are presented. Economic considerations in selecting a computer code are also discussed.

VIBRATION EXCITATION

(Also see No. 2352)

80-2311

Vertical Vibrations of a Rigid Circular Body on a Non-Homogeneous Half-Space Interrupted by a Frictionless Plane

A.O. Awaojobi

Dept. of Mech. Engrg., Univ. of Lagos, Nigeria, Intl. J. Numer. Anal. Methods Geomech., 4 (2), pp 159-174 (Apr/June 1980) 2 figs, 3 refs

Key Words: Harmonic response, Circular bars, Elastic properties, Seismic excitation, Half-space

An exact formulation for the problem of a rigid circular body performing harmonic vibrations on an elastic half-space whose shear modulus increases linearly with depth and is interrupted at some finite depth by a frictionless horizontal plane is presented. The static case is derived in the limit of zero frequency vibrations while the known result for the uninterrupted half-space is recovered in either extreme limit of the horizontal frictionless plane coinciding with the surface, or when it is pushed down to an infinite depth.

80-2312

Measurement, Calculation and Analysis of Vibrations. Part 1: Basics of Mathematical and Experimental Modal Analysis (Messung, Berechnung und Analyse von Schwingungen. Teil 1: Grundlagen der rechnerischen und experimentellen Modalanalyse)

R.-D. Müller

Lehrstuhl und Institut f. Werkzeugnaschinen und Betriebswissenschaften, Technische Universitat Munchen, Munchen, Germany, VDI Z., 122 (8), pp 325-330 (1980) 10 figs, 3 refs
(In German)

Key Words: Modal analysis, Natural frequencies, Multidegree of freedom systems

An introduction to the determination of natural frequencies of multidegree of freedom systems by means of modal analysis is presented.

80-2313

Measurement, Calculation and Analysis of Vibrations. Part 2: Basic Measuring Techniques and Digital Signal Processing (Messung, Berechnung und Analyse von Schwingungen, Teil 2: Messtechnische Grundlagen und digitale Signalverarbeitung)

R.-D. Müller
Lehrstuhl und Institut f. Werkzeugnaschinen und Betriebseissenschaften, Technische Universitat Munchen, Munchen, Germany, VDI Z., 122 (9), pp 365-368 (1980) 12 figs
(In German)

Key Words: Frequency analyzers, Vibration measurement

Experimental modal analysis of mechanical systems using digital Fourier analyzers are discussed.

80-2314

Identification of Vibrational Behavior Models of Complex Structures

H. Berger and J.-P. Chaquin
Office National d'Etudes et de Recherches Aerospatiales, Paris, France, Rept. No. ESA-TT-612 (Jan 1980) (English transl. from La Rech. Aerospatiales Bimonthly Bull. No. 1979-4, pp 85-88, July-Aug 1979)
N80-22254

Key Words: Error analysis, Stiffness coefficients, Finite element technique

A method for minimizing the errors between theoretical and analytical results in the investigation of structural vibrations is proposed. Finite element technique is used in the analysis, and it is assumed that the structure is linear and that the stiffness was erroneously estimated.

80-2315

Dynamic Damping Investigations of Composites

H. Georgi
Inst. fuer Bauweisen- und Konstruktionsforschung, Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart, West Germany, In AGARD Damping Effects in Aerospace Struct., 20 pp (Oct 1979)
N80-19581

Key Words: Composite materials, Fiber composites, Natural frequencies, Lateral vibration, Vibration damping

Characteristic regularities and data from a series of damping measurements on fiber reinforced composite materials and structures are presented. Experiments were carried out mainly on natural frequencies of lateral vibrations in free decay and forced excitation. Tests included composite materials with reinforcement by boron, carbon, glass, and synthetic fibers; structural components, sandwich and I-beams; and composite structures such as rotor blades. Experimental parameters considered were amplitude, temperature, vibration mode, frequency, air pressure, aspect ratio, and fiber orientation. Dynamic response properties of several composites were compared. Numerical extrapolations of the damping behavior of beams differing from experimental configurations in fiber orientation, air pressure, etc. are discussed.

80-2316

Dynamic Behavior of a Mechanical System of Which a Part Performs a Prescribed Relative Motion

P.J. Oosterloo
Delft Univ. of Tech., Mekelweg 2, Delft, The Netherlands, Computers Struc., 11 (4), pp 271-278 (Apr 1980) 9 figs, 7 refs

Key Words: Interaction: wheel-pavement, Coupled response, Moving loads, Dynamic response, Finite element technique

A method is presented to solve by means of a finite element analysis the problem of the dynamic behavior of a mechanical system, a part of which performs a prescribed relative motion. The kinematic coupling of this part to the rest of the system and the derivation of the matrix equations of motion are discussed, as well as the applied condensation method. Moreover the results of a computation based on this method are compared to those obtained by neglecting the dynamic interactions of both the parts of such a mechanical system.

80-2317

Analysis of Trunk Flutter in an Air Cushion Landing System

A.B. Boghani and R.B. Fish

Foster-Miller Assoc. Inc., Waltham, MA, Rept. No. WP-7819, 113 pp (Aug 1979)

AD-A079 008/9

Key Words: Air cushion landing systems, Flutter

This report deals with explaining the occurrence of flutter in the Air Cushion Landing System (ACLS) trunks and suggesting means of suppressing it. Suggestions on solving the flutter problem are based on either modifying the trunk or modifying the flow.

80-2318

Algorithms for Decoupling Vibratory Modes (Algorithmes de Decouplage Modes Vibratoires)

Garcin

Centre Technique des Industries Mechaniques, Senlis, France, Rept. No. CETIM-1-1E-24-1, 81 pp (Feb 1979)

N80-17788

(In French)

Key Words: Normal modes, Mode shapes, Coupled response

An algorithmic study of the decoupling of vibratory modes on a SAVIEM test rig is presented. Inconclusive results from the study are examined including a lack of accuracy in frequency measurement at the experimental stage, an insufficient number of measurement points, a highly nonlinear response to amplitude variations at the test rig, and the lack of an acceptable data smoothing procedure.

80-2319

Transformation of Vibratory Motion into Rotation or Translation Line by Means of Unbalanced Mass

[illegible] and A. Slavėnas

[illegible] Polytechnic Institute, Kaunas, [illegible] 3 (27), pp 149-155 (1977) [illegible] Polytechnic Insti- [illegible]

well as the existence and stability conditions of motion, are determined.

80-2320

The Problems of Non-Linear Element Study in Vibro-Insulation Platform by Means of Statistical Methods

V. Katinas, M. Medžiaušienė, K.-R. Petrauskas, Z. Pocius, and B. Rinkevičius

Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 83-87 (1977) 2 figs, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Vibration isolation, Plates, Statistical linearization, Harmonic analysis

A statistical and harmonic linearization for the study of nonlinear elements in vibroinsulation platform is described.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 2230, 2236, 2254, 2277, 2278, 2315, 2363, 2364, 2371)

80-2321

Critical Damping in Linear Discrete Dynamic Systems

D.E. Beskos and B.A. Boley

Technological Inst., Northwestern Univ., Evanston, IL, Rept. No. TR-1979-2, 23 pp (Nov 1979)

AD-A081 085/3

Key Words: Viscous damping, Linear systems, Critical damping

Free viscously damped vibrations of linear discrete structural systems are studied. The amount of damping varies among the various structural elements of the system resulting in several critical damping possibilities. A general method is developed for determining the critical damping surfaces of a system. Three examples presented in detail illustrate the [illegible] technique and some of the important characteris- [illegible]

80-2322

Apparatus for Damping Operator Induced Oscillations of a Controlled System

J.W. Edwards and J.W. Smith
Hugh L. Dryden Flight Research Center, NASA, Edwards, CA, US-Patent-Appl-SN-126064, 24 pp (Feb 1980)
N80-20488

Key Words: Vibration damping, Active damping, Control equipment, Aircraft, Spacecraft

The invention relates to an adaptive filter for suppressing operator induced oscillations of a control system such as a pilot controlled aircraft or spacecraft. The novelty of the invention is in the filter arrangements which effectively estimate frequency and amplitude to produce a signal that will provide damping without rate limiting.

80-2323

Viscoelastic Damping in USAF Applications

D.I.G. Jones, J.P. Henderson, and L.C. Rogers
Air Force Materials Lab., Wright-Patterson AFB, OH, In AGARD Damping Effects in Aerospace Struct., 24 pp (Oct 1979)
N80-19582

Key Words: Viscoelastic damping

The use of viscoelastic damping technology for vibration control in the United States Air Force is reviewed. The potential payoff in improved performance and maintainability of vibration critical sytems such as large flexible spacecraft structures, digital electronics systems, and rotating jet engine components is very high.

80-2324

Report on the Use of Abatement Techniques for Problems Related to Vibrations and Noise (Bilan sur la Mise en Oeuvre de Techniques d'Amortissement pour des Problemes Lies aux Vibrations et Bruit)

B. Duperray and L. Gaudroit
Societe METRAVIB., Ecully, France, In AGARD Damping Effects in Aerospace Struct., 9 pp (Oct 1979)
N80-19583
(In French)

Key Words: Vibration control, Noise reduction, Viscoelastic damping

The 10 year history of METRAVIB involvement in using viscoelastic materials to solve the vibration and noise problems encountered in the industrial, mechanical, electrical, and naval and aerospace construction sectors is reviewed. Particular attention is given to the development of models of structural dynamics, and a viscoelastimeter as well as the transfer of information to industries interested in developing new products using glass fiber reinforced composites and high temperature materials such as glasses and ceramics. Specific applications are cited to demonstrate the effectiveness of the techniques used.

80-2325

The Damping of the Main and Higher Amplitudes in a System with Limited Excitation by an Experimental Method

K. Ragulskis, E. Slavickas, G. Ulinskaitė, and B. Jančiukas
Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 131-135 (1977) 8 figs, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Damping, Vibration damping

Two dynamic dampers are connected to the system with limited excitation comprising a rod with rigidly fixed electric motor for reducing the main and the third harmonics. Amplitude-frequency and spectral analysis indicate that the damping of the main and the higher amplitudes are independent.

80-2326

The Vibration Damping of a Vibro-Shock System by Means of a Dynamic Damper

K. Ragulskis and G. Ulinskaitė
Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 137-141 (1977) 1 fig, 2 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Vibration control, Damping, Harmonic analysis

The reduction of the resonant vibration of a vibro-shock system by means of a linear dynamic damper is illustrated. The results are confirmed by means of harmonic linearization method.

80-2327

The Peculiarities of Antivibratory and Damping Properties of Connecting Devices on the Basis of Centrifugal Bonds

G. Jesin, G. Kaliagin, and S. Maslenikov

Chelyabinskii polytekhnicheskii institut im. Leninskogo, Komsomola, USSR, Vibrotechnika, 3 (27), pp 43-50 (1977) 5 figs, 3 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Damping, Joints (junctions)

The calculation and experimental investigations of systems with centrifugal bonds are presented. It is shown that the nonlinearity of characteristics, high degree pliability, and damping properties of the centrifugal bonds permit the adjustment of power systems against resonance conditions and compensate considerable eccentricity between the units coupled.

80-2328

The Investigation of Vibro-Damper with Pneumatic Damping

I. Filopov

Leningradskii ordena V.I. Lenina politekhnicheskii institut im. M.I. Kalinina, USSR, Vibrotechnika, 3 (27), pp 65-74 (1977) 4 figs, 5 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Damping, Vibration damping, Vibration isolation, Active isolation

A vibration isolator in continuous flow chambers with pneumatic damping is investigated. The dimensionless static feature is determined and the differential equations describing the dynamics of the passive as well as active vibration isolators, regulated by means of "jet shutter" with negative deflection feedback are derived. The expressions for the determination of self-excited vibration and damping are obtained, and experimental results are presented.

80-2329

The Use of a Damper with Electromechanical Feedback for the Protection of the Operator Against Vibration

J. Vasilev and A. Kniazev

Moskva Vsesoyuznii tsentralnii nauchno-issledovatelskii institut ochrani truda, Moscow, USSR, Vibrotechnika, 3 (27), pp 23-30 (1977) 1 ref, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Dampers, Active damping, Vibration damping, Human response

Damper matrix member formulas are proposed for the analysis of active vibration isolators for operator seats. The electromechanical system studied is reciprocal; that is, the matrix determinant of conversion is equal to 1.

80-2330

The Vibration of a System with Dynamic Dampers at Limited Energization

K. Ragulskis and G. Ulinskaitė

Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 75-81 (1977) 1 fig, 4 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979

(In Russian)

Key Words: Damping, Harmonic response

A system with two dynamic dampers is studied for the reduction of the first harmonic at the resonance frequency and the additional third harmonic down to the given level. The damping of the first and the third harmonics was found to be an independent problem. The number of dampers required must be equal to the number of harmonics being damped.

FATIGUE

(Also see Nos. 2192, 2209, 2233, 2255, 2260, 2261, 2277, 2359)

80-2331

Fatigue under Wide Band Random Stresses

P.H. Wirsching

Aerospace and Mechanical Engrg., Univ. of Arizona, Tucson, AZ, ASCE J. Struc. Div., 106 (ST7), pp 1593-1607 (July 1980) 7 figs, 3 tables, 16 refs

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

A method for predicting high cycle fatigue under stationary gaussian wide band stress processes is developed. The rainflow cycle counting method is used as the basis for predicting fatigue damage. Stress simulations from various spectral density models were analyzed using the rainflow method. Statistical analysis of these results provided a closed form expression for fatigue damage. A principal application of the method is to predict fatigue in the welded joints of offshore structures, an example of which is provided. A long term nonstationary sea state is modeled as a sequence of stationary sea states.

80-2332

Effects of Moisture Changes on Flexural and Fatigue Strength of Concrete

J.W. Galloway, H.M. Harding, and K.D. Raithby
Transport and Road Research Lab., Crowthorne, UK, Rept. No. TRRL-LR-864, 36 pp (1979)
PB80-127541

Key Words: Concretes, Pavements, Fatigue life

Results are given of flexural strength and fatigue tests on small unreinforced beams of pavement quality concrete to study the effects of various moisture conditions. Subsidiary tests included dynamic modulus of elasticity and equivalent cube crushing tests on the fractured specimens.

80-2333

Probability of Failure Prediction for Step-Stress Fatigue under Sine or Random Stress

R.G. Lambert
Aircraft Equipment Div., General Electric Co., Utica, NY, In Shock and Vibration Information Center, Shock Vib. Bull., Pt. 1, pp 31-41 (Sept 1979)
N80-16200

Key Words: Fatigue life, Failure analysis

A previously proposed cumulative fatigue damage law is extended to predict the probability of failure or fatigue life for structural materials with S-N fatigue curves represented as a scatterband of failure points. The proposed law applies to structures subjected to sinusoidal or random stresses and includes the effect of initial crack (flaw) sizes. The corrected cycle ratio damage function is shown to have physical significance.

80-2334

Action of Plastic Deformations in the Mechanical Damage Suffered by the Surface of Structures

W. Barrois
French Air Force, Vanves, France, Rept. No. ICAF-1114, 19 pp (1979)
N80-18435

Key Words: Fatigue life, Machinery components

The essential features of fatigue behavior of metal structures are reviewed. The role of plastic deformation and fatigue crack propagation on the fatigue of notched parts, as well as other modes of damage of machinery parts is described.

80-2335

A Reinterpretation of the Palmgren-Miner Rule for Fatigue Life Prediction

Z. Hashin
Dept. of Solid Mechanics, Materials and Structures, Tel Aviv Univ., Tel Aviv, Israel, J. Appl. Mech., Trans. ASME, 47 (2), pp 324-328 (June 1980) 6 figs, 4 refs

Key Words: Fatigue life, Cyclic loading

The simple Palmgren-Miner linear cumulative damage rule is shown to be a special case of a previously established general cumulative damage theory. Predictions of lifetimes for families of multistage loadings according to the Palmgren-Miner rule and the general cumulative damage theory are compared to obtain qualitative guidelines for applicability of the Palmgren-Miner rule in cyclic loading programs.

80-2336

A Reliability Analysis Approach to Fatigue Life Dispersion of Laminated Glass Fiber Composite Material

T. Tanimoto, S. Amijima, H. Ishikawa, K.J. Miller, and R.F. Smith
Doshisha Univ., Kyoto, Japan, Rept. No. ICAF-1127, 11 pp (1979)
N80-18437

Key Words: Fatigue life, Statistical analysis, Fiber composites, Glass, Layered materials

The statistical nature of the fatigue life of laminated glass fiber composite materials is studied using four different laminates. Unidirectional carbon fiber reinforced plastic was used for comparison. A statistical approach based on the Weibull distribution was applied to the test data to evaluate the dispersion in the fatigue life of the material. The effect of varying applied stress levels, specimen size, and glass fiber content on the fatigue life and its dispersion of the laminates is discussed.

80-2337

Repeated Plastic Deformation as a Cause of Mechanical Surface Damage in Fatigue, Wear, Fretting-Fatigue and Rolling Fatigue: A Review

W. Barrois
French Air Force, Vanves, France, Rept. No. ICAF-1116, 24 pp (1979)
N80-18436

Key Words: Fatigue life, Gears, Bearings

Statements bringing together essential features of the fatigue behavior of metal structures in service are reviewed. It is shown that the elementary phenomena of plastic deformation and fatigue crack propagation, which explain the fatigue behavior of notched parts, also play an important role in other modes of damage of machinery parts.

ELASTICITY AND PLASTICITY

(Also see No. 2351)

80-2338

Diffraction of Antiplane Shear Waves by an Edge Crack

S.F. Stone, M.L. Ghosh, and A.K. Mal
Dept. of Mechanics and Structures, Univ. of California, Los Angeles, CA 90024, J. Appl. Mech., Trans. ASME, 47 (2), pp 359-362 (June 1980) 7 figs, 6 refs

Key Words: Elastic waves, Cracked media, Discontinuity-containing media, Wave diffraction

The diffraction of time harmonic antiplane shear waves by an edge crack normal to the free surface of a homogeneous half space is considered. The problem is formulated in terms of a singular integral equation with the unknown crack opening displacement as the density function. A numerical scheme is utilized to solve the integral equation at any given finite frequency. Asymptotic solutions valid at low and high frequencies are obtained. The accuracy of the numerical solution at high frequencies and of the high frequency asymptotic solution at intermediate frequencies are examined. Graphical results are presented for the crack opening displacement and the stress intensity factor as functions of frequency and the incident angle. Expressions for the far-field displacements at high and low frequencies are also presented.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see No. 2313)

80-2339

Prepolarized Condenser Microphones for Measurement Purposes

E. Frederiksen, N. Eirby, and H. Mathiasen
Bruel & Kjaer, Denmark, Noise Vib. Control, 11 (3), pp 88-96 (Mar 1980) 18 figs

Key Words: Measuring instruments, Noise measurement

Prepolarized condenser microphones primarily intended as sound level meters are presented. This paper discusses design considerations, gives measurement results for the type of prepolarized element which has been used, describes the new microphones, and mentions applications.

80-2340

Oscilloscopes Go Digital

M. Hurley
Laboratory Instruments Div., Tektronix Inc., Beaverton, OR, Mach. Des., 52 (12), pp 96-102 (May 22, 1980)

Key Words: Oscilloscopes, Digital techniques

New types of oscilloscopes based on digital electronics are described. With these oscilloscopes the waveforms acquired can be displayed, stored, recalled, and manipulated for a variety of display purposes. In addition, the waveforms held in memory can be fed to desk top calculators on computer terminals for the calculation of such characteristics as rise time, peak energy, or frequency.

80-2341

Torsional Wave Propagation in an Infinite Piezoelectric Cylinder (622) Crystal Class

V.R. Srinivasamoorthy and C. Anandam

Dept. of Mathematics, A.C. College of Tech., Madras-600 025, India, J. Acoust. Soc. Amer., 67 (6), pp 2034-2035 (June 1980) 1 table, 4 refs

Key Words: Piezoelectric transducers, Torsional excitation, Resonant frequencies

Torsional wave motion in an infinite right circular hollow piezoelectric cylinder belonging to (622) crystal class is investigated when the cylindrical surfaces are either traction-free or subjected to relative displacement. Open and short-circuit resonant frequency equations are formulated. Fundamental resonant frequency curves are given for traction-free cylinders. The theory is applied to the vibrations of annular accelerometers.

80-2342

Real Time Analyzers - Practical Guide

B. Gracey

Noise Consultants & Instrument Engineers, Noise Vib. Control, 11 (4), pp 127-132 (Apr 1980) 11 figs

Key Words: Spectrum analyzers, Real time spectrum analyzers

The capabilities and operations of narrow band spectrum analyzers and third octave real time analyzers are discussed in detail.

80-2343

Widening the Scope of FFT Analysis

C. Thomsen and R. Upton

Bruel & Kjaer, Naerum, Denmark, Noise Vib. Control, 11 (4), pp 135-138 (Apr 1980) 5 figs

Key Words: Spectrum analyzers, Fast Fourier Transform

The new High Resolution Signal Analyzer is described whose memory stores 10,240 time function samples: 10 times more than the usual 1,024. This results in a new and truly useful zoom function, enhanced transient analysis capabilities using the 'Scan' function, alias-free tracking analysis over a 15:1 speed range, and numerous other advantages.

80-2344

Studies on Dynamic Measurement Method of Mass and Weight (Part 1) Dynamic Weighing Method - A

T. Ono, K. Kameoka, and K. Nakajima

College of Engrg., Univ. of Osaka Prefecture, Sakai, Japan, Bull. JSME, 22 (166), pp 497-503 (Apr 1979) 10 figs, 2 tables, 10 refs

Key Words: Dynamic weighing method, Vibration transducers, Displacement transducers, Computer-aided techniques

The Dynamic Weighing Method is described in which the quantity to be measured is estimated by using the transient signal from a weighing transducer. The state estimation algorithm of the Kalman filter or of the truncated second-order filter is proposed as its estimation algorithm. The feasibility of the proposed method is examined with a digital computer and compared in weighing time and accuracy with the theoretical results by the conventional method. The implementation of the proposed method by a real-time data processor is also discussed.

80-2345

Studies on Dynamic Measurement Method of Mass and Weight (Part 2) Dynamic Weighing Method - B

T. Ono, K. Kameoka, and K. Nakajima

College of Engrg., Univ. of Osaka, Prefecture, Sakai, Japan, Bull. JSME, 23 (117), pp 439-445 (Mar 1980) 8 figs, 1 table, 3 refs

Key Words: Dynamic weighing method, Vibration transducers, Displacement transducers, Computer-aided techniques

A simple estimation algorithm of mass and weight for use on a nonlinear dynamic weighing device is described. It is obtained from a deterministic version of weighing dynamics. The accuracy of the algorithm is compared to the actual data obtained by means of a displacement and/or a velocity pick-up attached to the weighing device. The results obtained by means of the velocity pick-up were more accurate than with the displacement pick-up. Real-time data processing on a minicomputer using velocity pick-up is also discussed.

80-2346

The Measuring of Vibration of Rotating Cylindrical Members by Means of Laser

A. Iliankov and M. Levit

Moskovskii ordena Lenina aviatsiannii institut im. C. Ordzhonikidze, Moscow, USSR, Vibrotechnika, 3 (27), pp 7-12 (1977) 4 figs, 6 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Vibration measurement, Lasers, Measuring instruments, Displacement transducers

Vibration measurement of cylindrical members by means of laser beam are discussed. The influence of surface curvature on weakening of light stream registered by photo senser is shown. The device variants for determining the amplitude of cylindrical member vibration are suggested.

80-2347

The Balancing of Turbine Generator Rotors by Means of Laser Beams

A. Iliankov and M. Levit

Moskovskii ordena Lenina aviatsiannii institut im. C. Ordzho-nikidze, Moscow, USSR, Vibrotechnika, 3 (27), pp 13-17 (1977) 2 figs, 8 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Turbine engines, Rotors (machine elements), Shafts (machine elements), Balancing techniques, Displacement transducers

The interrelation diagram of laser beam with the surfaces of moving objects is discussed. The formula for the determination of absolute displacement of the rotating unbalanced and elastic rotor shaft surface is presented. The generating lines of this displacement are discussed and analyzed, as well as, the isolation possibilities of pure deflection from the absolute displacement. The measuring diagram of the pure deflection is presented.

DYNAMIC TESTS

(Also see Nos. 2360, 2377)

80-2348

Acoustic Emission: Who Needs It and Why?

J.C. Spanner

Materials Engrg. Dept., Hanford Engrg. Development Lab., Richland, WA, Rept. No. HEDL-SA-1808-FP, 27 pp (May 1979)
N80-20605

Key Words: Acoustic emission, Nondestructive tests

The growing industrial interest in acoustic emission is examined. Some of the inherent limitations of conventional nondestructive test methods are discussed, and several surveys of defects found during the manufacture and operation of pressure boundary components are reviewed. Acoustic emission offers potential for providing increased assurance of both initial and continued structural integrity.

80-2349

Unique Environmental Test Facilities at Wright-Patterson Air Force Base

R.W. Scott

Wright-Patterson Air Force Base, OH, J. Environ. Sci., 23 (2), pp 13-17 (Mar/Apr 1980) 8 figs, 3 tables, 6 refs

Key Words: Test facilities

A cross section of the unique environmental test facilities at WPAFB is briefly discussed. The facilities discussed are: The Vibration and Aeroelasticity Facility, Dynamic Analyzer Facility, Dynamic Environmental Simulator, Large Amplitude Multimode Aerospace Research Simulator, Six Mode Vibration Research Facility, and Vertical Acceleration Facility.

80-2350

The Vibro-Protection of Platforms for Testing Sensitive Members of a System of Inertial Navigation

V. Katinas, A. Kurlavičius, and Z. Pocius

Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuania, Vibrotechnika, 3 (27), pp 19-22 (1977) 2 figs, 3 refs, Kaunas A. Sniečkus Polytechnic Institute, Kaunas, Lithuanian SSR, 1979
(In Russian)

Key Words: Vibration control, Foundations, Test facilities, Instrumentation response

A vibro-protective system for the stabilization of platforms used for testing of sensitive gyroscopic devices is developed. Optimal characteristics of the control system are estimated and a recurrence formula for use with digital computers is derived. The changes with time of the optimal transmission coefficient of the corrected member is illustrated graphically.

80-2351

Identification of the Elastic Constants for Composites Using Modal Analysis

T.G. Carne and J.A. Wolf, Jr.

Applied Mechanics Div., Sandia Labs., Alburquerque, NM, Rept. No. SAND-79-0527, 14 pp (Aug 1979) N80-21457

Key Words: Composite materials, Elastic properties, Vibratory techniques, Testing techniques, Modal analysis

A procedure is described for determining the elastic constants of isotropic materials based on an impact vibration test of freely supported panels. An attractive alternative to currently used techniques because of ease and speed with which the determinations can be made, this procedure is particularly applicable to fiber-reinforced composites, since the calculations yield average elastic constants rather than those of a small localized specimen of the material. As an overall test of the accuracy of the procedure, panels of known metallic materials are evaluated, and the values of their elastic constants are reproduced to within 3 percent of their reference values.

SCALING AND MODELING

80-2352

Developing, Mechanizing and Testing of a Digital Active Flutter Suppression System for a Modified B-52 Wind-Tunnel Model

J.R. Mathew

Boeing Co., Wichita, KS, Rept. No. D3-1168-1; NASA-CR-159155, 129 pp (Mar 1980) N80-19566

Key Words: Flutter, Active control, Wind tunnel tests, Test models

A digital flutter suppression system was developed and mechanized for a significantly modified version of the 1/30-scale B-52E aeroelastic wind tunnel model. The hardware and software required to implement the flutter suppression system were designed and mechanized using digital computers in a fail-operate configuration. The model equipped with the system was tested in the Transonic Dynamics Tunnel at NASA Langley Research Center.

DIAGNOSTICS

80-2353

SLAM the Door on Material Failure from Internal Flaws

D.E. Yuhas and L.W. Kessler

Sonoscan Inc., Bensenville, IL, Indus. Res. Dev., 22 (7), pp 108-112 (July 1980) 6 figs

Key Words: Diagnostic instrumentation, Failure analysis, Lasers

Various applications of the scanning laser acoustic microscope (SLAM) as an effective tool for the control of quality in manufactured products are described, particularly for the detection of internal flaws that cannot be found or characterized by other techniques.

80-2354

Pressure Transducers Take Off with Microprocessor Control

R.C. Meyer

Hamilton Standard Div., United Technologies Corp., Windsor Locks, CT, Des. News, 36 (7), pp 144-145, 148, 150, 152 (Apr 7, 1980) 2 tables

Key Words: Diagnostic instrumentation, Transducers, Detectors

The vibrating-cylinder digital pressure sensor and various sensor compensation techniques, requiring a digital microcomputer, are described. In some applications, the interface with microcomputer is part of a much larger system (an engine-condition monitoring system and a supersonic fighter air inlet control), while in other systems (a high-altitude research sensor, for example), the pressure sensor is the end product and its output is all that is required.

80-2355

Let's Take a Closer Look at NDE - How Can We Use It?

D.G. Smith

Tennessee Technological Univ., Cookville, TN, Indus. Res., 22 (6), pp 154-157 (June 1980)

Key Words: Nondestructive tests, Diagnostic techniques

The development and the aims of nondestructive evaluation (NDE) are presented. The application of holographic interferometry, speckle interferometry, acoustical holography, and quantitative NDE is briefly discussed.

80-2356

The Components of an Acoustic Emission Analysis System (Komponenten fur ein System zur Schallemissionanalyse)

VDI Z. 122 (3), pp 101-102 (Feb 1980)
(In German)

Key Words: Diagnostic techniques, Acoustic emission, Monitoring techniques

The components and setting up of a system for an acoustic emission analysis are described. The system may be used in failure detection of nuclear reactors as well as in monitoring of pipelines.

80-2357

Initial Imperfection Measurements of Integrally Stringer Stiffened Cylindrical Shells

J. Singer, H. Abramovich, and R. Yaffe

Dept. of Aeronautical Engrg., Technion- Israel Inst. of Tech., Haifa, Israel, Rept. No. TAE-330, 124 pp (Dec 1978)
N80-16374

Key Words: Shells, Cylindrical shells, Failure analysis, Fourier series

The initial geometric imperfections of integrally stringer stiffened laboratory scale cylindrical shells were measured in a special scanning system. The system consists essentially of a probe, traveling along a helical path inside the shell, whose output is recorded digitally on a minicomputer. The imperfection measurements of 19 shells, employed in different test programs, are presented both in graphical form and as coefficients of Fourier series - a proposed standard representation for imperfection data.

BALANCING

(See No. 2347)

MONITORING

(Also see Nos. 2355, 2356)

80-2358

Spectrum Analysis in the Process Industry

A.J.R. Lord

Nicolet Instruments Ltd., Noise Vib. Control, 11 (3), pp 84-86 (Mar 1980) 4 figs

Key Words: Monitoring techniques, Spectrum analysis

The application of spectrum analysis in the monitoring of machinery health is described. Four case histories from the process industry are discussed where spectrum analysis and structural investigation have helped solve a major problem.

80-2359

Fatigue Measuring Gauges (FMG): A New System for Monitoring Fatigue Loads

W. Ludwig, K.F. Sahm, and E. Steinheil

Dornier-Werke G.m.b.H., Friedrichshafen, West Germany, Presented at Tenth ICAF Symp., 23 pp (May 17, 1979)
N80-18443

Key Words: Fatigue (materials), Measuring instruments, Monitoring techniques

An optical fatigue measuring gage (FMG), which provides monitoring of integral fatigue loads of individual structural units up to any given state in operational life, is described and evaluated. It is based on specially prepared, polished, and annealed metal foils which are cemented to the sites of structural units to be controlled, and which have the property of storing dynamic loads via well defined changes in surface properties due to plastic deformation. The measuring apparatus is made up of an optical measuring head and a display unit. The measuring head contains an illumination system with lenses producing a parallel beam as well as electron optical receivers. The FMG reveal information on load history of structural units for the time the foils have been attached. The various possibilities for monitoring fatigue loads are described and FMG data are correlated with fatigue failure data of materials and structural units.

80-2360

Influence of Monitoring Conditions on the Stress Wave Emission Data Recorded During Tensile Testing of a GRP

G.D. Sims and D.G. Gladman

Div. of Material Applications, National Physical Lab., Teddington, UK, Rept. No. NPL-DMA(R)5, 33 pp (June 1979)
N80-17523

Key Words: Monitoring techniques, Acoustic emission, Failure analysis, Fiber composites, Reinforced plastics, Plastics

A stress wave/acoustic emission monitoring technique was assessed for its potential in detecting failures in reinforced plastics. Repeat tensile tests were conducted using a standardized procedure for a glass fiber/epoxy laminate of low variability for several monitoring parameters such as system gain, transducer type, transducer to failure site separation distance, specimen dimensions, ringdown versus event, and total count versus count rate. Under most conditions a similar trend of emission data with increased applied stress was obtained. In some cases there was a considerable variation in the absolute count levels recorded.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see Nos. 2184, 2312, 2314, 2318)

80-2361

Partitioned Transient Analysis Procedures for Coupled-Field Problems: Stability Analysis

K.C. Park

Applied Mechanics Lab., Lockheed Palo Alto Research Lab., 3251 Hanover Street, Palo Alto, CA 94304, J. Appl. Mech., Trans. ASME, 47 (2), pp 370-376 (June 1980) 1 fig, 19 refs

Key Words: Integral equations, Transient response

A general partitioned transient analysis procedure is proposed, which is amenable to a unified stability analysis technique. The procedure embodies two existing implicit-explicit procedures and one existing implicit-implicit procedure. A new implicit-explicit procedure is discovered, as a special case of the general procedure, that allows degree-by-degree implicit or explicit selections of the solution vector and can be implemented within the framework of the implicit integration packages. A new element-by-element implicit-implicit procedure is also presented which satisfies program modularity requirements and enables the use of single-field implicit integration packages to solve coupled-field problems.

80-2362

An Extension of the Van der Pol Oscillator

J.P. Ottoy

Dept. of Applied Mathematics, Univ. of Ghent, Coupure Links 533, Ghent, Belgium, J. Intl. Control, 31 (4), pp 691-703 (Apr 1980) 4 figs, 12 refs

Key Words: Oscillators, Perturbation theory

An application of the perturbation method for the differential equation: $\ddot{x} + \omega^2 x + 2a^2x^3 = \mu(1-b^2x^2)\dot{x}$ is treated. For this equation, which is perturbed by a Van der Pol damping factor, the non-perturbed solutions are periodic and can be expressed with the elliptic functions of Jacobi. Not only excellent solution accuracy, but also an approximation of the equation of the limit-cycle is obtained.

MODELING TECHNIQUES

(Also see Nos. 2205, 2288, 2367, 2368)

80-2363

Mathematical Formulation of Damping for Structural Response Analysis

H.H. Ottens

National Aerospace Lab., Amsterdam, Netherlands, In AGARD Damping Effects in Aerospace Struct., 10 pp (Oct 1979)
N80-19573

Key Words: Mathematical models, Spacecraft, Aircraft, Damping effects

A survey of damping models that are commonly used in the structural response analysis of aerospace structures is presented. The various damping models are evaluated with respect to the required knowledge of structural damping, the mathematical complexity and the accuracy of the calculated response. The survey is limited to linear damping models and models which represent lightly damped structures are highlighted.

80-2364

Numerical Modelling of Structures to Account for Internal Damping

R.F. Baldacci, A. Corsanego, and A. DelGrosso

Istituto di Scienza delle Costruziono, Genoa Univ., Italy, In AGARD Damping Effects in Aerospace Struct., 9 pp (Oct 1979)
N80-19575

Key Words: Mathematical models, Finite element technique, Damping effects, Internal damping

Various numerical analysis techniques are examined concerning the inclusion of the structural damping effects from the point of view of representing the structural behavior by means of finite element models. The consequences of assuming some of the more popular damping models are discussed in terms of the solution algorithms. Uncoupling techniques that are only approximate when the structural models possess a nonproportional damping matrix are emphasized and criticized. Various diagonalization schemes are presented for the damping matrix and emphasis is given to the evaluation of the errors involved in the computation.

STATISTICAL METHODS

(See Nos. 2211, 2336)

PARAMETER IDENTIFICATION

(Also see Nos. 2193, 2373)

80-2365

Identification of Lumped Linear Systems in the Presence of Unknown Initial Conditions via Poisson Moment Functionals

D.C. Saha and G.P. Rao

Dept. of Electrical Engrg., Indian Inst. of Tech., Kharagpur-721302, India, Intl. J. Control, 31 (4), pp 637-644 (Apr 1980) 2 tables, 6 refs

Key Words: Parameter identification technique, Lumped parameter methods

A method of including the effect of unknown initial conditions in the general algorithms for transfer function synthesis via Poisson moment functionals is presented. The proposed technique is of considerable practical importance in problems of parameter identification in which input-output data is available on an arbitrary but active interval of time. The technique is tested with process data containing zero mean noise and is found to be remarkably immune to such noise.

80-2366

Identification and Control of a Laboratory Model Turbogenerator

M.M. Sharaf and B.W. Hogg

Dept. of Electrical Engrg. and Electronics, Univ. of Liverpool, Liverpool L69 3BX, UK, Intl. J. Control, 31 (4), pp 723-739 (Apr 1980) 7 figs, 17 refs

Key Words: System identification techniques, Turbomachinery, Computerized simulation

The application of a recursive least squares algorithm to identify a laboratory turbogenerator system is described. The algorithm was initially tested in a computer simulation, which indicated that identified low-order models can represent the small-signal dynamics of a non-linear system more accurately than the corresponding linearized analytical models. This was confirmed by laboratory tests, which clearly showed the difficulty of representing the system by analytical models, and the substantial improvement obtained by identification.

80-2367

Analytical Model Improvement Using Modal Test Results

J.C. Chen and J.A. Garba

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, AIAA J., 18 (6), pp 684-690 (June 1980) 4 figs, 5 tables, 14 refs

Key Words: Parameter identification techniques, Matrix methods, Perturbation theory

A matrix perturbation method is proposed to calculate the Jacobian matrix and to compute the new eigendata for the parameter estimation procedure. The advantages of the method are the applicability to large complex structures without knowing the analytical expressions for the mass and stiffness matrices, and a cost effective approach for the recomputation of the eigendata. This method also allows the use of other measurements such as modal forces, kinetic energy distribution, and strain energy distributions in the estimation procedure. A realistic sample problem is presented to demonstrate the effectiveness of the proposed method.

COMPUTER PROGRAMS

(Also see Nos. 2256, 2293)

80-2368

FIC: A Finite Element Code for Calculating Added Mass and Damping Coefficients: User's Manual

S.M. Batill

Argonne National Lab., Argonne, IL, Rept. No. ANL-CT-79-46, 59 pp (July 1979)
N80-17737

Key Words: Finite element technique, Computer programs, Mass coefficients, Damping coefficients

A user manual is presented for a code capable of calculating the hydrodynamic reactions on multiple interacting bodies undergoing simple harmonic motion. Input requirements are documented and the program output is described. A sample data set and program listing are also included. It should be noted that the program is not prepared for production applications but is intended for use as a research tool.

80-2369

Headseas Wave Diffraction Computer Program. User Manual

R.F. Beck

Dept. of Naval Architecture and Marine Engrg., Univ. of Michigan, Ann Arbor, MI, Rept. No. AD-A079 316/6, 108 pp (Aug 1979)

Key Words: Ships, Water waves, Wave diffraction, Computer programs

The purpose of this computer program is to compute the dynamic pressure distribution and related quantities of interest due to the diffraction of sinusoidal head waves. The method of computation is based on slender-body theory. The theoretical analysis is based on the assumption that the ship is slender. In addition, it is assumed that the incident waves are of small amplitude and their wavelength is short relative to the ship length.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

80-2370

Report on Ship Vibration Symposium 1978, Sheraton National Hotel, Arlington, VA, October 16, 17, 1978

E.S. Dillon

Ship Structure Committee, Washington, DC, Rept. No. SSC-292, 60 pp (Sept 1979)

AD-A079 291/1

Key Words: Ships, Vibration response, Proceedings

The interagency Ship Structure Committee and the Society of Naval Architects and Marine Engineers jointly sponsored this Symposium to bring together representatives of the maritime community from the United States and from abroad to discuss all aspects of ship vibration, noise, and machinery/hull incompatibility. This report covers the contents of 18 papers delivered at the Symposium together with discussions and authors' closures.

80-2371

Damping Effects in Aerospace Structures

Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine, France, Rept. No. AGARD-CP-277, 193 pp (Oct 1979)

N80-19572

(In English and French)

Key Words: Aircraft, Spacecraft, Damping effects, Proceedings

Mathematical models, vibration tests, and predictions of structural damping are discussed in terms of aerospace problems where structural damping plays a basic role. Topics addressed include numerical modeling of structures to account for internal damping, spacecraft damping considerations in structural design, damping problems in acoustic fatigue, and damping effects in joints and riveted specimens. Individual papers are abstracted in the appropriate sections of this issue of the DIGEST.

80-2372

Proceedings of the National Meeting of the Universities Council for Earthquake Engineering Research (5th) Held at Massachusetts Inst. of Tech., Cambridge, MA

Universities Council for Earthquake Engineering Research, Pasadena, CA, Rept. No. UCEER-5; NSF/RA-780633, 291 pp (June 1978)

PB80-142250

Key Words: Proceedings, Seismic design, Ground motion, Interaction: soil-structure, Earthquake response

The purpose of this meeting was to provide a vehicle for the exchange of information related to current and projected university research in earthquake engineering and to evaluate progress in specific areas of research and establish goals and priorities for future work. Ninety-five individuals gave reports. The written summaries of these reports as well as some summaries not presented orally are contained in this report. The summaries are organized under the following topics: ground motion; soils and soil structure interaction; structural elements; structural response, experimental; structural response, analytical; seismic risk, seismic design and codes.

80-2373

Parameter Identification

Advisory Group for Aerospace Research and Development, Paris, France, Rept. No. AGARD-LS-104, 353 pp (Nov 1979)
N80-19094

Key Words: Aircraft, Parameter identification techniques, Proceedings

The present state of the art of aircraft parameter identification techniques is reviewed. A critical appraisal of current methods developed and applied to the problems of analysis of flight test data in a number of NATO countries is given. Particular emphasis is placed on the practical aspects of aircraft parameter estimation to generate information useful for the flight test engineer. Individual papers are listed in the appropriate sections of this issue of the DIGEST.

TUTORIALS AND REVIEWS

80-2374

Publications in Acoustic and Noise Control from NASA Langley Research Center During 1940-1979

B.A. Fryer

Langley Research Center, NASA, Langley Station, VA, Rept. No. NASA-TM-80211, 104 pp (Jan 1980)
N80-18884

Key Words: Noise generation, Noise prediction, Ducts, Rotor blades, Sonic boom, Human response

Reference lists of approximately 900 published Langley Research Center reports in various areas of acoustics and noise control for the period 1940-1979 are presented. Specific topic areas covered include: duct acoustics; propagation and operations; rotating blade noise; jet noise; sonic boom; flow surface interaction noise; structural response/interior noise; human response; and noise prediction.

80-2375

Research and Pedagogy in Noise and Vibration Control

Inst. of Sound and Vibration Research, Southampton Univ., UK, Annual Report, 43 pp (Mar 1979)
N80-19020

Key Words: Noise reduction, Vibration control, Reviews

Research and activities for the period 1978/79 are reported. Fields covered include fluid dynamics and acoustics, automotive engineering, operational acoustics and audiology as well as structural dynamics. Work in data analysis, electronic research and development, industrial noise research and development, and in noise and vibration control is also summarized. Pedagogical activities for the year are outlined.

80-2376

Low Cost Aircraft Flutter Clearance

Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine, France, Rept. No. AGARD-CP-278, 155 pp (Sept 1979)
AD-A079 293/7

Key Words: Aircraft, Flutter

This Specialists Meeting was held to evaluate the usage of low cost aircraft flutter clearance procedures. Some results occurring from such procedures (weight efficiency, safety, flight incidents, and overall costs) were discussed relative to those from methods using advanced state-of-the-art. The relative technological-financial position of the small lightweight aircraft manufacturer was also discussed. The difficulties that still exist and the progress to be expected in the next few years were exposed.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(See No. 2197)

BIBLIOGRAPHIES

80-2377

The Definition and Adaptation of Acoustic Beams for Ultrasonic Inspection. Part 4. Bibliography (La Definition et l'Adaptation du Faisceau Acoustique en Controle Par Ultrasons)

F. Lambert and Y. Pralus

Centre Technique des Industries Mecaniques, Senlis, France, Rept. No. CETIM-1-5H-10-0-PT-4, 10 pp (May 1979)
N80-17494
(In French)

Key Words: Bibliographies, Nondestructive tests, Testing techniques, Acoustic tests

The use of focused ultrasonic acoustic beams for nondestructive parts inspection is considered. The structures of acoustic fields around transducers are analyzed theoretically. A traditional definition of the acoustic field of a phase transducer is presented. The influence of a focusing lens is then examined. Results show that two models for representing these beams are possible. One is based on a focal point concept, the other on the beam width. Agreement between the practical characterization of these beams and the theoretical models developed is good, provided that the analysis of the beam is carried out under precisely controlled conditions. How these models can be used to characterize transducers for ultrasonic inspection is shown.

80-2378

Aircraft Sonic Boom: Studies on Aircraft Flight, Aircraft Design, and Measurement (Citations from the NTIS Data Base)

G.E. Habercom, Jr.

NTIS, Springfield, VA, 206 pp (Mar 1980)

PB80-806326

Key Words: Bibliographies, Aircraft, Aircraft wings, Sonic boom

The reports discuss aerodynamic design of aircraft and wings, flight characteristics and maneuvers, supersonic transport characteristics, acoustic fields and noise measurement, Government policies and regulations, meteorological parameters, shock waves, and supersonic and hypersonic wind tunnel tests, along with other theoretical and general investigations. Structural and biological effects are documented in separate published searches.

80-2379

Nonlinear Acoustics (Citations from the NTIS Data Base)

B. Carrigan

NTIS, Springfield, VA, 510 pp (Mar 1980)

PB80-805518

Key Words: Bibliographies, Sound transmission

Studies include nonlinear acoustic theory and applications to sound transmission in the atmosphere, underwater, solids, liquids, and gases. Nonlinear relationships are included for shock tubes, sonar equipment, sonic booms, acoustic defectors, sound generators, acoustic delay lines, porous materials, pipes, ducts, and jet engine noise.

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AUTHOR INDEX

CALENDAR

OCTOBER 1980

6-8 Computational Methods in Nonlinear Structural and Solid Mechanics [George Washington University & NASA Langley Research Center] Washington, D.C. ***(Professor A.K. Noor, The George Washington University, NASA Langley Research Center, MS246, Hampton, VA 23665 - (804) 827-2897)***

14-15 Textile Engineering Technical Conference [ASME] Atlanta, GA ***(ASME Hq.)***

21-23 51st Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, D.C.] San Diego, CA ***(Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, D.C. 20375)***

27-31 ASCE Annual Convention & Exposition [ASCE] Hollywood, FL ***(ASCE Hq.)***

28-30 Eastern Design Engineering Show [ASME] New York, NY ***(ASME Hq.)***

NOVEMBER 1980

16-21 ASME Winter Annual Meeting [ASME] Chicago, IL ***(ASME Hq.)***

18-21 Acoustical Society of America, Fall Meeting [ASA] Los Angeles, CA ***(ASA Hq.)***

DECEMBER 1980

Aerospace Meeting [SAE] San Diego, CA ***(SAE Hq.)***

8-10 INTER-NOISE 80 [International Institute of Noise Control Engineering] Miami, Fl ***(INTER-NOISE 80, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603)***

9-11 Western Design Engineering Show [ASME] Anaheim, CA ***(ASME Hq.)***

MARCH 1981

8-12 26th International Gas Turbine Conference and Exhibit [ASME] Houston, TX ***(ASME Hq.)***

21-Apr 1 Lubrication Symposium [ASME] San Francisco, CA ***(ASME Hq.)***

APRIL 1981

6-8 22nd Structures, Structural Dynamics, and Materials Conference [AIAA, ASME, ASCE, AHS] Atlanta, Georgia ***(AIAA, ASME, ASCE, AHS Hqs.)***

MAY 1981

4-7 Institute of Environmental Sciences' 27th Annual Technical Meeting [IES] Los Angeles, CA ***(IES, 940 East Northwest Highway, Mt. Prospect, IL 60056)***

JUNE 1981

1-4 Design Engineering Conference and Show [ASME] Chicago, IL ***(ASME Hq.)***

8-10 NOISE-CON 81 [Institute of Noise Control Engineering and the School of Engineering, North Carolina State University] Raleigh, North Carolina ***(Dr. Larry Royster, Program Chairman, Center for Acoustical Studies, Dept. of Mechanical & Aerospace Engr. North Carolina State University, Raleigh, NC 27650)***

22-24 Applied Mechanics Conference [ASME] Boulder, CO ***(ASME Hq.)***

SEPTEMBER 1981

20-23 Design Engineering Technical Conference [ASME] Hartford, CT ***(ASME Hq.)***

OCTOBER 1981

Eastern Design Engineering Show [ASME] New York, NY ***(ASME Hq.)***

4-7 International Lubrication Conference [ASME - ASLE] New Orleans, LA ***(ASME Hq.)***

NOVEMBER 1981

15-20 ASME Winter Annual Meeting [ASME] Washington, D.C. ***(ASME Hq.)***

30-Dec 4 Acoustical Society of America, Fall Meeting [ASA] Miami Beach, Florida ***(ASA Hq.)***

DECEMBER 1981

8-10 Western Design Engineering Show [ASME] Anaheim, CA ***(ASME Hq.)***

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