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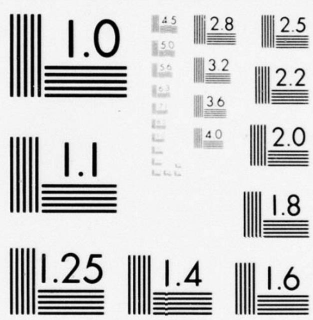

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SVIC NOTES

As I once again take my turn in this column, I can't resist returning to one of my favorite topics. Technical meetings, conferences, symposia, workshops, or gatherings of this type by any other name have been the subject of considerable debate about their merit. On the negative side, it is argued that scientists and engineers spend entirely too much time at such meetings. Why would they not derive equal benefit by simply buying and reading the proceedings? Some detractors claim that the added costs for travel and subsistence, plus the burden of the loss of productive work time, are greater than the return realized from conference participation. Furthermore, there are so many meetings that it becomes next to impossible to select those that are sure to enhance organizational research and development objectives. These are all valid points, but they are arguments more for an objective selection process than they are against meetings.

Attendance statistics at technical meetings have been on a general downward trend for the last several years. This may be due in part to an increase in the number of meetings on the calendar, but it is probably because of the severe travel restrictions sometimes laid down by many research and development managers. Careful scrutiny of conference activities is not only justifiable, but desirable. Broad policies which prohibit conference travel except possibly for the presentation of a paper are, in my opinion, rather short-sighted. A manager with such views runs a risk of infecting his researchers with a severe case of "tunnel vision." Ultimately, some limiting effect on their competitive capabilities in the research and development arena may be expected.

This brings me to some of the points in favor of carefully-planned participation in technical meetings. In the first place, one cannot interrogate a set of proceedings. The interchanges that take place during discussion periods can be extremely valuable, both for those who participate and for those who listen. Furthermore, the informal contacts and discussions provide significant benefits beyond those realized from the formal program. The technical presentations provide an ideal back-drop for the effective transfer of information and technology through the conversations in the corridors, the hotels, and the bars.

How then should management decisions related to technical meetings be made? I offer the following suggestions as a framework for organizational policy in this area.

- Restrict employees to one, but no more than two conferences per year, except in rare circumstances.
- Select the conference(s) based primarily on immediate direct benefit to current work, but secondarily on its possibilities for broadening technical capabilities in line with organizational objectives.
- Encourage active participation either by the presentation of a paper, or in the discussion periods. For technical society meetings, encourage participation in technical committee activities. Emphasize the benefits of informal contacts and discussions.
- Where possible, arrange for a debriefing and critique after the meeting. This can benefit fellow employees and provide a basis for decision on future participation in a given conference series.

H.C.P.

EDITORS RATTLE SPACE

VIBRATION IN ENGINEERING EDUCATION

As an educationalist responsible for two undergraduate degree programmes in Aeronautical Engineering and Design and Automotive Engineering and Design, I am interested in the degree programmes offered to all engineering undergraduates and the extent to which these programmes cover specific fundamental and applied topics. As a vibration-oriented engineer I am particularly interested in the extent to which such courses cover vibration theory and practice.

If we agree (do we?) that this is a fit subject for inclusion in undergraduate engineering degree courses what is the extent to which we should go in drafting such courses. Should vibration appear as a compulsory or optional subject? Should it be offered in each year of the course? What proportion of the teaching time available should be devoted to this subject? Do certain engineering disciplines place more emphasis on dynamic problems (including vibration) than others. Is it true that civil engineering courses are traditionally 'static'?

I would welcome feedback from readers with either academic or industrial affiliations to such general questions and to more specific ones such as:

How many hours in total in a first degree course should be devoted to vibration theory and applications?

Would you please send me details of syllabus content (showing also the hours involved) of vibration topics in degree courses of which you are currently aware?

Is there a need for first degree courses specifically designed to cover vibration as a principal discipline in its own right -- just as we have degrees in say Mechanical Engineering or Civil Engineering?

Based on the replies received to this Editorial I will prepare a summary and submit it to the Editor and I am sure this will be of interest to many readers. Our own personal experiences as students, University teachers, industrially-based engineers can be drawn upon in making comments and I hope for a large response.

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DAMPING PROPERTIES OF TURBINE BLADES

N.F. Rieger*

***Abstract** - This article reviews damping literature pertaining to internal material damping, damping of steam turbine blade groups, and gas turbine blade damping.*

The **Subject and Author Cumulative Index** to the **Transactions of the ASME**, from 1957 to 1975 [9] was reviewed for papers on damping of steam turbine blades under the category of **Blades, Blading**. Of the 70 relevant papers published between 1957 and 1975 two papers are specifically related to steam turbine blade damping technology. Under the general category of **Dampers, Damping**, a total of 93 papers was published; eight are judged to be relevant to steam turbine blade damping technology. The majority of the damping papers deal with such topics as theory of viscoelastic beams, layered beams, and random loading effects. Other papers deal with proposed noise suppression procedures. **The Shock and Vibration Digest** published several reviews of damping literature between 1967 and 1976. The survey by Jones [10] contains references to five papers pertaining to turbine blade vibration. These papers relate mainly to gas turbine blade damping technology and damping mechanisms.

Useful sources for damping data on steam turbine blades are Lazan [1] and Wagner [8]. These sources are discussed in the following paragraphs. Several other references have been published [3-6, 10, 11].

INTERNAL MATERIAL DAMPING

Lazan [1] is a comprehensive source for data on damping properties of 2,000 materials. The result of more than 25 years of careful materials research, this source contains the most comprehensive review of damping technology available. A general account of various possible rheological approaches for analysis of damping properties is given and includes all main damping mechanisms. The various models for linear, nonlinear, and time-dependent damping are reviewed and categorized. Each model is discussed with regard to materials and their effects, including interface stick-slip damping. Both linear and nonlinear material damping are classified in terms of the specific damping energy loss factor.

$$\eta = \frac{D}{2\pi U}$$

D is the specific damping energy, and U is the nominal strain energy implied by the hysteresis loop dimensions. The book contains explanations of how the various factors that influence damping are related to specific damping energy and how different models have been developed to account for nonlinearities observed in the damping response. The influences of uniaxial stress and biaxial stress in the damping model are discussed in detail. The book contains an extensive reference list of damping literature.

A compilation of damping properties for several hundred metals and alloys in terms of stress amplitude, temperature, loading direction, frequency, and cold working is included. A small section is devoted to interface damping; the high energy losses that can result in blades are discussed. Possible disadvantages of interface damping (fretting corrosion) and optimization procedures (viscoelastic coatings) are given.

DAMPING OF STEAM TURBINE BLADE GROUPS

Wagner [8] conducted tests to measure blade group damping in a single turbine stage. Blade groups with strain gages were vibrated by rotating them through a stationary water jet. Dynamic strain decay rates of the groups were recorded to measure the damping present. The influences of wheel speed and turbine

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back pressure on damping were investigated. It was found that, for the conditions studied, the logarithmic decrement of damping was generally less than two percent.

Wagner's damping study is important because it provides good statistical data from blade groups tested *in situ* at speed under flow conditions, and the results include the effects of all types of damping present in the instrumented blade groups.

The results may be used as guidelines for assessing the damping of other related blade groups. However, Wagner's study has limitations. First, it applies to a single type of blade group design. There is no evidence that a different root design would give similar results. Second, no modal damping data were obtained. The damping values contain the effects of all modes excited simultaneously by the water jet impacts. Third, reported damping values may be generally high because impactive conditions are known to give rise to high damping values [1]. Finally, no correlation was achieved between impulse damping data and steady-state vibration amplitude levels. Similar comments apply for blade group natural frequencies.

STUDIES OF GAS TURBINE BLADE DAMPING

Jones [10] reviewed the general problem of damping at high temperatures. He referred to several studies of turbine blade damping, including the work of Chubb [6]*, who successfully used wire damping to control vibrations in gas turbine blades. The wire used was presumably a loose tiewire in which blade motions were suppressed (in a relatively low centrifugal field) by rubbing friction. Such damping requires holes through the blades. The related stress concentrations are suppressed by local reinforcement. This technique has fallen into disfavor in steam turbine use because of flow distortions and manufacturing problems.

Studies of the potential effectiveness of root friction damping have been reported by Beards [2], based on other studies [3-5]. Typical experimental results for stick-slip dissipation with optimum contact pressure gave a 7:1 improvement. Goodman and Klumpp [3] found that "a highly beneficial reduction in resonant stresses can be achieved by friction damping." Hanson [5] describes a simple blade damping test device, a 15,000 RPM rotating disk with a single blade, excited by either a transverse air jet or by ball impact. He gives data on material damping vs RPM and root friction vs RPM. Fir-tree root blades were found to have the highest root friction, as opposed to pin- and wedge-root blades, but the damping decreased in all instances with increased RPM. Hanson [4] also studied a proposed friction damping device using the same rotating disk apparatus and demonstrated its effectiveness in suppressing blade vibrations.

*This paper was not available for review at the time of writing

These gas turbine blade damping studies were probably intended as qualitative evaluation procedures -- to classify various blade materials and structural geometries. Such statistical questions as repeatability of results and the relationship of results to parametric variations in dimensional tolerances, stress field, humidity, and surface condition/coatings were not evaluated. No attempt was made to relate frictional conditions in the root, blade, and cover to a general modal theory for blade groups.

CONCLUSIONS

Damping technology data exist for typical steam turbine blade materials. Blade/disk root damping has been tested for several gas turbine blade root designs. The results of one reported study are available for steam turbine blade damping.

It appears that most of the damping technology effort in the period surveyed has been directed toward gas turbines. With the exception of a paper by DiTaranto [12], there appear to have been no novel damping devices proposed for steam turbine blades. Little of the viscoelastic, high temperature gas turbine blade work appears to be potentially useful for steam turbine blades.

It is concluded that no meaningful technical development has occurred in the area of steam turbine blade damping for at least the past 20 years.

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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 review articles on finite element-related techniques as applied to acoustic propagation in the ocean and wind excited behavior of structures.

Dr. Kalinowski of the Naval Underwater Systems Center, New London, has written a two part article on acoustic propagation in the ocean. Part 2 describes transparent boundary simulation techniques.

Professor Johns of the University of Technology, Loughborough, Leics., England, has written an update of an article previously published in the DIGEST. The present article reviews recent literature on wind excited responses of structures. Responses included are vortex shedding, galloping oscillations, flutter, divergence and buckling, and turbulence.

A SURVEY OF FINITE ELEMENT-RELATED TECHNIQUES AS APPLIED TO ACOUSTIC PROPAGATION IN THE OCEAN
Part II: Transparent Boundary Simulation Techniques

A.J. Kalinowski*

Abstract - This two part article deals with finite element-related techniques applied to acoustic propagation in the ocean. Methods for modeling and simulation of boundary conditions are discussed including the related Boundary Solution Method and the Boundary Integral Method in Part 1 and transparent boundary simulation techniques in Part 2.

The finite element method is a flexible way to treat the major aspects of a realistic ocean-bottom interaction problem.

The chief disadvantage -- aside from the obvious large number of degrees of freedom required to model a problem -- is the proper treatment of the infinite domain truncation. A typical finite element model for an ocean-bottom problem typically involves four separate boundaries of an overall elongated region bounded by four sides (as shown in Fig. 4). The region is a planar section for two-dimensional Cartesian coordinate problems or a cross section of a torus for rotationally symmetric (r-z cylindrical coordinate) problems. The surface boundary is perhaps the only clear-cut one; a zero pressure condition is thus imposed along this side. The bottom boundary condition can be any of several models, depending upon the degree of bottom detail desired: it can be rigid, have a prescribed impedance, or have finite elements terminated by either of the two previously mentioned options; alternately, it can have finite elements and be terminated with a prescribed impedance or with finite elements that are terminated with a transparent boundary condition. The remaining two vertical boundaries cut through and thus truncate both the fluid and the bottom domain. Each vertical boundary requires the imposition of a proper radiation (i.e., transparent) boundary condition. If loading is such that a plane of symmetry exists (e.g., the sample problem considered below), a boundary condition demanding that the particle motions are zero normal to the plane of symmetry takes care of one vertical boundary. The remaining vertical boundary has received much attention in the literature. Only once [28] [2] has the most general case -- a vertical boundary of part fluid and part solid -- been considered; the transparent boundary treatment for each type of medium is usually considered separately.

SOLID DOMAIN BOUNDARIES

A simple way to handle the transparent boundary has been described [3]. A plane wave boundary condition of the form

$$\sigma_n = \rho c_p v_n$$
$$\sigma_t = \rho c_s v_t \qquad (16)$$

is applied at the truncation of the solid finite elements; σ_n and σ_t are the normal and tangential interface stresses, ρ is the solid media mass density, c_d and c_s are the dilatational and shear wave speeds, and v_n and v_t are the corresponding normal and tangential velocities at a typical point on the solid boundary surface. Conditions are exact if the radiating energy impinging on the surface is made up of plane waves that are normally incident to the surface. As has been pointed out [3], the boundary conditions are still reasonably accurate even when either wave type is substantially off normal incidence. A displacement finite element approach in which the unknown parameters $\{a\}$ are displacement quantities at the finite element grid work is used. The transparent boundary acts as if viscous dampers

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[2] See Part I of this article in the March, 1979, issue of the Digest for a complete list of References

have been applied normal and tangential to the solid domain boundary points; at these points the velocity coefficient, multiplied by an appropriate area factor, represents the value of the viscous damping constant. An application of this absorber is illustrated in Figure 4. When Rayleigh waves rather than plane wave are the dominant waves traveling through the solid media, an approach similar to that defined by equation (16) is taken [3, 37]. The principle difference is that the right sides of equation (16) are multiplied by additional factors $\tilde{a}(kz)$ and $\tilde{b}(kz)$, respectively; they depend on the depth coordinate and the frequency parameter $k=\omega/c$. The dynamic displacement beneath a surface-contacting rigid strip loaded by a prescribed force $P=P_o e^{i\omega t}$ has been determined [3]. The solution for the resulting nondimensional dynamic strip displacement ratio $\tilde{F}$, where $\tilde{F}$ is the nondimensional vertical deflection of the strip, nondimensionalized by the static piston deflection $P_o/\tilde{K}$, is given in Figure 2, P_o is the amplitude of the harmonic driving force, and $\tilde{K}$ is the static spring constant. Comparison of the exact solution and the solution by the FEM shows that no substantial difference exists between the response using the standard viscous damper, equation (16), and the more complicated Rayleigh wave type damper. A mesh [3] included 682 nodal points (accounting for the plane of symmetry), and the solution required eight minutes on a CDC 6400 computer [3]. Boundaries were placed at 1-½ times the Rayleigh wavelength for a solid medium Poisson's ratio equal to 1/3. The viscous damper boundary condition has been compared with the exact solution for a very similar problem [36, 47]. It was concluded [36] that elementary viscous boundaries can give satisfactory results if they are located far enough from the source force functions. Figure 2 is not an ocean-bottom interaction problem, but the strip radiating into the solid medium is analogous to the pressure acting over a $2r_o$ span of the ocean bottom. Total loading for the complete ocean-bottom interaction problem can be thought of as the superposition of a sequence of strips, each acting over one subsection of the ocean floor. It is thus evident that the successful application of equation (16) to Figure (2) parallels the potential application of such transparent boundary absorbers to the ocean-bottom interaction problem.

A semi-analytic consistent boundary concept, called hyperelements for layered strata [27], has been considered [26, 27]. Although the technique is oriented toward buried structures and earthquakes, it could be applied to the ocean-bottom interaction problem. Because the far field, represented by an elastic, layered stratum, is activated only through the forces existing at the buried structure-soil interface, the motion at the structure-soil interface and at the far field will be determined by the interaction forces. Note that the buried structure can be viewed as an actual buried structure or, more generally, as a combined domain consisting of the structure plus any local soil irregularities surrounding the structure. Correspondingly, a generalized boundary cut is an interface between the local soil irregular domain and the regular soil domain. The problem is thus to

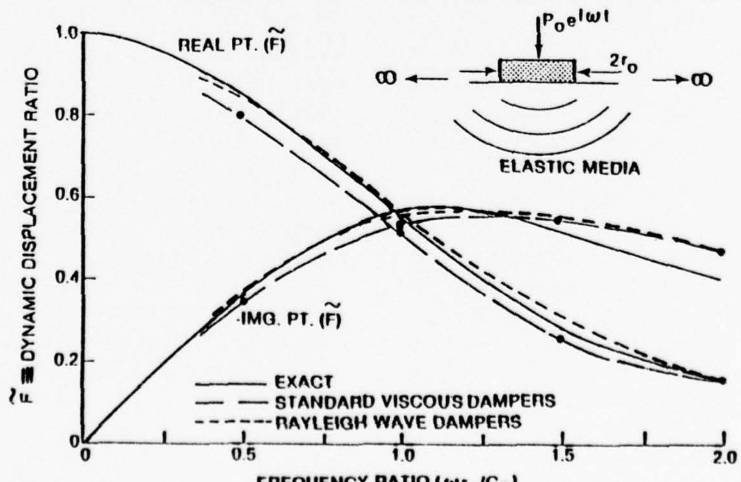

Figure 2. Comparison of Responses with Standard and Rayleigh Viscous Dampers

find the dynamic relation between the generalized structure-soil interface forces and the corresponding displacements. This relationship can be called the motion-force interaction law existing at the general-ized boundary cut. After this interaction law has been established, only the generalized structure need be analyzed. The interaction law can be used to uncouple the generalized structure equations from the regular surrounding field media equations. Details for formulating the interaction law, which in effect serves as the infinite domain boundary condition, have been given [26, 27] and are summarized below. The eigenvalues and eigenfunctions must be found for a layered domain surrounding the buried structure; they are numerically the solution to a quadratic eigenvalue problem. The eigenfunctions not corresponding to outward propagating waves are discarded, and the modal interaction forces are combined so as to match any given force distribution at the generalized structure-solid interface. Participation factors can then be computed and, correspondingly, the dynamic interaction law relating generalized boundary force to generalized boundary motion. This procedure might also be applicable to the ocean-bottom interaction problem; the buried structure would be the irregular part of ocean bottom -- e.g., the part containing sea mounds and variable sound speeds. The remaining part of the ocean bottom could also be treated [26, 27]. Another procedure for planar solutions involves both Love and Rayleigh waves [4, 25] and is similar to the case in which rotationally symmetric three-dimensional regions are considered [26, 27]. A transmitting boundary approach [23] is analogous to the method described [26, 27], except that finite element substructuring allows a large domain of finite elements to be treated for the irregular zone usually modeled with finite elements.

The FEM -- for representation of a region containing irregularities in geometry and material variations -- has been coupled to the BSM or BIM to model the connecting media and to represent outgoing radiated waves [8]. An approach for treating the infinite boundary said to be a generalization of hyperelements [26] has been described [38]. The idea is to model the solid media with finite elements in all spatial coordinate directions except one, which is represented continuously rather than discretely. For example, the finite element field solution usually given by equation (3) is now represented in the form

$$\{\phi(\overline{x})\} \equiv \phi(x,y,z) \approx \hat{\phi}(x,y,z) = [N(y,z)]\,\{a(x)\} \quad (17)$$

where [N(y,x)] are the usual shape functions. Only a function of the spatial coordinates, say y and z, are discretely represented by finite elements, and $\{a(x)\}$ are continuous unknown functions to be determined. The FEM minimization operation, equation (5), results in a continuous counterpart of equation (7), namely

$$[D]\,\{a(x)\} = \{F\} \quad (18)$$

where [D] is a differential operator in the continuous variable x. The numerical solution procedure for the multipoint differential equation, equation (18), is directly related to the manner in which the boundary condition at infinity is handled. The solution of equation (18) involves the numerical operations necessary to obtain the eigenfunctions for the homogeneous form of the equation. These operations in turn require the numerical solution of a complex quadratic eigenvalue problem of the form $[\lambda^2 [K_2] - i\lambda\,[K_1] + [K_0]]\,\{V\} = 0$, where λ is an eigenvalue to be determined, and $\{V\}$ is the discrete vector for which the coresponding eigenfunction is sought. The homogeneous problem solution is exponential where half the eigenfunctions will have amplitudes that go unbounded as the continuous variable x approaches infinity. In order to maintain a null solution for ϕ at infinity, these unbounded eigenfunctions must be discarded from the total solution expansion. This step takes care of the infinite boundary condition; the differential equation boundary conditions need only be enforced at the remaining finite boundary. Details for treating the inhomogeneous portion of the solution have been given [38].

FLUID DOMAIN BOUNDARIES

In theory, it should be possible to apply the various schemes described for the solids case to fluids by discarding the shear wave response. Consider the viscous boundary condition given in equation (16). This boundary condition has been used for pressure element formulation [39], and considered for a displacement fluid element formulation [5, 35]. The accuracy of this boundary absorber, relative to fluid applications, has been discussed in detail

[18, 35]. A viscous boundary condition and one derived from a variational method are compared in Figure 3b.

A generalized radiation condition applied to a rotationally symmetric media [18] prevents spurious reflections at the truncation of the finite element mesh and has been incorporated into a Galerkin type variational formulation for the application of equation (4). A $\partial\phi/\partial r = T(\phi)$ generalized boundary condition is applied at the truncation of the fluid domain; the expression for $T(\phi)$ involves a series expressions in Hankel functions to represent outgoing waves evaluated at the truncation radius. The counterpart of equation (16) -- i.e., the use of viscous absorbers -- is the approximation $T(\phi) \approx i\omega\phi$. The coefficients in the Hankel function expansion are determined as part of the Galerkin variational process [18]. The plot shown in Figure 3a is an annular region bounded by a free surface from above and a rigid bottom from below. The region is loaded by a spatial variation of the form $\phi(r = 1, z,t) = \sin(z\pi/2)e^{i\omega t}$ at the inner radius of r=1, where $k = \omega/c = 6.0$ for the problem at hand. The exact solution is superimposed on Figure 3a. The accuracy of the solution is remarkable in that approximately eight radial wavelengths of the field response are represented by only 12 radial discrete mesh points.

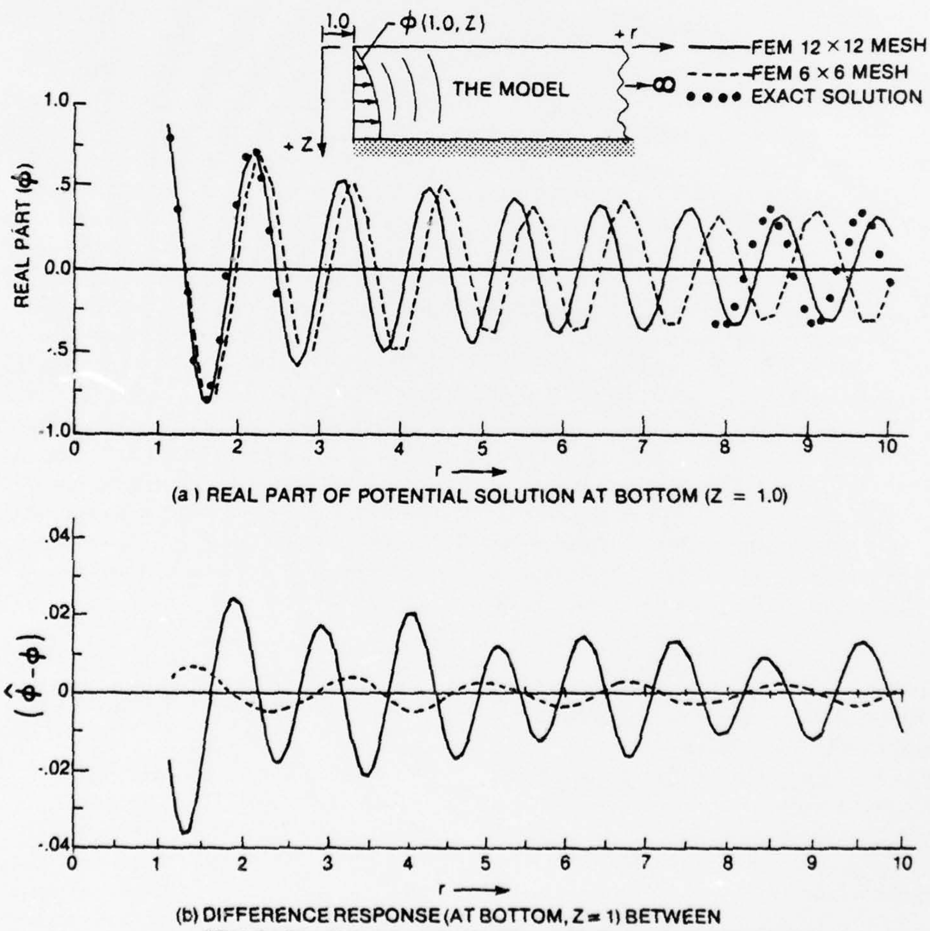

Figure 3. FEM Solution Sensitivity to Mesh Size and the Transparent Boundary Condition

A straightforward finite element approach would have required substantially more nodal discretizations for the same accuracy (e.g., eight nodes per wavelength are needed in a displacement FEM formulation [35]). The numerical solution appears to fall away increasingly from the exact solution (phase error) as the distance from loading increases. Note that the exact solution is given by $\phi = H_0(\sigma_1 r) \sin(\omega_1 z)/H_0(\sigma_1 r_0)$, where $\sigma_1 = 5.79073$, $\omega_1 = \pi/2$, $r_0 = 1.0$, and $H_0(\ )$ is the Hankel function of the first kind. The plot shown in Figure 3b compares the generalized radiation boundary condition [18] and the viscous boundary condition -- first of equations (16). Figure 3b shows that, for this particular case, the differences between the two responses relative to the magnitudes of the peaks in the exact solution are not insignificant; the responses are close enough, however, so that the viscous boundary result is sufficiently accurate to predict the general character of the field solution both quantitatively and qualitatively. Note that Figure 3b is a plot of the difference between two numerical solutions, not a comparison with the exact solution.

An interesting concept for terminating a finite element modeled fluid domain -- namely, by introducing infinite elements that form the last (outermost) elements of the domain -- has been described [40, 41, 54]. The infinite element concept has been treated generally [41]. A specific set of field equations for determining gravity surface waves rather than acoustic waves has also been used [40]. In a subcase of this approach [40] the Helmholtz equation, equation (8), is solved in a two-dimensional region (deep-water approximation) by analogy, this approach is applicable to the acoustic fluid media of interest here. The process begins with selection of an infinitely long, finitely wide rectangular strip to represent the parent shape element. An isoparametric representation is used to map the strip into the appropriately shaped domain. The shape function N_j for the j^{th} node along the s coordinate is given by

$$N_j = \tilde{g}_j(s) e^{-s/L} e^{iks} \qquad j = 1, 2, \ldots J-1 \qquad (19)$$

where s is a special coordinate defined in the direction of the parametric coordinate ξ extending to infinity; s is so scaled that lengths along it are equal to those of the original coordinates of the problem. Specifically, the s coordinate is defined as $s = \xi (ds/d\xi)_{mean}$. The $\tilde{g}_j(s)$ is a polynomial in s, L is a decay length, and k is the wave number parameter of equation (8). For the shape function of equation (19) taken, e^{iks} represents the basic wave form, $e^{-s/L}$ represents the wave decay with increasing s, and the $\tilde{g}_j(s)$ term allows for the usual shape changes with smaller s. Thus the shape function of equation (19) satisfies the Sommerfeld radiation condition; i.e., waves traveling outward in the direction of increasing s tend toward zero amplitude. The $\tilde{g}_j(s)$ function has been selected [40] as a Lagrange polynomial [42].

$$g_j(s) = e^{-s_j/L} \prod_{\substack{q=1 \\ \neq j}}^{q=J-1} \left(\frac{s_q - s}{s_q - s_j} \right) \qquad j = 1, 2, \ldots J-1$$

The shape function of equation (19) is valid for J points along s, the Jth point being at infinity. The shape function for the last point must be constructed to satisfy the usual condition $N_J = 1 - \sum_1^{J-1} N_j$. Success has been reported [40, 41, 54] with this infinite element concept in a series of test problem for which exact solutions are known.

Generalized outflow boundary condition have been derived by applying Fourier transforms in the region exterior to the computational region [43]. This approach treats the transparent boundary from a mathematical point of view and has not yet been directly applied to finite elements. It has been suggested [18] that the approach [43] might not be applicable to the layered (variable sounds spread) fluid domain. Although techniques employing the BIM are often used to handle the infinite fluid domain, they are mainly concerned with radiation or scattering problems related to various types of solids [5, 34, 44, 45] submerged in constant sound speed fluid media.

A semi-infinite, homogeneous body of water contained by a dam has been studied with the BSM [46]. The fluid domain shape functions, equation (3), satisfy the Helmholtz equation and all fluid interface boundary conditions (including infinity) except the fluid-dam interface. The $\{a\}$ unknowns are related to the fluid-dam interaction motion, which is solved by coupling with the finite element model response of the dam.

COMBINED SOLID-FLUID DOMAIN BOUNDARIES

Application of the FEM to the ocean-bottom interaction problem requires some ingenuity in using the various techniques described for treating the solid domain alone and for treating the fluid domain alone.

As an example, consider the pressure response in a variable sound speed, two-dimensional fluid region bounded by a free surface from above and by a multi-material soil media (terminated by rock) from below. The input is a steady state line source, whose axis is normal to the two-dimensional domain. For convenience in modeling, assume that the source lies on a plane of symmetry; thus an appropriate plane of symmetry boundary condition can be used along one vertical face. The remaining vertical face, at the opposite end of the model, requires the transmitting boundary condition. This boundary, shown at the right in the finite element model, Figure 4, contains part fluid and part solid media. The elementary viscous boundary conditions, equation 16, are used for both the solid and fluid (viscous shear dampers are not needed for the fluid case). Viscous damper values are assigned values according to the material they are directly contacting. The 430 element model is used only as a demonstration of the approach; the size of the mesh modeling, particularly in the solid domain, is rather coarse. The model is selected to emphasize some of the positive features of the finite element method summarized earlier -- namely, the irregularly shaped bottom, the variable material bottom, inclusion of dissipative loss factor in the bottom, and variable sound speed fluid domain. Note that fluid layers need not be flat and parallel with the global coordinate system. The generalization of the above problem to additional material variations and more complicated sound speed profiles is straightforward. The finite element model is constructed from a displacement formulation for both the solid and fluid domains -- an alternate approach is to represent the fluid with pressure type finite elements, and only the solid domain with displacement type elements. The model satisfies the fluid-solid interface boundary condition of equal displacements normal to each point of interface contact. Such physical constants of the example problem as mass density ρ, dilatational sound speed c_p, shear wave sound speed c_s, and loss factor η are specified directly as shown in Figure 4. A 10 Hz line-source pressure loading is represented by a set of nodal forces applied at the open cut in the Figure 4 mesh; it corresponds to a unit pressure at the initial wave front. All other response pressure plots are non-dimensionalized relative to this reference value. The effect of the bottom compliance on the down range pressure response is apparent when the problem

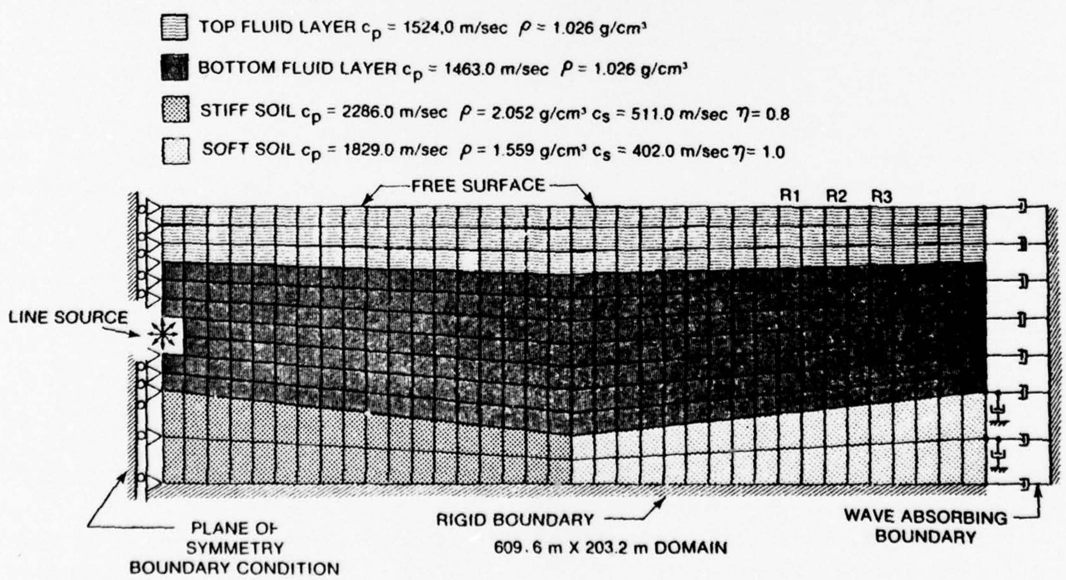

Figure 4. Ocean-Bottom Interaction Finite Element Model

is solved twice: once with a compliant soil sloping bottom as shown in Figure 4 and again with a rigid sloping bottom. The Figure 5 pressure profiles, as computed with the NASTRAN program [29], are plotted against depth at three successive ranges located approximately three quarters of the way down the length of the model. They are denoted by the center-of-element R1, R2, R3 reference points in Figure 4. The marked difference in response for soil and rigid bottom models illustrates the importance of a good model for representing the compliant ocean bottom. The solution time on a Univac 1108 computer is approximately four minutes per incident frequency considered.

Another method for displaying the sample problem response is with contour plots (Fig. 6). Because the solution is complex, plots reflecting both the real and imaginary parts (alternatively the amplitude and phase angle) are usually made. The amplitude and phase angle contours are perhaps the most informative for ocean-bottom interaction problems. Contour lines of constant pressure amplitude reveal where possible shadow zones are located; lines of constant phase indicate wave fronts. Lines normal to the constant phase contours are analogous to rays indicating the direction of wave propagation. The package used to generate the results shown in Figure 6 is not a sophisticated contour plotter -- that is, contours approaching the boundary nodes are not as reliable as contours near interior nodes due to the interpolation scheme employed at the boundary. Consequently, the contours are terminated at nodes just inside the boundary nodes. Further, only pressure amplitude in the fluid (i.e., omitting the solid domain) is plotted.

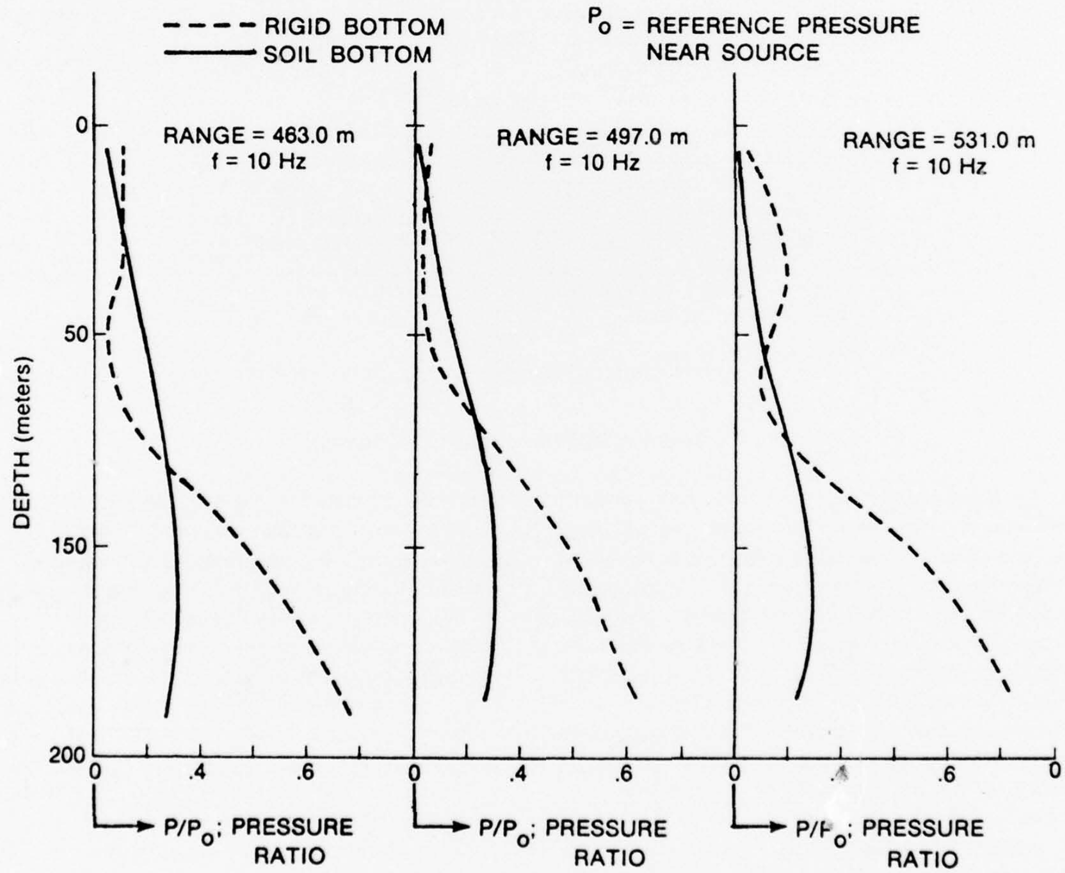

Figure 5. Radiated Pressure vs Depth at Three Successive Ranges

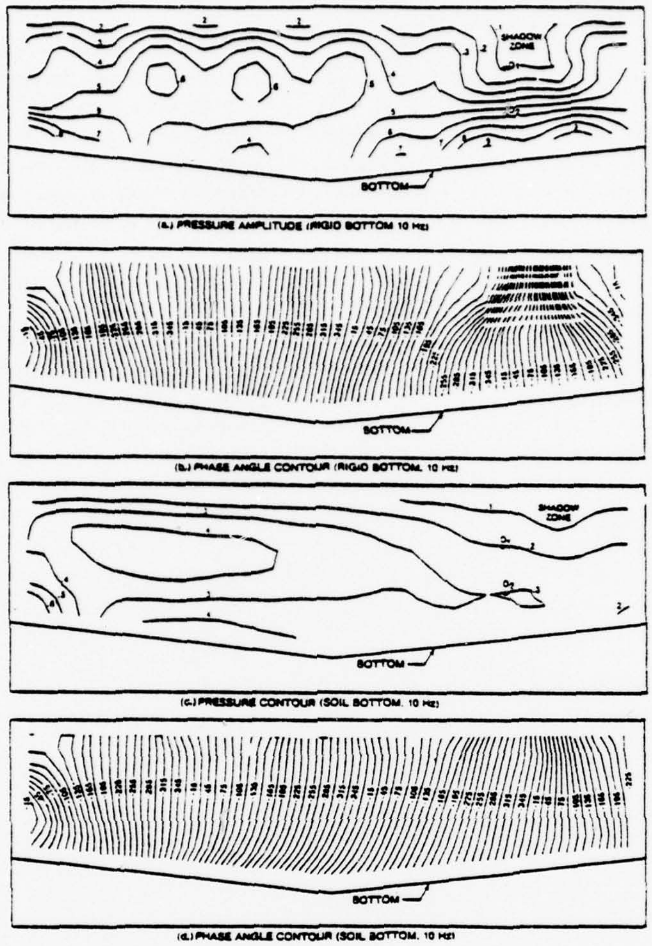

Figure 6. Finite Element Response Contours

For the phase angle plots, the 0° and −360° contours mathematically represent the same plotted line; this non-unique situation creates some confusion for the contour plotter, particularly for closely packed contours. The computer plotted phase angle contours shown in Figure 6b were considered unreliable in the shadow zone area. As a result the contours were sketched in by hand (dotted portion of contours) based on conjecture and analogy with Figure 6d. The importance of modeling the compliance of the bottom becomes obvious when the corresponding rigid bottom and soil bottom plots are compared. A close look at the data reveals how some erroneous conclusions could be drawn from an improperly modeled bottom; e.g., if the bottom were approximated as rigid to simplify the model. Consider, for example, the point labeled D_1 in Figure 6a and 6c; the rigid bottom pressure amplitude indicates that point D_1 is in a shadow zone in which the soil bottom pressure amplitude for the same point, all other things held constant, is twice as large. Conversely, comparison of points D_2 (same range but roughly 44 meters deeper) on Figures 6a and 6c reveals just the reverse -- that the rigid bottom pressure amplitude is twice as large as the coresponding soil bottom pressure amplitude. If such large differences are representative of the short ranges considered here, it is likely that the differences are even greater farther down range. Misleading information regarding the down range signal strength and orientation of radiated wave front could influence the success of detecting a source by a passive sonar device located at point D_1 or D_2.

Finally, with regard to the suitability of the standard viscous transparent boundary in the fluid domain, note that, in Figure 6d, normals to the wave fronts at the right end are very nearly perpendicular (90° is normal incidence) to the right side vertical face. This is the ideal situation for this viscous absorber. On the other hand, Figure 6b shows that the normals to the wave fronts are as much as 55° off normal. Percent error vs angle of incidence θ plots that have been published [35] indicate that, at 55°, approximately 97 percent of the energy is still absorbed by a plane wave obliquely incident upon a set of viscous absorbers (see Fig. 4). In fact, 90 percent of the incident energy is absorbed even at a shallow 30° angle of incidence [35]. The phase angle contour plots approaching the mesh termination boundary thus provide a secondary function that helps the modeler check the validity conditions of the viscous absorbers. It appears feasible to alter the size of the damper, velocity coefficient in equation (16), according to the observed angle of incidence as determined from a contour phase angle plot. Absorbers at portions of the boundary that do not meet a prescribed tolerance regarding the deviation from the ideal normal incidence could be adjusted by a prescribed amount determined [35] so that a second iteration computer run could improve the fluid portion transparent boundary performance.

FLUID-FINITE ELEMENTS

Solid finite elements have been treated elsewhere [1, 15, 42]. Fluid elements, on the other hand, require additional discussion because of the interface of solid and fluid elements. FEM problems that explicitly model the fluid, can be approached in three ways: the *pressure formulation* for the fluid domain in which there is one scalar (pressure) per gird point in the FEM mesh [1, 39, 48]; the displacement formulation in which there are N unknowns per grid point where N corresponds to the number of independent spatial coordinates (1, 2, or 3) needed to describe the response [5, 49-51]; and the mixed formulation in which both pressure and the displacement vector (or equivalent velocity potentials ϕ and $\nabla \cdot \phi$) are taken as the unknowns [19, 20]. The displacement formulation has the advantage of easy implementation -- practically any existing solids-oriented computer program such as NASTRAN or SAP can readily be adapted [52], even though the program might have been designed to handle only solid elastic finite elements. On the other hand, the pressure formulation requires a special treatment in which a mixture of ocean bottom (solid) displacement variables and ocean fluid pressure variables must be properly combined [1, 39, 42, 48]. The pressure formulation has the advantage that fewer degrees of freedom are required to model the fluid domain; however, the manner in which the variables appear in the discrete equation of motion are less favorable with regard to numerical computation than the displacement formulation: with the displacement method the coefficient matrix of the unknowns (e.g., the stiffness matrix) is symmetric and banded; with the pressure formulation, the corresponding coefficient matrix is non-symmetric. This loss in symmetry increases computer run times compared to a symmetric matrix of the same size and bandwidth. A disadvantage of the displacement method, if derived as the limiting process of a solid continuum -- i.e., the medium Lamé constant, $\mu \rightarrow 0$ [49, 50, 52] -- is that the governing fluid field equations admit modes of deformation in addition to rigid body modes that do not produce volume change and consequently should not produce fluid pressure if the irrotational mode is accurately represented by the fluid mesh. These modes result from the fact that the fluid field equations do not produce irrotational motion unless irrotationality is forced as a constraint on the system of governing equations. These modes do not explicitly appear during a transient or steady-state analysis; however, they appear during an eigenvalue extraction of the governing discrete finite element equations of motion. The irrotational modes can be removed by introducing a Lagrange multiplier into the finite element variational formulation. Irrotationality is thus forced as a constraint on the element displacement fields at the expense of additional Lagrangian multiplier unknowns; the unknown variable count approaches that of the mixed formulation [19, 20]. In an alternate approach [52] multi-point constraints enforcing irrotationality are imposed on the assembled, unconstrained displacement field. Sample calculations have shown that this approach is successful but expensive -- particularly NASTRAN [29]. A new scheme for solving systems of equations with large number of multi-point constraints has been suggested [53]. The irrotationality constraint has been handled [58] by introducing a penalty function, α, during formulation of the element stiffness. The method, a direct application of the more general constraint procedure [56], involves adding the expression $\alpha \int_{\Omega} [C(a)]^T [C(a)] d\Omega$ to equation (4). The [C(a)] matrix corresponds to the expression $[C(a)] \equiv \nabla X \{\phi(\bar{x})\} = 0$. Introducing α results in a system of equations similar to equation (7). Details on selecting α and special precautions for avoiding numerical problems have been given [56]. The mixed formulation [19, 20] is relatively new but may prove to have certain advantages over the displacement and pressure element approaches.

A different approach has been formulated [57], but numerical results are not yet available. The method might be classified as a pressure formulation; however, pressures at the mesh grid points do not appear explicitly as unknowns $\{a\}$. With the new approach, a preferred interpolation formula is obtained by using Green's function over the element domain. Green's formula, as applied to the reduced wave equation, gives the pressure interior to the element in terms of pressure on the element boundary. Pressure is matched on a continuous basis across one element to the next; the unknowns $\{a\}$ correspond to series expansions resulting from Green's function. Each term in the series satisfies exactly the governing partial differential equation within the element domain. Accuracy is dependent upon truncation of the infinite series expression rather than upon the coarseness of the mesh. The primary advantage of the method is that it allows a larger element to cover a domain of space that would require many more conventional displacement or pressure fluid elements.

CONCLUSIONS

Much finite element work is directly or indirectly applicable to the ocean-bottom interaction problem; unfortunately the treatment is segmented. The stress wave propagation in the bottom portion of the overall interaction problem has been treated by those interested in seismology, especially earthquake response. The acoustic wave propagation in the ocean portion of the interaction problem is mainly concerned with interaction between steady-state (transient) acoustic waves and totally submerged structures rather than with the ocean bottom. With the exception of the few papers referred to and the demonstration problem, little work has been done to apply the FEM directly to the ocean-bottom interaction problem. The FEM is not well suited to high-frequency steady-state response problems, mainly because both fluid and solid media are modeled with finite elements, thus creating rather large systems of equations (the higher the incident frequency, the more discrete points are needed to model a wavelength). The application of BSM and BIM do not require fluid finite element modeling within the interior domain of interest. Unfortunately they do not offer much promise for problems dealing with depth- and/or range-dependent sound speeds. This is due to the lack of available singularity functions G_1, G_2 in the case of the BIM and to the lack of shape functions that satisfy the domain p.d.e.'s exactly in the case of the BSM. For low frequency problems, the FEM has advantages in that features that are normally difficult to treat can easily be accommodated: irregularly shaped bottoms; irregularly-shaped surfaces; non-simply connected fluid domains (e.g., voids simulating a dense school of fish); depth- and range-dependent sound speed profiles in both the fluid and solid domains; directional sources; and dissipative losses in the ocean-bottom model via a frequency-dependent material loss factor.

The biggest problem in completely modeling all important aspects of the ocean-bottom interaction problem is the proper treatment of the boundary face terminating the finite element mesh. This problem is not unique to finite elements. Application of the viscous boundary condition is the easiest to apply, but its application is valid only under special conditions having to do with the normality of the wave front relative to the mesh truncation interface, and placement of the viscous absorbers sufficiently far from the radiating source. Although other more advanced concepts with respect to a more accurate treatment of the infinite boundary condition could be applied to either the fluid domain or the solid domain, no integrated scheme yet combines techniques in both the solids and fluid fields surveyed. The problem is particularly difficult at the vertical interface where fluid and solid meet along the truncation section of the finite element mesh. With ingenuity, it should be possible to find some combination of the transparent boundary techniques that will treat the ocean-bottom interaction problem accurately and efficiently.

WIND EXCITED BEHAVIOR OF STRUCTURES. II

D.J. Johns*

Abstract - This article reviews recent literature on wind-excited responses of structures. Such responses include vortex shedding, galloping oscillations, flutter, divergence and buckling, and turbulence.

A paper, "Wind Excited Behavior of Structures," published in April, 1976, [1] outlined technical literature related to the dynamic response and aeroelastic behavior of typical structural forms. The present paper is an update of the literature during the period 1975 - 1978. Some publications are more directly concerned with water flows and nuclear reactors but are also relevant to wind-excited behavior.

THE NATURE OF WIND

Several publications are available on the current state of knowledge on the nature of wind [112, 124, 126-128]; a few others are particularly useful [21, 42, 82]. Hurricanes and tornadoes have also received detailed consideration [104, 112]. The simulation of random fluctuations of the natural wind has been of interest [9], as has the use of wind tunnels for testing [94].

MECHANISMS

Wind-excited responses considered below include vortex shedding, consequential in-line and cross-flow bending oscillations, ovalling oscillations, and torsional oscillations; galloping oscillations; flutter; divergence and buckling; and turbulence effects [1].

Relevant reviews have been published containing general information [5] and information about bridges [26]; nuclear reactor system components [32]; cylinders, parallel flow and stationary fluids [80]; cylinders, in-line and cross flows [83]; overhead transmission lines [93]; and cylinders [97]. Other papers provide insight into the mechanisms involved [6, 12, 65]. The qualitative behavior of a pair of nonlinear differential equations that arise in uniform flow wind loading and the most dangerous excitation conditions have been described [99].

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VORTEX SHEDDING

Basic data on vortex shedding have been given [1]. Other pertinent references [80, 83] deal with cylinders. A mathematical model for vortex-excited behavior [14] introduces a nonlinear aerodynamic damping term of fifth order. This model has not yet been exploited fully. Other mathematical models have been described [61]. Information about comparable models [13, 18] has been summarized [111]. Valuable insights into phenomena associated with vortex shedding, unsteady wakes, and feedback mechanisms are available [29, 46, 48, 52, 68, 69, 74, 84, 88-90, 101, 113].

In-Line and Cross-Flow Bending Oscillations

Much information is available relevant to in-line and cross-flow bending oscillations [2, 3, 7, 8, 13, 14, 18, 22, 30, 34-36, 39, 44-48, 50, 58, 59, 61, 64, 76, 77, 84, 88, 89, 96, 101, 111, 113, 121]. Information for a single circular cylinder oscillating in-line has been summarized [113], and the existence of two adjacent but separate instability regions has been shown. The reduced velocity range $1.25 < V/nD < 2.5$ corresponds to velocities equal to one quarter of those necessary for cross-flow oscillations; V = velocity, n = natural frequency (Hz), D = diameter. This instability region is identified with symmetric vortex shedding; maximum amplitudes occur at $V/nD \simeq 2.1$. The second instability region, $2.7 < V/nD < 3.8$, is identified with asymmetric (alternate) vortex shedding; maximum amplitudes occur at $V/nD \simeq 3.2$. These regions are known for at least the first three normal modes of cantilever oscillations in-line for water flows. The amplitudes of oscillation are approximately equal in the two regions and have a maximum value of y/D = 0.2 at the tip of the cantilever. The amplitudes are significantly influenced by the magnitude of k_s, the non-dimensional mass damping parameter; and the length to diameter ratio. k_s is equal to $2m\delta/\rho D^2$. In the equation m is the effective mass per unit length, inlcuding the mass of the displaced fluid; ρ is the fluid density, and δ is the logarithmic decrement. The length to diameter ratio is particularly important at low amplitude ratios; it affects the degree of correlation of the unsteady vortex-induced forces along the cylinder length. In fact, in-line oscillations are significant only if $k_s < 1.2$.

However, for cross-flow vibrations of circular cylinders much larger values of k_s are required to inhibit instability ($k_s > 17$), and much larger amplitudes occur ($y/D \rightarrow 2$) than for in-line oscillations. It has been reported [113] that, for air, the range of cross-flow oscillations can extend over $4.75 < V/nD < 8$ and, for water, over $4.5 < V/nD < 10$. Maximum amplitudes occur respectively (as $k_s \rightarrow 0$) in the ranges $5.5 < V/nD < 6.5$ and $6.5 < V/nD < 8$. These results are dependent upon length to diameter ratio and other factors.

Various mathematical models have been used to predict the vortex-excited resonant amplitudes of cross-flow cylinder motion as a function of various structural and flow parameters [111]. A linear model -- applicable to low amplitudes ($y/D\gamma < 0.2$) and to fully correlated subcritical flow -- yields a result.

$$y/D\gamma = 1/k_s \qquad (1)$$

where γ is a modal shape parameter that typically varies from 1 (rigid cylinder) to 1.3 (first cantilever mode).

The wake oscillator model of Iwan [13] includes the effect of increasing vibration amplitude ($y/D > 0.2$), thereby reducing the amplitude of the vortex-induced forces. As a result equation (1) is modified as y/D increases to 1 and above. A limit cycle amplitude occurs when k_s is small -- about 0.1. The corresponding equation for a Strouhal number of 0.2 (subcritical flow) is

$$y/D\gamma = \frac{1.75}{(k_s + 1.9)}\left[0.30 + \frac{3.6}{(k_s + 1.9)}\right]^{1/2} \qquad (2)$$

The correlation model of Blevins and Burton [18] takes account of the fact that the spanwise correlation of the unsteady vortex-induced forces is not perfect; consequently the net force acting is a function of both cylinder length-to-diameter ratio (L/D) and of cylinder amplitude-to-diameter ratio (y/D). This model predicts lower amplitudes than the wake oscillator model, especially for large values (> 10) of length-to-diameter.

Results from the two models are shown separately [111] for a variety of structural model shapes and corresponding values of γ. Earlier experimental results led to the empirical result for rigid cylinders of

$$y/D = 0.55/k_s \qquad (3)$$

This result compares well with the correlation model for cylinders with $25 > L/D > 10$.

There is now a significant literature on such problems as parallel cylinders [30, 47, 84, 96], a line of cylinders [10, 15, 36, 51, 74, 77], cylinders with close wall confinement [29], cylinders with additional parametric excitation [59], and on such structural forms as underwater cables and overhead transmission lines [3, 7, 44-46, 59, 74, 76, 93]. Useful summaries of data on Strouhal number for various sections are available [111, 112].

Ovalling Oscillations

There has been little apparent interest in ovalling oscillations in the past three years [27, 114]. Experimental data of the circumferential bending strains in thin circular cylindrical shells subjected to a transverse airflow have been published [114], as has a corresponding theoretical analysis for predicting fatigue life of such structures for anticipated variable wind speeds. The data show how various shell bending modes can be identified from strain spectra and the relationship of particular ovalling mode frequencies to the predominant vortex shedding frequency. Damaging ovalling oscillations can be minimized by the judicious use of stiffening rings in the shell structure.

Torsional Oscillations

Few papers seem to have appeared on torsional oscillations. The unsteady aerodynamics of a two-dimensional structural angle section during stationary and vortex excited oscillatory conditions were studied [128g]. Both plunging and torsional degrees of freedom were examined. Plunging had a significant effect of fluctuating pressures and wake width; but the torsional resonance had virtually no effect.

Wind tunnel tests of a 1/64 section model of a suspension bridge stiffening truss in uniform and turbulent flow with and without the presence of an upstream obstacle has been described [20]. Aerodynamic damping was determined only for single-degree-of-freedom torsional motion. A useful discussion of such torsional phenomena points out that associated analytical procedures do not yet exist [112]. However, a quasi-analytical prediction of torsional building response using deterministic and probabilistic analysis methods has been published [72]. Torsional effects are likely to be large for sections that are bluff and elongated in the flow direction -- such as the H-section, which is also torsionally weak.

GALLOPING OSCILLATIONS

Excellent reviews of this topic are available [111, 112, 124, 126, 128]. Plunge stability, torsion stability, and coupled plunge and torsion stability (flutter?) have been discussed [111]. The bulk of the literature deals with plunge or cross-wind galloping. Such galloping can, under certain conditions, give large amplitude oscillations -- greater than ten times the width of the structure -- at much lower frequencies than would occur for vortex shedding for the same section.

The application of the quasi-steady theory of galloping has been extended to towers of square section and compared with experimental results [126g, 128c]. The theoretical variation with tower height of the wind speed and sectional transverse force were incorporated. Theoretical results agreed well with experimental results. The effect on galloping of the proximity of resonance due to vortex shedding was also examined. Comparable results for three rectangular prisms have been published [22]. The linear quasi-steady theory for galloping was applicable unless the frequency of oscillation was close to the frequency of vortex excitation; this result was possibly fortuitous.

Experimental data for the aeroelastic response of square and H-sections in low-turbulence and high-turbulence flows are available [64]. The square section in low turbulence flow shows a vortex-excited response superimposed on a galloping oscillation, but the vortex excitation is not apparent in high turbulence. Similar results were found for the H-section with the flange parallel to the flow. However, when the flange is normal to the flow, only vortex excitation occurs for all levels of turbulence intensity.

Two other review papers discuss the galloping problem and possible cures [93, 98]. Several papers deal with wake galloping involving more than one cylinder in tandem [96, 111, 112, 128].

FLUTTER

Flutter has been discussed [112]; data for various typical bridge sections were used as examples. Suspension bridge deck flutter has also been considered [53, 56, 67, 95, 100, 103, 115, 116, 118, 123, 126c].

It has been shown from experiments [53] that models designed for binary coupled flutter investigations can also show a single-degree-of-freedom flutter or an intermediate type of flutter. The geometry of the deck section is the most important parameter influencing the type of flutter. Appropriate multi-degree-of-freedom theoretical analyses were also presented [53].. Comparative analyses of different deck sections are available [100], as are analytical treatments [56, 67].

The response to buffeting loads was considered [67], and the necessity to use experimental data for the quasi-steady aerodynamic coefficients, was emphasized [56, 67].

Most analyses are based on the energy (Lagrangian) method; however, assumed normal modes were used in a multi-degree-of-freedom system employing the finite element technique [95]. A suitable method was developed to improve the numerical stability.

Some original and interesting aeroelastic analyses related to tandem arrangements of cylinders -- with transmission lines as the possible application -- are available [74, 90]. A mathematical model allows both windward and leeward bodies to be in motion and accounts for the effects of time delays associated with the gap between the bodies [74]. Effects not previously dealt with include bunching of the wake due to accelerated motions of the windward body and virtual displacement of the leeward body due to flow retardation in its stagnation region. A study in which only in-line notions were permitted [90] showed that flutter and divergence type instabilities can occur. Flutter can occur in this case only if the two cylinders are coupled mechanically. The mechanism is weak if the spacing exceeds five diameters. One application might be transmission lines. It has been postulated [113] that in-line vibration amplitudes are low if the spacing exceeds six diameters or if the mass-damping parameter k_s is greater than 1.2. In air it is difficult to achieve a value of $k_s < 1.2$; the results [90] were not surprising.

DIVERGENCE (BUCKLING)

Very little work has apparently been done on buckling. Buckling collapse of open-ended circular cylindrical shells under a steady wind pressure has been considered and comparisons made of simple theory, existing codes of practice, refined theory, and experiments [124, 129a]. Simple empirical criteria were proposed.

A summary of various analytical, experimental, and numerical contributions to the buckling analyses of large hyperbolic cooling towers is available [4]. Previously published results for axisymmetric and asymmetric (wind) pressures were compared with results using a finite element method. A pair of smooth circular cylinders mounted in tandem in an airstream and free to execute only streamwise small motions have been considered [90]. Flutter and divergence instabilities were possible; stability diagrams were used.

TURBULENCE EFFECTS

A significant amount of published literature has appeared on turbulence in recent years, including an excellent summary [112].

A technique for simulating random wind fluctuations -- applicable specifically to the ascent phase of the space shuttle but relevant to wind excitation of buildings -- has been developed [9].

A useful review of wind loads, random vibration, and fatigue of tall buildings is available [10]. An analytical method shows the effects of neglecting damping and inertia terms associated with floor flexure motions and presents an approximate method accurate to within 10 percent of exact results [24].

The turbulence problem has been analyzed in the time domain and the dynamic response obtained in terms of displacement, velocity, acceleration, and rate of change of acceleration time histories [33]. Although strength and stability criteria were calculable by the fundamental mode, such higher response parameters as acceleration and rate of change of acceleration, both significant in terms of serviceability and human comfort, necessitated inclusion of higher frequency modes of vibration. A similar problem has been analyzed [40] using the finite element method. Data on the unsteady pressures experienced on rectangular building shapes in turbulent wind are available [117].

The dynamic interaction of the wind and a hyperbolic cooling tower has been considered [38]. Gust factors for such towers were obtained. Other work also deals with such cooling towers [66, 102].

A multi-guyed slender tower 830 feet tall has been considered [62]. A computer simulation of its response to hurricane force winds was presented, as were details of the structural idealization.

Earlier tall building analyses dealt primarily with along-wind response with or without vortex shedding effects. Coupled lateral and torsional degrees of freedom and response to wind using both probabilistic and deterministic methods have now been considered [72].

Coupled vertical and torsional motions of suspension bridges and their response to turbulence and buffeting have been examined [78]. Numerical results are obtained using frequency and time domain. In other studies of suspension bridges results for calculated vertical and torsional responses for two typical types of construction for wind speeds in the range 60-90 mph (27-40 m/s) are given [81].

An interesting study of probability distributions of structures oscillating under wind action [91] shows that some processes are not normally distributed.

There is also a discussion of the mechanism of local loading on cladding. Turbulence effects on windows have been considered [87]. Other structural forms considered in the literature include tube banks [10], shallow shells [23], suspension roofs [41], and bridges [63].

FULL-SCALE DATA

There is an increasing amount of data on the behavior of full-scale structures due to wind action. Data on the dynamic response to wind of an unusually shaped nuclear power station charge hall are available [49]. The data were analyzed and compared with theoretical values using a simplified structural model. Correlation between measured and predicted frequency was better than 10 percent.

Examination of wind damage in relation to actual wind speeds and code wind speeds revealed deficiencies in structural design and construction for a number of configurations [54].

Sign support structures have been considered [73] and comparisons made between experimental data and a recently developed analytical procedure [92]. The predicted resonant frequencies and lowest critical wind speed that caused resonance were confirmed by the tests. Full-scale measurements have been reported for a glass clad building of medium height [87]. An attempt was made to derive an appropriate mathematical model for the response of the windows.

Full-scale data have been given for a 130 m concrete chimney [119] and a 190 m television tower and the installation of anti-vibration pendulum absorbers [122]. The tower response was measured with two pairs of accelerometers. Movements of the tower foundation were measured with a clinometer. The wind velocity was also measured. Other field studies have also been reported [126l, 128f]. A comparison [122] of theoretical and measured displacements in the wind direction yielded a greater agreement than comparison of the vibrations cross-wind.

TECHNIQUES TO MINIMIZE WIND EXCITED DYNAMIC RESPONSE

New techniques attempt to change the shape of the building or the magnitude of the input forces: the mass, stiffness, and frequency spectra; and damping by isolation, absorbers (passive), or active devices. General discussions of techniques are available [21, 106, 111, 112], as are recommendations for designs to minimize the possibility of detrimental flow-induced vibration [75].

Papers containing general considerations of damping are available [37, 43, 79]. The use of rubber isolation mountings in buildings has been discussed [11]. Other forms of passive damper devices include tuned dampers [17, 28, 85, 122]. Special problems of overhead transmission lines have been examined [93, 98].

A special damping pad placed between the base of a steel chimney and its foundation block has been shown experimentally to raise the mass-damping parameter so as to preclude vortex excitation [1]. Analysis of such configurations has confirmed its potential [129a].

Active control technology to minimize building vibrations due to wind has been considered [25, 57, 71].

It has been assumed [25] that minimization of the performance index involves the covariances of both the structural responses and the control forces. The optimal control law is a linear feedback control; it was applied to a multi-degree-of-freedom structure under stationary wind loads. Significant reductions in response could be obtained by an active control system.

Human comfort and safety have been used as criteria in two studies [57, 71]. Two different measures were used to indicate the energy requirement for active control. It was found from a limited number of sample functions that one feedback control law for comfort and another for safety were feasible.

Methods for shape changes and vibration reduction have been studied [128n] for such circular cylindrical structures as chimneys. A form of vertical slatted structure mounted externally around the circular section was proposed. Benefits were comparable to helical strakes and perforated shrouds without the corresponding drag penalty.

It has been shown [53] that the aerodynamic shape of a suspension bridge deck is the most dominant parameter affecting its stability. Results of studies of the stability of certain closed bridge cross sections indicate that the hexagonal form of a cross section with spoilers and flaps can be sufficiently stable [68].

DISCUSSION AND CONCLUSIONS

The literature since 1975 has been cited and reviewed. Important advances have been made in our understanding of various phenomena and in the collection of data suitable for design purposes.

The textbooks that are now appearing suggest that some codification of all available data is approaching. Future symposia could concentrate on such codification.

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d. Van Koten, H., "The Response of Tall Structures," pp 333-365.

e. Hjorth-Hansen, E. and Sigbørnsson, R., "Design Specification for Dynamic Wind Loads," pp 366-384.

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g. Parkinson, G.V. and Sullivan, P.P., "Aeroelastic Galloping of Tall Structures," pp 636-642.

h. Ervik, M., "Wind Induced Oscillations of Power Transmission Lines," pp 643-652.

i. Melzer, H.J., "Computation of the Dynamics of Structures by Random Loading with a Comparison of the Results Obtained in the Frequency Domain and the Statistically Evaluated Results Obtained in the Time Domain," pp 653-670.

j. Maes, P. and Jensen, J.J., "Wind Response of Cantilever Bridges under Construction," pp 671-677.

k. Torset, O.P., et. al., "Fatigue Behaviour of Slender Free Standing Towers Subjected to Wind Gustiness and Support Vibration," pp 678-688.

l. Christensen, O. and Frandsen, S., "A Field Study of Cross-Wind Excitation of Steel Chimneys," pp 689-697.

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d. Mahrenholtz, O. and Bardowicks, H., "Aeroelastic Problems at Masts and Chimneys," pp 35-48.

e. Panggabean, H. and Melzer, H.J., "Dynamic Response of Structures Under Aerodynamic Load with some Aspects of Non-Gaussian Excitation," pp 49-66.

f. Dalgleish, W.A. and Rainer, J.H., "Measurements of Wind-Induced Displacements and Accelerations of a 57-Storey Building in Toronto Canada," pp 67-78.

g. Modi, V.J. and Slater, J.E., "Unsteady Aerodynamics of an Angle Section during Stationary and Vortex Excited Oscillatory Conditions," pp 79-90.

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i. Panggabean, H. and Reichmann, K.H., "Two-Dimensional Response of Tower-Like Structures under Wind Load and Evaluation of Thermal Loads due to Solar Irradiation," pp 107-135.

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k. Van Langenhove, G. and Berlamont, J., "Fluid Dynamic Interference on the Oscillatory Movements of Pairs of Cylinders," pp 151-162.

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m. Ruscheweyh, H., "Winderregte Schwingungen Zweier Engstehender Kamine," pp 175-184.

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BOOK REVIEWS

THE MECHANICS OF FRACTURE

ASME-AMD, Volume 19, 1976
A compilation of papers presented at the
ASME Winter Annual Meeting, December 1976
organized by F. Erdogan

The stated purpose of this symposium volume was to critically reappraise the development of the field of fracture mechanics, and to discuss current research trends in the field and possibly to identify directions for desirable future research. Eight papers are included in this volume:

- "Some Microscopic and Atomic Aspects of Fracture," R. Thomson
- "Elastic-Plastic Fracture Mechanics," J.R. Rice
- "Fracture of a Glassy Polymer," A.N. Gent
- "Fracture of Solids Possessing Deformation Rate Sensitive Material Properties," W.G. Knauss
- "Dynamic Crack Propagation," L. B. Freund
- "Stress Pulses Emitted in the Brittle Fracture of Solids," H. Kolsky
- "Fracture of Nonhomogeneous Solids," F. Erdogan
- "Application of Fracture Mechanics to the Prediction of Crack Damage Accumulation in Structures," H.A. Wood, J.P. Gallagher, and R.M. Engle, Jr.

In the introductory paper by Thomson, the physical bases for ductile and brittle fractures are explained, and some new and provocative ideas about brittle fracture in ductile materials are presented. A number of questions concerning the nature of cracks in real materials are discussed. It is pointed out that ductile fracture is less well understood than brittle fracture.

Rice relates elastic-plastic fracture mechanics to the processes of crack growth in ductile and semi-ductile structural metals. The stress analysis of cracks, the J integral, microstructural processes of ductile and brittle fracture, and models for stable crack growth are discussed in this interesting paper.

Gent describes stress-induced crazing and fracture in glassy polymers, with attention to effects of temperature, strain rate, and environment. Knauss provides a broad view of developments in polymer fracture and treats the fracture of a linearly visco-elastic solid in some detail.

Dynamic crack propagation is analyzed by Freund for cases in which inertia of the material is important and fracture primarily occurs under conditions of small-scale yielding. During brittle dynamic fracture of solids, stress pulses are emitted. Kolsky reviews the current state of knowledge concerning the dynamic stress fields accompanying the propagation of cracks during brittle fracture.

Erdogan considers the problem of fracture initiation from localized imperfections in composite materials. Emphasis is placed on the description of the mechanics of flaws near or at the bimaterial interfaces.

The final paper deals more with the application of fracture mechanics than the others. Current methods of predicting crack growth damage accumulation are described, as are lifetime prediction procedures and the confidence with which such predictions can be made.

Overall, the volume is a worthwhile review of the state of the art of fracture mechanics in a number of diverse but interrelated areas. The present situation is defined, and areas in need of further research are indicated. This is a concise and useful review of an important field.

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PLATES AND SHELLS WITH CRACKS

G.C. Sih, Editor
Noordhoff, 1977

This is the third in a series on the mechanics of fracture. The previous books are "Methods of Analysis and Solutions of Crack Problems" (1973) and "Three-Dimensional Crack Problems" (1975). This volume is a collection of articles containing stress intensity factor solutions for cracks in plates and shells; it was written by nine well-known researchers in fracture mechanics. The editor is not only one of the world's foremost authorities on crack propagation and fracture but is also known for his clear and understandable writing and explanations of concepts. This style is evident throughout the monograph.

The nine chapters are listed below, along with their authors.

Introductory chapter, "Strain Energy Density Theory Applied to Plate Bending Problems," G.C. Sih

Chapter 1, "Interaction of Arbitrary Array of Cracks in Wide Plates under Classical Bending," M. Isida

Chapter 2, "Improved Approximate Theories of the Bending and Extension of Flat Plates," R.J. Hartranft

Chapter 3, "Through Cracks in Multilayered Plates," R. Badaliance, G.C. Sih, and E.P. Chen

Chapter 4, "Asymptotic Approximations to Crack Problems in Shells," E.S. Folias

Chapter 5, "Crack Problems in Cylindrical and Spherical Shells," F. Erdogan

Chapter 6, "On Cracks in Shells with Shear Deformation," G.C. Sih and H.C. Hagendorf

Chapter 7, "Dynamic Analysis of Cracked Plates in Bending and Extension," G.C. Sih and E.P. Chen

Chapter 8, "A Specialized Finite Element Approach for Three-Dimensional Crack Problems," P.D. Hilton

The chapters typically have excellent lists of about 20 references. In addition, author and subject indexes appear at the end of the monograph.

For those interested in shock and vibration, Chapter 7 is particularly relevant. The classical plate theory is first discussed; crack length and input wavelength are assumed to be large in comparison with plate thickness. The input waves are generated by a combination of bending moments applied to the plate edge causing the plate to vibrate in the transverse direction. The solution of the problem is presented for a plate having a crack of length $2a$ excited by propagating flexural waves which are scattered when they encounter the crack.

However, the classical plate theory permits only two boundary conditions on the crack surface. To represent more accurately the three physical boundary conditions of vanishing bending moment, twisting moment, and transverse shear force, a higher order plate theory is necessary. Thus, Mindlin's sixth order dynamic plate theory is introduced, including the effects of shear deformation and rotary inertia, and the previously described problem is again solved.

Next, the case of incident extensional waves encountering the crack is considered. The shortcomings of the plane elasticity solution are described, and the higher order, two-dimensional extensional theory of Kane and Mindlin is introduced and used to solve the problem.

Finally, the flexural response of a cracked plate subjected to shock or impact moments is taken up. Solutions for dynamic moment intensity factor according to both the classical and Mindlin plate theories are given.

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FATIGUE STRENGTH OF MATERIALS AND STRUCTURAL ELEMENTS UNDER SONIC AND ULTRASONIC FREQUENCY OF LOADING

V.A. Kuzmenko, Editor
Kiev, SSR: Naukova Dumka Publishers, 1977

The book contains the reports of an all-union seminar held in Kiev in May, 1975. Investigation of fatigue strength of materials by sonic and ultrasonic frequency of loading is a comparatively new technique in the study of fatigue problems. Progress depends on the perfecting of testing equipment and development of a sound theoretical basis for the problem. The reports presented in the book can be divided into three groups according to the problems investigated.

The first group of problems has to do with the efficiency and various exciters of mechanical vibrations and techniques for high-frequency fatigue testing. Problems associated with high-frequency acoustic techniques using piezoelectric or magnetostrictive transducers as vibration sources and developing a mechanical resonant system are described. Generation of wideband noise using a powerful siren and the possibility of fatigue testing of sheet materials in the aocustic field of loading are discussed. A method for investigating structural materials under repeated-static loading with imposed vibrations at room and cryogenic temperatures is considered. Of the designs presented, the hydrodynamic emitter with the spectrum of frequencies from 100 Hz to 30 KHz is of particular interest.

The second group includes investigations of the dependence of fatigue strength on frequency of loading. It is shown that, for some classes of materials, the influence of frequency in the full sonic range is not essential; therefore, the results of high-frequency tests can be used for faster determination of fatigue characteristics. Faster methods for fatigue testing are based on the fact that, in high-frequency cyclic loading, one of the two factors influencing the fatigue strength of the material -- the quantity of changes of cyclic loading -- is actually simulated. Results have been obtained for various classes of materials using both laboratory specimens and real parts; e.g., structural elements of flying machines, reinforcement of ferro-concrete structures, and plastic articles.

The results of numerous experiments show that, in most cases with sufficient heat sink, a steady increase in strength limit is observed as the frequency of loading increases. This is true for both uniform and nonuniform compression tension. The similarities and differences of fatigue failure mechanisms at low and high frequencies of loading is shown, as is the interaction of increasing fatigue strength with increasing cyclic strain rate and decreasing fatigue strength with local overheating of microdimensions of the material under investigation. The influence of such factors, as heat exchange, environmental conditions, plasticity of the material, amplitudes and asymmetry of the loading cycle on the regularity of change of fatigue strength with frequency of loading is considered.

The third group involves comparative analysis of the influence of various factors on the characteristics of the strength and dissipative properties of structural materials under sonic and ultrasonic frequencies of loading. The influence of such technological factors as the content of doping elements, the class of surface finish, conditions of surface and thermal treatment, and mode of welding are given. A number of papers consider the influence of structural and operational factors on fatigue strength.

The results of these investigations will be of interest to the aircraft and jet industries, and the power and transport-machine building industries.

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SHORT COURSES

APRIL

MACHINERY VIBRATION MONITORING AND ANALYSIS SEMINAR

Dates: April 10-12, 1979
Place: New Orleans, Louisiana
Objective: This seminar will be devoted to the understanding and application of vibration technology to machinery vibration monitoring and analysis. Basic and advanced techniques with illustrative case histories and demonstrations will be discussed by industrial experts and consultants. Topics to be covered in the seminar include preventive maintenance, measurements, analysis, data recording and reduction, computer monitoring, acoustic techniques, misalignment effects, balancing, mechanical impedance and mobility, turbomachinery blading, bearing fault diagnosis, torsional vibration problems and corrections, and trend analysis. An instrumentation show will be held in conjunction with this seminar.

Contact: Dr. R.L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254.

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS

Dates: April 16-20, 1979
Place: UCLA
Objective: This course covers the latest practical techniques of correlation and coherence analysis (ordinary, multiple, partial) for solving acoustics and vibration problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to: classify data and systems; measure propagation times; identify source contributions; evaluate and monitor system properties, predict output responses and noise conditions; determine nonlinear and nonstationary effects; and conduct dynamics test programs.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

APPLIED TIME SERIES ANALYSIS

Dates: April 23-27, 1979
Place: UCLA
Objective: This course is intended for users of digital time series who require modern methods of data analysis. Topics include data collection and processing, digital filtering, filter design and stability, statistical problems in data analysis, fast Fourier transform and its implementation, power spectral density calculations and input transform functions from data.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

NOISE-CON SEMINAR

Dates: April 26-28, 1979
Place: Purdue University
Objective: This seminar will emphasize the fundamentals of noise control engineering, machinery noise control, in-plant noise, and measurements and facilities for noise control. This is the eighth Seminar which has been organized by the Institute to acquaint individuals just entering the field with the basic principles of noise control and with practical methods for control of machinery and in-plant noise.

Contact: NOISE-CON Seminar, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719.

EARTHQUAKE ANALYSIS OF MULTISTORY FRAME AND SHEARWALL BUILDINGS

Dates: April 30-May 1, 1979
Place: University of California, Berkeley
Objective: This seminar is intended for engineers involved in the design and analysis of earthquake-

resistant structures. It will be devoted to the practical application and use of computer programs for static and dynamic analysis. Among the programs discussed will be TABS, ETABS, DRAIN 2D, and DRAIN-TABS, which have a proven history of successful application to building earthquake studies.

Contact: Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720 - (415) 642-4151.

MAY

SCALE MODELING IN ENGINEERING DYNAMICS

Dates: May 7-11, 1979
Place: Southwest Research Institute
Objective: To introduce and illustrate to engineers, physicists, and scientists investigating transient phenomena the powerful tool of modal analysis. The course will begin with a drop test demonstration of damage to model and prototype cantilever beams made from different materials. Formal mathematical techniques of modeling will be presented including the development of scaling laws from both differential equations and the Buckingham Pi Theorem. Specific analyses relating to a variety of dynamic vibrations and transient response problems will be presented. Types of problems presented include impact, blast, fragmentation, and thermal pulses on ground, air and floating structures.

Contact: Peter S. Westine, Southwest Research Institute, P.O. Box 28510, San Antonio, TX 78284.

MACHINERY VIBRATION ANALYSIS

Dates: May 8-10, 1979
Place: Houston, Texas
Dates: September 5-7, 1979
Place: Atlantic City, New Jersey
Dates: December 11-13, 1979
Place: New Orleans, Louisiana
Objective: The topics to be covered during this course are: fundamentals of vibration; transducer concepts; machine protection systems; analyzing vibration to predict failures; balancing; alignment; case histories; improving your analysis capability; managing vibration data by computer; and dynamic analysis.

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

(ITD) IBRAHIM TIME DOMAIN MODAL VIBRATION TESTING TECHNIQUE

Dates: May 17-18, 1979
Place: Virginia Beach, Virginia
Objective: The ITD method is applicable to almost all kinds of structures. The workshop is designed such that attendees, after the workshop, will be able to apply the technique to their specific application. Material for the workshop will include computer programs for the time domain identification and the random decrement techniques.

Contact: W. McMahon, Director, Industrial Programs, School of Continuing Education, Old Dominion University, Norfolk, VA 23508 - (804) 489-6467.

THE FIFTH ANNUAL RELIABILITY TESTING INSTITUTE

Dates: May 14-18, 1979
Place: University of Arizona
Objective: To provide reliability engineers, product assurance engineers and managers and all other engineers and teachers with a working knowledge of analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, failure rates, and reliabilities; small sample size, short duration, low cost tests, and methods of analyzing their results; Bayesian testing; suspended items testing; sequential testing; and others.

Contact: Special Professional Education, College of Engineering, University of Arizona, Old Engineering Bldg., Tucson, AZ 85721 - (602) 626-3054.

STRUCTURED PROGRAMMING AND SOFTWARE ENGINEERING

Dates: May 21-25, 1979
Place: The George Washington University
Objective: This course provides up-to-date technical knowledge of logical expression, analysis, and invention for performing and managing software architecture, design, and production. Presentations will cover principles and applications in structures pro-

gramming and software *engineering, including* step-wise refinement, program correctness, and top-down *system development.*

Contact: Continuing Engineering Education Program, George Washington University, Washington, D.C. 20052 - (202) 676-6106 or toll free (800) 424-9773.

JUNE

NON-LINEAR PARTIAL DIFFERENTIAL EQUATIONS IN ENGINEERING AND APPLIED SCIENCES

Dates: June 4-8, 1979
Place: Univeristy of Rhode Island
Objective: The conference will feature overview lectures and talks on recent developments in non-linear partial differential equations with emphasis in the areas of solitons, bifurcation, solid and fluid dynamics, non-linear waves, and non-linear diffusion.

Contact: Emilio Roxin or John Papadakis, Dept. of Mathematics, University of Rhode Island, Kingston, Rhode Island 02881 - (401) 792-2709.

ACOUSTIC EMISSION STRUCTURAL MONITORING TECHNOLOGY

Dates: June 18-19, 1979
Place: Los Angeles, California
Objective: A theory and practice course covering each of the various facets of acoustic emission structural monitoring technology; basic phenomena, state-of-the-art applications, field testing experience, applicable codes and standards and instrumentation design and calibration. This course also includes "hands-on" operation of minicomputer and microcomputer acoustic emission systems. This course is designed for potential users of acoustic emission structural monitoring systems.

Contact: C.A. Parker, Nuclear Training Center, Atomics International, P.O. Box 309, Canoga Park, CA 91304 - (213) 341-1000, Ext. 2811.

INSTRUMENTATION FOR MECHANICAL ANALYSIS

Dates: June 25-29, 1979
Place: University of Michigan
Objective: Emphasis is on the use of instruments by non-electrical engineers to analyze systems. Attendees will use a wide range of transducers and associated instrumentation. Lectures are devoted to theory and hands-on laboratory work and demonstrations.

Contact: Engineering *Summer Conferences,* 200 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109.

MACHINERY VIBRATIONS SEMINAR

Dates: June 26-28, 1979 & October 23-25, 1979
Place: Mechanical Technology Inc., Latham, NY
Objective: To cover 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 analysis and diagnosis of rotor vibration problems; and an appreciation of how these techniques are applied to correct vibration problems. Technical personnel who will benefit most from this course are those concerned with the rotor dynamics evaluation of motors, pumps, turbines, compressors, gearing, shafting, couplings, and similar mechanical equipment. The attendee should possess an engineering degree with some understanding of mechanics of materials and vibration theory. Appropriate job functions include machinery designers; and plant, manufacturing, or service engineers.

Contact: Mr. Paul Babson, MTI, 968 Albany-Shaker Rd., Latham, NY 12110 - (518) 785-2371.

JULY

FINITE ELEMENT METHOD IN MECHANICAL DESIGN

Dates: July 23-27, 1979
Place: University of Michigan
Objective: Applications of the finite element method to practical problems of stress analysis and design are covered. Also included is the derivation of the

method from energy principles. Graphics used for data preparation and interpretation of results will be presented.

Contact: Engineering Summer Conferences, 200 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109.

AUGUST

THE SCIENTIFIC AND MATHEMATICAL FOUNDATIONS OF ENGINEERING ACOUSTICS

Dates: August 13-24, 1979
Place: Massachusetts Institute of Technology
Objective: The program emphasizes those parts of acoustics -- the vibration of resonators, properties of waves in structures and air -- the generation of sound and its propagation that are important in a variety of fields of application. The mathematical procedures that have been found useful in developing the desired equations and their solutions, and the processing of data are also studied. These include complex notation, fourier analysis, separation of variables, the use of special functions, and spectral and correlation analysis.

Contact: Richard H. Lyon, Massachusetts Institute of Technology, Room 3-366, Dept. of Mech. Engrg., Cambridge, MA 02139.

SEPTEMBER

DIGITAL SIGNAL PROCESSING

Dates: September 18-20, 1979
Place: Washington, D.C.
Objective: This seminar covers theory, operation and applications -- plus additional capabilities such as transient capture, amplitude probability, cross spectrum, cross correlation, convolution coherence, coherent output power, signal averaging and demonstrations.

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

OCTOBER

VIBRATION CONTROL

Dates: October 8-12, 1979
Place: The Pennsylvania State University
Objective: The seminar will be of interest and value to engineers and scientists in industry, government, and education. Topics include dynamic mechanical properties of viscoelastic materials; structural damping; isolation of machinery vibration from rigid and nonrigid substructures; isolation of impact transients; reduction of vibration in beams, plates, and shells; reduction of the flow-induced vibration of complex structures; case histories in vibration reduction; and characteristics of multi-resonant vibrators.

Contact: Professor John C. Snowdon, Seminar Chairman, Applied Research Lab., The Pennsylvania State University, P.O. Box 30, State College, PA 16801 - (814) 865-6364.

NOVEMBER

DYNAMIC ANALYSIS WORKSHOP

Dates: November 5-9, 1979
Place: San Diego, California
Objective: This course will cover the latest techniques of analyzing noise and vibration in rotating machinery and power-driven structures. The workshop will cover both the theory and practical aspects of tracking down malfunctions and preventing failures caused by unbalance, misalignment, wear, oil whirl, etc. Included in the course will be demonstrations and practical, hands-on experience with the latest noise and vibration instrumentation; Real Time Analyzers, FFT Processors, Transfer Function Analyzers and Computer-Controlled Modal Analysis Systems. Actual case histories and specific machinery signatures will be discussed.

Contact: Spectral Dynamics Training Manager, P.O. Box 671, San Diego, CA 92112 - (714) 565-8211.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

NOISE-CON '79
Machinery Noise Control
April 30-May 2, 1979

NOISE-CON 79, the 1979 National Conference on Noise Control Engineering, will be held at Purdue University in West Lafayette, Indiana, on April 30 - May 2, 1979.

The theme of NOISE-CON 79 is Machinery Noise Control. Several different sessions will be held in which both invited and contributed papers will be presented. Ten sessions are presently planned on the following topics: agricultural and construction equipment noise, forging and impact noise, metal cutting noise, noise of engines and components, diagnostic measurements, measurement of noise emission, noise of machine elements, hydraulic and pneumatic system noise, mining equipment noise and noise of home appliances.

In addition to the Conference, a Seminar emphasizing machinery noise control will be held on April 26-28. The purpose of this seminar is to acquaint individuals entering the field of noise control with the basic principles of acoustics and noise control.

For further information concerning the Conference, contact Joan McGlothlin, Conference Secretary, Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907 or call (317) 749-6323. For further information concerning the Seminar, contact the Institute of Noise Control Engineering, P.O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603 or call (914) 462-6719.

1979 DESIGN ENGINEERING ASME CONFERENCE & SEMINARS
McCormick Place, Chicago
May 7-10, 1979

Power Transmission Elements

The Fundamentals of the Design of Fluid Film Bearings - Part I
Wednesday, May 9: 9:00-11:00 A.M.
This is the first of two sessions, tutorial in nature, concerned with fundamentals of the design of fluid film bearings. In particular, this session introduces fluid film lubrication theory, high-speed bearing design, and the design of hydrostatic bearings.

The Fundamentals of the Design of Fluid Film Bearings - Part II
Wednesday, May 9: 3:30-5:30 P.M.
This is the second of two sessions, tutorial in nature, concerned with fundamentals of the design of fluid film bearings. In this session, the practical question of lubricant and bearing material selection are discussed. Topics related to the computer-aided design of dynamically-loaded journal and hybrid conical bearings are presented, as well as an introduction to oil whirl phenomena.

Analytical Approaches to Design

Practical Analysis Techniques - I
Mechanical Signature Analysis: Potentials and Applications
Monday, May 7: 9:30-11:30 A.M.
The scope and uses of signature analysis as a maintenance and diagnostic tool is presented. Various disciplines are involved in its application which

include modeling, instrumentation, signal processing, statistical evaluation and decision strategy. Various data reduction and processing methods (time, frequency and amplitude domain) are presented, and relative merits are discussed. Typical examples are presented in rotating machinery subcomponents and systems, illustrating merits and pitfalls.

Dynamic Digital Signals in Mechanism Analysis
Acquisition of dynamic signals in digital form is a significant forward step in the instrumentation field. Advantages when applied to the analysis of mechanisms are described. Simplicity of operation, alternative analyses, and immediate presentation of results are key features.

INTERNATIONAL TIRE NOISE CONFERENCE
Stockholm, Sweden
August 28-30, 1979

An international conference on exterior tire noise will be held August 28-30, 1979 at the Sheraton Hotel in Stockholm. The conference is being organized by the "Steering Committee for the STU Tire Noise Projects." It is sponsored by STU (The National Swedish Board for Technical Development).

The aims of the conference are to use today's knowledge as a base for reducing tire noise; unify the methods of measuring tire noise; and find a closer approach to the mechanisms of tire noise generation.

The subjects to be covered are: Regulation, standard and financial aspects of tire noise control; Measurement techniques recommended for standards, legislation and research; Road surface and tire properties specifications with respect to tire noise; Generating mechanisms and influence of parameter variations; and Practical techniques for reducing tire noise.

Papers for the final program of the conference will be selected before August 1979. For further information contact: National Swedish Board for Technical Development, Attn: Ms Inger Dunér, Private Bag, S-100 72 Stockholm, Sweden.

INTER-NOISE 80 IS ANNOUNCED

"Noise Control for the Eighties" will be the theme of INTER-NOISE 80, the ninth International Conference on Noise Control Engineering which will be held at the Hotel Intercontinental, Miami, Florida on December 8-10, 1980.

The conference will include Technical Sessions consisting of invited and contributed presentations on world-wide noise control technology as well as noise clinics and an exhibition of the latest equipment and instrumentation for noise control. A series of lectures on various aspects of "Noise Control for the Eighties" will be presented by recognized specialists in the field. The emphasis throughout will be on practical solutions to important noise control problems and a view of activities in noise control in the decade of the 1980s.

INTER-NOISE 80 is sponsored by the International Institute of Noise Control Engineering (INTERNATIONAL/INCE) and will be organized by the Institute of Noise Control Engineering of the United States of America, Inc., (INCE/USA). For further information, contact INTER-NOISE 80, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603.

INCE ELECTS NEW OFFICERS & DIRECTORS

John C. Johnson, Director of the Applied Research Laboratory of the Pennsylvania State University has been elected President-Elect of the Institute of Noise Control Engineering. Johnson will serve as President-Elect and as Executive Vice President during 1979 and will assume the Presidency of INCE in 1980. Elmer L. Hixson, William J. Galloway, and Malcolm J. Crocker were reelected as Vice President-Membership, Vice President-Technical Activities, and Vice President-Communications. George C. Maling, Jr. was elected to Vice President-Adminstration. James G. Seebold was elected Treasurer and Richard J. Peppin as Secretary of the Institute. In addition, five new Directors have been elected: Robert C. Chanaud, Robert M. Hoover, Frederick M. Kessler, Jiri Tichy, and William E. Zorumski. Zorumski was elected by the Board for a two-year term to fill the vacancy created by Harvey H. Hubbard who was the 1978 President-Elect and who now serves as President of INCE.

MECHANICAL FAILURES PREVENTION GROUP TO HOLD 29th SYMPOSIUM May 23-25, 1979

The 29th MFPG Symposium on "Advanced Composites: Design and Applications" will be held at Gaithersburg, Maryland, May 23-25, 1979.

Topics to be covered are Aerospace and Aircraft Applications & Design; Automotive Applications & Design; Industrial Applications & Design; Failure Modes in Advanced Composites; and Marine Applications & Design.

The complete program will be included in next month's issue of the DIGEST.

For further information contact J.E. Stern, Code 721, Goddard Space Flight Center, Greenbelt, MD 20771 - (301) 344-7657.

ACOUSTICAL SOCIETY PUBLISHES NEW NOISE DOSIMETER STANDARD

A new American National Standard, ANSI S1.25-1978 has been approved by the American National Standards Institute (ANSI) and published by the Acoustical Society of America (ASA). ASA holds the Secretariat for American National Standards Committee S1 on Acoustics which was responsible for the development of the standard.

The new standard contains specifications for performance characteristics of personal noise dosimeters which may be used to determine the noise exposure of people. The standard makes provision for two or more exchange rates, the trading of exposure duration with exposure level, to accomodate various governmental regulations. The standard provides tolerances for the entire instrument including frequency, exponential averaging, threshold, dynamic range and other characteristics. For further information contact Ms. Avril Brenig, ASA Standards Secretariat, 335 East 45th St., New York, NY 10017.

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 Commissioner 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

ANALYSIS AND DESIGN

ANALYTICAL METHODS

79-551

On the Use of Coordinate Stretching in the Numeral Computation of High Frequency Scattering

A. Bayliss
Inst. for Computer Applications in Science and Engrg., Langley Res. Center, NASA, Hampton, VA 23665, J. Sound Vib., 60 (4), pp 543-553 (Oct 22, 1978) 3 figs, 6 tables, 8 refs

Key Words: Aircraft noise, Acoustic scattering

The scattering of the sound of a jet engine by an airplane fuselage is modeled by solving the axially symmetric Helmholtz equation exterior to a long thin ellipsoid. The integral equation method based on the single layer potential formulation is used. A family of coordinate systems on the body is introduced and an algorithm is presented to determine the optimal coordinate system.

79-552

A Frontal-Based Solver for Frequency Analysis

L. Cedolin and R. Gallagher
Dept. of Structural Engrg., Cornell Univ., Ithaca, NY, Intl. J. Numer. Methods Engr., 12 (11), pp 1659-1666 (1978) 2 figs, 1 table, 8 refs

Key Words: Eigenvalue problems, Matrix methods, Lumped parameter method, Condensation method

An approach extending the capacity of the frontal solution algorithm of Irons to eigenvalue and eigenvector calculation is presented in this paper. The development given presumes that the mass matrix of the structure is available in diagonal, or lumped form. The procedure described makes use of different aspects of the frontal solver to: perform a condensation of the degrees-of-freedom with which no mass is associated; conduct a determinant search of the reduced system of equations to calculate the eigenvalues; and perform a final calculation for the complete eigenvectors.

79-553

An Accurate Method of Dynamic Condensation in Structural Analysis

A.Y. Leung
Dept. of Aeronautical Engrg., Univ. of Bristol, Bristol, UK, Intl. J. Numer. Methods Engr., 12 (11), pp 1705-1715 (1978) 4 figs, 3 tables, 8 refs

Key Words: Eigenvalue problems, Condensation method

A new and efficient method of dynamic condensation is presented. It reduces the order of dynamic matrices. The resulting frequency dependent eigenvalue problem is solved by a combined technique of Sturm sequence and subspace iteration. Examples are given for a space frame and substructure problem. Results are compared to the complete solution.

79-554

Condensation: A Method of Calculation for Reducing the Degrees of Freedom in Structural Dynamics (Die Kondensation, ein Rechenverfahren zur Verringerung der Frei-Heitsgradanzahl bei Strukturdynamik-Aufgaben)

H. Rohrle
Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 403-423 (Mar 23, 1978) 11 figs, 4 tables, 11 refs (In German)

Key Words: Condensation method, Reduction methods, High frequency response

The condensation method is a calculation method in structural dynamics for reducing the degrees of freedom describing the calculation model. Besides the static condensation method, which is suitable for the fundamental vibrations, the dynamic condensation method is explained. It is applied to the calculation of high-frequency vibrations and is also used iteratively. The manifold possibilities, limits, and work involved in the static and dynamic condensation are shown by means of theory and examples.

NUMERICAL ANALYSIS

(Also see No. 602)

79-555

Dual Formulations for Acusto-Structural Vibrations

B. Tabarrok

Dept. of Mech. Engrg., Univ. of Toronto, Toronto, Canada, Intl. J. Numer. Methods Engr., 13 (1), pp 197-201 (1978) 1 fig, 3 refs

Key Words: Numerical analysis, Coupled response, Acoustic excitation

Among the variety of numerical procedures for the solution of acousto-structural vibration problems in aeronautical engineering are those based on variational statements. In these procedures certain functions which satisfy prescribed admissibility requirements of the variational statement are selected and the functional is extremized. Depending upon the admissibility restrictions, a variety of functionals can be used for the determination of modes and frequencies of an elastodynamic system.

79-556

Numerical Calculations of Non-deterministic Vibrations (Numerische Berechnung Nicht-deterministischer Schwingungen)

E. Gossmann and H. Waller

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 332-351 (Mar 23, 1978) 8 figs, 8 refs

(In German)

Key Words: Numerical analysis

The various methods of numerical integration in connection with time-history computations are discussed. Linear differential equations in vibration theory can be solved with such methods as transition matrices, modal analysis or integral-transformations. Nonlinear problems must be calculated with one- or multi-step integration formulas or extrapolation techniques. Finally, it is shown how multistate random processes can be simulated using a digital computer.

79-557

Numerical Solution of Differential Equations by Means of Integration Matrices (Numerische Lösung von Differentialgleichungen mit Hilfe von Integrationsmatrizen)

H. Rubin

Inst. f. Baustatik u. Messtechnik, Univ. Kaiserstrasse 12, D-7500 Karlsruhe 1, Federal Rep. of Germany, Ing. Arch., 47 (5), pp 303-314 (1978) 3 figs, 2 tables, 3 refs

(In German)

Key Words: Numerical analysis, Differential equations, Rods, Follower forces

A numerical integration method is discussed solving differential equations of any required accuracy. Integral- and integral-differential equations are also covered. The required matrices and vectors for one to four time integrations are derived for the case of equally spaced intervals. Boundary conditions are taken into account and the application of the method is demonstrated on a rod subjected to tangential follower forces. The eigenvalues are calculated using the theory of the kinetic stability. The four most important support conditions are treated.

OPTIMIZATION TECHNIQUES

79-558

An Algorithm for Optimal Structural Design with Frequency Constraints

J. Kiusalaas and R.C.J. Shaw

Dept. of Engrg. Science and Mechanics, The Pennsylvania State Univ., University Park, PA, Intl. J. Numer. Methods Engr., 13 (2), pp 283-295 (1978) 4 figs, 21 refs

Key Words: Optimization, Minimum weight design, Natural frequencies, Structural members, Finite element technique

This paper presents a finite element method for minimum weight design of structures with lower-bound constraints on the natural frequencies and upper and lower bounds on the design variables. The design algorithm is essentially an iterative solution of the Kuhn-Tucker optimality criterion.

79-559

Second Order Approximation of Natural Frequency Constraints in Structural Synthesis

H. Miura and L.A. Schmit, Jr.

School of Engrg., Univ. of Southern California, Los Angeles, CA, Intl. J. Numer. Methods Engr., 13 (2), pp 337-351 (1978) 7 figs, 1 table, 9 refs

Key Words: Structural synthesis, Optimization, Natural frequencies

Structural optimization problems with constraints imposed on natural frequencies are studied, giving special attention to the inherent non-linearity of natural frequency constraints. Assuming that the system mass and stiffness matrices are expressed as linear functions of the design variables, it is shown that there are two sources of non-linearity for natural frequencies in such a design space. Recognizing the inherent non-linear characteristics of natural frequency constraints, a second order Taylor series approximation for each eigenvalue of the equations of motion is derived and applied successfully to improve stability and overall efficiency of the automated synthesis process.

STATISTICAL METHODS

(Also see No. 640)

79-560

Combination Resonance of a Stochastically Excited Vibrating System (Kombinationsresonanz eines stochastisch erregten Schwingungssystems)

R. Model

Zentralinstitut f. Mathem. u. Mech., der Akad. d. Wissenschaften d. DDR, 108 Berlin, Mohrenstrasse 39, East Germany, Z. angew. Math. Mech., 58 (8), pp 377-382 (Sept 1978) 5 figs, 6 refs

(In German)

Key Words: Parametric excitation, Stochastic processes, Resonant response

The combination resonance of a nonlinear vibrating system excited parametrically by narrow-band random forces is investigated. The application of the integral equation method leads to approximated formulae for the probability densities of the two response amplitudes. The results are evaluated numerically in dependence of the linear and nonlinear damping.

VARIATIONAL METHODS

79-561

Systematization of Variational Principles of Elasticity Theory and Their Application to the Finite Element Technique (Ein Beitrag zur Systematisierung von Variationsprinzipien der Elastizitatstheorie und zu ihrer Verwendbarkeit für Finite-Element-Verfahren)

K. Knothe

Technical Univ., Berlin, Inst. f. Luft- und Raumfahrt, Salzufer 17/19, Geb. 4.1, 1 Berlin 10, West Germany, Z. angew. Math. Mech., 58 (9), pp 405-412 (Sept 1978) 4 figs, 1 table, 6 refs

(In German)

Key Words: Variational methods, Finite element technique

This paper presents a systematic synopsis on variational principles with relaxed continuity requirements for linear elastic continua. Two-field functionals with deformations and stresses such as unknown functions and one-field functionals derived therefrom are considered. The general applicability of these variational principles for finite element procedures is evaluated.

FINITE ELEMENT MODELING

79-562

Application of the Finite Element Technique (Zur Anwendung der Methode der finiten Elemente)

E. Giencke

Technical Univ., Berlin, West Germany, Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Republic of Germany, Rept. No. CR1-K1/78, pp 47-71 (Mar 23, 1978) 10 figs, 1 table, 7 refs

(In German)

Key Words: Finite element technique

In this paper the modeling of the real structure to a finite element model is treated to smear out stiffnesses to a continuum and to concentrate the distributed mass to lumped masses. References are given for the choice of the element size. The duality between the problems is shown.

PARAMETER IDENTIFICATION

79-563

Identification by Means of Parametric Models and Estimation Methods (Identifikation mit parametrischen Modellen und Schatzverfahren)

N. Cottin

Lehrstuhl f. Schwingungs- und Messkunde, Curt-Risch-Institut, TU Hannover, Aeroelastic Problems

Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 102-140 (Mar 23, 1978) 6 figs, 18 refs
(In German)

Key Words: Parameter identification technique

Methods for the determination of dynamic parameters of vibrating elastomechanical structures by means of experimental system analysis (system identification) are presented. The methods differ by the type of models used, mathematical procedures applied, and the manner by which stochastic noise is taken into account.

CRITERIA, STANDARDS, AND SPECIFICATIONS

79-564

Design Standardization for Wind Loads (Normung der Windlastannahmen)

H. Hirtz

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Republic of Germany, Rept. No. CR1-K1/78, pp 450-458 (Mar 23, 1978)
(In German)

Key Words: Standards, Buildings, Bridges, Structural members, Wind-induced excitation

The author describes the shortcomings of various regulations and safety calculations, as presented by German Standards, for the determination of natural wind loads on structures and structural components.

79-565

Seismic Instrumentation for Nuclear Power Plants: An Interpretative Review of Current Practice and the Related Standard in Germany

M. Bork and H.J. Kaestle

Kerntechnischer Ausschuss (KTA), Geschäftsstelle bei der GRS, D-5000 Köln 1, Federal Rep. of Germany, Nucl. Engr. Des., 50, pp 347-352 (Oct 1978) 2 figs, 1 table

Key Words: Nuclear power plants, Seismic design, Standards and codes

The German nuclear safety standard KTA 2201: "Design of nuclear power plants against seismic events," consists of the following parts: 1. basic principles; 2. characteristics of seismic excitation; 3. design of structural components; 4. design of mechanical and electrical parts; 5. seismic instrumentation; and 6. measures subsequent to earthquakes. The requirements of the safety standard KTA 2201.5 deal with the number of location (number and location of acceleration recording systems for different sites, single-block plants and multi-block plants); the characteristics of instruments (readiness and operation of instruments, margin or errors, dynamic and operation characteristics, duration of records, seismic switch); triggering and information (loss of electric power, start of the acceleration recording systems, threshold of acceleration for triggers and seismic switches, optical and acoustic information); and documentation (results of recordings, inspection and tests). The purpose of this paper is to present some detailed requirements of the safety standard KTA 2201.5, with its philosophy, and compare these with corresponding requirements in the US.

SURVEYS AND BIBLIOGRAPHIES

79-566

Critical Evaluation of the German Standard DIN 4133 by Considering Measurement Results Taken at Natural Wind Conditions (Kritische Auseinandersetzung mit der DIN 4133 unter Berucksichtigung von Messergebnissen im naturlichen Wind)

W.-J. Gerasch

Lehrstuhl f. Schwingungs- und Messkunde, Curt-Risch-Institut, TU Hannover, Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 581-606 (Mar 23, 1978) 9 figs, 8 refs
(In German)

Key Words: Buildings, Vibration measurement, Standards

Long term measurements of the oscillations were carried out on three slender buildings with a circular cross section and on one building with a rectangular cross section. The criteria for the selection of the buildings are identified damages, and observed high amplitude oscillations or oscillation measurements required according to the DIN 4133. The report describes the practical measurements performed on the buildings and evaluated the results. Suggestions for adapting the standard to objective conditions are developed.

MODAL ANALYSIS AND SYNTHESIS

79-567

Substructure Methods in Dynamic Investigations (Substrukturmethoden bei dynamischen Untersuchungen)

H.G. Natke

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 17-46 (Mar 23, 1978) 4 figs, 4 tables, 10 refs (In German)

Key Words: Component mode synthesis

The partition of structures of large technical objects into substructures yields advantages in structural analysis as well as in identification by reducing the expenditure of computational work. The dynamic investigation of the total structure is done by coupling the substructures (synthesis) by an expression according to the Ritz method. Following an introduction in the substructure methods a formalism is given to discrete, linear substructures with rigid coupling. Approximated formalisms and their errors are given when modifying the exact equations. The modal statement is discussed and demonstrated by a calculated example concerning the free structure.

COMPUTER PROGRAMS

GENERAL

(See No. 571)

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 648, 649)

79-568

The Application of Coherence Function Techniques for Noise Source Identification

M.E. Wang

Ph.D. Thesis, Purdue Univ., 321 pp (1978)
UM 7821515

Key Words: Noise source identification, Coherence function technique

The application of coherence function techniques for noise source identification is investigated. Two different but related approaches are studied. The concept of the frequency response function and the coherent residual spectral density function are employed. In both approaches the noise generation system with multiple noise sources is modeled as a multiple-input, linear, time-invariant system. The inputs of the model are the noise signals measured by microphones placed close to the selected noise sources and the output is the noise measured by a remote microphone.

79-569

Theoretical and Experimental Studies of Acoustic Propagation in Inhomogeneous Moving Media

S. Candel

European Space Agency, Paris, France, Rept. No. ESA-TT-477; ONERA-P-1977-1, 315 pp (June 1978)
N78-30909

Key Words: Sound waves, Wave propagation, Nozzles, Wind tunnel tests, Numerical analysis

Three problems are treated: the propagation of plane and modal pressure waves in nozzles and diffusers; the adiation of the jet noise high-frequency components; and the propagation of an acoustic field in the free flow of an open wind tunnel. A numerical algorithm based on the geometrical approximation is developed and allows the calculation of the wave field (amplitude and phase) in the case of very general media (inhomogeneous, dispersive, including reflecting surfaces). A comparison between calculations and experimental results obtained in an open wind tunnel is made to check the proposed numerical method and to demonstrate its practical utility.

79-570

Flight Effects on the Aerodynamic and Acoustic Characteristics of Inverted Profile Coannular Nozzles

H. Kozlowski and A.B. Packman

Pratt and Whitney Aircraft Group, East Hartford, CT, Rept. No. NASA-CR-3018, 197 pp (Aug 1978)
N78-32836

Key Words: Nozzles, Jet noise, Wind tunnel tests, Noise measurement

The effect of forward flight on the jet noise of coannular exhaust nozzles, suitable for Variable Stream Control Engines (VSCE), is investigated in a series of wind tunnel tests. The primary stream properties are maintained constant at 300 mps and 394 K. A total of 230 acoustic data points is obtained. Force measurement tests using an unheated air supply covered the same range of tunnel speeds and nozzle pressure ratios on each of the nozzle configurations.

SEISMIC

(Also see Nos. 565, 621, 685)

79-571

Optimum Structural Design for Simultaneous Multi-component Static and Dynamic Inputs

F.Y. Cheng and D. Srifuengfung
Dept. of Civil Engrg., Univ. of Missouri-Rolla, MO,
Intl. J. Numer. Methods Engr., 13 (2), pp 353-371 (1978) 15 figs, 23 refs

Key Words: Seismic design, Computer-aided techniques, Design techniques, Computer programs

The method of optimality criterion and recursion procedure is employed for the design of braced and unbraced structural systems subject to various static and dynamic forces. The dynamic excitations can be applied forces, ground motions, or the equivalent seismic forces of the Uniform Building Code (UBC).

79-572

A Note on Probabilistic Computation of Earthquake Response Spectrum Amplitudes

J.G. Anderson and M.D. Trifunac
Dept. of Civil Engrg., School of Engrg., Univ. of Southern California, University Park, Los Angeles, CA 90007,
Nucl. Engr. Des., 50 (2), pp 285-294 (Oct 11, 1978) 6 figs, 2 tables, 18 refs

Key Words: Earthquake damage, Damage prediction

This paper analyzes a method for computation of Pseudo Relative Velocity (PSV) spectrum and Absolute Acceleration (SA) spectrum so that the amplitudes and the shapes of these spectra reflect the geometrical characteristics of the seismic environment of the site. The estimated spectra also incorporate the geologic characteristics at the site, direction of ground motion and the probability of exceeding these motions. An example of applying this method in a realistic setting is presented and the uncertainties of the results are discussed.

79-573

Earthquake Response of Linear Continuous Systems

G. Ahmadi
Dept. of Mech. Engrg., School of Engrg., Pahlavi Univ., Shiraz, Iran,
Nucl. Engr. Des., 50, pp 327-345 (Oct 1978) 53 refs

Key Words: Earthquake excitation, Beams, Bernoulli-Euler method, Plates

The response of a general elastic linear continuous system to earthquake ground motion is considered. The existing stochastic models of earthquake strong motion are briefly reviewed. The general expressions for the power spectrum and correlation functions as well as the mean-square response are derived. It is shown that for small damping coefficients, relatively simple results for the mean-square response functions can be obtained. The reliability of design is considered and the probability of barrier crossing is discussed. This paper is concluded by consideration of examples of earthquake responses of Euler-Bernoulli beams, nonuniform shear beams, and uniform plates.

SHOCK

79-574

Side Impact - Crucial Point for Motor Vehicle Development (Seitenaufprall - Schwerpunkt für die Fahrzeugentwicklung)

Automobiltech. Z., 80 (10), pp 465-468 (Oct 1978) 13 figs, 3 tables, 5 refs
(In German)

Key Words: Collision research (automotive), Testing techniques

Vehicle to vehicle collision tests and moving rigid barrier into the side of the vehicle tests are described. Representative test procedures for the simulation of lateral accidents are discussed.

79-575

Low-Cycle Fatigue Tests of Hollow Concrete Spheres with Implications for the Survivability of Deep-Underground Rock Openings

M.B. Balachandra, C.F. Bagge, and H.H. Haynes
Agbabian Associates, El Segundo, CA, Rept. No. AA-R-7740-4551, DNA-4433F, AD-E300 275, 140 pp (Apr 1978)
AD-A058 365/8GA

Key Words: Hardened installations, Underground structures, Nuclear weapons effects, Fatigue tests

This investigation comprises tests and data analyses to examine the significance of low-cycle fatigue damage inflicted on deep-underground rock openings subjected to ground shock from sequential, multiple bursts of nuclear weapons. Nine hollow concrete spheres, reinforced with steel-wire fibers, are instrumented and tested under cyclic, hydrostatic loads in a pressure vessel. Strain gages are mounted on the inner surface and inside the wall to detect the onset of in-plane cracking and to monitor the progressive degradation of the test specimens. Cylinders cast at the same time as the spheres are tested to define the material properties. Fatigue curves are prepared from the cyclic test data and a power law equation was fitted. A methodology was developed for designing a failure mode to meet a survivability goal or to assess the survivability of a design.

79-576

The Propagation of Sound from Quarry Blasting

M.J. Griffiths and J.A.H. Oates
Imperial Chemical Industries Limited, Buxton, Derbyshire, UK, J. Sound Vib., 60 (3), pp 359-370 (Oct 8, 1978) 11 figs, 2 tables, 5 refs

Key Words: Mines (excavation), Sound propagation, Explosions

Experimentally obtained information is presented for some of the parameters upon which depend the propagation of sound from various types of quarry blasting. These include distance, wind direction, alignment of the quarry face, and barriers such as hills. The relationships derived from observations at one quarry were shown to apply to similar blasts at two other quarries.

79-577

Generalized Poisson Shock Models

S.M. Ross
Operations Res. Center, California Univ., Berkeley, CA, Rept. No. ORG-78-6, 10 pp (Apr 1978)
AD-A058 510/9GA

Key Words: Shock response, Damage, Stochastic processes, Mathematical models

When shocks hit a device in accordance with a nonhomogeneous Poisson process with intensity function lambda the shock causes a damage assumed to be independent and identically distributed positive random variables. The data processing aspect of this work is improved in this report.

GENERAL WEAPON

79-578

Prediction of Constrained Secondary Fragment Velocities

P.S. Westine and J.H. Kineke, Jr.
Southwest Research Inst., San Antonio, TX, Shock Vib. Bull., U.S. Naval Res. Lab., Proc., Vol. 48, Pt. 2, pp 183-190 (Oct 18-20, 1977) 4 figs, 1 table

Key Words: Explosives

A nondimensionalized solution for estimating the specific impulse imparted to flat surfaces, cylindrically shaped bodies, and spherically shaped objects in the vicinity of cylindrical explosive charges is presented. The second solution shows how to estimate the velocity of fragments which had been constrained cantilever and clamped-clamped beams of any material and cross-sectional area by accounting for the structural strain energy associated with fracturing these structural components at their supports.

PHENOMENOLOGY

DAMPING

79-579

Analysis of Errors in Investigating the Complex Modulus of Viscoelastic Materials by the Coated Beam Method

T. Pritz

Central Res. and Design Inst. for Silicate Industry, 1034 Budapest, Becsi ut 126/128, Hungary, J. Sound Vib., 60 (3), pp 319-334 (Oct 8, 1978) 10 figs, 11 refs

Key Words: Viscoelastic media, Vibration dampers, Complex modulus, Coatings, Coated beam method, Error analysis

The coated beam method has been used extensively for investigating the dynamic elastic characteristics of vibration damping materials. With this method, the beam is coated with the damping material on one side, or on both sides, and the resonances of bending vibration of the metal and coated beam are investigated for the determination of the dynamic characteristics. A complete error analysis for both beams is discussed. Relationships and diagrams are given by which the error in the dynamic characteristics can be calculated. Measurement results are discussed that can be well explained on the basis of the error analysis performed.

FLUID

(Also see Nos. 555, 564, 608, 609, 635, 636, 637, 638, 639, 641, 652, 653, 657, 658, 664, 705, 707, 708, 709, 710)

79-580

A Displacement Method for the Analysis of Vibrations of Coupled Fluid-Structure Systems

M.A. Hamdi, Y. Ousset, and G. Verchery

Centre Technique des Industries Mecaniques/(CETIM), Senlis, France, Intl. J. Numer. Methods Engr., 13 (1), pp 139-150 (1978) 7 figs, 10 refs

Key Words: Interaction: structure-fluid, Harmonic response, Coupled response, Finite element technique

A variational principle in terms of displacements in the fluid and the structure with a penalty for irrotationality of displacement in the fluid is developed for the analysis of harmonic vibrations of ideal compressible fluid and elastic structure systems. Its discretization by the finite element method leads to an algebraic eigenvalue problem with a positive definite symmetric banded matrix. Numerical examples are obtained for pure acoustic and coupled cases.

79-581

Equations of Motion and Two-Equation Turbulence Model for Plane or Axisymmetric Turbulent Flows in Body-Oriented Orthogonal Curvilinear Coordinates and Mass-Averaged Dependent Variables

J.P. Sislian

Inst. for Aerospace Studies, Toronto Univ., Ontario, Canada, Rept. No. NASA-CR-3025; UTIAS-225, 49 pp (Aug 1978)

N78-30552

Key Words: Equations of motion, Turbulence, Mathematical models

The full Navier-Stokes time-dependent, compressible, turbulent, mean-flow equations in mass-averaged variables for plane or axisymmetric flow are presented. The equations are derived in a body-oriented, orthogonal, curvilinear coordinate system. Turbulence is modeled by a system of two equations for mass-averaged turbulent kinetic energy and dissipation rate proposed. These equations are rederived and some new features are discussed. A system of second order boundary layer equations is then derived which includes the effects of longitudinal curvature and the normal pressure gradient.

SOIL

(Also see No. 592)

79-582

Structural Response of Earth Penetrators in Angle-of-Attack Impacts

J.D. Colton

SRI International, Menlo Park, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc., Vol 48, Pt. 2, pp 131-141 (Oct 18-20, 1977) 8 figs, 7 refs

Key Words: Penetration, Soils

An analysis based on a one-dimensional beam-mass model is developed to predict the early-time response of penetrator structures in angle-of-attack impacts. It was found that the peak compressive strain, which determines whether or not the penetrator casing fails, depends on the magnitude of the lateral load produced by impacts at an angle of attack, the load rise time (which is inversely proportional to impact velocity), and the relative mass of the nose and aft sections. By relating the loading to the impact conditions through empirical data, a procedure was devised to characterize the strength of penetrator structures in terms of impact velocity and angle of attack.

VISCOELASTIC

(Also see Nos. 579, 601)

79-583

An Experimental Determination of the Dynamic Young's Modulus of Selected Viscoelastic Materials

V.M. Maza

Appl. Research Lab., Pennsylvania State Univ., University Park, PA, Rept. No. ARL/PSU/TM-76-313, 77 pp (Dec 14, 1976)

AD-A058 465/6GA

Key Words: Elastomers, Vibration isolators, Viscoelastic properties, Modulus of elasticity

In this study, results of the dynamic characteristics of the Young's modulus over a wide range of frequencies are obtained for eight different elastomers. Samples of the different viscoelastic materials are attached to an oscillator and different vibratory frequencies are excited.

EXPERIMENTATION

BALANCING

79-584

Practical Considerations for a Rated Speed Shop Balance

E.A. Bulanowski, Jr.

Res. and Advanced Product Dev., Delaval Turbine, Inc., Trenton, NJ, Gas Turbine Labs., Proc., 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 87-94 (Dec 5-7, 1978) 5 figs, 3 tables, 3 refs

Key Words: Balancing techniques, Rotors, Turbomachinery

The present paper develops the aspects of flexible rotor balancing which should be evaluated when considering the necessity and benefits of a rated speed balance. Three classes of industrial turbomachine rotors are investigated using a "rotor response" and an "influence coefficient" computer balance program. These results illustrate the concepts established in the analysis and present a practical example of how the influence coefficient and modal balancing methods complement one another, resulting in a complete approach to balancing.

79-585

A Procedure for Force-Balancing Planar Linkages Using Counterweights

K. Oldham and M.J. Walker

Dept. of Mech. Engrg., The Univ. of Newcastle upon Tyne, UK, J. Mech. Engr. Sci., 20 (4), pp 177-182 (Aug 1978) 6 figs, 5 refs

Key Words: Balancing techniques, Linkages

This paper presents a procedure for obtaining the conditions for a full force-balance of a planar linkage. It includes a check on whether a full force-balance is possible where the presence of prismatic joints or links that cannot be counterweighted for some reason may preclude this. The procedure automatically uses the minimum number of counterweights and keeps the added inertia low. An example demonstrates the advantages of the procedure over those methods that require the derivation of the kinematic equations of motion for the linkage.

DIAGNOSTICS

(Also see No. 620)

79-586

Compressor Response to Synchronous Motor Startup

G.K. Mruk

Joy Manufacturing Co., Buffalo, NY, Gas Turbine Labs., Proc., 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 95-101 (Dec 5-7, 1978) 13 figs, 1 ref

Key Words: Diagnostic instrumentation, Compressors, Synchronous motors, Torsional vibration

Mathematical models for the shaft system of a coupled compressor are solved by direct integration on both analog and digital computers. Important aspects of the model include: representation of the electrical power feed network for the motor, an equivalent circuit description of the motor itself, and a non-linear characterization of the shafts and couplings connecting the compressors to the motor.

79-587

Using Modified Acoustic Emission Techniques for Machinery Condition Surveillance

H.P. Bloch and R.W. Finley

Exxon Chemical Co., Baytown, TX, Gas Turbine Labs., Proc., 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 139-158 (Dec 5-7, 1978) 42 figs, 20 refs

Key Words: Acoustic techniques, High frequency resonance technique, Machinery

Acoustic emission is the release of high frequency sound energy in a material under strain. Design concepts and field experience with advanced, second generation acoustic IFD (incipient failure detection) systems are described and many actual incipient failure warning events illustrated in detail.

EQUIPMENT

79-588

Combined Tension-Torsion Impact Testing Apparatus and an Experimental Study in the Incremental Wave Propagation

S. Tanimura, H. Igaki, H. Majima, and M. Tada

College of Engrg., Univ. of Osaka Perfecture, Osaka, Japan, Bull. JSME, 21 (160), pp 1455-1461 (Oct 1978) 13 figs, 16 refs

Key Words: Testing apparatus, Wave propagation

The experimental methods to examine the existence of the instantaneous plastic property and to obtain a practical form of the general equation are given. Combined tension-torsion impact testing apparatus with special mechanics is designed. In an experiment of specimens, the analogous phenomena to the instantaneous plastic response were observed for both materials.

INSTRUMENTATION

79-589

Data Acquisition Systems for the Immediate Future

J.F. Schneider

Civil Engrg. Research Div., Air Force Weapons Lab., Kirtland AFB, NM, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 48th Symp. on Shock and Vibration; Huntsville, AL, Vol. 48, Pt. 4, pp 127-137 (Oct 18-20, 1977) 7 figs, 1 table, 4 refs

Key Words: Environmental effects, Data processing, Digital techniques

This paper addresses the acquisition problems with transient data in an extremely hostile environment. Digital techniques have become attractive due to rapid progress in semiconductor technology. The most important feature of digital systems is the reduction of data uncertainties by an order of magnitude. Two digital systems are considered. One is the analog multiplex system that transmits data in real time. Application guides and formulae are given for all systems, and a comparison is presented which lists respective system merit parameters for similar data handling requirements.

79-590

Torsional Vibration Measurement on Rotating Machinery

W. Vesser

Tektronix Inc., Noise Control Vib. Isolation, 9 (8), pp 327-328 (Oct 1978) 6 figs

Key Words: Torsional vibration, Vibration measurement, Measuring instruments

Various ways of measuring torsional vibration are presented.

79-591

The Estimation of Reliable Spectral Information When Recording Low Intensity Data

A.P. Jeary

Bldg. Research Station, Garston, Watford WD2 7JR, UK, J. Sound Vib., 60 (3), pp 401-409 (Oct 8, 1978) 9 figs, 7 refs

Key Words: Accelerometers, Data recorders, Buildings, Wind-induced excitation

The method is presented to facilitate more accurate interpretation of spectral information when recording very low level data. The noise introduced into the recorded data by the recording device is removed without a knowledge of excitation or input data being necessary.

TECHNIQUES

(Also see Nos. 574, 583, 590)

79-592

Dynamic Properties of Frozen Cohesionless Soils Under Cyclic Triaxial Loading Conditions. Volume II

T.S. Vinson, R.L. Czajkowski, and J.C. Li

Div. of Engrg. Res., Michigan State Univ., East Lansing, MI, Rept. No. MSU/CE-77/1, 303 pp (Jan 1977)

PB-284 952/9GA

Key Words: Frozen soils, Dynamic tests, Testing techniques

As part of a long-term study to evaluate dynamic properties of frozen soils under simulated earthquake and low frequency loading conditions, dynamic Young's moduli and damping ratios of several types of artificially frozen soils and ice at two densities are evaluated using cyclic triaxial test equipment. The scope of studies associated with the research program includes the development of the cyclic triaxial test system and experimental techniques employed to evaluate dynamic properties of frozen soils and ice, a discussion of the experimental results, and a comparison of the experimental results obtained in the present study to those obtained by previous investigators. The work presented in this volume is associated with the experimental techniques employed to evaluate dynamic properties of frozen cohesionless soils, a discussion of the experimental results, and a comparison of the experimental results of the present study to those obtained by previous investigators.

COMPONENTS

SHAFTS

79-593

Vibration Tests on Harbour Personnel Boat

G. Long and C.M. Bailey

Aeronautical Res. Labs., Melbourne, Australia, Rept. No. ARL/STRUC-TM-274, 22 pp (Apr 1978)

AD-A058 487/0GA

Key Words: Shafts (machine elements), Boats, Vibration tests

An investigation of the problem of excessive propeller shaft bearing wear which has occurred on a series of 10 metre harbour personnel boats constructed for the Royal Australian Navy is presented.

BEAMS, STRINGS, RODS, BARS

(Also see Nos. 573, 643)

79-594

Approximate Determination of the Dynamic Stiffness Coefficients of Beams

G.H. Sotiropoulos

Laboratory of Structural Analysis, Aristotle Univ. of Thessaloniki, Greece, Ing. Arch., 47 (5), pp 319-327 (1978) 3 figs, 2 tables, 11 refs

Key Words: Beams, Stiffness coefficients

Approximate frequency dependent functions are presented for the calculation of beam element dynamic stiffness influence coefficients, i.e. time dependent end forces and moments due to harmonic unit end displacements and rotations. The method proposed is placed between the exact and the consistent mass method trying to combine accuracy offered by the first with formulation's simplicity offered by the second.

79-595

Frequency and Loss Factors of Sandwich Beams Under Various Boundary Conditions

D.K. Rao

Indian Inst. of Tech., Kharagpur, West Bengal, India, J. Mech. Engr. Sci., 20 (5), pp 271-282 (Oct 1978) 13 figs, 2 tables, 18 refs

Key Words: Beams, Sandwich structures, Equations of motion, Boundary condition effects, Energy methods

Exact and approximate frequency and loss factors of sandwich beams are presented. A complete set of equations of motion and boundary conditions governing the vibration of sandwich beams are derived by using the energy approach. They are solved exactly for important boundary conditions. These results are presented in the form of design graphs and formulae, and their usage is illustrated by examples.

79-596

Dynamic Behaviour of a Beam Subjected to a Force of Time-Dependent Frequency (Continued)

S.-I. Suzuki
Dept. of Aeronautics, Nagoya Univ., Nagoya, Japan,
J. Sound Vib., 60 (3), pp 417-422 (Oct 8, 1978) 5 figs, 7 refs

Key Words: Beams, Periodic excitation, Critical speeds

The dynamic behavior of a beam is investigated in detail when the (radian) frequency of an external force passes through the first critical one ω_1 of the beam, increasing or decreasing. The case is also treated where the beam is subjected to constant axial force. Integrations involved in the theoretical results are carried out by Simpson's rule.

79-597

Free Wave Motion in Periodic Systems with Multiple Disorders

A.S. Bansal
Dept. of Mech. Engrg., Punjab Agricultural Univ., Ludhiana-141004, India,
J. Sound Vib., 60 (3), pp 389-400 (Oct 8, 1978) 6 figs, 11 refs

Key Words: Beams, Wave propagation, Flexural vibration

This paper presents a general method for the analyses of free wave propagation through mono-coupled periodic systems with multiple disorders. The method is applied to investigate the free flexural wave motion in infinite beam type systems on simple supports, comprising a large number of identically disordered repeating units. A more practical case of disorder due to unequal support spacings is considered. Flexural wave propagation in disordered periodic beams is compared to that in periodic beams. The effect of the disorder on the attenuation of free flexural waves in undamped and damped periodic beams is discussed.

79-598

Soil-Structure Interaction for Tower Structures

G.B. Warburton
Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham, UK,
Intl. J. Earthquake Engr. Struc. Dynam., 6 (6), pp 535-556 (Nov/Dec 1978) 8 figs, 4 tables, 21 refs

Key Words: Towers, Beams, Interaction: soil-structure, Harmonic response

The soil-structure system is modeled as a uniform vertical beam, which terminates in a base or foundation mass; this mass is attached to the surface of an elastic half-space. Using known force-displacement relations for the coupled vibrations of a rigid disc on an elastic half-space, the natural frequencies and response to a transverse harmonic force, applied at the tip of the beam, are determined through a continuum approach. Effectively the problem reduces to a beam with frequency-dependent boundary conditions. A brief study of the response of the structure to a free-field harmonic acceleration, applied at the soil-structure interface, suggests that interaction depends upon material and geometric properties of the system, rather than on the nature of the excitation.

79-599

Dynamic Interaction for Idealized Off-Shore Structures

G.B. Warburton and S.G. Hutton
Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham, UK,
Intl. J. Earthquake Engr. Struc. Dynam., 6 (6), pp 557-567 (Nov/Dec 1978) 9 figs, 5 refs

Key Words: Off-shore structures, Beams, Harmonic response, Interaction: structure-fluid

The structure is idealized as a uniform slender beam of circular cross-section which supports a rigid tip mass and which is connected at its base to a rigid foundation mass, the latter being attached to the surface of a viscoelastic half-space. An analytical solution for harmonic response of the partially submerged structure is obtained in terms of the normal modes of the corresponding structure in vacuo. This is achieved by introducing fluid-structure coupling into the model.

79-600

Vibrations of String with Time-Varying Length

T. Kotera
Faculty of Engrg., Kobe Univ., Rokkodai, Nada, Kobe, Japan,
Bull. JSME, 21 (160), pp 1469-1474 (Oct 1978) 5 figs, 6 refs

Key Words: Strings, Free vibration

Free vibrations of a string with time-varying length are analyzed. An equation of motion is the well-known wave equation. New variables of position and time are introduced and the equations of motion with respect to the new variables are solved by method of separation of the variables.

Eigenvalues (or eigenfrequencies) and eigenfunctions are determined; eigenfunctions have no orthogonality. Eigenfunctions and initial conditons are expanded into Fourier sine series and algebraic equations of infinite dimensions are introduced.

79-601

The Effect of Boundary Conditions on the Vibration of a Viscoelastically Damped Cantilever Beam

P. Trompette, D. Boillot, and M.-A. Ravanel
Laboratoire de Mecanique des Structure, Institut National des Sciences Appliquees de Lyon, 20, Avenue Albert Einstein, 69621 Villeurbanne Cedex, France, J. Sound Vib., 60 (3), pp 345-350 (Oct 8, 1978) 2 figs, 2 tables, 10 refs

Key Words: Cantilever beams, Viscoelastic damping, Viscoelastic core-containing media, Boundary condition effects

The dynamical behavior of a three-layer cantilever beam damped by a viscoelastic core is studied. Two selected boundary conditions are compared, one of them requiring the omission of the hypothesis used by several authors that the ratio of the longitudinal displacements in the elastic parts of the beam is constant. A finite element analysis and supporting experimental results indicate that the omission of this hypothesis may influence significantly the estimated value of the fundamental frequency.

79-602

Numerical Determination of Minimum Mass Structures with Specified Natural Frequencies

A. Miele, A. Mangiavacchi, B.P. Mohanty, and A.K. Wu
Rice Univ., Houston, TX, Intl. J. Numer. Methods Engr., 13 (2), pp 265-282 (1978) 16 tables, 17 refs

Key Words: Cantilever beams, Optimization, Natural frequencies, Minimum weight design, Numerical analysis

The problem of the axial vibration of a cantilever beam is investigated both analytically and numerically. The mass distribution that minimizes the total mass for a given value of the frequency parameter β is determined using both the sequential ordinary gradient-restoration algorithm (SOGRA) and the modified quasilinearization algorithm (MQA).

79-603

Structural Behavior of Layered Composites of Nonlinear Materials

W.-H. Feng
Ph.D. Thesis, Purdue Univ., 176 pp (1978)
UM 7821445

Key Words: Composite beams, Shock wave propagation, Forced vibration, Harmonic excitation

The fiber-reinforced composite is modeled by a medium consisting of layers of a nonlinear matrix material alternating with effective fibrous layers of linearly elastic material. A set of three dimensional constitutive equations for the gross composite is derived. The nonlinear terms are expressed in terms of octahedral strain. The propagation of shear waves through the nonlinear composite medium is studied. The stability of the shock front, the growth and decay of the shock waves, the distortion of the sinusoidal wave, and the particle velocity of the acceleration wave are investigated. A special type of layered composite, a sandwich beam with a core of nonlinearly elastic material, is considered. Equations of motion for this case are derived based on von Karman's large deflection theory. Shear deformation of the core and the extensional rigidity of the whole structure are taken into consideration in the analysis. A forced vibration problem of a sandwich beam subjected to a harmonic load is studied. Special attention is given to the effects of the physical and geometrical nonlinearities on the amplitudes and frequencies of the response. The higher harmonics induced by the nonlinearity are discussed. A simplified nonlinear sandwich beam theory for small deflection is developed.

79-604

Elastic Impact Between a Finite Conical Rod and a Long Cylindrical Rod

R.B. Gupta and L. Nilsson
Dept. of Mech. Engrg., Univ. of Lulea, Lulea, Sweden, J. Sound Vib., 60 (4), pp 555-563 (Oct 22, 1978) 6 figs, 1 table, 8 refs

Key Words: Rods, Elastic waves, Wave propagation

Elastic impact between a truncated finite conical rod and a long cylindrical rod is studied experimentally; analytically, by using one-dimensional wave theory to obtain a closed-form solution; and numerically, by using a three-dimensional axisymmetric finite element model. The results are compared for cones of different lengths but with the same end diameters.

BEARINGS

79-605

Dynamic Stiffness and Damping Coefficients of Aerostatic, Porous, Journal Bearings

N.S. Rao and B.C. Majumdar
Indian Inst. of Tech., Kharagpur, West Bengal, India,
J. Mech. Engr. Sci., 20 (5), pp 291-296 (Oct 1978) 9 figs, 12 refs

Key Words: Journal bearings, Dynamic stiffness, Damping coefficients, Perturbation theory

A perturbation method is given for calculating the dynamic stiffness and damping coefficients of aerostatic, porous, journal bearings. The effects of supply pressure, frequency of vibration, feeding parameter and porosity parameter on these two coefficients are investigated. A periodic (displacement) disturbance is imposed on an aerostatic, porous, journal bearing of finite length under steady-state conditions. The dynamic pressure distribution is obtained by a pressure perturbation analysis of Reynolds equation and a modified flow continuity equation in a porous medium. Dynamic stiffness and damping coefficients for different operating conditions are calculated numerically, using a digital computer, and presented in the form of design charts.

79-606

The Role of Subatmospheric Film Pressures in the Vibration Performance of Squeeze-Film Bearings

B. Humes and R. Holmes
School of Engrg. and Appl. Sci., The Univ. of Sussex, UK,
J. Mech. Engr. Sci., 20 (5), pp 283-289 (Oct 1978) 7 figs, 1 table, 5 refs

Key Words: Squeeze-film bearings, Mathematical models

A theoretical model of the squeeze-film bearing unassisted by a retainer spring is developed, based on experimental information revealing the ability of the squeeze-film to sustain appreciable subatmospheric pressure.

BLADES

79-607

Linearized Supersonic Unsteady Flow in Cascades

T. Nagashima and D.S. Whitehead
Dept. of Engrg., Cambridge Univ., UK,
Rept. No. ARC-R/M-3811; ARC-37198; BR61587, 39 pp (1978)
N78-30065

Key Words: Fan blades, Forced vibration, Flutter, Computer programs

A linearized theory is presented for the calculation of force and moment coefficients for two-dimensional cascades of blades in supersonic flow. The cases of both supersonic and subsonic axial velocity are treated. The perturbations are due to bending vibration, torsional vibration, and wakes shed from moving obstructions upstream. The method leads to analytical results in the quasi-steady case, and to a fast computer program for the general unsteady case. Results are in good agreement with previous work. The method can be used to predict forced vibration and flutter in transonic fan blades.

COLUMNS

79-608

Response of a Latticed Transmission Tower to Wind

H.I. Laursen and L. Kempner
Dept. of Civil Engrg., Oregon State Univ., Corvallis, OR,
Rept. No. HIL/OSU/BPA-1, 59 pp (Sept 29, 1977)
PB-285 123/6GA

Key Words: Towers, Transmission lines, Wind-induced excitation, Columns

The report describes the procedures used and the results obtained in a study of the response of a latticed steel transmission line tower to wind loading. The test tower, 110 feet in height, is on a 500-kV line and supports 3 twin-bundle conductors. Strong wind recordings, in digital form on magnetic tape, were obtained for stresses in the tower members, load on the tower from the conductors and overhead groundlines, the longitudinal and transverse swing of the insulators, and wind speed and direction. The results indicate the general nature of how the tower responds to wind loading as well as the dynamic response obtained through random data analysis techniques. Stresses measured in the tower are compared with values obtained by the Bonneville Power Administration computerized tower analysis procedure.

CONTROLS

79-609

The Importance of System Evaluation in the Prediction of Structural Peril Caused by Flow-Induced Excitation (Bedeutung der Systembehandlung für Vorhersagen der Bauwerksgefahrdung durch stromungserregte Schwingungen)

E. Naudascher

Universität Karlsruhe, Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 300-331 (Mar 23, 1978) 13 figs, 17 refs
(In German)

Key Words: Valves, Fluid-induced excitation

A simple valve-conduit-surge-tank system is used to show how different the valve vibrations can be depending on the type of excitation mechanism responsible for the vibration. It is shown that all of these vibration cases can be viewed as a result of different interactions of three oscillators in the system: a body-, a flow-, and a fluid-oscillator.

CYLINDERS

(Also see No. 709)

79-610

Normal Mode Solution of Fluid-Coupled Concentric Cylindrical Vessels

W.F. Stokey and R.J. Scavuzzo

Dept. of Mech. Engrg., Carnegie-Mellon Univ., Pittsburgh, PA 15213, J. Pressure Vessel Tech., Trans. ASME, 100 (4), pp 350-352 (Nov 1978) 4 figs, 1 table, 5 refs

Key Words: Cylinders, Cylindrical shells, Normal modes

A normal mode solution is developed for concentric cylinders coupled by fluid between them and subjected to foundation input motion. Both time-history and spectral inputs can be specified. Example problems are presented.

DUCTS

79-611

Computation of Nonlinear One-Dimensional Waves in Near-Sonic Flows

A.H. Nayfeh, B.S. Shaker, and J.E. Kaiser

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, AIAA J., 16 (11), pp 1154-1159 (Nov 1978) 7 figs, 12 refs

Sponsored by NASA, Langley Research Center

Key Words: Ducts, Variable cross section, Sound waves, Wave propagation

A nonlinear analysis is developed for sound propagation in a variable-area duct in which the mean flow approaches choking conditions. A quasi-one dimensional model is used; results of the standard linear theory are compared with the nonlinear results to assess the significance of the nonlinear terms. The nonlinear analysis represents the acoustic disturbance as a sum of interacting harmonics.

79-612

Non-Linear Attenuation of Sound in Circular Lined Ducts

A.I. El Sharkawy

Engrg. Science and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Appl. Acoust., 11 (4), pp 259-268 (Oct 1978) 7 figs, 1 table, 25 refs

Key Words: Ducts, Linings, Sound attenuation

The attenuation of high intensity sound in circular ducts lined with fibrous material is investigated. With no mean flow, the sound pressure levels are varied to illustrate the linear and non-linear absorption characteristics of the liner. Effects of liner thickness, perforation ratio of the duct wall and the d/t ratio are analyzed.

GEARS

79-613

Transient Analyses of Synchronous Motor Trains

F.R. Szenasi and W.W. von Nimitz

Industrial Applications Dept., Applied Physics Div., Southwest Research Inst., San Antonio, TX, Gas Turbine Laboratories, Proc. 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 111-117 (Dec 5-7, 1977) 8 figs, 6 refs

Key Words: Critical speeds, Synchronous motors, Torsional vibration, Periodic excitation, Transient excitation, Gears, Couplings

This paper discusses the philosophy of optimum location of torsional critical speeds which will be excited by the transient startup, as well as methods of adjusting the resonant frequencies. Pulsating torque, average torque, and acceleration rate during startup are considered in choosing the best frequency range for the resonances. Both steady-state and transient torsional excitation are discussed along with the applicable stress criterion. A method to determine the allowable number of startups is presented involving cumulative fatigue considerations which apply to the transient torsional stresses. The severity of backlash in gears and geared couplings is discussed and methods for calculating the response of the system to instantaneous negative torque are presented.

LINKAGES

79-614

Dynamic Response Characteristics of Contact Separation in a Preloaded Mechanical Joint

F.Y. Chen and R.Y. Chang

Ohio Univ., Athens, OH, ASME Paper No. 78-DET-48

Key Words: Joints (junctions), Dynamic response

The analytical approach of contact separation phenomena in a constrained mechanical system caused by the externally applied force excitation is treated using a discrete system model. The condition of contact separation is expressed in terms of a nondimensional characteristic factor.

MEMBRANES, FILMS, AND WEBS

79-615

Membrane Vibrations of Conical Shells

C.H. Chang

Dept. of Aerospace Engrg., Mech. Engrg. and Engrg. Mechanics, The Univ. of Alabama, University, AL 35486, J. Sound Vib., 60 (3), pp 335-343 (Oct 8, 1978) 3 figs, 18 refs

Key Words: Conical shells, Free vibration, Membranes (structural members)

Exact solutions for membrane vibrations of conical shells due to forces acting in the meridional direction are obtained. Frequency equations for the free vibration of conical shells with various end conditions but free from the in-plane shearing force are presented along with the asymptotic expressions, numerical results of frequency spectra, and some typical normal modes. The formula solutions for the transient and forced vibrations of such cones are also presented.

79-616

Determination of Eigenvalues in a Class of Doubly Connected Regions in Problems Governed by Helmholtz's Equation

P.A.A. Laura, C.E. Gianetti, R.H. Gutierrez, and L. Diez

Inst. of Applied Mechanics, Base Naval Puerto Belgrano, 8111, Argentina, J. Sound Vib., 60 (4), pp 499-509 (Oct 22, 1978) 11 figs, 12 refs

Key Words: Membranes, Flexural vibration, Eigenvalue problems, Conformal mapping, Variational methods

This paper deals with the determination of eigenvalues in polygonal domains with concentric circular perforations. The proposed method consists of constructing appropriate coordinate functions which identically satisfy the boundary conditions and making use of a variational approach to generate a simple frequency equation. The results are verified by using a conformal mapping-variational approach. A reasonable agreement is attained.

PANELS

79-617

Influence of Fluid Loading and Compliant Coating on the Coupling Loss Factor Across a Rib

G. Maidanik

David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD 20084, J. Sound Vib., 60 (3), pp 313-318 (Oct 8, 1978) 5 figs, 7 refs

Key Words: Panels, Naval ships, Coupled response, Coatings, Fluid-induced excitation, Statistical energy analysis

Transfer of vibratory energy across boundaries between adjacent structural components can be estimated by means of statistical energy analysis. Significant parameters of the statistical energy analysis are the coupling loss factors between structural components. A coupling loss factor is related simply to the transmission efficiency across the boundary between two structural components. Thus, the assessment of the influence of fluid loading and compliant coating on the transmission efficiency relates to the influence of fluid loading and compliant coating on the coupling loss factor. Previous estimates of the transmission efficiency are used to estimate this influence on the coupling loss factor in a simple case of two panels separated by a rib. The implications of this influence on the energy transfer between the two panels are discussed.

PIPES AND TUBES

(Also see No. 686)

79-618

Automated Analysis of Multiple-Support Excitation Piping Problems

K.R. Leimbach and H. Schmid
Haverkampstrasse 12, D-463, Bochum-Linden, Federal Rep. of Germany, Nucl. Engr. Des., 51, pp 245-252 (1979) 9 figs, 2 tables, 5 refs

Key Words: Piping systems, Nuclear power plants, Computer programs, Response spectra, Spectrum analysis

An automated solution algorithm is presented for the treatment of multiple-support excitation piping problems. The method is an extension of the well-known response spectrum analysis method which is used for seismic analysis of structural systems. The new algorithm was incorporated in Kraftwerk Union's proprietary computer code KWUROHR for static and dynamic analysis of piping systems. In this paper the numerical results from the use of envelope and multiple-support acceleration input spectra are presented for two typical piping systems in nuclear power plants.

79-619

Acoustic Wave Propagation in Cylindrical Tubes Containing Slightly Rarefied Gas

K. Rathnam and M.M. Oberai
Dept. of Mech. Engrg., Indian Inst. of Tech., Kanpur 208016, India, J. Sound Vib., 60 (3), pp 379-388 (Oct 8, 1978) 4 refs

Key Words: Pipes (tubes), Cylindrical shells, Elastic waves, Wave propagation, Sound waves

A theoretical study of the Kirchhoff theory of acoustic wave propagation in long cylindrical tubes is presented with the objective of including corrections due to velocity slip, temperature jump and temperature fluctuations at the tube wall. Emphasis is laid on the calculation of analytical expressions for the attenuation coefficient and speed of propagation. Explicit results are obtained for both large and small values of the tube radius.

79-620

Influence of Inner Surface Defects on the Fatigue Strength of Pipe Subjected to Cyclic Internal Pressure

Y. Yazaki, S. Hashirizaki, S. Nishida, and C. Urashima
Yawata Works, Nippon Steel Corp., Kitakyusyu-shi, Japan, J. Pressure Vessel Tech., Trans. ASME, 100 (4), pp 360-368 (Nov 1978) 18 figs, 6 refs

Key Words: Pipes (tubes), Fatigue life, Acoustic techniques, Diagnostic techniques

Cyclic internal oil pressure fatigue tests are carried out on medium-diameter ERW pipes of API 5LX-X60 in an attempt to determine the influence of surface defects on the fatigue strength. Experimental factors investigated are the depth and location of internal surface notch in relation to the axis of pipe. The specimen is subjected to cyclic internal pressure, and during the test, Acoustic Emission (AE) techniques are applied to detect the fatigue crack initiation. Pulsating tension fatigue tests are also carried out on specimens with the same surface notches as the cyclic internal pressure fatigue test specimen.

79-621

Seismic Response Analysis of Offshore Pipelines in Contact with the Sea-Bed

B. Nath and C.H. Soh
Dept. of Civil Engrg., Queen Mary College, Univ. of London, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 181-196 (1978) 9 figs, 26 refs

Key Words: Pipelines, Off-shore structures, Seismic response

The seismic behavior of an offshore pipeline is characterized by the confluence of structural dynamics, hydrodynamics and soil mechanics and the dynamic interactions between these aspects. This paper contains a study dealing with the seismic response analysis of such a pipeline including pressure drag effects. A numerical analysis based on the assumption that the pipe behaves linearly elastically and that pipe deflection is elastoplastically related, without loss, to sea-bed resistance shows that pipe response is significantly attenuated by contact.

79-622

Transverse Seismic Response Analysis of Offshore Pipelines in Proximity to the Sea-Bed

B. Nath and C.H. Soh

Dept. of Civil Engrg., Queen Mary College, Univ. of London, UK, Intl. J. Earthquake Engr. Struc. Dynam., 6 (6), pp 569-583 (Nov/Dec 1978) 11 figs, 1 table, 39 refs

Key Words: *Pipelines, Offshore structures, Harmonic response, Seismic response*

Both harmonic and seismic responses of several idealized offshore oil pipelines in proximity to the sea-bed have been studied in this paper by using a digital computer algorithm. Spatial discretization is based on finite elements, with nodal lumped masses, while a step-by-step explicit forward integration scheme is implemented for processing in the time domain. Relevant fluid dynamic aspects affecting system response as well as possible effects of marine growth on pipe surface and structural/chemical degradation of the pipe coating are also discussed.

PLATES AND SHELLS

(Also see Nos. 573, 610)

79-623

Interactive Buckling Analysis of Box Sections Using Dynamic Relaxation

P.A. Frieze and P.J. Dowling

Dept. of Civil Engrg., Imperial College, London, UK, Computers Struc., 9 (5), pp 431-439 (Nov 1978) 5 figs, 9 refs

Key Words: Plates, Box beams, Mathematical models, Dynamic relaxation

A procedure is presented for the exact analysis of plates forming box sections subject to generalized loading. The numerical method used in the formulation, dynamic relaxation, is described in some detail. Emphasis is placed on the modifications necessary to extend the method beyond the form already used for isolated panel analyses. The equilibrium and compatibility requirements for complete interaction at the adjoining edges of plates are presented and their incorporation into the present formulation is considered. The influence of mesh size is studied and comparisons are made with isolated panel results. The simplifying assumptions concerning edge interaction adopted by earlier workers are validated for axial loading and some results are presented for a square column under axial loading in which the effect of varying the flange plate thickness and of the mode and magnitude of plate initial deformations is considered.

79-624

Thin Plate Semiloof Element for Structural Analysis - Including Stability and Natural Vibrations

R.A.F. Martins and D.R.J. Owen

Dept. of Mech. Engrg., Engrg. Faculty of Oporto, Portugal, Intl. J. Numer. Methods Engr., 12 (11), pp 1667-1676 (1978) 7 figs, 1 table, 16 refs

Key Words: Plates, Shells, Natural frequency

This paper presents a thin plate element formulated along parallel lines to the general three-dimensional Semiloof shell element. This plate version possesses only one half of the total number of degrees-of-freedom of the shell element and has the advantage that the formulation of the strains and other terms is very much simplified. The element is first assessed in static situations and then its performance in the solution of eigenvalue problems is considered.

79-625

Input and Transfer Admittances of Thick Plates Driven by a Uniform Line Moment

P.W. Smith, Jr. and C.L. Dym

Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, J. Sound Vib., 60 (3), pp 441-447 (Oct 8, 1978) 2 figs, 1 table, 7 refs

Key Words: Plates, Vibration excitation, Mindlin theory

The response of an infinite homogeneous elastic plate to an external oscillatory moment, applied uniformly along a straight line, is analyzed within the framework of the Mindlin model for the dynamics of a thick plate. That model includes the two antisymmetric modes of lowest order.

79-626

A Re-Examination of the Non-Linear Interaction Between an Acoustic Fluid and a Flat Plate Undergoing Harmonic Excitation

J.H. Ginsberg

School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 60 (3), pp 449-458 (Oct 8, 1978) 7 figs, 13 refs

Key Words: Plates, Fluid-induced excitation, Harmonic excitation, Acoustic response

In a recent study a direct renormalization procedure to evaluate the structural and acoustic response resulting from resonant harmonic excitation of a flat plate was employed. An explicit criterion for the location of a shock is obtained, and it is proven that shocks form along a series of straight lines. A quantitative example depicts various spatial and temporal responses. The distortion effects are explained in terms of self-refraction phenomena.

79-627

Non-Linear Interactions of Acoustic Fields with Plates Under Harmonic Excitations

A.H. Nayfeh and S.G. Kelly

Dept. of Engrg. Science and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 60 (3), pp 371-377 (Oct 8, 1978) 6 refs

Key Words: Plates, Acoustic excitation, Harmonic excitation

The method of renormalization is used to determine a uniformly valid expansion for the problem of non-linear interactions of acoustic fields with plates under harmonic excitations. The expansion obtained is in agreement with that obtained by Ginsberg, who used the method of strained coordinates to render the potential uniform and then used the method of renormalization to render the non-uniform pressure and velocity components calculated from the resulting potential uniform.

79-628

Vibration Analysis of a Rectangular Plate Subjected to a Thermal Gradient

M.S. Dhotarad and N. Ganesan

Machine Dynamics Lab., Indian Inst. of Tech., Madras-600036, India, J. Sound Vib., 60 (4), pp 481-497 (Oct 22, 1978) 10 figs, 8 tables, 17 refs

Key Words: Rectangular plates, Thermal excitation, Vibration response

The dynamic free response of thin rectangular plates subjected to one and two dimensional steady state temperature distributions satisfying Laplace's equation is analyzed. The governing equations of motion are derived by a finite difference method and solved by a simultaneous iteration technique to obtain eigenvalues and eigenvectors. The accuracy of the method is assessed by comparing the results for some typical cases with those obtained by classical methods. The finite element method is also employed for the problem and the results obtained compare well with those of the finite difference method. Plates of different boundary conditions, with at least one edge clamped, free to expand or contract in their planes, are studied.

79-629

Free Vibration of Layered Circular Plates

S. Venkatesan and V.X. Kunukkasseril

Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras 600036, India, J. Sound Vib., 60 (4), pp 511-534 (Oct 22, 1978) 17 figs, 14 refs

Key Words: Circular plates, Layered materials, Free vibration

Free vibrational characteristics of layered circular plates are considered in this work. Each layer is isotropic and in general the layers are assumed to have different material properties and thicknesses. The equations incorporating shear deformation and rotatory inertia are developed for the asymmetric motion. For axisymmetric motion, exact closed form solutions are obtained. For plates with layers of equal Poisson's ratio it is shown that solution for asymmetric modes can be obtained in terms of Bessel functions. Numerical results for various layer arrangements and boundary conditions are obtained for axisymmetric modes. The mode shapes and corresponding frequencies are tabulated. The axisymmetric results are compared with the theoretical values.

79-630

Stresses in a Human Skull Due to Pulse Loading

J.C. Misra, C. Hartung, and O. Mahrenholtz

Indian Inst. of Technology, Kharagpur 2, West Bengal, India, Ing. Arch., 47 (5), pp 329-337 (1978) 18 figs, 7 refs

Key Words: Head (anatomy), Shells, Viscoelastic core-containing media, Pulse excitation

Assuming the human skull to be an isotropic homogeneous viscoelastic prolate spheroidal shell and the brain to be a homogeneous viscoelastic fluid, the stresses in the skull due to three various types of pulse loading for different load-durations are reported in the present paper.

79-631

Shell-Type Response of Cooling Towers – State of the Art and Open Questions (Das Schalentragverhalten von Naturzugkuhlturmen -- Kenntnisstand und offene Fragen)

W.B. Kratzig

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 72-83 (Mar 23, 1978) 10 figs, 12 refs
(In German)

Key Words: Cooling towers, Shells

This paper presents a general view on cooling tower problems in the field of structural mechanics. Using the scheme of a nonlinear shell theory, subproblems are defined, which are dealt with numerically. The known response phenomena of cooling towers are described.

79-632

Turbulence Induced Shell Vibrations of Reinforced Concrete Cooling Towers (Turbulenzinduzierte Schalenschwingungen von Naturzugkuhlturmen aus Stahlbeton)

H.-J. Niemann

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 538-560 (Mar 23, 1978) 7 figs, 5 refs
(In German)

Key Words: Cooling towers, Shells, Wind-induced excitation, Reinforced concrete

Natural draught cooling towers are shell structures which are subjected to random vibrations due to wind turbulence. The random response is analyzed using a spectral approach and assuming a linear elastic behavior of the structure. Coupling between the different modes of vibration is considered. The excitation is given in terms of spectra and cross-spectra of the pressure fluctuations on the shell surface, which are related to the spectrum of wind turbulence.

79-633

Moving Loads on Viscoelastic Cylindrical Shells

C.-C. Huang

Dept. of Mech. Engrg., Univ. of Western Australia, Nedlands, Western Australia 6009, Australia, J. Sound Vib., 60 (3), pp 351-358 (Oct 8, 1978) 5 figs, 11 refs

Key Words: Cylindrical shells, Periodic response, Moving loads, Viscoelastic media, Internal damping, Critical speed

The problem of steady state forced response of an infinitely long, viscoelastic cylindrical shell subject to an axially symmetric ring load which travels at a constant velocity is treated. The shell is modeled by applying the correspondence principle to the refined theory derived by Herrmann and Mirsky. The Fourier transform method in conjunction with the contour integral is applied to obtain the solution. A numerical illustration is given.

79-634

Axially Symmetric Transient Dynamic Response of Thick Cylindrical Shells

C.-C. Huang

Dept. of Mech. Engrg., The Univ. of Western Australia, Nedlands, Western Australia 6009, Australia, J. Sound Vib., 60 (4), pp 471-480 (Oct 22, 1978) 10 figs, 1 table, 10 refs

Key Words: Cylindrical shells, Transient response, Longitudinal response

This paper presents a theoretical analysis of a dynamic boundary value problem of a finite length, homogeneous, isotropic, linearly elastic, cylindrical shell. The shell is subject to time-dependent surface tractions and/or time-dependent boundary conditons. Formal solutions have been derived by using the classical method of eigenfunction expansion combined with the modal acceleration method to treat the time-dependent boundary conditions. A numerical example of the transient response of a hollow cylinder subject to a longitudinal impact is worked out to study the influence of the transverse normal strain and for comparison with the results of the thin shell theory.

79-635

Acoustic Vibration of a Liquid Filled Distorted Circular Cylindrical Shell

D. Firth

Risley Nuclear Power Development Labs., Risley, Warrington, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 151-164 (1978) 3 figs, 4 refs

Key Words: Cylindrical shells, Fluid-filled containers, Coupled response, Acoustic excitation

A theory is developed whereby acoustic and structural modes are coupled by means of geometrical distortions in a circular cylindrical shell filled with liquid. The prediction is that a circularly symmetric discrete frequency acoustic wave in the liquid will excite in the shell not only a circular symmetric 'breathing mode' (which would be the only one present in an undistorted shell) but also short wavelength flexural waves at the excitation frequency. It is possible, even for quite small distortions, for the displacement amplitude of some of these flexural waves to exceed that of the 'breathing mode,' The results of calculations for a particular shell are shown to be consistent with experimental results.

STRUCTURAL

(Also see No. 598)

79-636

Response of Bridge Structural Members Under Wind-Induced Vibrations

M. Chi

Chi Associates, Inc., Arlington, VA., Rept. No. FHWA/RD-78/25, 279 pp (June 1976)
PB-284 783/8GA

Key Words: Bridges, Structural members, Wind-induced excitation

Structural dynamics of long slender member of contemporary cross-section shapes are investigated in a comprehensive manner for the purpose of precluding vortex excited vibration and mitigating damages to the member due to fatigue. The unique features are: the ends can have various degree of elastic restraint; different levels of axial tension are allowed for both flexural and torsional vibrations; and flow regime can be either subcritical (single-frequency resonance) or supercritical (random shedding). The text consists of recommended design guide with design charts appended with supplements which show the basis of the design guide, mathematical theories, illustrative examples and a lengthy bibliography.

79-637

Determination of Strouhal Characteristics and Power Spectrum for Elastically Restrained H-Shape Sections

M. Chi, E. Neal, and B.G. Dennis, Jr.

Chi Associates, Inc., Arlington, VA, Rept. No. FHWA/RD-78/26, 85 pp (Aug 1977)
PB-284 784/6GA

Key Words: Structural members, Bridges, Wind-induced excitation, Wind tunnel tests

This document provides results of experimental investigation of Strouhal numbers and power spectral density of H-shaped members. The aspect ratios of the cross-sections of the members examined were approximately 1:1, 3:4, and 1:2, respectively. The specimens were sharp-cornered and mounted on adjustable springs at the ends. The tests were conducted in a wind tunnel having minimum upstream turbulence. The Reynolds number ranged from 100,000 to 1,700,000.

79-638

Design of Reinforced Wind-Resistant Structural Components for Tall Buildings (Die Auslegung aussteifender Bauteile von Hochhausern gegen Windeinwirkung)

G. Konig

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 459-482 (Mar 23, 1978) 12 figs, 7 refs
(In German)

Key Words: Structural members, Reinforced structures, Multistory buildings, Wind-induced excitation

The actual wind speed is assumed to consist of a mean component (e.g. mean-hourly wind speed) and a fluctuating component. The induced load effects in a structure are considered to consist of a mean component, a nonresonant or background fluctuating component, and a resonant or dynamic component. An approach is developed for estimating a gust response factor (the ratio of the peak value of the response of a building to the mean value of the response).

79-639

Test Methods for Windows and Walls – The Need for a Testing Program

H.R. Trechsel

National Bureau of Standards, Washington, D.C., Pub. in Proc. RILEM/ASTM/CIB Symp. on Evaluation of Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Vol. 2, pp 374-382 (Aug 28-Sept 2, 1977)
PB-285 139/2GA

Key Words: Structural members, Walls, Windows, Dynamic tests

Despite an advanced state of the art in the design of building walls and windows, and despite the extensive testing on building envelope elements, failures of such elements have occurred in recent years. The paper discusses several selected factors affecting the reliability of test results: number of specimens to be tested, process for selecting specimens and single performance characteristic tests. Based on these factors, it is proposed that testing be considered as an integral part of the design and build process. It is suggested that the systems approach be used for developing a test program based on the various trade-offs between cost for the testing and the potential risk for failure.

79-640

Criticism of Statistical Energy Analysis for the Calculation of Sound Insulation - Part 1: Single Partitions

A. Elmallawany

Acoustics Dept., Bldg. Research Centre, P.O. Box 1770, El-Tahreer St., Dokky, Cairo, Egypt, Appl. Acoust., 11 (4), pp 305-312 (Oct 1978) 4 figs, 8 refs

Key Words: Walls, Acoustic insulation, Statistical energy methods

The method of statistical energy analysis to calculate the sound insulation of single and double partitions is employed. This paper deals with the degree of agreement between the results obtained by this method for sound insulation of single partitions and measured values. The advantages and disadvantages of this method compared with classical methods are discussed. A comparison between the statistical energy analysis method and classical methods for the calculation of the sound insulation of single partitions is made.

79-641

Variable Vibration Damping of Flat and Prismatic Bodies in Stationary and Moving Air (Variable Dämpfung bei Schwingungen platten- und prismenförmiger Körper in ruhender und strömender Luft)

H. Quadflieg and H. Mankau

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Republic of Germany, Rept. No. CR1-K1/78, pp 164-186 (Mar 23, 1978) 14 figs, 19 refs
(In German)

Key Words: Prismatic bodies, Plates, Roofs, Fluid-induced excitation, Wind-induced excitation, Wind tunnel tests

In wind-tunnel tests the influence of aerodynamic and structural damping on the galloping of a flat roof and on the vortex induced vibration of circular cylinders and cones is investigated. In order to determine the aerodynamic and the structural part of the damping, the models are studied under vacuum and atmospheric conditions.

SYSTEMS

ABSORBER

79-642

Sea Trials of a Damped Vibration Absorber on H.M.A.S. Balikpapan

G. Long and P.A. Farrell

Aeronautical Research Labs., Melbourne, Australia, Rept. No. ARL/STRUC-TM-270, 41 pp (Jan 1978)
AD-A058 482/1GA

Key Words: Absorbers (equipment), Ship structural components, Flexural vibration, Vibration damping

Sea trials of a damped vibration absorber installed on a 550 ton ship are described. The absorber is designed to increase the damping in the fundamental vertical bending mode of the ship.

79-643

Optimal Dynamic Vibration Absorbers for General Beam Systems

R.G. Jacquot

Dept. of Electrical Engrg., Univ. of Wyoming, Laramie, WY 82070, J. Sound Vib., 60 (4), pp 535-542 (Oct 22, 1978) 5 figs, 17 refs

Key Words: Dynamic vibration absorption (equipment), Beams, Bernoulli-Euler method

A technique is developed to give the optimal dynamic vibration absorber parameters for the elimination of excessive vibration in sinusoidally forced Bernoulli-Euler beams. The result is presented in a general form so as to include all possible sets of ordinary boundary conditons and absorber attachment points. A single mode expansion for the beam is employed in an assumed mode approach. The general equations developed are then applied to a point-forced cantilever beam with a viscously damped dynamic absorber attached at the beam midpoint. The optimal values developed for the single mode approximation are then evaluated with account taken of the first five beam modes where discrepancies are noted near the higher order beam resonances which are shifted somewhat due to the absorber.

79-644

On the Effect of a Variable Stiffness-Type Dynamic Absorber with Eddy-Current Damping

K. Seto and M. Yamanouch

Dept. of Mech. Engrg., National Defense Academy, Yokosuka, Kanagawa, Bull. JSME, 21 (160), pp 1482-1489 (Oct 1978) 19 figs, 9 refs

Key Words: Dynamic vibration absorption (equipment), Variable material properties

This paper presents a new dynamic absorber which consists of a variable stiffness-type spring, a mass, and a magnetic damper using the damping effect of eddy-currents. It has advantages that the absorber is able to use for improving the damping property of a main vibration system where changes of the natural frequency take place, and it is stable in damping characteristics under varying environment. The damping performance of the absorber is studied in both experimental and theoretical aspects with a specific view to improving the dynamic stiffness of the ram structure. The relation between viscous damping coefficient and intermediate factors of the magnetic damper is deduced.

79-645

The Development of Energy-Absorbing Devices for Aseismic Base Isolation Systems

J.M. Kelly and D.F. Tsztoo

Earthquake Engrg. Res. Center, California Univ., Richmond, CA, Rept. No. UCB/EERC-78/01, NSF/RA-780190, 54 pp (Jan 1978)

PB-284 978/4GA

Key Words: Energy absorption, Isolators, Seismic design

This report describes the behavior of mild steel energy-absorbing devices that can be used in earthquake isolation systems. The devices are rigid under service-type loading, but yield and absorb energy under large earthquake-type loading. The hysteresis loops developed by sinusoidal loading of the devices effectively bounded the loops obtained by the random loading of the devices. The actual incorporation of the devices in a structural steel frame is being investigated in ongoing research.

NOISE REDUCTION

79-646

Experimental Investigation of Noise Reduction from Two Parallel-Flow Jets

W.V. Bhat

Boeing Commercial Airplane Co., Seattle, WA, AIAA J., 16 (11), pp 1160-1167 (Nov 1978) 24 figs, 2 tables, 2 refs

Key Words: Noise reduction, Jet noise

The acoustic characteristics of two parallel-flow jets have been investigated as a fundamental study aimed at understanding jet noise suppression mechanisms which then could lead to improved jet noise suppressors. Model-scale tests were conducted in an anechoic environment. Acoustic measurements were made in the plane containing the axis of the two jets using a far-field microphone array. The effect of tube geometry (lateral tube spacing, longitudinal tube staggering, and tube size) is studied with the same flow through both tubes. The effect of flow parameters is investigated using twin coplanar jets. Detailed acoustic test results are evaluated in terms of engineering as well as subjective units.

79-647

Filter Silencer System for Large Diesels

Diesel Gas Turbine Prog., 44 (11), p 51 (Nov 1978) 1 fig

Key Words: Diesel engines, Noise reduction

A compact filtration and silencing system for diesel engines, which incorporates features usually found only on much larger systems, is described. In addition to its compact size, it offers large air flow capacity; longer life than panel filters; more efficiency than oil bath or conventional panel filters; and easier servicing. The compact silencer reduces high frequency noise generated by turbocharged engines.

AIRCRAFT

(Also see Nos. 551, 708)

79-648

A Further Survey of Some Effects of Aircraft Noise in Residential Communities Near London (Heathrow) Airport

J.B. Ollerhead and R.M. Edwards

Dept. of Transport Tech., Loughborough Univ. of Tech., UK, Rept. No. TT-7705, 148 pp (June 1977)

N78-30910

Key Words: Aircraft noise, Human response

Six hundred residents of suburban communities near London (Heathrow) airport were interviewed in a pilot survey designed to compare alternative methods of scaling aircraft noise exposure and human reactions to it. The various associations between noise variables are discussed.

79-649

A Comparison of Annoyance Caused by Aircraft Noise Near London, Manchester, and Liverpool Airports

J.B. Ollerhead

Dept. of Transport Tech., Loughborough Univ. of Tech., UK, Rept. No. TT-7706, 77 pp (June 1977)

N78-30911

Key Words: Aircraft noise, Human response

In a postal survey designed to investigate the validity of Noise and Number Index (NNI) for scaling aircraft noise impact at airports other than London (Heathrow), questionnaires were sent simultaneously to some 3000 residents near London (Heathrow), Manchester and Liverpool airports. Results are discussed and recommendations made.

79-650

Potential Acoustic Benefits of Circulation Control Rotors

R.M. Williams and I.C. Cheeseman

Naval Ship Res. and Dev. Center, Bethesda, MD, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 149-179 (Aug 1978)

N78-32825

Key Words: Vertical take-off aircraft, Rotor blades (rotary wings), Noise generation

The fundamental aeroacoustic mechanisms responsible for noise generation on a rotating blade are theoretically examined. Their contribution to the overall rotor sound pressure level is predicted. Results from a theory for airfoil trailing edge noise are presented. Modifications and extensions to other source theories are described where it is necessary to account for unique aspects of circulation control (CC) aerodynamics. The circulation control rotor (CCR), as embodied on an X-wing vertical takeoff and landing (VTOL) aircraft, is used as an example for computational purposes.

79-651

Stabilization Techniques for Improved Response of the F-15 Aircraft

S.L. Whitemarsh

School of Engrg., Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/GGC/EE/78-6, 130 pp (June 1978)

AD-A058 514/1GA

Key Words: Aircraft, Dynamic response, Stabilization

The purpose of this study is to show that by moving an aircrafts' center-of-gravity aft of the aerodynamic neutral point, thus making it statically unstable, the use of a feedback control system produces a more responsive stable aircraft. Pitch rate, normal acceleration, and angle-of-attack rate are used as the feedback parameters in a pitch orientational control system having two feedback loops. The inner loop is used to improve the dynamic response characteristics and the outer loop to stabilize the aircraft.

79-652

Methods and Problems in the Derivation of Dynamic Answers in Aircraft Construction (Verfahren und Probleme der Ermittlung der dynamischen Antworten im Flugzeugbau)

H. Zimmermann, S. Vogel, and P. Borgwardt
VRW-Fokker Bremen, Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 372-402 (Mar 23, 1978) 11 figs, 21 refs
(In German)

Key Words: Aircraft, Dynamic response, Equations of motion

The dynamic response of a flexible aircraft in the form of kinematic quantities and sectional loads is calculated to determine the strength of load-carrying members. The main sources of aircraft excitation are gusts, landing shocks, taxiing, and buffeting. The equations of motion for the calculation of the response are presented. The models used for the various excitations are described, as well as methods for solving the equations of motion with numerical problems.

79-653
Nonlinear Unsteady Potential Flow Calculations for Three-Dimensional Oscillating Wings
W. Geissler
Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt V., Aerodynamische Versuchsanstalt Göttingen, West Germany, AIAA J., 16 (11), pp 1168-1174 (Nov 1978) 6 figs, 14 refs

Key Words: Aircraft wings, Aerodynamic loads

A numerical method has been developed to calculate steady and unsteady pressure distributions on harmonically oscillating three-dimensional wings in incompressible flow. In this method the geometric boundary condition is matched on the real wing surface, thus taking into account thickness and camber effects as well as a static mean incidence of the wing. The wake geometry, which is assumed to be known, may be of arbitrary shape. Wing and wake surfaces are represented by a large number of small plane-surface elements each having a constant source sink and doublet distribution of yet unknown strength. The source strengths are determined by solving a large linear system of equations. The doublet strengths are found by applying the Kutta condition at the trailing edge of the wing. Results of the present method are compared with other methods as well as with experimental data.

79-654
Considerations on Wing Stores Flutter Asymmetry, Flutter Suppression
AGARD, Neuilly-Sur-Seine, France, Rept. No. AGARD-R-668, 44 pp (July 1978)
AD-A058 679/2GA

Key Words: Flutter, Aircraft wings, Wing stores, Vibration control

The two papers of this report presented to the Sub-Committee on Aeroelasticity of the Structures and Materials Panel during the 46th Meeting of the Panel deal with two different aspects of the problem of aeroelasticity and flutter with aircraft carrying more and more stores.

BIOENGINEERING
(Also see No. 630)

79-655
Design of a Load Simulator for the Dynamic Evaluation of Prosthetic Knee Joints
N.J. Zachman, B.M. Hillberry, and D.B. Kettelkamp
Purdue Univ., West Lafayette, IN, ASME Paper No. 78-DET-59

Key Words: Knee (anatomy), Prosthetic devices, Dynamic tests, Test equipment

A testing machine has been developed whereby the loads normally produced across a knee joint during dynamic activity can be simulated in the laboratory. The primary function of this device dubbed the Accu-Flexor, is to evaluate the mechanical performance, life and failure modes of prostheses under simulated load conditions.

BRIDGES

79-656
The Analysis of Aerodynamic Stability of Bridges, for example, The Bridge on River Rhein Between Düsseldorf and Flehe (Der Nachweis aerodynamischer Stabilität von Brücken am Beispiel der Rheinbrücke Düsseldorf - Flehe)
F. Thiele
Aeroelastic Problems Oustide Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78,

pp 561-580 (Mar 23, 1978) 10 figs, 7 refs
(In German)

Key Words: Bridges, Wind-induced excitation

For the experimental determination of wind loads on bridges, instead of testing a model of the entire bridge in the wind tunnel, the author proposes to test only a longitudinal cross-sectional model. A three dimensional model is thus reduced to a two dimensional one. For the calculation, the element is inserted in the bridge system.

BUILDING

(Also see Nos. 566, 638, 707)

79-657

Design of Tall Wind-Resistant Buildings, Especially Regarding their Serviceability (Die Auslegung on Hochhäusern gegen Windeinwirkung unter besonderer Berücksichtigung der Gebrauchsfähigkeit)

K. Zilch

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 483-503 (Mar 23, 1978) 7 figs, 4 tables, 30 refs
(In German)

Key Words: Multistory buildings, Wind-induced excitation

Limit states of serviceability are considered in the design of tall buildings. This paper gives a description of the wind loading process with regard to the evaluation of the serviceability. Limit states of serviceability -- maximum drift and acceleration -- are defined and probabilities of occurrence are given as deisgn criteria.

79-658

Problems, Solutions and Failures in Construction and Aeroelasticity (Baupraxis und Aeroelastik Probleme - Losungen - Schadensfalle)

C. Petersen

Aeroelastic Problems Ouside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 424-449 (Mar 23, 1978) 19 figs, 26 refs
(In German)

Key Words: Buildings, Wind-induced excitation, Vibration dampers

Several structural engineering problems of particular interest in aerodynamics and aeroelasticity are discussed. Among such problems are: wind-drag-coefficients, wind-pressure, gust-factor, and lateral vibrations. Formulas and a table are provided for calculation of frequencies and for changing the logarithmic damping decrement. The use of dampers is described.

79-659

The Effect of Wind Direction on the Static and Dynamic Wind Loads on a Square Section Tall Building

T.A. Reinhold, P.R. Sparks, H.W. Tieleman, and F.J. Maher

National Bureau of Standards, Washington, D.C., Pub. in Proc. 3rd Colloq. on Industrial Aerodynamics, Aachen, Germany on June 14-16, 1978, Paper in Building Aerodynamics, Pt. 1, pp 263-279 (May 1978)
PB-285 145/9GA

Key Words: Buildings, Wind-induced excitation, Wind tunnel tests

This paper presents the results of a wind-tunnel investigation into the effect of wind direction on the wind loads of a square cross-section building model with sharp corners and an aspect ratio of 8.33 to 1. The studies were carried out in a flow which simulated the mean and turbulent properties expected for an urban boundary layer wind. The static and dynamic wind loads were determined at 6 levels throughout the height of the model. Local and overall force coefficients are presented toegther with spectra for the modal forces and modal torques associated with the fundamental translational and modes of the corresponding full structure.

79-660

Design Guide for Reducing Transportation Noise In and Around Buildings

D.S. Pallett, R. Wehrli, R.D. Kilmer, and T.L. Quindry

National Engrg. Lab. (NBS), Washington, D.C., Rept. No. NBS-BSS-84, 109 pp (Apr 1978)
PB-284 988/3GA

Key Words: Buildings, Traffic noise, Noise reduction, Design techniques

This design guide presents a unified procedure for the selection of noise criteria in and around buildings, for the prediction of exterior and interior noise levels arising as a consequence of transportation systems operations, and for the evaluation of the adequacy of building designs with regard to environmental noise. Noise criteria levels are suggested in terms of equivalent sound levels (Leq). Simplified predictive methods enable the estimation of noise levels arising as a consequence of highway, railway, and aircraft operations. The sound isolation provided by the building shell is estimated by means of a new single-figure rating system. Finally, design manipulations which may make possible the improvement of the acoustic conditions in and around buildings are suggested.

HELICOPTERS

79-661

Helicopter Vibration Reduction with Higher Harmonic Blade Pitch

F.J. McHugh and J. Shaw

Boeing Vertol Co., Philadelphia, PA, J. Amer. Helicopter Soc., 23 (4), pp 26-35 (Oct 1978) 15 figs, 14 refs

Key Words: Helicopters, Vibration control

A wind-tunnel test supported by theoretical analysis has been used to evaluate higher harmonic blade pitch for the reduction of helicopter vibration. This investigation focuses on the hingeless rotor. The new results are the first obtained for higher harmonic pitch on a hingeless rotor at close to full-scale tip speed, with blade dynamic characteristics properly modeled. The higher harmonic pitch was obtained by higher harmonic oscillation of the swashplate in vertical and whirling modes.

79-662

Structural Dynamics, Stability, and Control of Helicopters

L. Meirovitch and A.L. Hale

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. NASA-CR-158909, 55 pp (July 1978)

N78-30139

Key Words: Helicopters, Dynamic synthesis, Mathematical models, Component mode synthesis

The dynamic synthesis of gyroscopic structures consisting of point-connected substructures is investigated. The objective is to develop a mathematical model capable of an adequate simulation of the modal characteristics of a helicopter using a minimum number of degrees of freedom. The basic approach is to regard the helicopter structure as an assemblage of flexible substructures. The variational equations for the perturbed motion about certain equilibrium solutions are derived.

79-663

Improved Methods for Calculating the Thickness Noise

Y. Nakamura and A. Azuma

Tokyo Univ., Tokyo, Japan, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 323-337 (Aug 1978)

N78-32832

Key Words: Helicopter rotors, Noise generation, Helicopter noise

Advanced methods to compute the rotor thickness noise which is predominant in the case of high speed rotor are developed. These methods are deduced by transforming the integral coordinate, commuting the order of integration and differential, and/or performing chordwise integration analytically with some adequate assumption. The necessary computational times and waveforms obtained by the previous and three advanced methods are compared.

79-664

Noise Due to Rotor-Turbulence Interaction

R.K. Amiet

United Technologies Res. Center, East Hartford, CT, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 109-126 (Aug 1978)

N78-32823

Key Words: Turbulence, Noise generation, Helicopter rotor, Propeller blades

A procedure for calculating the noise due to turbulent inflow to a propeller or helicopter rotor in hover is summarized. The method is based on a calculation of noise produced by an airfoil moving in rectilinear motion through turbulence. At high frequency the predicted spectrum is broadband, while at low frequency the spectrum is peaked around multiples of blade passage frequency. The results of a parametric study of the variation of the noise with rotor tip speed, blade number, chord, turbulence scale, and directivity angle are given. A comparison of the theory with preliminary experimental measurements shows good agreement.

79-665
Theoretical Models of Helicopter Rotor Noise
D.L. Hawkings
Westland Helicopters Ltd., Hayes, UK, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 89-108 (Aug 1978)
N78-32822

Key Words: Helicopter rotors, Noise generation, Noise prediction, Mathematical models

For low speed rotors, it is shown that unsteady load models are only partially successful in predicting experimental levels. A theoretical model is presented which leads to the concept of unsteady thickness noise. This gives better agreement with test results.

79-666
Helicopter External Noise Prediction and Correlation with Flight Test
B.P. Gupta
Textron Bell Helicopter, Ft. Worth, TX, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 263-275 (Aug 1978)
N78-32829

Key Words: Helicopter noise, Noise prediction

Mathematical analysis procedures for predicting the main and tail rotor rotational and broadband noise are presented. The aerodynamic and acoustical data from Operational Loads Survey (OLS) flight program are used for validating the analysis and noise prediction methodology. For the long method of rotational noise prediction, the spanwise, chordwise, and azimuthwise airloading is used.

79-667
Bounds on Thickness and Loading Noise of Rotating Blades and the Favorable Effect of Blade Sweep on Noise Reduction
F. Farassat, P.A. Nystrom, and T.J. Brown
Joint Inst. for Advancement of Flight Sciences, George Washington Univ., Washington, D.C., In: NASA, Langley Res. Center, Helicopter Acoustics, pp 373-385 (Aug 1978)
Sponsored by AROD
N78-32834

Key Words: Rotor blades (rotary wings), Noise reduction, Helicopter rotors, Helicopter noise

The maxima of amplitudes of thickness and loading noise harmonics are established when the radial distribution of blade chord, thickness ratio, and lift coefficient is specified. It is first shown that only airfoils with thickness distribution and chordwise loading distributions which are symmetric with respect to midchord need be considered for finding the absolute maxima of thickness and loading noise.

79-668
Noise Requirements from a Military Point of View
C.C. Crawford, Jr.
Army Aviation Res. and Dev. Command, St. Louis, MO, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 33-44 (Aug 1978)
N78-32816

Key Words: Aircraft noise, Helicopter noise, Noise reduction

External and internal aircraft noise requirements are discussed in terms of application to military helicopters. The impact of the application of noise reduction technology to comply with FAA standards on cost and performance is emphasized.

79-669
Prediction and Reduction of Rotor Broadband Noise
R.E. Hayden and K.S. Aravamudan
Bolt Beranek and Newman, Inc., Cambridge, MA, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 61-87 (Aug 1978)
N78-32821

Key Words: Helicopter noise, Noise reduction, Noise prediction

Prediction techniques which can be or have been applied to subsonic rotors, and methods for designing helicopter rotors for reduced broadband noise generation are summarized. It is shown how detailed physical models of the noise source can be used to identify approaches to noise control.

79-670

Exploratory Wind-Tunnel Investigation of the Effect of the Main Rotor Wake on Tail Rotor Noise

R.J. Pegg and P.A. Shidler

Langley Res. Center, NASA, Hampton, VA, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 205-219 (Aug 1978)

N78-32827

Key Words: Helicopter noise, Noise reduction, Design techniques

Approaches to minimizing the noise generated by the interaction of the tail rotor blades with the wake of the main rotor considered include repositioning of the tail rotor with respect to the main rotor, changes in the rotational direction of the tail rotor, and modification of the main rotor tip vortex. A variable geometry model was built which had the capability of varying tail rotor position relative to the main rotor as well as direction of tail rotor rotation. Acoustic data taken from the model in the Langley anechoic noise facility indicates interaction effects due to both main rotor shed vortex and the main rotor turbulence.

79-671

Hovering Impulsive Noise: Some Measured and Calculated Results

D.A. Boxwell, Y.H. Yu, and F.H. Schmitz

AVRADCOM Res. and Tech. Labs., In: NASA, Langley Res. Center, Helicopter Acoustics, pp 309-322 (Aug 1978)

N78-32831

Key Words: Helicopter rotors, Noise measurement, Helicopter noise

In-plane impulsive noise radiating from a hovering model rotor is measured in an anechoic environment. The hover acoustic signature is compared with exsiting theoretical prediction models with previous forward flight experiments using the same model rotor. These hover tests show good experimental consistency with forward flight measurements, both in pressure level, and waveform character, over the range of Mach numbers tested (0.8 to 1.0).

79-672

Helicopter Noise Research at the Langley V/STOL Tunnel

D.R. Hoad and G.C. Green

AVRADCOM Res. and Tech. Labs., In: NASA, Langley Res. Center, Helicopter Acoustics, pp 181-204 (Aug 1978)

N78-32826

Key Words: Helicopter noise, Wind tunnel tests

The noise generated from a 1/4-scale AH-1G helicopter configuration was investigated in the Langley V/STOL tunnel. Data presented indicate a high degree of similarity between model and flight test results. It was found that the pressure time history waveforms are very much alike in shape and amplitude.

79-673

Wind Tunnel Investigations of Model Rotor Noise at Low Tip Speeds

K.S. Aravamudan, A. Lee, and W.L. Harris

Massachusetts Inst. of Tech., Cambridge, MA, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 221-261 (Aug 1978)

N78-32828

Key Words: Helicopter noise, Wind tunnel tests

Experimental and related analytical results on model rotor rotational and broadband noise obtained in the anechoic wind tunnel and rotor facility are summarized. Factors studied include various noise sources, effects of helicopter performance parameters on noise generated by a model main rotor, appropriate scaling laws for the various types of main rotor noise, and the effects of intensity and size scales of injected turbulence on the intensity and spectra of broadband noise.

79-674

A Study of the Noise Radiation from Four Helicopter Rotor Blades

A. Lee and M. Mosher

Ames Res. Center, NASA, Moffett Field, CA, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 387-402 (Aug 1978)

N78-32835

Key Words: Helicopter rotors, Rotor blades (rotary wings), Acoustic measurement, Wind tunnel tests, Helicopter noise

Acoustic measurements were taken of a modern helicopter rotor with four blade tip shapes in the NASA Ames 40-by-80 Foot Wind Tunnel. The four tip shapes are: rectangular, swept, trapezoidal, and swept tapered in platform. Acoustic effects due to tip shape changes are studied based on the dBA level, peak noise pressure, and subjective rating. The measured high speed impulsive noise was compared with theoretical predictions based on thickness effects; good agreement was found.

79-675

The Impact of Urban Operations on Helicopter Noise Requirements

S.R. Spector

Hughes Helicopters, Culver City, CA, In: NASA, Langley Res. Center, Helicopter Acoustics, pp 45-59 (Aug 1978)

N78-32820

Key Words: Helicopter noise, Human response

The interrelationship of urban helicopter operations, helicopter noise, and the establishment of urban public-use heliports is discussed. Public resistance to urban helicopter operations due to concern for safety and noise is shown to negatively impact the establishment of public-use heliports in urban centers. It is indicated that increased government and industry effort to reduce helicopter noise is needed to ensure continued growth in the helicopter industry.

79-676

Helicopter Noise Regulations: An Industry Perspective

R.A. Wagner

Helicopter Association of America, Washington, D.C., In: NASA, Langley Res. Center, Helicopter Acoustics, pp 17-32 (Aug 1978)

N78-32818

Key Words: Helicopter noise, Noise measurement, Noise reduction

A review of helicopter noise measurement programs and noise reduction/economic studies of FAA is given along with a critique of a study which addresses the economic impact of noise reduction on helicopter noise. Modification of several helicopters to reduce noise and demonstrate the economic impact of the application of the current state-of-the-art technology is discussed. Specific helicopters described include Boeing Vertol 347, Hughes OH-6, and Hughes 269C. Other topics covered include: noise trends and possible noise limits; accuracy of helicopter noise prediction techniques; limited change possibilities of derivatives; and rotor impulsive noise. The unique operational capabilities of helicopters and the implications relative to noise regulations and certification are discussed.

HUMAN

(See Nos. 648, 649)

ISOLATION

79-677

Shock and Vibration Performance of an Epoxy Chocking Compound Chockfast Orange, PR-610CF (Philadelphia Resins Corp.)

E.W. Elements

Naval Research Lab., Washington, D.C., Rept. No. NRL-MR-3795, AD-E000 202, 44 pp (June 1978)

AD-A058 589/3GA

Key Words: Ship structural components, Equipment mounts

This report describes a series of tests in which structures resembling shipboard equipment items in mechanical features were mounted on epoxy chocks cast from one of the commercially available compounds. These structures were subjected to shock and vibration tests in accordance with the specifications required for acceptance of equipment items for installation on Navy combatants.

MECHANICAL

(Also see No. 615)

79-678

Elementary Synthesis of Damping in Conjunction with Planar Mechanisms

G.K. Matthew

Vanderbilt University, Nashville, TN, ASME Paper No. 78-DET-49

Key Words: Structural synthesis, Mechanisms

Graphical and analytical techniques are developed which allow the attachment of a linear dashpot to a planar mechanism in order to satisfy two designer-specified values of torque at the mechanism input. The two-position problem is shown to result in four solutions and is analytically developed in a manner to allow later expansion to three-, four-, or five-position capability.

79-679

The Response of a Hooke's Joint Gyroscope to Linear Vibration

J.S. Burdess, C.H.J. Fox, and L. Maunder

Dept. of Mech. Engrg., The Univ. of Newcastle upon Tyne, UK, J. Mech. Engr. Sci., 20 (4), pp 189-195 (Aug 1978) 6 figs, 3 refs

Key Words: Gyroscopes, Vibration response, Unbalanced mass response

The response of an unbalanced Hooke's-joint gyroscope to linear vibration is considered. Six major resonant frequencies are identified. It is shown that, if the gyroscope is subjected to linear vibration either along the spin axis at the spin frequency, or perpendicular to the spin axis at twice the spin frequency, measurement errors may be generated as a result of mass unbalance.

79-680

Stick Slip Stability by Transfer Lubrication

G. Cockerham and G.R. Symmons

Dept. of Mech. and Production Engrg., Sheffield City Polytechnic, UK, Proc. Instn. of Mech. Engrg., 192, pp 259-268 (Sept 1978) 11 figs, 21 refs

Key Words: Stick-slip response, Lubrication, Mechanical systems

A transfer lubrication technique is used to stabilize the vibratory motion of a mechanical system subject to stick slip. The most effective transfer lubricants are found to be p.t.f.e. and graphite lubricating steel on steel and cast iron on cast iron junctions respectively. The effectiveness of three different surface finish conditions for the slideway is examined. Experimental results are shown to correlate well with current stability theories and also indicate the practical limitations of the transfer lubrication technique in converting stick slip to a steady continuous slip motion.

METAL WORKING AND FORMING

79-681

Determination of Dynamic Characteristics of an Impact Forming Machine Structure

A.E.M. Osman, W.A. Knight, and M.M. Sadek

British Ship Research Assoc., Wallsend, Co., Durham, UK, J. Engr. Indus., Trans. ASME, 100 (4), pp 434-440 (Nov 1978) 12 figs, 11 refs

Key Words: Metal working, Noise generation, Dynamic tests, Mode shapes

The noise generated from an impact forming machine arises mainly from structural vibrations and consequently accurate determination of the modal characteristics of the machine is necessary in order to bring about design modifications with the aim of reducing noise levels. Various methods of dynamic testing are applied to a high speed forming machine structure. It is found that the modes of vibration can be successfully identified by impulse tests, with the force pulse generated either by operation of the machine or by means of a hand held hammer.

OFF-ROAD VEHICLES

79-682

Contribution to the Calculation of Driving Cycles for Tracked Vehicles. Part II (Beitrag zur Berechnung von Fahrzyklen für Kettenfahrzeuge)

W. Merhof, W. Zimmermann, and B. Hasenpusch

Automobiltech. Z., 80 (10), pp 471-476 (Oct 1978) 13 figs

Key Words: Off-highway vehicles, Tracked vehicles, Gears

The simulation of the off-road course of vehicles provides the comparison of handling characteristics of real vehicles. In addition this simulation gives aid to the investigation on drive conceptions (engine, gearbox, steering). In this paper the criterion is the time which is necessary for one driving cycle. Solutions are discussed for the following partial problems: definition of the test course; calculation of a *maximum* speed within the analyzed section of the course under the consideration of the combination engine-torque converter, of the efficiencies of gearbox and steering gear, and of the slip of the power transmission to the ground; the dynamic interrelation of the individual sections of the course including acceleration and deceleration procedures.

PACKAGE

79-683

Scaling and Prediction of Impact Puncture of Shipping Casks for Radioactive Materials

W.E. Baker

Southwest Research Inst., San Antonio, TX, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 48th Symp. on Shock and Vibration, Huntsville, AL, Vol. 48, Pt. 2, pp 143-152 (Oct 18-20, 1977) 7 figs, 5 tables, 8 refs

Key Words: Shipping containers, Radioactive materials, Scaling, Penetration

To aid in puncture-resistant design, drop tests have been conducted at Oak Ridge National Laboratory on prismatic and cylindrical simulants of shipping casks of various sizes, and several empirical design formulas for incipient casing puncture developed on the basis of the test results, which apply only to full-scale test drops. This paper reports the similitude and energy balance analyses, and gives scaled puncture threshold prediction equations. The equations are valid for any self-consistent set of units. All data from ORNL tests are shown to agree well with the scaled equations, which are independent of scale and apply for similar jacket materials.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see No. 586)

79-684

Determination of Turbofan Inlet Acoustics Using Finite Elements

R.K.Sigman, R.K. Majjigi, and B.T. Zinn

Georgia Inst. of Tech., Atlanta, GA, AIAA J., 16 (11), pp 1139-1145 (Nov 1978) 12 figs, 23 refs

Key Words: Turbofans, Acoustic properties, Finite element technique, Galerkin method

This paper describes the application of the finite-element method in combination with Galerkin's method in the determination of the acoustic properties of turbofan inlets containing high subsonic Mach number steady flows. An approximate solution for the steady inviscid flowfield is obtained using an integral method for calculating the potential flowfield in the inlet with a correction to account for compressibility effects. The accuracy of the finite element technique in predicting the acoustic properties of annular ducts has been checked by comparison with available analytical solutions for the problems of plane and spinning wave propagation through a hard-walled annular duct with a constant mean flow. Results are presented comparing low-frequency plane wave propagation through a hard-walled turbofan inlet containing a one-dimensional steady flow with the same inlet containing a fully two-dimensional axisymmetric steady flow.

79-685

The Earthquake Design and Analysis of Equipment Isolation Systems

W.D. Iwan

California Inst. of Tech., Pasadena, CA, Intl. J. Earthquake Engr. Struc. Dynam., 6 (6), pp 523-534 (Nov/Dec 1978) 7 figs, 1 table, 2 refs

Key Words: Seismic design, Equipment response, Equipment mounts, Earthquake response

A method is presented whereby the response spectrum may be used to predict the response of lifeline system components, generally classified as equipment. Included in this classification are air handling equipment, pumps, compressors, auxiliary power generators, etc. This type of equipment is mounted on an isolation system with non-linear motion limiting constraints. The results of the approximate method are compared with results obtained by direct numerical integration for a representative piece of equipment.

79-686

Subsynchronous Vibration in a Large Water Flood Pump

J.E. Corley

Arabian American Oil Co., Dhahran, Saudi Arabia, Gas Turbine Labs., Proc. 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 103-110 (Dec 5-7, 1978) 14 figs, 3 refs

Key Words: Pumps, Piping systems, Shafts, Vibration control

This paper describes the solution of a severe DVMF pump shaft vibration problem. Testing of one unit with both vibration and pressure pulsation instrumentation indicated the problem was caused by a hydraulic excitation of a shaft critical speed. The suction and discharge piping from abrupt bell shaped reducing/expansion section is modified to long tapers with a 3 to 1 length to diameter ratio.

79-687

High Speed and Large Capacity Compressor-Driving Turbines for Chemical Plants

M. Teramoto, K. Katayama, and M. Fujimuru

Hiroshima Shipyard and Engine Works, Mitsubishi International Corp., Hiroshima, Japan, Gas Turbine Labs., Proc. 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 59-69 (Dec 5-7, 1978) 20 figs, 4 refs

Key Words: Steam turbines

This paper gives a brief description of compressor-driving steam turbines for use in chemical plants. Turbines used for ethylene plants, ammonia plants and LNG plants, in particular, are large-capacity, high-speed variable-speed steam turbines. Their present state and the state of their development are described. Rotor dynamics technique which is the basic design technique for the attainment of their stable operation and blade design and manufacturing techniques are described in detail. Further, the construction of each component part is described.

RAIL

79-688

Detection of Flaws in Railroad Wheels Using Acoustic Signatures

K. Nagy, D.A. Dousis, and R.D. Finch

Dept. of Mech. Engrg., Univ. of Houston, TX, J. Engr. Indus., Trans. ASME, 100 (4), pp 459-476 (Nov 1978) 18 figs, 1 table, 11 refs

Key Words: Railroad cars, Vehicle wheels, Wheels, Acoustic signatures, Diagnostic techniques

A system for automatic inspection of railroad wheels using acoustic signatures is proposed. Methods of processing the signals from the detection transducers are examined. Some preliminary laboratory and field tests of such systems are described.

79-689

A Simple Dynamic Model for Simulating Draft-Gear Behavior in Rail-Car Impacts

T.-K. Hsu and D.A. Peters

Washington Univ., St. Louis, MO, J. Engr. Indus., Trans. ASME, 100 (4), pp 492-496 (Nov 1978) 7 figs, 8 refs

Key Words: Mathematical models, Railroad cars, Impact response

A new, simple dynamic model is developed for use in simulating draft-gear behavior in rail-car impacts. The model is based on an analysis of the individual components inside several types of draft gears. The transition from kinetic to static friction during the impact is included. Comparisons with drop-hammer tests and full-scale impacts show good agreement with the experimental forces and deflections.

79-690

Study on the Mechanism of Train Noise and Its Countermeasure (Part 1: Characteristics of Wheel Vibration)

S. Sato and H. Matsuhisa

Faculty of Engrg., Kyoto Univ., Japan, Bull. JSME, 21 (160), pp 1475-1481 (Oct 1978) 10 figs, 2 tables, 9 refs

Key Words: Railroad trains, High speed transportation systems, Noise generation

One of the main causes of train noise is the vibration of the wheels. A wheel noise and vibration testing machine which has two wheels simulating the train wheel and the rail is described. The relationship between the noise and the vibration is studied.

REACTORS

(See No. 618)

ROAD

79-691

Case Studies of Pavement Performance. Phase I. Kentucky

P.J. Vedros, Jr. and W.R. Barker

Army Engineer Waterways Experiment Station, Vicksburg, MS, Rept. No. FHWA/RD-77-103, 175 pp (July 1977)

PB-286 137/5GA

Key Words: Pavements, Vibration tests

The objective of this study is to identify the causes and mechanisms associated with cracking and rutting of flexible highway pavements. This objective is approached through in situ field investigations, laboratory testing, and theoretical analysis. Field tests were accomplished at two test locations near Lexington, Kentucky. Extensive laboratory tests were performed on sampled materials of pavement, base, and subgrade. Resilient and creep characteristics of materials are developed and used to evaluate existing prediction techniques.

79-692

Case Studies of Pavement Performance. Phase II. Texas

P.J. Vedros, Jr. and W.R. Barker

Soils and Pavements Lab., Army Engineers Waterways Experiment Station, Vicksburg, MS, Rept. No. FHWA/RD-77-104, 120 pp (July 1977)

PB-286 138/3GA

Key Words: Pavements, Vibration tests

The objective of this study is to identify the causes and mechanisms associated with cracking and rutting of flexible highway pavements. This objective is approached through in situ field investigations, laboratory testing, and theoretical analysis. Field tests were accomplished at two test locations -- one on Highway 69 near the town of Lufkin and the other on Highway 79 near the town of Buffalo. A test trench was opened at each site, and tests including CBR, moisture, density, cyclic plate tests, vibratory measurements, and surface profile were conducted. Laboratory tests were performed on sampled materials of pavement, base, and subgrade. Resilient and creep characteristics of materials were developed and used to evaluate the existing prediction techniques.

79-693

The Role of the Parkhilovskii Model in Road Description

J.D. Robson

Rankine Professor of Mech. Engrg., Univ. of Glasgow, UK, Vehicle Syst. Dyn., 7 (3), pp 153-162 (Sept 1978) 4 figs, 4 refs

Key Words: Pavement roughness, Road roughness, Mathematical models, Ride dynamics

Models of road surfaces to be used as a basis for vehicle response determination must define both direct and cross spectral densities for the profiles of pairs of parallel tracks. The model proposed by Parkhilovskii is compared with that based on isotropy.

79-694

An Investigation of the Origins of Vibration of an Automobile Rear Axle

K.M.A. Kamash

Central Electricity Generating Board (Bristol), UK, Vehicle Syst. Dyn., 7 (3), pp 123-134 (Sept 1978) 5 figs, 1 table, 8 refs

Key Words: Automobiles, Road roughness, Ride dynamics, Vibration measurement

An investigation is carried out to determine the origins of vibration of an automobile rear axle with the object of establishing the significance of road-surface-induced vibratory inputs. The vibratory acceleration of the rear axle of an automobile as it traverses straight sections of typically paved roads at uniform speeds is measured and the results are compared with those obtained by laboratory simulation.

79-695

Noise Levels Inside Passenger Cars

S.M.J. Ali and S.P. Sarna

Dept. of Mech. Engrg., College of Engrg., Univ. of Mosul, Mosul, Iraq, Appl. Acoust., 11 (4), pp 277-284 (Oct 1978) 5 figs, 4 refs

Key Words: Automobiles, Interior noise, Power transmission systems, Vibration frequencies

This paper deals with sound pressure level readings taken inside five different makes of cars running on the streets of the city of Mosul, Iraq. The problem of noise and vibration produced by cars is reviewed and discussed in its several aspects, namely the source, transmission, range of frequencies and the level of noise in cars. The acceptable levels of noise in cars and methods of noise control are also discussed.

79-696

Hunting Stability of the Three Axle Locomotive Truck

R.E. Rinehart
Locomotive Production Dept., General Electric Transportation Systems, Erie, PA, J. Engr. Indus., Trans. ASME, 100 (4), pp 483-491 (Nov 1978) 13 figs, 8 refs

Key Words: Trucks, Hunting motion, Wheels, Vehicle wheels, Suspension systems (vehicles)

The hunting stability of the 3-axle locomotive truck is evaluated, using a linear eleven degree of freedom model. Predictions from the model are validated with test data, and the effects of wheel profile and secondary suspension damping on hunting stability are shown.

ROTORS

79-697

Stability of Rotor Systems Having Asymmetric Elements

T. Iwatsubo
Kobe Univ., Rokko, Nada, 657 Kobe, Japan, Ing. Arch., 47 (5), pp 293-302 (1978) 4 figs, 11 refs

Key Words: Rotors (machine elements), Rotor-bearing systems, Parametric resonance

This paper deals with a problem of parametric resonance of a rotor system. First the equation of motion of the system, which has two asymmetric rotors, asymmetric shafts and asymmetric bearings, is derived in a fixed coordinate system. This is a linear ordinary differential equation, but has time-varying inertia, damping and stiffness coefficients. Stability conditions for some cases are obtained.

79-698

Computer-Aided Balancing of Elastic Rotors Using the Normal Mode Theory and the Influence Coefficient Method (Computergestütztes Auswuchten elasticher Rotoren nach Eigenformtheorie und Einflusskoeffizientenverfahren)

J. Drechsler
Regmentsgatan 73, 72345 Vasteras, Sweden, Ing. Arch., 47 (5), pp 267-283 (1978)
(In German)

Key Words: Rotors (machine elements), Computer-aided techniques, Influence coefficient matrix, Normal modes

A consistent data-process for the balancing of elastic rotors is presented, which includes both the modal methods and the influence-coefficient method. The influence matrix is set up from the experimental data by a least squares procedure. In case of a matrix-singularity (too many balancing planes) the recommended weight-set is determined such that the weight sum is a minimum. Experimental results are given.

79-699

Turbomachinery Rotor Vibrations as a Result of Leakage Flow Effects (Schwingungen von Turbomaschinen-Laufern infolge von Spalstromungseffekten)

H.-J. Thomas
Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 84-101 (Mar 23, 1978) 12 figs, 16 refs
(In German)

Key Words: Turbomachinery, Rotors (machine elements), Self-excited vibrations

The paper enumerates the causes for self-excited vibrations of turbomachinery rotors and the characteristics of different types of these vibrations. An evaluation of the exciting forces from clearance losses and pressure distribution in radial clearances, as well as theoretical approaches and experimental research are presented. The structures of the vibration system, and the influence of different parameters, especially of the anisotropic behavior of the bearings, are investigated.

79-700

Dynamics of Short Eccentric Plain Seals with High Axial Reynolds Number

P.E. Allaire, C.C. Lee, and E.J. Gunter

Univ. of Virginia, Charlottesville, VA., J. Spacecraft Rockets, 15 (6), pp 341-347 (Nov/Dec 1978) 10 figs, 17 refs

Key Words: Rotary seals, Rotating structures, Rotors (machine elements), Stiffness coefficients, Damping coefficients

Plain seals with high axial flow rates produce large stiffness and damping coefficients that can help stabilize high-speed rotating machinery. When the shaft is eccentric in the seal, a Bernoulli effect low-pressure region occurs on the large-clearance side of the shaft. A fluid-restoring force tends to center the shaft and reduce vibrations. This work extends the previous theory for short plain centered seals to large eccentricities using a perturbation analysis. Surface roughness effects are also included.

79-701

An Investigation of the Flexural Vibration Behavior of Slender Rotors in Drum-Type Condensing Turbines

R. Sparmann

Development Section, Industrial Turbine Div., Siemens AG, Wesel, West Germany, Gas Turbine Labs., Proc. 7th Turbomachinery Symp., Texas A&M Univ., College Station, TX, M.P. Boyce, ed., pp 71-86 (Dec 5-7, 1978) 30 figs, 10 refs

Key Words: Turbine engines, Rotors (machine elements), Shafts, Flexural vibration

This paper describes a drum-type rotor of large bearing span and small diameter in the region of the first drum stages, and large diameter in the region of the low-pressure stages and gives its calculated dynamic characteristics. This type of rotor has a markedly higher shaft elasticity compared with the rotors of the two-cylinder machine. The test results for the properly balanced condition, and for the artificially heavily unbalanced condition are described. The shaft vibration values measured during the test-run are compared with the assessment criteria for rotor dynamic performance used at present.

SHIP

(Also see Nos. 617, 677)

79-702

Numerical Integration of the Motions of a Tethered Buoyant Platform

R.A. Ashford and W.L. Wood

Halcrow Ewbank Petroleum and Offshore Engrg. Co., Intl. J. Numer. Methods Engr., 13 (1), pp 165-180 (1978) 5 figs, 13 refs

Key Words: Off-shore structures, Cables, Water waves

The motion of a tethered buoyant platform (TBP) in a regular wave train is investigated numerically using the Zienkiewicz four-time-level scheme. Wave forces are calculated using an equation and linear wave theory. Results are presented for the theoretical response to the periodic forcing function for an optimized method.

79-703

Nonlinear Hydrodynamic Forces on Floating Bodies

B.D. Nichols and C.W. Hirt

Los Alamos Scientific Lab., New Mexico, Rept. No. LA-UR-77-437; Conf-770910-1, 4 pp (1977) N78-30557

Key Words: Floating structures, Cylinders, Hydrodynamic excitation, Computer programs

Two- and three-dimensional SOLA codes are used to investigate nonlinear and three-dimensional effects influencing the hydrodynamic forces on floating cylinders. In particular, nonlinear effects arising during large amplitude swaying motions of a two-dimensional 60 deg triangular cylinder are presented. The results of the numerical studies are compared with data and an intrepretation of the observed nonlinear effects is discussed. A second study is presented that compares two- and three-dimensional calculations of the triangular cylinder in sway. Nonlinear finite amplitude effects for the three-dimensional triangular cylinder are also studied. Finally, some results are presented for other nonlinear forces experienced by cylinders in two- and three-dimensional situations.

SPACECRAFT

79-704

Automatic Environmental Control System for Mission Profile Testing

R. Schilken

Pacific Missile Test Center, Point Mugu, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 48th Symp.

on Shock and Vibration, Huntsville, AL, Vol. 48, Pt. 4, pp 15-23 (Oct 18-20, 1977) 9 figs

Key Words: Environmental effects, Environmental simulation, Missiles

A simple and inexpensive Automatic Environmental Control System is developed for controlling realistic mission profile environmental tests. Hardwired logic and reprogrammable electronic storage are used in the general purpose control system. Coding techniques and a random number generator for simulating temperature day variations in the mission are presented. The entire thermoacoustic environmental generation facility used for missile captive flight simulation is described including a newly developed high efficiency noise modulator driver.

STRUCTURAL

79-705

Guyed Masts (Erfahrungen mit abgespannten Masten)

H. Hertzog

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 504-518 (Mar 23, 1978) 2 figs, 5 refs

(In German)

Key Words: Antennas, Wind-induced excitation, Vibration control

Investigations of wind-excited oscillations are made on existing guyed masts and suitable remedial measures are applied by mounting stabilization systems consisting of swinging, concentrically suspended masses which, via shock absorbers, directly respond to oscillations of the mast.

79-706

Measures for the Prevention of Dangerous Chimney Vibrations (Massnahmen zur Verhinderung gefährlicher Schwingungen von Kaminen)

H. Ruscheweyh

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 519-537 (Mar 23, 1978) 12 figs, 21 refs

(In German)

Key Words: Chimneys, Vortex-induced vibration, Wind-induced excitation, Vibration damping

The dependency of the aerodynamic exciting force of a circular cylinder on the oscillating amplitude is briefly described. Three types of measures for avoiding vortex exciting oscillations are discussed. Aerodynamic and damping devices are compared with each other and dependencies of parameters are shown. Logarithmic decrements of damping, measured at full-scale stacks, are presented.

79-707

Numerical Investigation of Flutter of Linear Frameworks in the Building Industry (Numerische Flatteruntersuchung von Linientragwerken im Bauwesen)

H.-H. Hennlich and G. Rosemeier

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 352-371 (Mar 23, 1978) 13 figs, 7 refs

(In German)

Key Words: Buildings, Bridges, Wind-induced excitation, Finite element technique

Wind-induced vibrations of bridges or buildings are treated by means of numerical models. The general non-linear equations are derived using the finite element method for the structural analysis of wind forces. The equations of motion are discussed using a linearized stability theory with an algebraic criterion and in the nonlinear case, numerical time integration theory is used.

79-708

The Mechanisms of Aeroelasticity (Die Mechanismen der Aeroelastizitat)

O. Mahrenholtz

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 1-16 (Mar 23, 1978) 17 figs, 13 refs

(In German)

Key Words: Aeroelasticity, Mathematical models, Flutter, Aircraft, Bridges

A survey of aeroelastic phenomena, their mathematical models, and the historical evolution of this branch of mechanics are given. The paper deals with the static aeroelastic divergence. The flutter problem is considered. The flutter instability of a plate which is suspended with two degrees of freedom in a potential flow is examined. The phenomenon of galloping is determined by the shape of the body itself.

79-709

Aeroelastic Vibrations of Sharp-Edged Prismatic Bodies (Aeroelastische Schwingungen scharfkantiger prismatischer Körper)

H. Bardowicks and O. Mahrenholtz

Aeroelastic Problems Outside Aeronautics and Astronautics, Proc. Mtg. held at Technical Univ., Hannover, Federal Rep. of Germany, Rept. No. CR1-K1/78, pp 281-299 (Mar 23, 1978) 23 figs, 15 refs

(In German)

Key Words: Prismatic bodies, Fluid-induced excitation, Structural members, Shear vibration, Angular vibration

The paper deals with aerodynamically excited vibrations of prismatic bodies with sharp-edged cross-sections. Lateral as well as rotatory vibrations caused by both vortex-excitation and galloping excitation in a stationary flow are considered. Characteristic properties of some typical cross-sections are described and measures for preventing aeroelastic vibrations are discussed.

79-710

A Laboratory Study of the Fluid-Structure Interaction of Submerged Tanks and Caissons in Earthquakes

R.C. Byrd

Earthquake Engrg. Res. Center, California Univ., Berkeley, CA, Rept. No. UCB/EERC-78/08, 167 pp (May 1978)

PB-284 957/8GA

Key Words: Off-shore structures, Storage tanks, Interaction: structure-fluid, Seismic excitation, Computer programs, Earthquake damage

An experimental study comparing the results of measurements of forces on a submerged tank model due to earthquake excitation is presented. The experimental results are compared with analytical solutions for the case where the model is submerged in water of depth equal to 2.5 times the tank height and for the case where the depth exactly equals the height. Details are presented for the design of a 1 to 100 scale model of a circular cylindrical structure which is 34 meters in height with a mass of approximately 250,000 tons. The model includes a foundation system which simulates elastic half-space soil stiffness in three degrees of freedom. The experimental results are presented in the form of inertia coefficients measured in harmonic motion at varying amplitudes and over a frequency range of 0.3 Hz to 2 Hz in prototype scale. Coefficients are presented for horizontal, vertical, rotational, and horizontal-rotational coupling. The relationship between these coefficients and the physics of the fluid-structure interaction are discussed in detail.

TURBOMACHINERY

(See No. 584)

AUTHOR INDEX

TECHNICAL NOTES

J. Backus
A Comment on Unrealistic Resonance Curves
J. Acoust. Soc. Amer., 64 (4), pp 1201-1203 (Oct 1978) 1 fig, 10 refs

M. Sathyamoorthy
Shear Effects on Vibration of Plates
J. Sound Vib., 60 (2), pp 308-311 (Sept 22, 1978) 11 refs

H.R. Britz and H.F. Pollard
Computational Analysis of Coupled Resonators
J. Sound Vib., 60 (2), pp 305-307 (Sept 22, 1978) 2 figs, 3 refs

G. Gaunaurd, K.P. Scharnhorst, and H. Uberall
New Method to Determine Shear Absorption Using the Viscoelastodynamic Resonance-Scattering Formalism
J. Acoust. Soc. Amer., 64 (4), pp 1211-1213 (Oct 1978) 1 fig, 6 refs

H.E. Bass and R. Raspet
Vibrational Relaxation Effects on the Atmospheric Attenuation and Rise Times of Explosion Waves
J. Acoust. Soc. Amer., 64 (4), pp 1208-1210 (Oct 1978) 2 figs, 8 refs

N. Ganesan
Calculation of Higher Frequencies of Beams by the Simultaneous Iteration Technique
J. Sound Vib., 60 (4), pp 599-601 (Oct 22, 1978) 1 table, 8 refs

A.K. Gupta
Rational and Economical Multicomponent Seismic Design of Piping Systems
J. Pressure Vessel Tech., Trans. ASME, 100 (4), pp 425-427 (Nov 1978) 1 fig, 4 tables, 6 refs

C. Mei
Large Amplitude Vibrations of Plates with Initial Stresses
J. Sound Vib., 60 (3), pp 461-464 (Oct 8, 1978) 2 figs, 16 refs

M.S. Dhotarad, N. Ganesan, and B.V.A. Rao
Transmission Line Vibration with 4R Dampers
J. Sound Vib., 60 (4), pp 604-606 (Oct 22, 1978) 3 figs, 2 tables, 5 refs

M. Iguchi
Comments on the Paper: 'Seismic Response Due to Travelling Shear Wave Including Soil-Structure Interaction with Base-Mat Uplift'
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CALENDAR

APRIL 1979

30-May 2 NOISE-CON 79, [INCE] Purdue University, IN *(NOISE-CON 79, 116 Stewart Center, Purdue University, West Lafayette, IN 47907 - Tel (317) 749-2533)*

30-May 2 Environmental Sciences Meeting, [IES] Seattle, WA *(Dr. Amiram Roffman, Energy Impact Assoc., Inc., P.O. Box 1899, Pittsburgh, PA 15230 - Tel. (412) 256-5640)*

30-May 3 1979 Offshore Technology Conference, [ASME] Astrohall, Houston, TX *(ASME Hq.)*

MAY 1979

7-10 Design Engineering Conference & Show, [ASME] McCormick Place, Chicago, IL *(ASME Hq.)*

20-25 Spring Meeting and Exposition, [SESA] San Francisco, CA *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

JUNE 1979

12-16 Acoustical Society of America, Spring Meeting, [ASA] Cambridge, MA *(ASA Hq.)*

18-20 Applied Mechanics, Fluid Engineering and Bioengineering Conference, [ASME-CSME] Niagra Hilton Hotel, Niagra Falls, NY *(ASME Hq.)*

JULY 1979

9-13 5th World Congress on the Theory of Machines and Mechanisms, [ASME] Montreal, Quebec, Canada *(ASME Hq.)*

SEPTEMBER 1979

9-14 Petroleum Mechanical Engineering Conference [ASME] Hyatt Regency, New Orleans, LA *(ASME Hq.)*

10-12 ASME Vibrations Conference, [ASME] St. Louis, MO *(ASME Hq.)*

10-13 Off-Highway Meeting and Exposition, [SAE] MECCA, Milwaukee, WI *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

11-14 INTER-NOISE 79, [INCE] Warsaw, Poland *(INTER-NOISE 79, IPPT PAN, ul. Swietokrzyska 21, 00-049 Warsaw, Poland)*

OCTOBER 1979

7-11 Fall Meeting and Workshops, [SESA] Mason, OH *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

16-18 50th Shock and Vibration Symposium, Colorado Springs, CO *(H.C. Pusey, Director, The Shock and Vibration Information Center, Code 8404, Naval Research Lab., Washington, D.C. 20375 - Tel (202) 767-3306)*

16-18 Joint Lubrication Conference, [ASLE-ASME] Dayton, OH *(ASME Hq.)*

17-19 Stapp Car Crash Conference [SAE] Hotel del Coronado, San Diego, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

NOVEMBER 1979

4-6 Diesel and Gas Engine Power Technical Conference, San Antonio, TX *(ASME Hq.)*

5-8 Truck Meeting, [SAE] Marriott, Ft. Wayne, IN *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

26-30 Acoustical Society of America, Fall Meeting, [ASA] Salt Lake City, UT *(ASA Hq.)*

DECEMBER 1979

Aerospace Meeting [SAE] Los Angeles, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

2-7 Winter Annual Meeting, [ASME] Statler Hilton, New York, NY *(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

AHS: American Helicopter Society
30 E. 42nd St.
New York, NY 10017

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 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, MA 02173

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