AMERICAN SOCIETY OF CIVIL ENGINEERS

TECHNICAL NOTES

Proc. Paper 12837

DISCUSSION

Proc. Paper 12833

KEY WORDS: **Buildings; Couplings; Dynamic structural analysis; Earthquake resistant structures;** Earthquakes; Response time; **Torsion;** Torsion tests

ABSTRACT: A simple procedure is developed for analysis of elastic response of a particular class of torsionally coupled multistory buildings to earthquake ground motion, characterized by smooth response spectra. In this procedure the response of a N-story torsionally coupled building — a system with 3N degrees-of-freedom (DOF) — is determined by analyzing two systems: (1)An N-story torsionally uncoupled counterpart of the actual building — a system with N DOF; and (2)an associated one-story torsionally coupled system — a system with 3 DOF. The simpler analysis procedure leads to "exact" results if the variation of earthquake spectral acceleration with vibration period is idealized as flat or hyperbolic. For arbitrary but smooth shapes of the response spectrum, it is shown through a numerical example that the results of the simpler analysis are sufficiently accurate for design purposes.

REFERENCE: Kan, Christopher L., and Chopra, Anil K., "Elastic Earthquake Analysis of a Class of Torsionally Coupled Buildings," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12877**, April, 1977, pp. 821-838

12894 BUCKLING OF STAYED COLUMNS

KEY WORDS: Buckling; **Cables (ropes); Columns (supports); Poles (supports);** Prestressing; Stability; **Stay lines; Struts**

ABSTRACT: The elastic buckling load of a metal column may be increased many times by reinforcing the column with rigidly connected crossarm members and prestressed stays. Such columns are referred to as "stayed columns." A procedure based on the finite element method is presented for determining the buckling load of multiple-crossarm stayed columns. This method is compared to an exact solution using stability functions. The buckling loads from the two methods and, where applicable, from previously published results are compared and found to be in excellent agreement. Numerical examples are included which illustrate the increased load carrying capacity of stayed columns, the advantage of using stays with a high modulus of elasticity, and the importance of configuration on the buckling load.

REFERENCE: Temple, Murray C., "Buckling of Stayed Columns," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12894**, April, 1977, pp. 839-851

12885 PROOF-LOAD FACTORS AND RELIABILITY

KEY WORDS: **Codes;** Cost analysis; Design; **Load factors; Loading tests;** Optimization; Probability; **Reliability; Safety factor;** Structural engineering

ABSTRACT: For a complete implementation of second moment reliability concepts in structural design codes, rules must be established for proof-loading tests on the basis of a safety index or of proof-load factors derived therefrom. The safety index after test is defined conveniently (as a distance in an associated Gaussian probability space) as an extended definition of the Hasofer-Lind safety index. Limitations of this safety index in the context of proof-load tests are considered. Two categories are studied: "Active" proof-load tests, in which the purpose is to determine the optimal design parameter given a successful test on a particular structure prior to service; and "passive" tests, leading to reliability statements about a structure during or prior to service. Examples show how to calculate the proof-load factors. Current building standards provisions on proof-load tests are examined from the reliability point of view.

REFERENCE: Fujino, Yozo, and Lind, Niels C., "Proof-Load Factors and Reliability," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12885**, April, 1977, pp. 853-870

12847 R/C MATERIALS—A REMARKABLE HERITAGE

KEY WORDS: **Admixtures;** Aggregates; Cements; **Concrete (reinforced); Concrete (reinforced);** Fiber composites; **History;** Polymers; Prestressing; Proportioning; **Reinforcing materials;** Reinforcing steels; Strength; Sulfur; **Welded wire fabric**

ABSTRACT: Although reinforced concrete as known today was introduced in the middle of the nineteenth century, the materials from which it is made were developed over a period of several centuries. Most of the significant improvements in concrete and its reinforcement that relate to modern use in this country have occurred within the past 200 yr. Concrete, the one major construction material formulated by the civil engineer, has undergone great improvement in durability and steady improvement in strength. Many of the changes in concrete are related to its most critical constituent, portland cement. Concrete has been reinforced with many materials. But steel has always dominated and has been used in various sizes and shapes ranging from structural shaped sections to fibers. Current developments in the energy, ecological, and environmental areas indicate that reinforced concrete will be an important construction material in the future.

REFERENCE: Kesler, Clyde E., "Reinforced Concrete Material - A Remarkable Heritage," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12847**, April, 1977, pp. 747-757

12864 CONCRETE BEAMS IN TORSION AND BENDING

KEY WORDS: **Beams (supports); Bending; Concrete (reinforced);** Reinforcement; Strength; Structural engineering; **Torsion**

ABSTRACT: Using the familiar skew-bending model, a general theory is developed for reinforced concrete beams in combined torsion and bending. The theory is applied to predict the complete behavior of beams up to failure, the strengths of overreinforced and underreinforced beams, and balanced steel ratios. Agreement between the theory and available test data is remarkably good. The paper also includes a simplified method for the calculation of strength of partially or fully overreinforced beams.

REFERENCE: Rangan, B. Vijaya, Staley, Russell F., and Hall, A. Stanley, "Behavior of Concrete Beams in Torsion and Bending," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12864**, April, 1977, pp. 759-772

12881 PLATE WITH A HOLE UNDER UNIFORM END LOAD

KEY WORDS: **Algorithms; Constraints;** Convergence; Finite element method; **Plates (structural members);** Scaling; **Stress analysis;** Stress ratio; **Synthesis**

ABSTRACT: The paper considers plane stress elements with stress constraints synthesis application. Plane stress elements are one type of elements included among others in a large-scale optimization finite element program by the writer called DESAP 1.

REFERENCE: Isreb, Mustafa, "Plate with Hole under Uniform End Load Synthesis with Stress Constraints," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12881**, April, 1977, pp. 773-779

12875 FATIGUE BEHAVIOR OF TWO FLANGE DETAILS

KEY WORDS: Beams (supports); **Bridges (girder); Cracking; Failure (mechanics); Fatigue (materials); Flanges;** Tests; Welding

ABSTRACT: The fatigue behavior of a cover-plated beam with transverse end welds ground to a taper of 1:3 and of a butt welded beam with a flange plate thickness transition ground to a slope of 1:4 are examined. Both specimens were tested under constant and variable amplitude stress cycling. The finishing-process which reduced the stress concentration factor at the weld toe was found to be an effective method of increasing the fatigue resistance. The constant and variable amplitude fatigue lives correlate well when plotted versus the root-mean-cube stress range.

REFERENCE: Yamada, Kentaro, and Albrecht, Pedro, "Fatigue Behavior of Two Flange Details," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12875**, April, 1977, pp. 781-791

12888 FLEXURAL REINFORCEMENT IN CONCRETE SLABS

KEY WORDS: Concrete (reinforced); **Concrete slabs;** Design; **Flexural strength; Moments;** Plates (structural members); **Reinforcement; Slabs**

ABSTRACT: Reinforced concrete slabs are designed based on the equilibrium or the yield line method. The equilibrium approach is recommended because the latter method gives an upper bound on strength which may require several iterations before an acceptable solution is obtained. With the advent of digital computers, sophisticated numerical methods, such as the finite element method, are often used to obtain an equilibrium solution based on the theory of elasticity. An elasticity solution, in general, yields a set of three moments at any point, i.e., M_x, M_y, and M_{xy}. Methods for designing flexural reinforcement in slabs analyzed elastically are presented.

REFERENCE: Gupta, Ajaya K., and Sen, Siddhartha, "Design of Flexural Reinforcement in Concrete Slabs," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12888**, April, 1977, pp. 793-804

12876 TORSIONAL COUPLING AND EARTHQUAKE FORCES

KEY WORDS: **Buildings; Couplings; Dynamic structural analysis; Earthquake resistant structures;** Earthquakes; Response time; **Torsion;** Torsion tests

ABSTRACT: The elastic response of torsionally coupled one-story buildings to earthquake ground motion, characterized by idealized shapes for the response spectrum, is studied. Influence of the basic system parameters on the response is investigated. The relationship between the forces — base shears and torque — in a torsionally coupled system and the base shear in a corresponding torsionally uncoupled system is established, and the effects of torsional coupling on earthquake forces are identified. Useful upper and lower bounds are presented for the base shears and torque due to simultaneous action of two horizontal components of ground motion of equal intensity.

REFERENCE: Kan, Christopher L., and Chopra, Anil K., "Effects of Torsional Coupling on Earthquake Forces in Buildings," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12876**, April, 1977, pp. 805-819

12893 TIME-DEPENDENT ANALYSIS OF COMPOSITE FRAMES

KEY WORDS: **Bridges (structures); Composite structures;** Computerized design; Concrete; Concrete (precast); Concrete (prestressed); Continuous beams; **Creep; Deflection; Frames;** Prestressing; **Relaxation (mechanics); Shrinkage;** Steel; Strain; **Stress; Time dependence**

ABSTRACT: A step-by-step computer method is presented for the analysis of the time-dependent stresses and deformations of continuous composite concrete beams and plane frames. It accounts for the effects of creep and shrinkage of concrete and the relaxation of prestressing steel. The frame members can be composed of one or more concrete parts reinforced with prestressed and nonprestressed steel, or of steel girder and concrete deck. A bridge example of a type commonly used in highway bridges is analyzed. It is shown that accurate analysis of composite prestressed concrete structures cannot be achieved without rational account of creep, shrinkage, and relaxation.

REFERENCE: Tadros, Maher K., Ghali, Amin, and Dilger, Walter H., "Time-Dependent Analysis of Composite Frames," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12893**, April, 1977, pp. 871-884

12889 ECONOMIC FEASIBILITY OF CONCRETE RECYCLING

KEY WORDS: **Concrete;** Concrete aggregates; Debris; **Debris removal; Demolition;** Economic analysis; **Waste disposal; Waste recycling**

ABSTRACT: The economics of using recycled concrete debris as aggregate for new concrete has been studied. The writers find that there is enough concrete debris generated in large metropolitan areas to support profitably the operation of at least one concrete recycling plant. The production cost of recycled concrete aggregate is about 38% lower than that of its competitor, natural aggregate. However, for equal performance with conventional concrete members, members that contain recycled concrete aggregate must be 20% larger in volume. Analysis of these findings suggest that, for equal delivery distance of the aggregate, conventional concrete is economically more attractive than concrete with recycled aggregate. This relation is, however, reversed in areas where there is a shortage of natural aggregate; specifically, for a difference in transportation distance of at least 15 miles (24 km) in favor of recycled concrete aggregate, concrete containing the latter is economically more attractive than conventional concrete.

REFERENCE: Frondistou-Yannas, Stamatia, and Itoh, Taichi, "Economic Feasibility of Concrete Recycling," *Journal of the Structural Division,* ASCE, Vol. 103, No. ST4, **Proc. Paper 12889**, April, 1977, pp. 885-899