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Discussion and closure of "survey of current structural research", Proc. ASCE, Vol. 91, ST6, December 1965, p. 302., Publication No. 263/65-2

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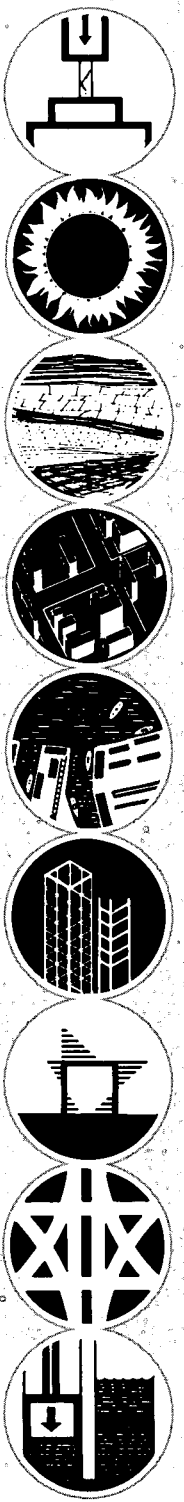

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Survey of Current Structural Research: Discussion-Closure

Committee on Research,
Structural Division

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SURVEY OF CURRENT STRUCTURAL RESEARCH[a]

Discussion and Closure by Committee on Research of the Structural Division

COMMITTEE ON RESEARCH OF THE STRUCTURAL DIVISION.—The discussions submitted were in the form of errata and additions to the survey. The material submitted has been arranged in a format identical to that in the main report (Journal of the Structural Division, ASCE, Vol. 91, No. ST1, Proc. Paper 4233, February, 1965, pp 13-102.). Within each administrative committee the breakdown is according to task committee. Under each task committee the appropriate individual research projects are listed. The first item is the title of the project; at the beginning of the second line is the institution at which the work is being done; the investigator's name next appears in parenthesis; and the final item in the heading is the name of the sponsor. (In the final item, the word "same" is used to indicate that the sponsor and institution at which the work is being done are the same.) The description of the project is as furnished by each investigator except for editing.

[a] February, 1965, by the Committee on Research of the Structural Division (Proc. Paper 4233).

TABLE 1 (REVISED).—COMMITTEES OF ASCE STRUCTURAL DIVISION: NUMBER OF PROJECTS

Committees	Number of Projects	Subtotal
1. Analysis and Design of Structures		
1.1 Factor of Safety	3	
1.2 Lateral Forces	55	
1.3 Tower Design	6	
1.4 Methods of Analysis	118	
1.5 Special Building Problems	6	
[a]1.6 Other Topics	23	211
2. Electronic Computation		
2.1 Conference	--	
2.2 Future Applications	6	
2.3 Guide of Program Manuals	--	
2.4 Publications	--	6
3. Masonry and Reinforced Concrete		
3.1 Composite Construction	25	
3.2 Reinforced Concrete Slabs	29	
3.3 Folded Plate Construction	6	
3.4 Limit Design	16	
3.5 Precast Structural Concrete Design and Construction	4	
3.6 Prestressed Concrete	56	
3.7 Reinforced Concrete Columns	8	
3.8 Reinforced Masonry Design and Practice	7	
3.9 Shear and Diagonal Tension	29	
[a]3.10 Other Topics	85	265
4. Metals		
4.1 Compression Members	36	
4.2 Light Gage Metals	8	
4.3 Lightweight Alloys	12	
4.4 Plastic Design	31	
4.5 Flexural Members	34	
4.6 Structural Steel Connections	42	
4.7 Orthotropic Plate Bridge	11	
4.8 Tubular Structures	10	
[a]4.9 Other Topics	42	226
5. Nuclear Structures and Materials		
5.1 Hot Laboratories	1	
5.2 Live Loads Due to Heat and Incidence	2	
5.3 Structural Aspects of Nuclear Incidents	-	
5.4 Structural Materials in Reactor Design	4	7
6. Wood		
6.1 Technical Literature	1	
6.2 Technical Presentation	2	
6.3 Wood Research	53	56
7. Plastics		
7.1 Structural Applications	11	
7.2 Properties of Selected Structural Plastics	3	
7.3 Design Criteria for Components	2	
7.4 Design Criteria for Adhesives	2	18
	Total	789

[a] Topics not covered by an existing committee.

The arrangement of the material within a particular task committee is alphabetical according to institution (beginning of second line).

The additional projects reported were placed in their respective category and were assigned numbers that continue from those used in the original paper. The additional projects are listed in the appendix along with the complete subject and institutional indexes.

It is emphasized again that reliance was placed on the questionnaires submitted as there was no opportunity for the committee to conduct a separate survey. Reference may be made, of course, to the surveys of WRC and ACI.

Tables 1 and 2 have been revised to include the new material submitted. They include a total of 789 projects.

TABLE 2 (REVISED).—SPONSORSHIP OF THE RESEARCH PROJECTS

Group Breakdown of Sponsors	Number of Projects Sponsored	% of Projects Listed
Industry and Trade Associations	91	11.5
Technical Societies & Research Councils	78	9.9
Local and State Governments	45	5.7
Federal, Non Department of Defense	84	10.6
Department of Defense	36	4.6
Other	150	19.0
University	103	13.1
None Listed	202	25.6
Total	789	100.0

The Research Committee of the Structural Division, ASCE, gratefully acknowledges the discussers and those who contributed to the original paper. It is the hope of the committee that publication of the original paper has stimulated contact between investigators, and that this "discussion and closure" will contribute to further exchanges. It is the intent of the Structural Division Research Committee to provide for a periodic up-dating of the survey.

Respectfully submitted,

Survey Committee
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J. A. Yura
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Research Committee
John D. Haltiwanger, Chairman
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Errata.—The following corrections should be made in the original paper:

Page 16, line 15: Change "Technical Societies and Research Councils" to read "University"

Page 28, Listing No. 30: Delete

Page 46, Listing No. 23: Add the following abstract

"Flexural cracking propagation and crack width relationship to stress in reinforcement wire is investigated at all stress levels. Also the post-elastic deflection behavior for these two-way slabs is investigated. The slabs are 5 ft-8 in. by 5 ft-8 in., some simply supported and others clamped."

Page 64, Listing No. 46: Should read

"THE LOW-TEMPERATURE PROPERTIES OF SOME STRUCTURAL MATERIALS

Ottawa, University of, Canada (C. Berwanger); National Research Council of Canada

A study of the low-temperature properties of reinforced concrete and plain concrete with respect to the evaluation of the coefficient of expansion of reinforced concrete slabs, as well as the modulus of elasticity of the concrete with temperature variations. A report for publication is being prepared covering the initial research work completed and further tests are planned to start before the end of 1965."

Page 72, Listing No. 5, line 2: Change to read "Illinois, University of (W. H. Munse); Civil Engineering Department, University of Illinois"

Page 77, Listing No. 7, line 2: Change to read "Illinois, University of (A. Ang); Caterpiller Tractor Co."

Page 81, Listing No. 8, line 2: Change to read "Illinois, University of (J. E. Stallmeyer); Gregory Industries"

Page 88, Listing No. 12, line 2: Change to read "Illinois, University of (W. J. Hall); N.S.F."

Page 88, Listing No. 13, line 2: Change to read "Illinois, University of (W. H. Munse); U. S. Navy, Bureau of Ships"

Page 88, Listing No. 14, line 2: Change to read "Illinois, University of (W. H. Munse); National Academy of Science, Ship Structures Committee"

Page 98, Institutional Index: Add "Monash University, Australia 5.2"

Page 102, Subject Index: Add "5.2 Thermal Stress"

CURRENT STRUCTURAL RESEARCH PROJECTS

The following additions should be made to the original paper:

1. Analysis and Design of Structures

1.2 Lateral Forces

(54) EARTHQUAKE STRESSES IN TALL BUILDINGS WITH SETBACKS

Michigan, University of (G. V. Berg); National Science Foundation

No abstract has been provided.

(55) THE RESPONSE OF FRAMED STRUCTURES TO EARTHQUAKE FORCES

Michigan, University of (G. V. Berg); American Iron and Steel Institute

No abstract has been provided.

1.3 Tower Design

(6) THE RESPONSE OF GUYED TOWERS TO DYNAMIC FORCES

Michigan, University of (G. V. Berg); National Science Foundation

No abstract has been provided.

1.4 Methods of Analysis

(115) ANALYSIS OF DOUBLY-CURVED SHALLOW TRANSLATIONAL SHELLS

Alberta, University of (Dr. S. H. Simmonds); National Research Council of Canada

The project has been in progress for 2 yr and consists of two distinct parts. The first part is the development of a numerical procedure for the analysis of shallow doubly-curved shells. This is accomplished using a physical analogue which approximates the behavior of the shell structure and permits consideration of any loading and elastic boundary condition. The second part is experimental verification of the analytical results. One model shell, 8 ft square in plan, has been tested. At present, a computer program is being prepared that will permit solution of shallow shells considering any input parameter for plan-dimensions, rise (if shallow) and boundary conditions.

(116) ANALYSIS OF NONLINEAR STRUCTURAL SYSTEMS

Arizona, University of (R. M. Richard); none

A method for analyzing structural systems subject to both material and geometric nonlinearities is being developed. This method, which is a direct generalization of the displacement method, treats the analysis of nonlinear structures as an initial value problem. The governing equations have been shown to be a set of simultaneous nonlinear first order equations in which the generalized displacements are the dependent variables and the applied loading the independent variables.

(117) BUCKLING STUDIES OF SHELL STRUCTURES

Arizona, University of (Howard Harrenstien); none

A statistical approach to the experimental determination of critical buckling pressures for shell structures is being developed. This approach involves the forming and testing of a large number of small polyvinyl chloride shells. Control over variables such as curvatures, boundary conditions and thicknesses are included. Use is made of the vacuum forming techniques to produce the "identical" shells that are involved in the test program.

(118) FUNICULAR SHELLS

Arizona, University of (Howard Harrenstien); none

A funicular shell is one that exhibits uniform direct stress under specified normal pressure loadings. The configuration of these structures sufficient to guarantee this stress distribution is being investigated. Numerical methods which solve the non-linear differential equations of shell equilibrium written for the membrane state are being used in the analysis. Design curves for some of the more common applications are being developed. The application of graphical approximate analyses to the solution to these problems are being investigated.

(119) ANALYSIS OF CURVED BEAMS WITH NONDEFORMABLE THIN-WALLED CROSS-SECTION

Politechnika, Gdansk, Poland (Ryszard Dabrowski); none

Torsion-bending of curved beams with a thin-walled (open and monosymmetrical or closed and asymmetrical) cross-section subject to loading normal to the plane of curvature is analyzed under the assumption of nondeformability of cross-section. For continuous curved beams, coefficients of equation matrix, with bending and warping moments at intermedi-

ate supports being the unknowns, are evaluated. Influence lines of section forces for stiffness parameters pertaining to curved bridge structures are calculated. (Three papers on the subject appear in "Der Stahlbau," 1964-1965.)

3. Masonry and Reinforced Concrete

3.1 Composite Construction

(22) THE USE OF EPOSY RESIN COMPOUNDS AS SHEAR CONNECTOR IN COMPOSITE T-BEAMS

Arizona, University of (J. D. Driegh and R. M. Richard); Arizona Highway Department and Bureau of Public Roads

An epoxy resin compound has been formulated which will serve as a shear connector for bonding fresh concrete to hardened concrete or steel. Static and dynamics tests have shown satisfactory performance. Present activity is related to development of mathematical analyses, design criteria, field test performance, and additional laboratory studies.

(23) STATIC STRENGTH OF PUSH-OUT SPECIMENS IN COMPOSITE BAR JOIST CONSTRUCTION

Vanderbilt University (P. G. Hoadley); Volunteer Structures and Vanderbilt University

Thirty push-out specimens have been tested and the results are now being analyzed. The push-out specimens were tested to determine the shear-slip relationship for a three (3) inch concrete slab acting compositely with two (2) angles by means of a stud connector between the angles. The information will be used to more intelligently design a series of experiments to study the behavior of composite bar joists.

(24) STATIC STRENGTH OF COMPOSITE BAR JOISTS

Vanderbilt University (P. G. Hoadley); Volunteer Structures and Vanderbilt University

Four (4) composite bar joists are now being designed as an experimental pilot study for the static strength of composite bar joists. A more comprehensive study is planned which will be based on this pilot study and the push-out test program which is nearly complete.

(25) AN INVESTIGATION OF THE EFFECTIVE SLAB WIDTH FOR COMPOSITE STEEL BEAMS

Vanderbilt University (P. G. Hoadley); American Iron and Steel Institute and Vanderbilt University

This program, which is just beginning, involves the experimental determination of the effective slab width for composite steel beams. Parameters to be studied include span-depth ratio, slab depth to beam depth ratio and beam spacing.

3.2 Reinforced Concrete Slabs

(28) ULTIMATE STRENGTH OF CONCRETE SLABS

Alberta, University of (Dr. S. H. Simmonds); none listed

By approximating the behavior of a slab by a physical analogue similar to Newmark's Plate Analogue, it is possible to obtain the moments and deflections at discrete points as cracking in the slab propagates to a failure condition. A computer program has been written and results obtained for rectangular and square slabs supported on hinged and free edges. Agreement with Johansen's Yield Line Theory and elastic analysis prior to first yield is within 32. A study of further parameters such as openings in the slab are contemplated.

(29) VAULT ACTION IN CONTINUOUS REINFORCED SLABS

Technische Hochschule Stuttgart, Germany (Dr. F. Leonhardt); Deutscher AusschuB fur Stahlbeton

In all center panels of continuous reinforced concrete slab systems considerable load capacities remain unused under the current methods of design and calculation. As soon as the typical surface cracks over the support lines of these central panels have appeared, pivoting lines are formed in the compression zone below. The center panels act as flat vaults against the horizontally stiff adjacent plates, which react as elastic abutments to the vault thrust. The flexural stresses are superimposed by additional compressive stresses, whose consideration allow a more economical reinforcement than the current methods of calculation, based on pure bending permit. Two test models of reinforced concrete beam-slab systems of same size were made: Each a 6 ft 7 in. square, 3 in. thick center panel, surrounded on all sides by 2 ft 6 in. wide slabs. The models differed only in their degree of reinforcement over the support lines of their center panels. Deflections, concrete and steel strains, and crack widths were measured in numerous points on top and on bottom. The compressive forces of the vault action could be proved clearly. They were identical in size in both models, i.e. independent of the varying degree of reinforcement. The collapse loads were considerably larger than the ultimate loads according to a pure bending analysis. The test results conformed with a new analytical method based on the vault action combined with bending. This method allows savings to 50% of the reinforcement of all center panels in a continuous reinforced concrete slab system, without any reduction in safety against rupture or unacceptable wide cracks.

3.3 Folded Plate Construction

(6) TESTS ON VERTICAL PLATES WITH VARYING ANGLES BETWEEN PRINCIPAL STRESSES AND DIRECTION OF REINFORCEMENT

Technische Hochschule Stuttgart, Germany (Dr. F. Leonhardt); Wirtschaftsministerium Baden-Wurttemberg and Deutsche Forschungsgemeinschaft

Ten reinforced concrete plates (5 ft 3 in. by 5 ft 3 in. by 0.3 in.) were subjected to pure tension. The reinforcement (square meshes) was inclined with respect to the tension force, the inclination δ varying from 0 to 45°. Results: Cracks occurred always perpendicular to the tension force, independently of the inclination of reinforcement. An increase of δ affected neither the number of cracks nor the distance between them. The crack-borders showed a vertical as well as a horizontal displacement relative to each other, which is a maximum for δ = 30° and a minimum for δ = 45°. The deformations in the direction of the tensile force increase with an increasing inclination δ. In the case of perpendicular reinforcement provided with bars of equal cross-section in both directions the deformations for δ = 45° are twice and for δ = 25° about 1.3 times as great as for δ = 0°. In plates and shells the reinforcement should be placed along the stress-trajectories. If, for practical reasons, this is not possible, and δ exceeds 25°, then sufficient latteral reinforcement has to be provided. All specimens failed almost at the same load, independently of the deviation δ.

3.4 Limit Design

(15) LIMIT BEHAVIOR AND MOMENT-ROTATION CHARACTERISTICS OF REINFORCED CONCRETE BEAMS AND FRAMES

Rutgers University (E. G. Nawy); same

Studies are made both analytically and experimentally of the moment-rotation relationship in reinforced concrete beams of a span of 8 ft subjected to both transverse load and combined axial compression and transverse midspan line load.

(16) MOMENT-ROTATION CHARACTERISTICS AND PLASTIC HINGE DEVELOPMENT IN PRESTRESSED BEAMS

Rutgers University (E. G. Nawy); same

Tests are being planned to evaluate the rotation of plastic hinges in prestressed post-tensioned bonded beams. The beams are simply-supported and loaded at midspan. Span is 9 ft 0 in. and cross-section is I-beam shape. Load applied statically. One major aim is to explore the possibility of increasing the ductility of the prestressed beam so as to achieve relatively elastic idealy-plastic moment-curvature relationship.

3.6 Prestressed Concrete

(55) DEFORMATION CHARACTERISTICS OF PRESTRESSED CONCRETE BEAMS

Alberta, University of (Dr. J. Warwaruk); University of Alberta and National Research Council of Canada

The project involves experimental and analytical investigations of the deformation characteristics of bonded prestressed concrete beams. Its objective is to predict, with reasonably accuracy, the entire moment-curvature, load-deflection characteristics of prestressed beams.

(56) TORSION AND SHEAR TESTS ON PRESTRESSED BOX GIRDERS

Technische Hochschule Stuttgart, Germany (Dr. F. Leonhardt); Betonund Monieurbau A. G., Dusseldorf

Torsion and shear tests were conducted on two prestressed box girders, one with a central load (bending and shear), and the other with an eccentric load (bending, shear and torsion). A photo-elastic model was also tested for the same loading conditions. It was found that for shear, as well as for torsion, the principal compressive stresses and not the principal tensile stresses are the governing failure criterion, if sufficient web reinforcement is provided. Therefore the allowable principal ctensile stresses could be increased, whereas the principal compressive stresses should be limited. After diagonal cracking the torsional stiffness decreased to about one fifth of the value before cracking. Further tension tests on small beams are presently being conducted.

3.7 Reinforced Concrete Columns

(8) STRENGTH OF REINFORCED CONCRETE COLUMNS UNDER SUSTAINED LOAD

Alberta, University of (J. C. MacGregor); National Research Council of Canada

This project involves an analytical study of the effects of creep and shrinkage on the strength of reinforced concrete columns in frames subjected to sustained loads.

3.9 Shear and Diagonal Tension

(28) DEVELOPMENT OF INCLINED CRACKS IN REINFORCED CONCRETE BEAMS

Alberta, University of (J. C. MacGregor); National Research Council of Canada

The combined stresses at the inception of inclined cracking are being studied for typical reinforced concrete beams. This study will include flexural stresses, direct shear stresses, doweling shear stresses and "tooth" deflection stresses in an overall study of the stresses adjacent to potential inclined cracks in reinforced concrete beams.

(29) SHEAR TESTS ON TWO-SPAN CONTINUOUS REINFORCED CONCRETE BEAMS

Technische Hochschule Stuttgart, Germany (Dr. F. Leonhardt); Deutscher AusschuB fur Stahlbeton

Tests were conducted on 26 two-span continuous reinforced concrete beams to study the behaviour of shear failures in the case of statically indeterminate members and to check the new design proposals suggested by the investigators to reduce the shear reinforcement. The main variables were: (1) Anchorage length of the longitudinal reinforcement (deformed bars) for rectangular beams without web reinforcement; (2) Moment-shear ratio (from 1 to 3) for rectangular beams; (3) Amount and type of web reinforcement in case of T-beams; (4) Shape of cross-section; and (5) Longitudinal reinforcement in case of rectangular beams. The influence of the moment-shear-ratio M/V d for continuous beams was about the same as for simply supported beams. For low or moderate shearing stresses the web reinforcement can be reduced with respect to the full web reinforcement according to the truss analogy. On the other hand, the allowable shearing stresses can considerably be increased, if sufficient web reinforcement is provided. There was considerable redistribution of the internal forces due to early cracking over the supports and due to formation of plastic hinges. The tests and conclusions have been fully reported in the Bulletins 151, 152, and 156 of the DAfSt.

3.10 Other Topics

(82) RESISTANCE OF REINFORCED CONCRETE SUBJECTED TO TORSION AND BENDING

Alberta, University of (Dr. J. Warwaruk); National Research Council and University of Alberta

Objective of research is to study the resistance, strength and deformation characteristics of simply supported rectangular reinforced concrete beams subjected to torsion loads and combined torsion and bending loads. The investigation is mainly experimental beginning with a loading sequence of bending first, then twisting to failure. Later other combinations of load will be used. The variables involved include concrete strength, and reinforcement types and amounts.

(83) MATERIALS AND METHODS FOR REPAIRING PORTLAND CEMENT CONCRETE AND STRUCTURES

Arizona, University of (J. D. Kriegh); U. S. Army Corps of Engineers

A review of existing materials and methods used for concrete and masonry protection and repair is being made.

(84) FLEXURAL STRENGTH OF GLASS-REINFORCED CONCRETE BEAMS

Rutgers University (E. G. Nawy and C. J. Phillips); same

Beams of span 3 ft 6 in. and reinforced with glass are being investigated. Problems of bond and flexural capacity are analyzed.

(85) TESTS ON DEEP BEAMS WITH DIFFERENT ARRANGEMENTS OF REINFORCEMENT AND LOADING

Technische Hochschule Stuttgart, Germany (Dr. F. Leonhardt); Deutscher Ausschuss fur Stahlbeton, Wirtschaftsministerium Baden-Wurttembert

In the first part of the investigation 9 beams (H:L = 1.0) with different arrangements and percentage of reinforcement were tested (5 beams loaded from top and 4 beams with loads suspended at the bottom). Results: (1) When the longitudinal reinforcement extends from support to support (without cut-off or bent-up bars), no shear cracks develop and there is no danger of shear failure. Bent up bars are, therefore, unnecessary and even disadvantageous since they weaken the tension. (2) The tension in the main reinforcement does not decrease according to the moment line but remains almost constant to the supports. (3) The main danger of failure lies in the diagonal compressive stresses of concrete and in the support pressures. The bending compressive stresses, on the other hand, are not critical. (4) To avoid the formation of wide cracks, the longitudinal tension reinforcement should be distributed at least over one tenth of the height of the beam. In continuation of these tests on simply supported beams, tests were conducted on two span continuous beams and also on beams with indirect loads and indirect supports.

4. Metals

4.1 Compression Members

(36) INELASTIC COLUMNS UNDER BIAXIAL BENDING FROM ELASTIC BEAMS

Imperial College of Science and Technology, London (A. R. Gent); none listed

This problem is similar to the eccentrically loaded elastically restrained column. Experiments on accurately machined model I and H-Section columns under symmetrical single curvature inelastic bending from elastic beams are being conducted and results correlated with a computer program for biaxial bending with appropriate end conditions; this is based on solving the cross sectional equations. The first experiments investigated the special case of minor axis buckling under major axis bending only and subsequently a limited number of experiments have examined the effect of variation of slenderness under biaxial bending. This work is being carried out to provide data necessary in following up a new approach to the economic design of nosway frames.

4.6 Structural Connections

(42) TEST ON HIGH TENSILE BOLT CONNECTIONS

Technische Hochschule Stuttgart, Germany (W. Zimmermann); Deutsche Bundesbahn

Since 1960 about 350 tests on high tensile bolt connections have been conducted to determine the coefficient of friction μ, depending on different factors: (1) Influence of the arrangement of the bolts: narrow tension members with two butt straps and 4 bolts arranged in the direction of the tensile force. Broad tension members with two butt straps and 4 bolts arranged perpendicular to the direction of the tensile force. (2) Influence of the treatment of the contact surfaces: Different methods of treating the contact surfaces have been employed: spray galvanising, blasting with quartz sand, steel grit or corrundum of ranging size of granulation and flame blasting. In these tests, the coefficient of friction, μ, was found to lay between $\mu = 0.48$ and $\mu = 0.71$.

4.9 Other Topics

(41) ANALYSIS AND DESIGN OF YIELDING MEMBRANE ELEMENTS

Arizona, University of (Howard Harrenstien); Office of Civil Defense

Thin mild steel diaphragms are being investigated as exterior structural surfaces for buried shelters. These elements resist dynamic overpressures by yielding into the membrane state of shell action. In addition, they induce favorable soil-structure interaction effects which serve to attenuate the magnitude of blast overpressures that are transmitted to the primary structure. Nonlinear methods of analysis of the configuration of these elements under loading are used. Design curves are being developed and applications through the use of models are suggested. Certain blast simulator studies which confirm favorable soil-structure interaction characteristics have been conducted.

(42) FREQUENCY CHARACTERISTICS OF PRESTRESSED STEEL BEAMS

Vanderbilt University (P. G. Hoadley); McMurray Steel Co. and Vanderbilt University

Four (4) steel rectangular box sections prestressed with high strength steel bars have been excited by a mechanical excitor to determine the effect of the prestressing force and other parameters on frequency characteristics. No appreciable change in frequency was found in the cases tested. The results agreed fairly well with an analytical method which was developed independently of the experimental program. Future plans for this project include the determination of what effect prestressing has on the damping characteristics of steel beams.

6. Wood

6.3 Wood Research

(24) EFFECT OF DELAMINATION ON SHEAR STRENGTH OF GLULAM BEAMS

Alberta, University of (J. Longworth); Department of Forestry, Canada

The effect of artificially inserted delaminations on the shear strength of glulam beams is being studied experimentally. Both static and cyclic loading effects are being studied.

(25) NON-DESTRUCTIVE TESTING OF WOOD

Association of American Railroads (F. P. Drew); Association of American Railroads Research Center AREA Committee 7

This program is continuing its purpose to determine internal decay of large structural timbers by non-destructive means. Nuclear and Sonic methods are being considered.

(26) STATIC AND REPEATED LOAD STRENGTH OF SOLID-SAWN DOUGLAS FIR STRINGERS

Association of American Railroads (F. P. Drew); Association of American Railroads Research Center AREA Committee 7

Full size treated Douglas fir stringers, 8 in. by 16 in. by 14 ft long are being investigated for static and fatigue properties. Tests will include loadings at various positions with respect to the end reaction. This test is being made with cooperation of the Forest Products Laboratory.

(27) THE STRENGTH OF POWER AND COMMUNICATION POLES

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

Thirty plantation-grown red pine poles will be tested in flexure using the machine method. Strength data will provide a comparison with previous data from forest grown poles. The machine shaved poles 30 ft long are being seasoned and butt soaked prior to testing.

(28) DEVELOPING DESIGN DATA FROM STRENGTH EVALUATIONS OF STRUCTURAL SIZE TIMBER

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

Although design stresses in North American have traditionally been based on tests of small clear specimens, the files of the Forest Products Laboratories of Canada contain data from the testing over the years of several hundreds of beams and joists of various species and sizes. These data will be assembled and re-examined. Statistical techniques will be used to check current working stresses against the previous ultimate stresses, and minimum factors of safety likely to be encountered will be measured. Recommendations will be made for such further testing as is deemed necessary to understand the behavior of structural timbers.

(29) THE LOAD CARRYING CAPACITY OF MULTIPLE CONNECTOR JOINTS

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

Current joint design theory assumes that the capacity of a joint made with n shear plates or split ring connector units is equal to n times the capacity of a single connector unit. Preliminary observations and a theoretical analysis of an elastic model indicate that the proportion of total load resisted by one of several connector units in a joint depends on a number of factors including relative position, elasticity of materials and number of units. A quantity of structural size glulam tension members using the two sizes of shear plates are being tested, and load distributions are being measured to determine the correlation between theoretical and actual behavior.

(30) METAL TRUSS PLATE PERFORMANCE AS INFLUENCED BY KNOTS AND MOISTURE CHANGES

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

A quantity of nominal 2 in. by 4 in. specimens using three different types of proprietary metal truss plates will be tested to destruction. The effects on load carrying capacity of such factors as knots under the plates, wetting and drying cycles, and in-place seasoning, will be studied.

(31) THE LATERAL STABILITY OF GLULAM BEAMS AND ARCHES

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

Studies to now have pointed up a satisfactory design approach for determining conditions of span, depth and breadth of beams required to insure lateral stability in the absence of lateral restraint. In most practical applications beams receive some degree of lateral restraint from secondary framing members. The object of the current phase of this study is to determine the magnitude of lateral support required to restrict buckling under various conditions, and to evaluate the role played by secondary framing members in providing this lateral bracing. Small scale as well as commercially fabricated full size specimens are being used. It is proposed to extend the study to include glulam arches.

(32) EVALUATING DESIGN TECHNIQUES FOR GLULAM BEAMS

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

A recently completed study of laminated hemlock beams gave evidence of a "width effect" on ultimate strength, with the narrower beams developing a higher modulus of rupture than the wider beams. Partly as a result of this, an extensive testing program was planned, to determine the effects of Ik/Ig, beam width, and beam depth, on the ultimate strength of Douglas-fir glulam beams. The laminating stock for some 57 beams of varying widths, depths and spans was passed through a commercial mechanical stress rating machine, and the size and location of all knots in each lamination were measured and recorded as they were laid up into beams. The beams will be tested in flexure and the data analyzed.

(33) EVALUATION OF MECHANICAL LUMBER GRADING

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

In the present phase of this investigation some 370 spruce 2 by 6 joists are being loaded to destruction in flexure in a universal testing machine, after having been evaluated in a proprietary stress rating machine. The data will be analyzed to determine the selection efficiency of the stress rating machine.

(34) THE IN-SERVICE PERFORMANCE OF SELECTED STRUCTURAL TIMBER MEMBERS

Forest Products Laboratory, Ottawa, Canada (D. E. Kennedy); same

Deflection measuring apparatus has been attached to the pitched cambered glulam roof beams in a sawmill, and deflections at particular time intervals and under gaged snow loads are being measured. A continuous record of the relative humidity in the building is being maintained, and changes in beam moisture content will be measured from time to time with a moisture meter. Data gathered over a period of years will be used to evaluate theories regarding the effects of load and time on wood flexural members.

(35) TENSILE STRENGTH OF STRUCTURAL TIMBERS

Forest Products Laboratory, Vancouver, Canada (W. J. Smith); same

Some 500 pieces of nominal 2 by 6 lumber will be subjected to full-scale tension tests to study the effects of various factors upon strength. The pieces will be both visually graded and machine graded in a commercial stress rating machine, before being tested to destruction. Data will be analyzed to determine the efficiency of grading methods as related to tensile strength.

(36) MOMENT CONNECTIONS FOR GLUED-LAMINATED STRUCTURES

Forest Products Laboratory, Vancouver, Canada (W. J. Smith); same

This study, which is now substantially completed, investigated the merits of various methods for transferring moments through connector joints for application in light and medium construction using glulam members. To complete the pro-

gram, the performance of a steel plate high strength nail fastening is being examined in large structural applications with particular emphasis on the effects of nail-spacing on strength and stiffness of beam to column and arch haunch connections.

(37) SPLICING PLYWOOD PANELS

Forest Products Laboratory, Vancouver, Canada (W. J. Smith); same

After evaluating several types of splices which might be used for joining together plywood panels of commercial sizes, a specific finger joint design was selected as being most suitable to local production on the West Coast. The evaluation was carried out on a Laboratory made joint. A thorough evaluation of this joint when manufactured commercially, is proceeding.

(38) ULTIMATE STRENGTH BEHAVIOR AND DESIGN OF TIMBER STRUCTURES

Michigan Technological University (G. P. Krueger); NSF, USFPL, Mich. Tech. Univ.

This comprehensive program is designed to develop ultimate strength design procedures for timber and timber composites similar to those of steel and concrete. The program includes three research areas and tentatively 26 subprojects in the various areas: Area I: Ultimate Strength of Reinforced and Unreinforced Structural Timber Sections (11 sub-projects); Area II: Elastic Design Of Timber Structures With Semi-Rigid Adhesive Joints (7 sub-projects); and Area III: Limit Design Of Timber Structures Using Ultimate Design Of Reinforced Sections and Semi-Rigid Joints (8 sub-projects). Phases of research are currently being carried out in each of the three areas under the direction of G. P. Krueger.

(39) TIME DEPENDENT BEHAVIOR OF WOOD BEAMS PRESTRESSED WITH BONDED TENSION ELEMENTS

Oregon State University (John Peterson); O.S.U. Engineering Experiment Station and U. S. Forest Products Laboratory

Time dependent deflection of wood beams prestressed with bonded tension elements and matched control beams under constant load is being measured. Both prestressed and control beams carry loads consistent with engineering design for a specific application. Two levels of loading, dead load and full load, are being studied.

(40) DEVELOPMENT OF DESIGN METHODS FOR GLUED LAMINATED TIMBER OF MACHINE STRESS-RATED LAMINAE

Potlatch Forests, Inc. (J. D. Snodgrass); same

Methods for design of glued laminated timber compatible with present accepted general concepts are being investigated using machine stress-rated laminae instead of conventionally graded material. Scope of research includes surveys and statistical interpretation of properties of raw materials, and fabrication and destructive testing of full-size laminated beams.

(41) DEVELOPMENT OF DESIGN METHODS FOR GLUED LAMINATED TIMBER HAVING VERTICAL GLUELINES

Potlatch Forests, Inc. (L. J. Nemeth); same

New methods for rational design of glued laminated beams having gluelines in vertical orientation are being developed, because available design concepts are generally founded on limited research and not confirmed by extensive testing. Scope of project includes development of theory of performance of members having vertical gluelines, survey and statistical interpretation of characteristics of raw materials, and destructive testing of full-size experimental beams.

(42) PERFORMANCE OF ROOF TRUSSES CONSTRUCTED WITH MACHINE STRESS-RATED LUMBER

Potlatch Forests, Inc. (R. J. Hoyle, L. J. Nemeth); same

Performance of roof trusses constructed of machine stress-rated (modulus-of-elasticity calibrated) numbers is being investigated. Testing of full-scale trusses is undertaken to determine optimum allocation of material, requirements of connections, and load capacities.

(43) TENSILE STRENGTH OF 2-INCH DIMENSION LUMBER OF STRUCTURAL GRADES

Potlatch Forests, Inc. (L. J. Nemeth); same

Destructive tensile tests are being made of full-scale dimension lumber in several structural grades. Purpose is to define more clearly the relationship between grade or natural features of lumber and ultimate tensile strength and elasticity. A special tension tester of suitable capacity and accuracy has been constructed. Joints of structural types for transmission of tensile loads also can be evaluated.

(44) AN INVESTIGATION OF THE ENERGY ABSORPTION CHARACTERISTICS OF COMPOSITE WOOD STRUCTURES SUBJECTED TO STATIC AND DYNAMIC LOADING

San Jose State College (K. Medearis); Office of Architecture and Construction, Department of General Services, State of California

Static and dynamic load tests will be made of typical plywood shear wall construction to determine dynamic characteristics and ultimate capacities. Wall specimens are 8 ft in height and of various widths.

(45) THE EFFECTIVENESS OF PRESTRESSING OF TIMBER STRUCTURES

Toronto, University of (C. F. Morrison); Department of Forestry of Canada

(a) A study of the existing condition of a few of the approximately 1,000 timber structures in which prestressing has been

used in Canada. (b) Laboratory studies to determine optimum use of prestressing. (c) Probable extension to the use of prestressing for the reinforcement of partially delaminated glulam structures.

(46) INVESTIGATION OF STRENGTH AND STRESS DISTRIBUTION IN TAPERED BENDING MEMBERS

U. S. Forest Products Laboratory (A. C. Maki and E. W. Kuenzi); same

Design criteria to be established to meet a continuing need for proper design of wood members which satisfy various architectural concepts as well as result in efficient safe structures. Deflection and stress design criteria for straight wood beams of single and double taper are to be developed through theoretical analysis and checked experimentally.

(47) THEORETICAL ANALYSIS OF THE INFLUENCE OF DECK STIFFNESS ON THE LATERAL STABILITY OF SUPPORTING BEAMS

U. S. Forest Products Laboratory (J. J. Zahn); same

The study is designed to establish the relevant deck property which determines the degree of lateral support which roof decks afford to supporting beams, and to analyze lateral stability for specific cases of loading and end support.

(48) TIME DEPENDENT BEHAVIOR OF PRESTRESSED WOOD BEAMS

U. S. Forest Products Laboratory (B. Bohannan); same

To determine the time dependent behavior of prestressed laminated wood beams to ascertain whether the induced prestress will be materially changed by the strain behavior of the wood under long continued loading.

(49) EFFECTIVENESS OF T-BEAMS

Virginia Polytechnic Institute (E. G. Stern); Independent Nail Corporation of Bridgewater, Mass.

The economy of integrating design-wise, e.g., the plywood roof sheathing and the lumber rafters into T-beams, by firmly jointing the panels to the rafters with closely spaced improved nails, can influence the cost of framing to a considerable extent, since under given conditions 2 by 4s can take the place of 2 by 6s and 2 by 6s that of 2 by 8s. With the widespread introduction of trussed rafters, allowing the use of small-size lumber, the design of rafters as T-beams has become especially promising.

(50) STRUCTURAL DESIGN WITH IMPROVED NAILS

Virginia Polytechnic Institute (E. G. Stern); Independent Nail Corporation of Bridgewater, Mass.

The design of lumber joints with helically threaded hardened-steel nails requires standardization. Data are provided on which the design criteria can be based for these improved nails in side-grain and end-grain lumber. The detailed specifications for designing with these fasteners are based on the conservative approach that they transmit the same loads as common wire nails of one-gage larger diameter.

(51) STRIP FLOORING AND NAILING BASE, AS A STRUCTURAL UNIT

Virginia Polytechnic Institute (E. G. Stern); Independent Nail Corporation of Bridgewater, Mass.

The effectiveness of various types of nails used in the fastening of strip flooring to lumber and plywood nailing bases is investigated by (1) determining the resistance to separation of the assembled components and (2) by loading individual nails in all principal directions during separate tests. The resulting information is based on data derived from more than 6,700 individual tests.

(52) AUTO-NAILED STRUCTURAL BUILDING COMPONENTS

Virginia Polytechnic Institute (E. G. Stern); Auto-Nailer Company of Atlanta and Kingsberry Homes of Chamblee

The mass-production of structural building components is imperative especially in the prefabrication of houses and industrial and farm structures. Built-up perimeter beams, girders, joists, ledger beams, headers, posts and columns can be mass-assembled by automatic auto-nailing at a rate of up to three nails per second. The effectiveness of such structural components is investigated.

(53) FURNITURE SKIDS

Virginia Polytechnic Institute (E. G. Stern); Auto-Nailer Company of Atlanta

A simplified skid design, based on engineering research on the jointing of its wood members, was advanced and approved by the ruling agency. This design permits the mass-production of skids at a rate of 1,500 skids per 8-hr day by two men, using two automatic nailing machines arranged in tandem. Complete details are presented in V.P.I. Wood Research Laboratory Bulletin No. 56, July, 1965.

7. Plastics

7.4 Design Criteria for Adhesives

(2) THE USE OF POLYSULFICE-EPOXY COMPOUNDS FOR STRUCTURAL ADHESIVES

Arizona, University of (J. D. Kriegh); Thiokol Chemical Corp.

Studies are being made of aging, freeze-thaw, temperature and humidity effects on polysulfide epoxy resin compounds.

INSTITUTIONAL INDEX[1]

[1] Refers to projects listed in the original paper.

SUPPLEMENTARY INSTITUTIONAL INDEX[2]

[2] Refers to projects listed in the discussion and closure.

SUBJECT INDEX[3]

[3] Refers to projects listed in the original paper.

SUPPLEMENTARY SUBJECT INDEX[4]

[4] Refers to projects listed in the discussion and closure.