NEW LIMITATION CHANGE

TO
Approved for public release, distribution unlimited

FROM
Distribution authorized to U.S. Gov’t. agencies and their contractors; Administrative/Operational use; Dec 1951. Other requests shall be referred to Department of Defense [DoD], Attn: Public Affairs Office Washington, DC 20301.

AUTHORITY
Sandia Corp. ltr 24 Oct 1966
Because of our limited supply, you are requested to return this copy when it has served your purpose so that it may be made available to other requesters. Your cooperation will be appreciated.

Notice: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U.S. government thereby incurs no responsibility for any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.
REPRODUCTION QUALITY NOTICE

This document is the best quality available. The copy furnished to DTIC contained pages that may have the following quality problems:

- Pages smaller or larger than normal.
- Pages with background color or light colored printing.
- Pages with small type or poor printing; and or
- Pages with continuous tone material or color photographs.

Due to various output media available these conditions may or may not cause poor legibility in the microfiche or hardcopy output you receive.

☐ If this block is checked, the copy furnished to DTIC contained pages with color printing, that when reproduced in Black and White, may change detail of the original copy.
masonry failure under impulsive loading

UNIVERSITY OF CALIFORNIA, LOS ANGELES
BIBLIOGRAPHY

ON

MASONRY FAILURE UNDER IMPULSIVE LOADING

COMPILED BY

ENGINEERING WEAPONS EFFECTS RESEARCH
SANDIA CORPORATION PURCHASE ORDER DR.169

DECEMBER 1951
BIBLIOGRAPHY
ON
MASSONRY FAILURE UNDER IMPULSIVE LOADING

COMPILED BY
ENGINEERING WEAPONS EFFECTS RESEARCH
SANDIA CORPORATION PURCHASE ORDER DR-169

DECEMBER 1961
FOREWORD

The bibliography presented herewith was compiled by the Department of Engineering, University of California, Los Angeles, under Purchase Order DR-169 with Sandia Corporation of Albuquerque, New Mexico.

Search for and examination of references was done by C.M. Duke, J.M. English, M. Feigen, W.T. Thomson, and A.H. White. Mr. White, with assistance from W.F. Hobe, did the work of editing and compilation.

In order that the bibliography shall be as promptly available to the profession as possible, it is issued at this time with the expectation that some inaccuracies and omissions may have escaped the editors. It is believed that these will not materially impair the usefulness.

C. Martin Duke
C. Martin Duke
Project Leader
Weapons Effects Research Project

Robert Bromberg
Robert Bromberg
Technical Representative of the Chairman
Department of Engineering
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>11</td>
</tr>
<tr>
<td>Part I - Explanation of Designations for References</td>
<td>1</td>
</tr>
<tr>
<td>Part II - Author Index</td>
<td>2</td>
</tr>
<tr>
<td>Part III - Bibliography</td>
<td></td>
</tr>
<tr>
<td><strong>A. Static Test Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Aa. Bricks, Concrete Blocks</td>
<td>8</td>
</tr>
<tr>
<td>Ab. Plain Concrete, Mortar, Glass</td>
<td>11</td>
</tr>
<tr>
<td>Ac. Unreinforced Masonry Structural Elements</td>
<td>13</td>
</tr>
<tr>
<td>Ad. Reinforced Concrete Structural Elements</td>
<td>15</td>
</tr>
<tr>
<td>Ae. Reinforced Masonry Structural Elements</td>
<td>16</td>
</tr>
<tr>
<td>Af. Masonry Construction Practices</td>
<td>19</td>
</tr>
<tr>
<td><strong>B. Dynamic Test Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Ba. Bricks, Concrete Blocks</td>
<td>22</td>
</tr>
<tr>
<td>Bb. Plain Concrete, Mortar, Glass</td>
<td>23</td>
</tr>
<tr>
<td>Bc. Unreinforced Masonry Structural Elements</td>
<td>25</td>
</tr>
<tr>
<td>Bd. Reinforced Concrete Structural Elements</td>
<td>26</td>
</tr>
<tr>
<td>Be. Reinforced Masonry Structural Elements</td>
<td>29A</td>
</tr>
<tr>
<td>Bf. Metals</td>
<td>30</td>
</tr>
<tr>
<td><strong>C. Blast Loading</strong></td>
<td></td>
</tr>
<tr>
<td>Ca. Propagation and Decay of Blast Waves</td>
<td>33</td>
</tr>
<tr>
<td>Cb. Reflection and Diffraction of Blast Waves on Structures</td>
<td>38</td>
</tr>
<tr>
<td>Co. Shock Tube Studies</td>
<td>42</td>
</tr>
</tbody>
</table>
# Table of Contents (cont’d.)

D. Elastic Structural Dynamics
   Da. General Theory and Methods ........................................ 44
   Db. Modeling ............................................................... 52
   Dc. Propagation of Stress and Strain ................................ 54

E. Theories of Failure
   Ea. Brittle Failure ..................................................... 57
   Eb. Plasticity ............................................................... 60
   Ec. Limit Theory .......................................................... 63

F. Failure of Buildings
   Fa. Static Tests ........................................................... 67
   Fb. High Explosive Bombs ................................................ 69
   Fc. Atomic Bombs .......................................................... 70
   Fd. Earthquakes .............................................................. 72

G. Design for Impulsive Loading ........................................... 74
PART I
EXPLANATION OF DESIGNATIONS FOR REFERENCES

Example: Ab43

The letters identify the subject classification and its subdivision as listed in the above Table of Contents. In this example the reference gives static test characteristics of plain concrete, mortar, or glass.

The numbers indicate the year of publication. Years prior to 1900 are indicated with four numbers (e.g. Ca 1871).

In keying technical reports to this bibliography, one may use parenthetical reference designations as above and add the author's surname. Thus: (Ab43 Smith).
# PART II

## AUTHOR INDEX

<table>
<thead>
<tr>
<th>Name</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen, D.N. de G.</td>
<td>Da51</td>
</tr>
<tr>
<td>Alford, J.L.</td>
<td>Da51,Fd51</td>
</tr>
<tr>
<td>Anderson, B.G.</td>
<td>Da51</td>
</tr>
<tr>
<td>Ayre, R.S.</td>
<td>Da51</td>
</tr>
<tr>
<td>Baker, J.F.</td>
<td>Ec49,Ec48</td>
</tr>
<tr>
<td>Bateson, H.M.</td>
<td>Eq50</td>
</tr>
<tr>
<td>Becker, R.</td>
<td>Ca42</td>
</tr>
<tr>
<td>Beggs, R.D.</td>
<td>Db35</td>
</tr>
<tr>
<td>Berling, G.</td>
<td>G43</td>
</tr>
<tr>
<td>Beakin, L.</td>
<td>Ec44</td>
</tr>
<tr>
<td>Bethesda, H.A.</td>
<td>Ca45</td>
</tr>
<tr>
<td>Birkenhauer, H.F.</td>
<td>Fd51</td>
</tr>
<tr>
<td>Bieplinghoff, R.L.</td>
<td>Da51,Da50,</td>
</tr>
<tr>
<td></td>
<td>Da49,Da44</td>
</tr>
<tr>
<td>Biot, M.</td>
<td>Da44,Da43,Da33</td>
</tr>
<tr>
<td>Bleakney, Walker</td>
<td>Ca48,Cb51,Cb50,</td>
</tr>
<tr>
<td></td>
<td>Cb49,Ca49</td>
</tr>
<tr>
<td>Bogasian, A.</td>
<td>De42</td>
</tr>
<tr>
<td>Bohmenblust, H.F.</td>
<td>Da50(?)</td>
</tr>
<tr>
<td></td>
<td>De44,De77</td>
</tr>
<tr>
<td>Bond, J.W.</td>
<td>Ca40</td>
</tr>
<tr>
<td>Bondy, O.</td>
<td>Fb41</td>
</tr>
<tr>
<td>Bowen, F.M.</td>
<td>Af45</td>
</tr>
<tr>
<td>Bowman, H.L.</td>
<td>Fc50</td>
</tr>
<tr>
<td>Brebner, A.</td>
<td>Ae23</td>
</tr>
<tr>
<td>Brickl, Cb51</td>
<td></td>
</tr>
<tr>
<td>Bridgman, P.W.</td>
<td>Bf44,Rb43</td>
</tr>
<tr>
<td>Brinkley, Cb47,Ca45</td>
<td></td>
</tr>
<tr>
<td>Brown, R.Q.</td>
<td>Ab41</td>
</tr>
<tr>
<td>Bucklin, G.</td>
<td>Bf49</td>
</tr>
<tr>
<td>Burkhardt, G.</td>
<td>Ca49</td>
</tr>
<tr>
<td>Byrne, R.E.</td>
<td>Db39</td>
</tr>
<tr>
<td>Caen, F.</td>
<td>Ac48</td>
</tr>
<tr>
<td>Cassen, B.</td>
<td>Ca45</td>
</tr>
<tr>
<td>Chambard, M.</td>
<td>Eb49</td>
</tr>
<tr>
<td>Chandrasekhar, S.</td>
<td>Ca43,Cb43</td>
</tr>
<tr>
<td>Claflin, W.M.</td>
<td>Da47</td>
</tr>
<tr>
<td>Clark, D.S.</td>
<td>Bf48,Dc49,Dc47,Dc45</td>
</tr>
<tr>
<td>Cleare, Ae2C</td>
<td></td>
</tr>
<tr>
<td>Cohen, Ca46</td>
<td></td>
</tr>
<tr>
<td>Cole, R.H.</td>
<td>Ca48,Cb48</td>
</tr>
<tr>
<td>Combs, T.C.</td>
<td>Fa35,Fd35</td>
</tr>
<tr>
<td>Conner, C.C.</td>
<td>Ac34</td>
</tr>
<tr>
<td>Converse, F.J.</td>
<td>Ae46,Fa34</td>
</tr>
<tr>
<td>Cooper, J.L.B.</td>
<td>Dc47</td>
</tr>
<tr>
<td>Courant, R.</td>
<td>Ca46,Ca47</td>
</tr>
<tr>
<td>Cowan, G.R.</td>
<td>Ca49</td>
</tr>
<tr>
<td>Creskoff, J.J.</td>
<td>Da34</td>
</tr>
<tr>
<td>Davies, R.M.</td>
<td>Ca50</td>
</tr>
<tr>
<td>Davis, H.E.</td>
<td>Db35</td>
</tr>
</tbody>
</table>
Davis, R.E., Da35
Dear, P.S., Aa48, Ae32
Deeds, Ca46
Degenkolb, H.J., Fa46
de Haller, P., Ca45
Dengler, M.A., Da51
Dewell, H.D., Fa48, Fd25
Dixon, H.B., CoC3
Dohrenwend, C.O., Bf45
Donaldson, C. du P., Co49
Donnell, L.H., Da30
Doring, W., Ca49
Dorn, J.E., Bf47, Dc47
Drucker, D.C., Ec50
Duff, R., Cb51, Cb50, Co51
Duffey, Ca49
DuMond, Ca46
Duvall, W.I., Bb41
Duwez, P.E., Bf48, Da50, Dc50, Dc47, Dc45
Edmonson, Ca50
Epstein, H.T., Co48
Emley, Aa20
Emrich, R.J., Co48
Evadson, R.L., Da49
Evans, R.H.; Ab46, Bb42
Everhart, J.C., Aa46
Eyring, Ca49
Feldovich, Cb47
Felgar, R.P., Jr., Da50, Da49
Feret, L., Ac48
Finkelstein, R., Da47
Fisher, J.C., Ea47
Fletcher, C.H., Ch50, Cb49, Co49
Fletcher, J.C., Co45
Flomhoff, Da49
Flügge, W., Dc42
Forkner, H.R., Aa48
Forsland, E., Cb48
Fotieo, G., Da49
Fox, E.N., Dc32
Frankel, J.P., Ea48
Frankland, J.M., Da49
Freeman, J.R., Fd32
Friedlander, Cb46
Friedrichs, E.O., Ca48
Gallagher, E.F., Ae35
Geiger, F.W., Co49, Co48
Gilkey, H.J., Ab38
Glanville, Dc35
Glauberman, M.H., Cb49
Goland, M., Da51
Gonderman, H.F., Ab28
Goodman, L.E., Da51
Goodrich, C.M., Ec40
Gould, Fa48
Gouzou, J., Br50
Green, N.B., Fa49, Fa35, Fd35
Griffith, A.A., Dc27, Ea21
Griffith, J.H., As31
Griffith, J.R., Af46,Cb51,Cb50
Griffis, L., Fb47
Grine, Bb35,Ca46,Db35
Guderley, G., Cc42
Haley, S.M., Jr., Da46
Hallowell, P.C., Jr., Da50
Halverson, R.R., Cb45
Hammill, H.B., Fa48
Hamrick, L.A., Cb50
Hansen, James H., Ae33
Hansen, R.J., Bd49,Bd48,Bf50
Haward, R.N., Ea49
Hermes, R.M., Db50,Db49
Herpin, Ca49,Ca47,Cb46
Hess, R.V., Ca48
Heyman, H., Ec50
Hollomon, J.H., De42,Ea47
Hollyer, Cb51,Cb50
Holmberg, A., Ad48
Homes, G., Bf50
Horne, M.R., Ec47
Horner, A.C., Fa49,Fa35,Fd35
Hornig, D.F., Ca49
Houbolt, J.C., Da45
Housner, G.W., Da51,Fd51
Hrennikoff, A., Ec47
Huber, F.W., Ca49
Hudson, G.E., Da49
Hyers, D.H., Dc??
Ingber, S.H., Ac24
Isakson, G., Da51,Db50,Db49
Jacobsen, L.S., Da49,Db49,Db39
Jensen, V.P., Eb43
Johnson, C.B., Fa50
Johnson, J.B., As50
Johnston, B.G., Eb49
Jones, G.O., Ea49
Jones, P.G., Bd36
Jost, W., Cc46
Karnan, T.v., Dc50,Dc??
Keenan, P.C., Cb44
Kalch, N.W., Ac31,Ac50,Ac49
Kirkwood, J.G., Ca47,Ca45,Ec48
Kluge, R.W., Bd43
Kramer, E.H., Bf49
Kreuger, H., Ac16
LeBarre, Fa34
Lashettre, M., Ac46
Lawson, A.W., Bf42
Lax, Ec48
Lee, E.H., Da40,Db51
Leibniz, M., Ec29
Leut, L.B., Ac31,Ac29
Lethersich, W., Ea48
Liepmann, Ca47
Lighthill, M.J., Cb50,Cb49
Lobb, R.K., Cc50
Love, A.E.H., Ca22
Lovewell, C.E., Aa33
Inkasiewicz, J., Co50
Lunaney, W.J., Bf49
Lusian, W.W., Eb48
Lyse, I., Ae34
Makino, Ca51
Malvern, L.E., Dc51
Maney, G.A., Ab41
Mar, J.W., Da50
Marquis, H., Da51
Marin, J., Eb49
Martel, R.R., Da51
Martens, H.E., Dc45
Martin, W.H., Ca47
Mautz, C.W., Co49, Cc48
McBurney, J.W., Aa33, Aa29, Aa28, Aa28, Aa33, Aa32
Mehaffey, W.R., Bf43
Mendenhall, J.D., Ad50
Miller, P., Bf42
Millowitz, J., Eb45
Nishkian, Fa48
Molloy, E., Ac42
Moorman, Ac32
Morey, G.W., Ab38
Morrison, J.L.M., Eb50
Mosher, A., Ae35
Munse, W.H., Bd44
Muphey, G., Ab38, Bf39
Neal, E.G., Ec51, G51
von Neumann, Ca50, Ca43
Newmark, N.M., Bf43, Bf42, Da50
Nutting, P.G., Bb43
Obert, L., Eb41
O'Brien, E.H., Dc42
O'Brien, T.F., Da49
Odmann, Sven T.A., Da48
Ojord, Bd50
Owen, J.B., Fa49
Palmer, L.A., Ae34
Panilicio, F., Ec47
Panofsky, Ca46
Parlin, Ca49
Parsons, D.A., Aa34, Ac38, Ad25, Ad30, Ae32, Be39
Patterson, G.N., Co49
Payman, W., Ca50, Cc46, Co41, Co28
Pearson, J.C., Aa43
Penzen, J., Bf50, Bf49, Da50, Ec50
Peterson, G., Fa50
Peterson, F.G.E., Ec41
Pfeiffer, G., Da47
Pfriem, H., Ca41
Phillips, A., Eb51, Ec50
Pian, T.H.H., Da50, Da49
Pidduck, F.B., Ca22
Pike, Ca50
<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pillow, A.F.</td>
<td>Ca49</td>
</tr>
<tr>
<td>Pipes, L.A.</td>
<td>Da42</td>
</tr>
<tr>
<td>Pippard, A.J.S.</td>
<td>Ae45</td>
</tr>
<tr>
<td>Plummer, H.C.</td>
<td>Ae50, Ae43</td>
</tr>
<tr>
<td>Polachek, H.</td>
<td>Ch44</td>
</tr>
<tr>
<td>Poncelet, E.F.</td>
<td>Ea46</td>
</tr>
<tr>
<td>Powell, E.G.S.</td>
<td>Ca49, Ec49</td>
</tr>
<tr>
<td>Praeger, E.H.</td>
<td>Fc46</td>
</tr>
<tr>
<td>Prager, W.</td>
<td>Da33, Eb49, Eb46, Ec50</td>
</tr>
<tr>
<td>Prescott, John</td>
<td>Da42</td>
</tr>
<tr>
<td>Preston, F.W.</td>
<td>Ab42, Bb35</td>
</tr>
<tr>
<td>Puckett, Ca47</td>
<td></td>
</tr>
<tr>
<td>Rauscher, M.</td>
<td>Da48</td>
</tr>
<tr>
<td>Read, W.T.</td>
<td>Cb45, Cc45</td>
</tr>
<tr>
<td>Kewer, M.</td>
<td>Eb48</td>
</tr>
<tr>
<td>Reynolds, G.T.</td>
<td>Co43</td>
</tr>
<tr>
<td>Richardson, J.M.</td>
<td>Ec49, Ec45</td>
</tr>
<tr>
<td>Richart, F.E.</td>
<td>Ac32, Bb36, Bd44, Bd45, Bd42</td>
</tr>
<tr>
<td>Richtmyer, Ca50</td>
<td></td>
</tr>
<tr>
<td>Rinehart, John S.</td>
<td>Dc51</td>
</tr>
<tr>
<td>Robertson, H.P.</td>
<td>Bd42, Da42, Dd42</td>
</tr>
<tr>
<td>Robertson, J.M.</td>
<td>Da46</td>
</tr>
<tr>
<td>Robertson, R.G.</td>
<td>Fd48</td>
</tr>
<tr>
<td>Rose, W.E.</td>
<td>Cc42</td>
</tr>
<tr>
<td>St. Rydlewski</td>
<td>Da49</td>
</tr>
<tr>
<td>Rudinger, G.</td>
<td>Cc49</td>
</tr>
<tr>
<td>Ruge, A.C.</td>
<td>Db38</td>
</tr>
<tr>
<td>Salvadori, M.G.</td>
<td>Da51</td>
</tr>
<tr>
<td>Sachs, R.G.</td>
<td>Bf47, Ca46, Ca44, Dc47</td>
</tr>
<tr>
<td>Schardin, H.</td>
<td>Ch32</td>
</tr>
<tr>
<td>Schwartz, E.B.</td>
<td>Da45</td>
</tr>
<tr>
<td>Seeger, R.J.</td>
<td>Cb44</td>
</tr>
<tr>
<td>Seitz, F., Jr.</td>
<td>Bf43, Bf42</td>
</tr>
<tr>
<td>Severn, R.T.</td>
<td>Da51</td>
</tr>
<tr>
<td>Shanley, F.R.</td>
<td>Bf49</td>
</tr>
<tr>
<td>Sheard, Ca46</td>
<td></td>
</tr>
<tr>
<td>Shepherd, W.M.</td>
<td>Eb50</td>
</tr>
<tr>
<td>Shepler, P.K.</td>
<td>Bf47</td>
</tr>
<tr>
<td>Shepherd, W.F., C.</td>
<td>Ca50, Co46, Co41</td>
</tr>
<tr>
<td>Shield, John E.</td>
<td>Af51</td>
</tr>
<tr>
<td>Shuman, E.C.</td>
<td>Ab28</td>
</tr>
<tr>
<td>Siddall, J.W.</td>
<td>Da52, Da50, Da49</td>
</tr>
<tr>
<td>Simms, L.G.</td>
<td>Bd45</td>
</tr>
<tr>
<td>Slutz, R.J.</td>
<td>Bd42, Da42</td>
</tr>
<tr>
<td>Smith, F.C.</td>
<td>Ab47</td>
</tr>
<tr>
<td>Smith, L.G.</td>
<td>Cb45</td>
</tr>
<tr>
<td>Sommerfield, A.</td>
<td>Cl1895</td>
</tr>
<tr>
<td>Spotts, M.F.</td>
<td>Da46</td>
</tr>
<tr>
<td>Stang, A.H.</td>
<td>Ae27, Ac38, Ac24, Ad30, Ad25, Ae32</td>
</tr>
<tr>
<td>Stanton, J.</td>
<td>Ca48</td>
</tr>
<tr>
<td>Stettbacher, A.</td>
<td>Ca45</td>
</tr>
<tr>
<td>Steyn, K.</td>
<td>Bd48</td>
</tr>
<tr>
<td>Stoner, Ca43, Ca45, Cb49, Co45</td>
<td></td>
</tr>
<tr>
<td>Stowell, E.Z.</td>
<td>Da45</td>
</tr>
<tr>
<td>Sutherland, J.G.</td>
<td>Da51</td>
</tr>
<tr>
<td>Sweet, H.A.</td>
<td>Ac43</td>
</tr>
</tbody>
</table>
PART III. BIBLIOGRAPHY

Aa. STATIC TEST CHARACTERISTICS—BRICKS, CONCRETE BLOCKS

See also: Ea48 Frankel, Af49 "Chalmers Tekuisha"


A complete listing of papers written by staff members of the Bureau of Standards on the subjects listed.

Aa50. Plummer, Harry C.


Portions of the handbooks "Brick Engineering" and "Tile Engineering" dealing with nonreinforced masonry only.


Report on tests made to determine physical properties of selected masonry materials, and to study effect of method of forming tension bond strength couplets.

Aa46. Lasseter, Majorie, and Everhart, J. O.


Several types of ceramic materials studied under stress with SR-4 strain gages to measure the strain. Behavior was similar to elastic materials, hard fired materials exhibit straight line deformation; soft fired materials have proportional limit—stress-strain curve deviates from a straight line.

Aa43. Pearson, J. C.


Modified cross brick couplet test and wall test gave results for modulus of rupture and tensile strength in bond.

Aa43. Plummer, H. C., and Reardon, L. J.


Contains bibliography, review of test data, and design information on brick masonry. Very complete handbook of design.
Aa39. Johnson, John B. (Withney, M.)


Aa33. McBurney, J.W., and Lovewell, C.E.

Aa31. Griffith, John H.

Aa39. McBurney, J.W.

"No general rule exists for converting values from a compressive test made with a brick on its flat side to the compressive strength with the brick on edge.---The modulus of rupture cannot be determined from a compressive test (nor vice versa) without possibility of great error."

Aa38. McBurney, J.W.

"Summary:
(1) An apparatus for making tensile tests on whole bricks is described.
(2) The tensile strengths of several types of brick are given.
The tensile strength of the bricks examined are between 30% and 10% of the modulus of rupture.

Aa27. Stang, A.H.
"A Portable Apparatus for Transverse Tests of Brick."

Aa27. Tucker, J., Jr.
"The Compressive Strength of Materials, with Applications,"
Franklin Inst. J. 204: 751 Dec 1927.

Aa24. Whittemore, H.L.
"Equalizer Apparatus for Transverse Tests of Bricks,"
Description of a new equalizer apparatus for making transverse tests of bricks, designed to insure proper loading and alignment, even with warped bricks.

Aa20. Emley and Cleare
Describes apparatus for tensile test of brick and gives some values.
Ab. STATIC TEST CHARACTERISTICS—PLAIN CONCRETE, MORTAR, GLASS

See also: Am50 "Masonry, Masonry Units, Etc.," Af49 "Chalmers Tekniska—."

Ab46. Evans, R.H.
"Extensibility and Modulus of Rupture of Concrete,
(Discussion: v.25, n.12 pp. 539-54 Dec. 1947.)

Account of results obtained from tests concerning ex-
tensibility of plain and reinforced concrete specimens in
tension and bending; data on tests; apparatus and material;
tests on briquettes, reinforced tension columns, plain and
reinforced beams; results presented in charts. Bibliography.
(Very good article.)

Ab46. Vivian, A.C.
"The Stress-Strain Relation of Concrete," J. Inst.

Ab43. Washa, G.W.

Ab42. Preston, F.W.

Contains bibliography.

Ab41. Maney, G.A.
"Concrete Under Sustained Working Loads; Evidence that
41:1021-1031 1941.

Ab41. Smith, F.C., and Brown, R.Q.
"The Shearing Strength of Cement Mortar," Univ. of Washington

Report of triaxial compression tests on cement mortar;
use of Mohr diagram; cohesive strength and angle of
internal friction.

Nov. 1939.

This paper presents results of a series of tests to show
the effect of two different types of molding, vibration
and tamping, on strength and other factors of concrete.
Ab38. Gilkey, H. J., and Murphy, G.
"Stress-strain characteristics of mortars and concretes;"
Gives results of extensive series of tests; includes many
stress-strain curves; shows influence of different factors
on strength and stress-strain characteristics.

Ab38. Morey, G.W.

"Compression, Flexure and Tension Tests of Plain Concrete;"

"The investigation described in this paper was made for the
purpose of determining the effect on the flexural and tensile
strength of plain concrete of some of the factors which are
known to influence the compressive strength."
Ac. STATIC TEST CHARACTERISTICS—UNREINFORCED MASONRY STRUCTURAL ELEMENTS

See also: Af49 "Chalmers Tekniska---", Aa43 Plummer, Aa50 Plummer


Study of causes of failure of various types of structures; influence of joints studied by tests, wall elements with high mechanical resistance connected with poor mortar render resistance greater than that of mortar; influence of type of mortar.

Ac49. "Dry Block Panel Shot with Jet-Crete," Construction Methods v.50 n.6 pp.56-8 June 1948.

Description of dry laid concrete blocks, sandwiched between two layers of Jet-Crete (air-applied concrete), tested in bending.


Ac43. "Breathing Walls of Brick and Tile, A New Masonry Conception," Brick and Clay Rec. 102:14-16 April 1943.


Report gives complete instructions concerning the procedure to be used in testing walls, partitions, floors and roofs in the series of tests to follow. Loading types to be used: compression, transverse, concentrated load, impact load, and racking loads.
Whittemore, Stang, and Parsons
"Structural Properties of Six Masonry Wall Construction,"
EMS 5 Bur. Ständ. 1936.

Report of tests made on walls by procedure given in EMS 5. Walls were of brick, clay tile, and concrete block. Report gives complete data on different types of loads and corresponding typical failure features. Several load-deflection curves.

Conner, C.C.
"Resultant Separation Cracking Between Various Mortars and Brick in Existing Brick Structures," Am. Soc. Test. Mat. v. 34 pt. 2 1934.

Richart, Moorman, Woodworth
"Strength and Stability of Concrete Masonry Walls,"
Univ. of Ill. Bul. No. 89, July 5, 1932.

Test results on: types of mortar, design of units, deformations of axially-loaded walls, walls under eccentric loading; flexural strength of walls.

Kelch, Norman W.

Gives results of testing of 24 walls, 4.5 ft. wide, 5.5 ft. high, some 8 inches and some 12 inches thick. It was shown that aging of lime mortar is essential. Brick masonry withstands earthquake shocks when mortar is matured by aging.

McBurney, J.W.

Data presented on tests of 186 brick walls with different makes of brick, methods of testing; tables of comp. strength.

Whittemore and Stang
"Compressive Strengths of Sand-Lime Brick Walls,"

Also gives some results of tensile tests.

Ingberg, S.H.

Description of brick masonry, test methods and effects, strength properties of individual bricks, compressive strength of masonry, ratio of masonry strength to brick strength.

Kreuger, R.
Ad50. Mendenhall, John D.


Ad48. Holmberg, A.

"Cracks in Lower Part of Concrete Wall," (In Swedish)


Development of equations which give critical length of wall and maximum strain; computation of reinforcement required to avoid cracks.


Ad25. Parsons and Stang

Ae. STATIC TEST CHARACTERISTICS—REINFORCED MASONRY STRUCTURAL ELEMENTS

Ae46. Converse, Frederick J.  
"Tests on Reinforced Concrete Masonry," Blg. Stand.  
Monthly Feb. 1946. (Reinforced Brick Masonry)  
Tests made of wall panels in flexure, core beams in flexure, and wall panels in racking or shear. Conclusions: walls behaved under test according to principles of reinforced concrete design. (All test specimens were of reinforced brick masonry.) Much specific test data and curves given.

Ae45. Pippy, A.J.S.  
Calculations and analyses of arch bridges and other types, considering different variables and solving for tensile and compressive strengths of the elements of the bridge; as well as thrusts and reactions of other elements. The ability of mortar to take some tensile stresses is adhered to in this analysis.


Ae35. Vaugh, M.  

Ae35. Gallagher, E.F.  

Ae35. Vaugh, M. and Mosher, A.  
Little damage to properly designed bldgs. Weaknesses in ordinary brick buildings are as follows: Use of arches, which can not withstand lateral forces; bldg. offers little resistance to twisting; vertical walls varied in damage with type of mortar used more than with any other observed factor; not tying parts of bldgs. together—he applies especially to walls and ceilings. Little difference in damage sustained by reinforced brickwork and reinforced concrete.

Ae34. Lyss, Inge  

"The results indicate that the column strength varies directly with the strength of the masonry and the percentage of longitudinal steel, and is increased by the use of lateral reinforcement. Strengths of 3000 psi based on gross area and over 7000 psi on the cores after shell spalling were attained."

Hansen, James H.

"This paper contains a brief history of the development of reinforced brick masonry to the time that engineers in the U.S. became interested in the subject. Its development is then given in detail by analysis of tests."

McBurney, J.W.

Withey, M.O.

Making and testing of brick masonry beams. Proof of validity of using reinforced concrete design procedure for design of reinforced brick masonry beams.

Parsons, Stang, and McBurney

Description of specimens and testing methods; results of beams tests: deformations in beams, positions of neutral axis; load-deflection curves, etc.


Whittemore and Dear
Extensive series of tests run on reinforced brick masonry slabs. Gives test results including strength of brick and mortar used, absorption of brick, load deflection curves, moment vs strain curves, measured vs calculated stresses; lists factors affecting strength of reinfored brickwork. A comparison of the performance characteristics of reinforced brick masonry slabs and reinforced concrete slabs.

Ae31. Lent, L.B.

A descriptive presentation of the practical use of reinforced brick masonry is given together with a historical survey of the development of its use.

Ae23. Brebner, A.
Af. STATIC TEST CHARACTERISTICS—MASONRY CONSTRUCTION PRACTICES

See also: Aa50 Plummer, Aa43 Plummer

Af51. Shield, John E.
"Reinforced grouted brick masonry provides wall resistant to lateral forces and to damage by fire."

Pamphlet, South West Builder and Contractor, for Brick Manufacturers Assoc. of Southern California. April 27, 1951.


Af50. Kelch, Norman W.

Article gives basis for design of reinforced grouted brick masonry in Southern California; excerpts from building codes with working stresses; description of construction practice; and results of recent tests on mortar, grout, and brick assemblies.


The code states that the individual cementing agents (quicklime, hydrated lime, portland cement) must meet the appropriate ASTM specifications.

Specifications for mortar proportions are as follows: Lime mortar, one part lime putty or hydrated lime and maximum of three parts of sand; cement lime mortar, one part lime putty, one part cement, maximum of six parts of sand; cement mortar, one part cement and maximum of three parts of sand and almost 15% of cement content can be hydrated lime or lime putty.

Tensile strength must be at least 150 psi at age of 28 days by standard test.

Masonry units must be tested according to proper ASTM specifications for given type of unit.

No specifications are given for brick reinforcement.

Af50. Building Officials Conference of America
"Basic Building Code, 1950."

Gives essentially same material in regard to masonry as that given by the New York Building Construction Code—See Aa50 above.
Keloh, Norman W.


Gives ultimate stresses in masonry elements and mortar; data on flexure tests of masonry materials; some standards from different countries on allowable and ultimate stresses. English summary and bibliography with 52 references included.

Wailes, C.D.; Jr.

Shows typical placement of reinforcement in construction of walls for small houses, connection of wall and roof.


Information given and wall sections shown in diagram may be used as a guide for small installations of reinforced brick masonry.

Griffith, J.R.

Design chart to determine flexural strength of reinforced brick masonry beams with balanced tensile reinforcing. Nomograph for design of reinforced brick masonry beams.

Bowen, F.M.

Review of British Standard 1146-1943 which specifies that fundamentals of design and analysis of reinforced concrete should form basis of brickwork standards; table gives sizes of steel needed, economical design constants for reinforced beams and slabs and permissible loads for axial and eccentric loads on columns.
Davidson Brick Company, 4701 Floral Drive, Los Angeles 22,
Calif.; c1945.
Design of walls, columns, bond beams, footings; rectangular
beams; anchorage of joists to walls; bending and direct
stress of columns; horizontal trusses; distribution of
lateral loads to shear walls; general tests, inspection
and calculations.

Af44. "American Standard Building Requirements -- Masonry,"
American Standards Assn. A41.1, 34pp.; 1944. (See also:
Indus. Standardization v.15 n.3, 1944; Cer.Age,
v.44 n.1, July 1944, pp.26-7.)

Af31. "Modifications in Recommended Minimum Requirements for
Masonry Wall Construction," Building Code Committee of Dept.
of Commerce (Supt. of Documents, Govt.Printing Office,
Washington, D.C.) 1931.
Amendment to "Recommended Minimum Requirements for Masonry
Wall Construction," prepared in 1924 by same Committee.
(See Af24.)

Af29. Lent, L.B.
Feb. 21, 1929 pp. 304-306.
Includes a survey of practice and tests in India, where
such construction has been used for floors, roof-
stairs, bridge decks, lintels, and cornices.

Af24. "Recommended Minimum Requirements for Masonry Wall
Construction," Building Code Committee, Dept. of Commerce
(Supt. of Documents, Govt. Printing Office) 1924.
Appendix contains an extensive bibliography of tests
of masonry. See Af31.

Af?? "Handbook of Building Regulations - Making of Building
Laws" (Danish).
Gives specifications for reinforcement in reinforced on
concrete firewall.
"The Building Commission does not consider lime mortar
as responsibly prepared if it does not contain at least
72% chalk hydrate. Carbide lime is not allowed for use."
Ba. DYNAMIC TEST CHARACTERISTICS---BRICKS, CONCRETE BLOCKS

No references in this section.
Bb. DYNAMIC TEST CHARACTERISTICS—PLAIN CONCRETE, MORTAR, GLASS

Bb49. Watstein, D.


Summary of Results: The impact tests made on 1 1/2 by 6 in. cylinders covered a range in rates of straining from 10^-4 in./in second to 0.8 in./in per second, with the lowest rate corresponding to static tests. The average static strength was 6570 psi. The dynamic specimens were tested in three series of tests designated as series A, B, and C. The duration of impact in these three series were, respectively: 0.78, 0.0112, and 0.0025 seconds, with the corresponding rates of straining being; respectively, 0.002, 0.148 and 0.81 in./in per second. Results show that the compressive strength of concrete increased only slightly for rates of straining up to about 0.1 in/in per second. Further increase in the rate of straining to 0.8 in/in/sec (Test C) was accompanied by an increase in the compressive strength of 48%, as compared with the static strength of 1 1/2 by 6 in. specimens. The dynamic secant modulus of elasticity, however, increased roughly to the same extent over the static value for all rates of straining; the ratios of the dynamic to static moduli were 1.18, 1.25 and 1.21 for series A, B and C respectively. Test A gave dynamic strength of 9.5% greater than the static strength of 6570 psi, while Test B gave same dynamic increase in strength (9.0%). The static E was about 4.11 x 10^6. A later series of tests (F) made on 3 by 6 in. cylinders gave the following results: Dynamic strength 45% greater than static strength, dynamic E about 16% greater than the static (secant) E. The rate of straining in test F was considerably greater than for the tests A, B and C.

Bb43. Nutting, P.G.


"Detailed discussion of general law of deformation advanced by author, which is relation between stress, strain, time and constant (a) representing ease of yielding to stress or deformability; formula developed covers whole range from elastic solids to viscous liquids and has found favor in research on paints, plastics, asphalts, and food products." Bibliography.
Evans, R.H.

Study of effect of rate of loading upon crushing strength of rich and lean mixes of concrete, and yield point, ultimate or tensile strength, % elongation, and reduction of area of mild steel.

Obert, L. and Duvall, W.I.

"To assist in standardizing the dynamic methods of testing concrete, the underlying theory, apparatus, effects of moisture, and size of specimen have been studied and the findings presented herein."

Jones, P.G., and Richart, F.E.

Description of tests run on 6 by 12 in. cylinders. Test results: stress-strain curves, relation between strength and rate of loading, creep of concrete during test, secant and tangent moduli.

Preston, F.W.
BC. DYNAMIC TEST CHARACTERISTICS—UNREINFORCED MASONRY STRUCTURAL ELEMENTS

See also: Ac36 Whittemore, Ac36 Parsons
Bd. DYNAMIC TEST PROPERTIES---REINFORCED CONCRETE STRUCTURAL ELEMENTS

See also: Dc35 Glanville, Dc32 Fox

Bd50. Ofjord, Wells, and Others

"This report presents a description of the experimental techniques, the results, and the conclusions from a series of laboratory investigations on the behavior of reinforced concrete beams and one way slabs and all steel beams subjected to static or impulsive loads, and the preliminary study of the behavior of plain and reinforced concrete shear walls under the action of static loads."

Bd50. Pensien, Joseph, and Ofjord, A.

Bd49. Hansen, R.J., and Wilbur, J.B.

Part I, Summary Report: Outline of investigation; objectives for different phases of program.
Part II: "Behavior within the Elastic Range": The principal conclusion reached from the study of beams loaded statically and impulsively in the elastic range of behavior is that the elastic dynamic theory is applicable for predicting the elastic behavior of structural elements subjected to impulsive loading conditions.
Part III: "Behavior within the Plastic Range": Among the number of conclusions drawn from the investigations are the following: Within the plastic range, simple beams are stronger when subjected to impulsive loads than they are under static loads of equal magnitude.---The upper limit of the plastic range is reached when the permanent central deflection is approx. equal to 1/32 of the span length of the beam.---Over-reinforced beams appear to have no plastic range; they fail suddenly and completely---For a certain range of dynamic rate of straining, the stress-strain curve over the first 3% strain, is raised approx. 40% over the static values.---
If the duration of the load is greater than a time approx. equal to the fundamental period of vibration of the beam, the effect of increasing the duration of the load is negligible on causing additional damage to the beam.

Part IV: "Design, Construction and Operation of Slab Machine". (An insufficient number of tests have been run so far to permit the drawing of any general conclusions regarding the behavior of slabs under impulsive loads. These results should be forthcoming in the next few months.)

---

Hansen, R. J.

Hansen, R. J.

Hansen, R. J., Pennsen, J.; Steyn, K.; and Wilbur, J. B.

Presents the results of lab investigation of 142 rein. conc. beams made to determine their structural behavior under the action of impulsive loads. Describes rapid load machine and test procedures and results. "The primary purpose of the investigation undertaken by the MIT has been to determine the permissible design stresses for use in the design of structures to resist blast waves of about 0.5 seconds duration."

Simms, L. G.

Tests to destruction of slabs and of simple beams designed to fail in bending. Tests on mild steel reinforcement. Impact tests performed by means of a falling mass. Tests show the limits of deformation in bending of some simple rein. conc. beams and slabs occurring after the steel had yielded or after the conc. had crushed. The form of damage was roughly the same under either static loading or impact. The damage due to impact was reasonably predicted from considerations of energy absorbed under static loading, used in conjunction with a simple energy equation, in which a reduction factor had been derived from considerations of an elastic material.
Munse, W.H., and Richart, F.E.

Effects of size of bearing plate and repetition of loading, span length. The change in static characteristics of a beam due to impact loading was found to be a good measure of the damage; beams weaker in repeated impact loading than in a single impact loading; strength of concrete not an important factor in beams with adequate web reinforcement.

Wilbur, J.B.

Wilbur, J.B.

Kluge, R.W.

A report of the tests conducted at the Bur. Stand for the Maritime Comm. The primary purpose of the tests was to compare the behavior under impact load of slabs with and without supplementary reinforcement in the form of overlapping spirals. Describes apparatus and test deflection curves. 16pp.

Newmark, N.M., and Richart, F.E.

Description, results, and conclusions of tests made on the effects of web reinforcement, longitudinal steel, strength of concrete and horizontal construction joints under impact loading. Web reinforcement found more important than longitudinal steel in impact grade and amount of steel unimportant. Concrete strengths unimportant except under great impacts. Construction joints or spalling planes unimportant.

Wilbur, John B.

Analysis of beams, one-way slabs, continuous beams, two-
way slabs; general theory of the effect of impulsive loadings as applied to flexural members; quantitative treatment; bibliography.

B442. Robertson, H.P., and Slutz, R.J.

B442. Richart, F.E., and Newmark, N.M.

Description of testing equipment used for static and impact load tests on beams; intermediate and high grade steel as effective as structural grade steel in concrete subject to impact. For low velocity impacts and low energy, beams act as if statically loaded. For low velocity, high energy less difference between steel types. For high velocity, diagonal tension failure.
Be. DYNAMIC TEST CHARACTERISTICS—REINFORCED
MASONRY STRUCTURAL ELEMENTS

No references in this section.
Bf. DYNAMIC TEST PROPERTIES—METALS

Bf50. Hansen, R.J., and Others
"Behavior of Structural Elements under Impulsive Load."
MIT report to Corps of Engrs. (Final) Part I, April 1950,
Part II, Nov. 1950.

Bf50. Homes, G., and Gouzou, J.

"The present article describes preliminary, purely experimental, investigations into the mechanism of fracture in simple tension of small standard flat test specimens of zinc and mild steel."

Bf49. Bucklin, Grant


Dynamic loads during landing impact. Accelerations, landing gear loads, rate of descent, tire and strut deflection. Six widely different aircraft types.

Bf49. Shanley, F.R.
"Analysis of Stress-Strain-Time Relations from the Engineering Viewpoint." (Preprint of paper to be presented at the second Symposium on Plasticity, Brown Univ., April 4-6, 1949).

"Stress-Strain diagrams for various loading histories are developed by a step-by-step process in which elastic action is assumed to be instantaneous and reversible, while plastic action is assumed to occur at constant stress, as a function of stress, time, and the extent of plastic straining."

Bf48. Clark and Wood

"A method of measuring the forces acting on a specimen during a tension impact test is described briefly in this paper." Part of conclusions: "The principles of the propagation of plastic strain provide a clear interpretation of the force measurements obtained with a dynamometer in tension impact testing." Gives stress-strain and other diagrams. Bibliography.

Thornton, D.L.

Applications occur in guns, ships and fortifications subject to effects of explosion or impact, in dams and other structures in seismic regions, and in development of metals for forming; two formulas given with which in rapid loading of structural system of given type, measure of damage or intensity is best expressed; these formulas are mutually consistent; (1) implies knowledge of amplitude, while (2) implies knowledge of time involved in action.

White, M.P.

Sachs, G.; Zener, C.; Dorn, J.E., and Others


Siepker, Paul R.

"The research that will be presented in this paper is concerned with the comparison of materials under high speed tensile impact with static tensile conditions." One of conclusions is that for all the materials tested, strength increased with the strain rate. Important tests, gives curves; shows equipment used. Extensive bibliography.
Bf46. Windenburg, D.F.

Charpy impact test curve (impact energy vs temperature). Discussion of ductility of metals and the effect of temp. on impact sensitivity, transition temps of metals, tests at low temp. Conclusion: materials used under tensile loading, especially at low temp., should be given impact test.

Bf44. Bridgman, P.W.

Bf43. Dohrenwend, C.O., and Mehaffey, W.R.

Contains good bibliography.

Bf43. Seitz, Frederick

Bf42. Seitz, Frederick, Jr.; Lawson, Andrew W.; and Müller, Park

Bf39. Murphy, Glenn
Ca51. Makino

Ca50. Davies, R.M.; and Taylor, G.

Ca50. Edmonson

"Purpose of book is to present, as accurately as is possible in the light of present knowledge, a technical summary of the results to be expected from the detonation of atomic weapons." Gives analytical treatment of air, ground and underground and underwater atomic bomb bursts; shows pictures of destruction in Japan, Bikini; treats radioactive effects, effects on personnel, protective measures.

Ca50. Pike

Ca50. von Neumann and Richtmyer

Ca50. Payman, W., Shepherd, W.F.C.
Winckler Von Voorhis Panocky Landenburg HDRC Der 2 OSRD No. 5204 1945.

Ca50. Taylor, Geoffrey

Ca50. Taylor, Geoffrey
Westervelt, Peter J.

Bond, J.W.

Cowan, G.R., and Hornig, D.F.

Doring, W., and Burkhardt, G.

Eyring, Powell, Duffey and Parlin

Hess, R.V.

Huber, P.W., Fitton, C.E., and Delpino, F.

Pillow, A.F.

Cassen, B., and Stanton, J.

Cole, R.H.

Study of scaling laws.

Courant, R., and Friedrichs, K.O.

Herpin
Ca46. Stoner and Bleakney

Ca47. Brinkley and Kirkwood
"Theory of the Propagation of Shock Waves from Infinite

Ca47. Brinkley and Kirkwood
"Theory of the Propagation of Shock Waves," Phys.Rev. 71:
606, 1947.

Ca47. Brinkley and Kirkwood
"Theory of the Propagation of Shock Waves from Cylindrical

Ca47. Courant
"Formation and Decay of Shock Waves," File No. IMM-NYU-159
May 1947.

Ca47. Courant

Ca47. Horpin

Ca47. Liepmann and Puckett

Ca47. Martin, Monroe H.

Ca47. Yung-Huai Kuo
"The Propagation of a Spherical Cylindrical Wave of Finite

Ca46. Dmond, Cohen, Panofsky, and Deeds
"Determination of the Wave Forms and Laws of Propagation
18:97, 1946.

Ca46. Grime and Sheard
"An Experimental Study of the Blast from Bombs and Bare

Ca46. Jost, W.
"Explosion and Combustion Processes in Gases," p.168
Ca46. Sachs, R.G.  

Ca46. Taylor, G.I.  


Ca45. Brinkley and Kirkwood  

Ca45. Brinkley and Kirkwood  

Ca45. de Hailer, F.  

Ca45. Kirkwood and Brinkley  

Ca45. Kirkwood and Brinkley  

Ca45. Stettbacher, A.  

Ca45. Stoner  

Ca44. Sachs  
"Ambient Pressure and Temperature," BRL-466, Aberdeen, May 1944 (Ballistics Research Lab.)

Ca44. Thomas  

Ca43. Chandrasekhar, S.  
Ca43. Von Neumann, J.


Ca41. Pfriem, H.
"The Two Dimensional, Undamped Pressure Wave of Large Amplitude," Forschung, v. 12 n. 1, p. 31 Jan-Feb 1941. RTP Trans. 2232.

Ca22. Becker, R.
"Shock Waves and Detonation," Ph.8:321, 1921. (In German)

Ca22. Becker, R.
"Physical Characteristics of Solid and Gaseous Explosives," Zeits f techn Physik v. 9, p. 2152, 1922. (In German)


Cal99. Vieille, P.
Cb. BLAST LOADING—REFLECTION AND DIFFRACTION OF BLAST WAVES ON STRUCTURES

Cb51. Bleakney, Griffith, Weimer, Brickl

Cb51. Duff and Hollyer

Cb50. Bleakney

Cb50. Bleakney

Cb50. Bleakney, White, and Griffith

Cb50. Duff and Hollyer

Cb50. Duff and Hollyer

Cb50. Fletcher, Weimer and Bleakney

Cb50. Lighthill, M.J.

Cb50. Uhlenbeck,
"Diffraction of Shock Waves Around Various Obstacles," UM-Q-1. (Univ. of Mich.)

Cb50. Weiss, S.E., and Hamrick, L.A.
Pb5O.

White, D.R., Weimer, D.K., and Bleakney, W.  

Bleakney, W.  

"The Effects of Atomic Weapons," U.S. Dept. of Defense and AEC.

See Cb50.

Bleakney, Walter  

Bleakney, W.; and Toub, A.H.  

Good on formation of Mach stem, etc.

Fletcher, C.H., Weimer, D.K., and Bleakney, W.  

Fletcher, C.H., Weimer, D.K., and Bleakney, W.  

Lighthill, M.J.  

Behavior of plane shock of any strength, traveling along wall, when it reaches corner of wall turning through small angle.

Stoner, R.G., and Glauberman, M.H.  

Cole, R.H.  

Study of scaling laws.
Cb46. Forslind, Erik
"Effect of Dynamic Forces on Structures," Int. Assoc. Bridge

Contents: The nature of dynamic load as produced by explo-
sives and impact; the properties and behavior of some building
materials under the action of dynamic load; characteristic
deformation properties of columns, beams and slabs; questions
with regard to their mode of function in various structural
systems.

Cb47. Feldovich

Cb47. Finkelstein, R.
1947.

Cb46. Friedlander

Cb46. Herpin
276, 1946.

Cb45. Halverson, R.R.
"The Effect of Air Burst on the Blast from Bombs and Small
Charges, part II, the Analysis of Experimental Results,"

Cb45. Smith, L.G.
"Photographic Investigation of the Reflection of Plane

Cb45. Read, W.T.
"Theory, Calibration and Use of Diaphragm Blast Meters,"

Cb44. Keenan, P.C.; and Seeger, R.J.
"Analysis of Data on Shock Intersections, Progress

Cb44. Polachek, H.; and Seeger, R.J.
"Regular Reflection of Shocks in Ideal Gases," Bu. Ord.
Explosives Research Rpt. no. 13, Navy Dept. Bu. Ord. Washington,
D.C., Feb. 1944. Also: "Interaction of Shock Waves in
Cb43. Chandrasekhar, S.  
BRL-439 Dec. 1943.

Cb52. Schardin, H.  
"Remarks on the Pressure Equalization Process in a  
Transmission Tube," Physik Zeitschr 30, p. 55,  
Jan. 15, 1932. (In German)

Cb1895. Sommerfeld, A. S.  
1895. (In German)
Co51. Duff, R.
(Univ. of Mich.)

Co50. Lobb, R.K.

Co50. Lukasiewicz, J.

Co50. Lukasiewicz, J.

Co49. Bleakney, Weimer, and Fletcher


Co49. Geiger, F.W.

Co49. Mautz, C.W.

Co49. Patterson, G.N.

Co49. Rudinger, G.

Co49. Weimer, D.K.; Fletcher, C.H.; and Bleakney, W.

Co49. Emrich, R.J.
Co43. Mautz, C.W., Geiger, F.W., and Epstein, H.T.
   "On the Investigation of Supersonic Flow Patterns by

Co46. Payman, W., and Shepherd, W.C.F.
   "The Disturbance Produced by Bursting Diaphragms with
   Sept. 1946.

Shock Tube 2.54 cm. in dia.

Co45. Fletcher, J.C., Read, W.T., Stoner, R.G., and Weimer, D.K.
   "Final Report on Shock Tube, Piezoelectric Gauges and
   Recording Apparatus," NDR A-356, OSRD 6321
   Nov. 17, 1945.

Co43. Reynolds, G.T.
   "A Preliminary Study of Plane Shock Waves Formed
   by Bursting Diaphragms in a Tube," NERC A-192, OSRD 1519
   June 15, 1943.

Co42. Guderley, G.
   "Unsteady Gas Flows in Thin Tubes of Variable Cross-section,

Co41. Payman, W., and Shepherd, W.F.C.
   "Explosion Waves and Shock Waves - Pt.VI, the Disturbance
   Produced by Bursting Diaphragms with Compressed Air,
   Ministry of Supply, Advisory Council 725, Phys/Ex. 98
   (W-12-187) 1941.

Co28. Payman, W.

Co03. Dixon, E.B.
Da51. Alford, J.L., Housner, G.W., and Martel, R.R.
"Spectrum Analyses of Strong Motion Earthquakes,"
Earthquake Research Lab., Calif. Inst. of Tech., Pasadena,

Spectrum is plot of response of simple oscillator vs
period of oscillator. 88 spectra computed by electric
analog under ONR contract. Damping found very im-
portant in overall problem, relatively small amounts
reduce structural response sharply. When damping in-
cluded, spectra are consistent with hypothesis of dis-
tribution about a mean value. Concept of "dominant
ground period" is not valid for purpose of asseismic
structural design. Proposed that mean value of damped
spectrum be used as a quantitative measure of earth-
quake intensity.

Da51. Allen, D.N.de G., and Severn, R.T.
"The Application of Relaxation Methods to the Solution
of Non-Elliptic Partial Differential Equations," J.
Mech. and applied Math., v. IV Pt. 2, 1953 (Separate)

Illustrated method of converting problems where end
conditions are all stated at one end of the range of
integration to one where end conditions to be imposed
are equal at both ends.

Da51. Dengler, M.A., and Goland, M.
"Transverse Impact of Long Beams, Including Rotatory
Midwest Research Inst., Kansas City, Mo. 1952.

To clarify the stress propagation phenomena in impacted
beams, closed solutions are deduced for the stresses
induced in a long beam of uniform section by the action
of an impulsive, concentrated transverse load. Rotatory
inertia and shear are accounted for in the differential
equation. For the special case when the Young's modulus
and the effective transverse shearing modulus of the
beam are equal, the results take on a simpler form and
numerical evaluation of the stresses is readily accom-
plished. When this equality of properties does not hold,
numerical evaluation of the solutions is difficult and
methods will have to be developed to permit this.

Da51. Marcus, Henri
"Introduction to Theory of Dynamic Behavior of Structures,"
mimeoographed.
Siddall, J.W., Isakson, G., and Bisplinghoff, R.L.

and Goodman, L.E.

Charles S., Anderson, B.G., and Salvadori, M.G.

Step-by-step method for analysis of earthquake stresses in rigid frame buildings developed from authors' experience with blast problems in structures. Method can be extended to cases of plastic strains. Examples of five story building subjected to various base displacements. Damping and ground rocking considered. Rigorous solution feasible for five or less stories; step-by-step thereafter. Step-by-step method preferable when plastic hinges considered. Desk calculator or IBM techniques suitable. Errors of calculation less than with previously developed procedures by Timoshenko, Newark.

Zizos, George A.

Dynamic effects negligible for loading times greater than a few multiples of fundamental period of plate, but they are an essential feature of the phenomenon for times of loading of the order of the fundamental period or smaller. For sufficiently small intervals of loading, the critical buckling load may be exceeded without danger, while for loads under the critical, the displacement may be up to twice as high as the static analysis would predict.

Duwez, P.R., Clark, D.S., and Bohenblust, H.F.

Isakson, G., and Bisplinghoff, R.L.
Contents: The procedures of analysis are applicable to loadings caused by wind, earthquake, or impact, as well as blast. The principal type of approximate method considered is a method based on the assumption of a shape or mode of deformation, in effect reducing the number of degrees of freedom of the structure to one. A general method and several approximate methods are given which are especially applicable to structures which are stressed to the point of failure and therefore which are loaded considerably beyond their range of elastic behavior. Fairly good results are given for the limiting conditions at or near failure of the structure.


The problem relates to an undamped, elastically non-linear, single-degree-of-freedom lumped system subjected to three forms of ground motion pulses (rectangular, cosine, and "skewed" cosine); each form consists of a single pulse, the duration of which has been varied over a wide range.


Definitions of terms used in study of impact loading—discussion of different cases—with comparison of theoretical and actual cases.


De49. St. Rydelewski
Frequency equations obtained for rigid joint trusses. Good for short spans where Polhausen's method fails.

De49. White, M.P.

De49. Young, Dana, and Felgar, R.P., Jr.
Clamped-clamped, free-free, clamped-free, clamped-supported, and free-supported beams.

De48. Odman, Sven T.A.
Method applies characteristic functions, so that differential equation holds good for any arbitrary boundary conditions and for several non-elastic moving loads; approximate solution.


De47. Claflin, W.M.
Design and testing of a model, dynamically similar to an actual airplane. Nondimensional "amplification factors" are determined. Gives brief review of the basic theory of dynamic response.

De47. Pfeiffer, G.

De46. Robertson, J.M., and Yorgiadis, A.G.
Spotts, M.F.
For bars and beams; calculation of stresses due to moving weights.

Wilbur, J.B.
Discussion of methods of analyzing structure for bending moments, shear and direct stresses caused by impulsive loads (blast loads, impact loads and ground shock due to bombing); investigations refer to elastic bodies with one or more degrees of freedom, i.e., bodies whose position can be defined by means of one or more dimensions; plastic instead of elastic analysis indicated.

Stowell, E.Z.; Schwartz, E.B.; and Houbolt, J.C.
Theoretical and experimental investigation of behavior of a cantilever beam in transverse motion when its root is suddenly brought to rest. Equations for acceleration, deflections, stresses: test on small tube cantilever.

Biot, M.A.; and Bisplinghoff, R.L.

Biot, M.A.
Status of the science... Many excellent discussions. References.

Wilbur, John B.
Develops concept of dynamic load factor by means of which one analyzes the dynamic behavior of beams and slabs, through the use of characteristic shapes and loads. It is shown that a dynamic load factor curve can be developed for each type of impulsive loading. A factor can then be applied readily to the impulsive load value to produce an equivalent static loading. Slabs are analyzed approximately by reducing them to an equivalent beam grid.
Da42. Pipes, L.A.
"The Operational Theory of Longitudinal Impact," J.

Da42. Prescott, John
"Elastic Waves and Vibrations of Thin Rods," Phil. Mag.
v.33, 7th Series 1942.

Da42. Robertson, H.P.; and Slutz, R.J.
"The Reactions of Thin Beams and Slabs to Impact Loads,
Part I, Theory; Part II, Beams," Natl. Research Council
Comm. on Passive Protection against Bombing, Interim

Da41. White, Merit P.

Da40. Lee, E.H.

Paper deals solely with central impact on beam simply
supported at ends; no difficulties encountered in general-
izing method for impact at any point along beam; develop-
ment leads to similar conclusions, relations being ex-
pressed in terms of normalized characteristic functions
for modes of vibration. Biblio.

Da39. Jacobsen, L.S.
"Natural Periods of Uniform Cantilever Beams," Trans.
ASCE 1939, p.402.

Da34. Creskoff, Jacob J.
"Dynamics of Earthquake Resistant Structures," McGraw-
Hill, 128pp. 1934.

Dynamics of earthquake motion: deflections of beams in
moment and shear; free transverse vibrations of a slender
beam; forced transverse vibrations of a slender beam;
distribution of seismic shear and moment; application to
buildings; aseismic design of a tall building; aseismic
design of a short building.

Da33. Biot, M.
"Theory of Elastic Systems Vibrating under Transient
Impulse, with an Application to Earthquake-proof

General method of evaluating random impulses on vibrat-
ing systems.
Donnell, L. H.

Ufand, Y. S.
"Propagation of Waves in Transverse Vibrations of Beams and Plates," (In Russian) Prikladnaya Matematika i Mechanika (USSR) vol. III no. 3.
Modeling methods for dynamic stress analysis and the concept of engineering accuracy are briefly discussed. Summary of the results of the analytical work on dynamic modeling of beams presented previously are given. The conclusions of the previous analysis is verified, namely: for those applications where damping can be neglected, modeling for stress similitude can be attained if the dimensionless radius of gyration is the same for prototype and model; and those applications where internal damping is of importance, geometric similarity between prototype and model is necessary.

Method of rendering the equations of motion of a vibrating beam in dimensionless form is presented. Parameters, which must be kept constant for model similitude, are derived. Internal damping is considered and the conclusion is reached that it can be satisfactorily modeled. Effect of internal damping is recognized and evaluated. The eigen-functions in dimensionless form are summarized for each of the six types of vibrating beams; also frequency equations. These functions are shown to be normalized with proper choice of coefficients.

Results of model tests. Experimental methods, Similarity.

New type of spring-element diagonal investigated.


Part I. --- Theory 1938
Part II. --- Model Investigations of Armored Structure 1940
Beggs, R. D., and Davis, H. E., and Davis, R. E.

Includes dynamic model theory and a complete (as of 1935) bibliography on model testing and dimensional analysis.

De. ELASTIC STRUCTURAL DYNAMICS—PROPAGATION OF STRESS AND STRAIN

See also: De42 Prescott

De51. Malvern, L.E.

The theory of propagation of longitudinal waves of plastic deformation is extended to apply to materials in which the stress is a function of the instantaneous plastic strain and strain rate. Solutions are given for an idealized flow law and compared with solutions based upon earlier theories which neglect strain-rate effect.

De51. Lee, E.H., and Wolf, H.

De51. Rinehart, John S.

De50. Thornton, D.L.

By means of strain gages and a cathode-ray oscillograph, records of the variation of strain with time is shown of a steel bar. Discussion of propagation of pressure-pulse of short duration when the amplitude of the strain-wave has exceeded the proportional limit of both ductile and brittle materials, including mathematical treatment and some experimental results for structural concrete elements.

De50. von Karman, T., and Dubiez, P.

Theoretical and experimental study of longitudinal impact at end of bar; experiments on propagation of plastic strains in specimen subjected to tension impact.

De49. Clark, D.S., and Wood, D.S.

"The design and construction of a special rapid-load
A testing machine is described with which tensile loads may be applied to a specimen within 5 milli-seconds and longer. Tests made on annealed low-carbon steel are presented and discussed in detail. It is concluded that the time delay is associated with the yield point of mild steel.

Do49. Vigness, L.,

Do47. Cooper, J.L.B.

Do47. Duwez and Clark

The theory of plastic strain propagation is reviewed with reference to longitudinal impact. Special impact testing equipment is described. Tests in tension on long wires and on specimens of other gage lengths are reported, together with the results of some tests made in compression. The effect of release of loading and reflection of plastic strain waves on plastic strain distribution are considered. The concept of critical velocity is discussed. The anomalous behavior of material for which there is a yield point is presented. Results indicate very satisfactory agreement between theory and experiment.

Do47. Bar, Zener, Dorp, and Others
"Fracturing of Metals," Published by the American Soc. for Metals, 311pp. (Cleveland, Ohio) 1947.


Do46. Taylor, G.I.

Methods of determining properties of materials subject to impact loading such as Hopkinson's experiment, bouncing-ball experiments, tests in which yield point is passed; influence of rate of strain, impact at very high speeds, study of stress waves in plastic materials; illustrated description of Mann's high-velocity tension impact machine.

Bibliography.
Dc45. Duwez, P.E., Martens, H.E., and Clark, D.S.

Dc44. Bohenblust, Henri Frederic

Dc42. Bogosian, A., and O'Brien, E.H.

Dc42. Flügge, W.

Dc42. Zener, C., and Hollomon, J.H.

Dc35. Glanville, Grime, and Davis
Extremely extensive (80 pp.) theoretical and experimental study, math. theories given; study of stress propagation.

Dc32. Fox, E.N.

Dc27. Griffith, A.A.

Dc?? Karman, Th. v., Bohenblust, H.F., and Hyers, D.H.
Ea. THEORIES OF FAILURE---BRITTLE FAILURE

Ea50. Bateson, H.M.
"Some Views on the Breaking of Glass Derived from the

Ea49. Haward, R.N.
"The Strength of Plastics and Glass," (A Study in Time-

Ea49. Jones, G.O.
"The Interpretation of the Experimental Data on the

"The main conclusions of experimental work on the strength
of glass are discussed from the point of view of the
Griffith flaw theory and of later theories of the strength
of solids. An attempt is made to present a broadly
correct interpretation of the phenomena and to suggest
why other explanations of particular phenomena may be
incorrect."

Ea48. Frankel, Jacob Porter
"Relative Strengths of Portland Cement Mortar in Bending

Assuming the behavior of standard mortar to be similar to
that of plain concrete, tests were performed on 99 small
mortar beams under sixth, third and center-point loading
to verify the applicability of the statistical theory of
the strength of brittle materials to concrete construction.

Ea48. Lethersish, W.
"A Theory of the Transition from Tough to Brittle Fracture
with Special Reference to Velocity Effects in Impact Test-

The energy to fracture, and tensile strength are discussed
in terms of a very simple model, with fracture obeying
maximum strain laws for both brittle and tough behavior.
For brittle fracture, it is assumed that the hydrostatic
component of the state of stress controls, while the
shear component controls ductile behavior.

Ea47. Fisher, J.C., and Hollomon, J.H.

Review of literature and theoretical mathematical analysis
of fracture stress of metallic and non-metallic materials; source of low fracture stress in glass; statistical analysis; ref to work of G. Sachs and J.D. Lubahn on notched bar test of cohesive strength of steels.

Es46. Poncelet, E.F.

Contents: It has been theorized that comminution of brittle solids occurs in the following steps:

1) Deformation of the solid to be comminuted by the application of outside forces resulting in tensile stresses.

2) Development of one or more cracks as a direct result of these stresses.

3) Formation of compression and transverse pulses caused by these breaks to travel through the solid, the later pulses causing the cracks to progress mainly at the critical crack velocity, a constant for the material.

4) Generation of tension and more transverse pulses by reflection of the compression pulses at the solid's free boundaries, causing offspring cracks to form and progress preferentially in the smaller fragments liberated by the parent cracks.

5) Formation of residual particles of smaller and smaller sizes as the process is repeated until the whole solid is reduced to a collection of residual particles.

Es41. Tucker, J., Jr.

There is an inherent difference in the strength of duplicate test specimen no matter how carefully these specimens are made or tested. Such differences are a natural characteristic of the materials and are more pronounced in some than in others. The paper shows how the variations in the strength of small elements of volume within a specimen will affect the modulus of rupture of beams of different dimensions and beams subjected to different loading. For example, the modulus of rupture of a beam will be decreased with beam depth and with beam length, and will be greater in centrally loaded beams than in similar beams loaded at third points.

Es39. Weibull, W.
Ingenjorsvetenskapssocietets, Handlinger no. 257, 159, 1939.

Develops a general statistical theory to explain the ultimate rupture strength of materials. Shows that the probability of rupture (S) is such that \( \log (1 - S) = -\mu f(\sigma) d\sigma \). Empirically determines the function of stress \( f(\sigma) \) on the
basis of tests of plaster of paris, porcelain, portland
cement mortar, wood, cotton yarn, and aluminum castings.

Griffith, A.A.

Establishes a fundamental theory of rupture predicated
on the influence of flaws. The flaws permit development
of stress concentrations which effectively reduce
average stress to cause rupture. Many subsequent works
of various authors are based on the "Griffith Flow
Theory."
Theories of Failure—Plasticity


A new method is given for finding Moment-Strain (max) curve in the case of a symmetrical pure bending of bars in plasticity.


Gives results of experimental investigation on thin-walled aluminum alloy tubes subjected to combined tension and torsion. Stress-strain diagrams for plastic range given. Curves, equations, and bibliography given.


Relation between bending moment and fiber stress in a curved beam with an assumption that cross section is of such shape that under increasing moment, inelastic action commences at concave surface of beam. Remarks on economy to be realized in working in inelastic range, and solution of problem is indicated for curved stress-strain diagrams.


Comprehensive theoretical treatment with tests; load-deflection curves; bibliography.
Eb48. Lusion, W.W., and Johnston, Bruce G.
"Plastic Behavior of Wide Flange Beams," Welding J.
Research Supplement v. 27, 17pp., Nov. 1948.

This report presents results of wide flange sections
tested as simple beams with third point loading
through the elastic and into the plastic range; bend-
ing behavior of beam depicted by $M$ (moment) - $\phi$ (rate
of change of slope of the beam axis) curves; diagram
of elastic stress distributions; local buckling; resid-
ual stresses; diagrams of general test setup using SR-4
strain gages; strain distribution diagrams across ten-
sion and compression flanges; summary of test results;
initial stress condition, initial yield moment, plastic
moment, calculated and observed values.

Eb48. Prager, W.
"Problem Types in the Theory of Perfectly Plastic

Consideration of different problem types; examples dis-
cussed; 6 pp; bibliography.

Eb48. Prager, W.

Typical theories of plastic flow and plastic deformation
are discussed, and concept of neutral change of stress
is introduced.

Eb48. Prager, W.
"The Stress Strain Laws of the Mathematical Theory of

Eb48. Reiner, M.
"Elasticity Beyond the Elastic Limit," Am. J. Math. v. 70
n. 2 pp. 433-446, April 1948.


Eb47. White, M.P., and Griffis, L.
"The Propagation of Plasticity in Uniaxial Compression,"

Eb45. Millowitz, Julius
"The Initiation and Propagation of the Plastic Zone in

Eb44. "The Propagation of the Plastic Zone Along a Tension Bar
Having a Well-defined Elastic Limit," A-250 OSRD 3864,
July 1, 1944.
Eb43. Bridgman, Percy Williams
"Plastic Deformation of Steel Under High Pressure,"

Eb43. Jensen, V.P.

The hypothesis is advanced that the stress-strain diagram for concrete under short time loading may be idealized for certain purposes so as to consist of two linear parts, one representing elastic behavior and the other representing plastic behavior. The former is measured by the "modular ratio" which is defined as the ratio of the E of steel to the initial E of concrete. The latter is measured by the "plasticity ratio" which is defined as the ratio of the plastic strain to the total strain at rupture of the conc. An empirical equation is given to express the relationship between the plasticity ratio and the compressive strength of the conc. Formulas are derived for the ult str of beams reinf in tension only.

Eb42. Whitney, Charles S.
Ec51. Neal, B.G., and Symonds, P.S.

Two-span rigid frame. Sequence of loading which may cause failure by incremental collapse is determined.

Ec55. Drucker, D.C.

Gives simple structural applications of plastic design. Example of beam, column, simple A-frame, and threewire problem.

Ec50. Heyman, J.

Ec50. Penzien, Joseph, and Williams, Harry A.

This report gives the detailed results of analytical studies of a number of problems which would arise in connection with the analysis or design of a frame building to resist the effects due to a long duration blast. Purpose of study was to explore the various methods of analysis and to establish the errors involved in simplified approaches. For best results in analyzing a final design, the general step-by-step procedure, assuming linear variation of acceleration is recommended. The simplified step-by-step method which assumes infinitely rigid girders is recommended for preliminary design. The average rate of stress build-up for the structure and loading conditions assumed for this investigation was rapid enough to warrant an increase in the yield point of steel.

Ec50. Phillips, Aris

Ec50. Symonds, P.S.; and Prager, W.
Ec49. Baker, J.F.

Ec49. Baker, J.F.

Presents an engineering approach to the design of portal frames, multi-storied building frames, and gabled bents by means of the principle of "Limit Design." An extensive bibliography, in which the author's earlier works are completely referenced, is provided.

Ec49. Powell, E.G.S.
"Don't be an Ostrich---'Limit Design' is Safer and More Economical," New Zealand Eng. v.4 nos.1/2, Jan.-Feb. 1949.

Factor of safety of 2 against plastic yield is considered desirable; numerical examples show that actual factor of safety or overload margin is much greater against failure than against plastic yield point assumed in calculations.


A study of plastic deformation of circular plates under various constraints.
(This work is summarized, and references to other authors are given in "Underwater Explosions," by R. H. Cole, Princeton Univ. Press, Chapter 10.)

Ec48. Van den Broek, J.A.
Ec47. Horne, M.R.
"A Moment Distribution Method for Rigid Frame Steel Structures Loaded beyond the Yield Point," British Welding Research Assoc. (Special Report no. 25.)
(Also: Welding Research v.1 n.3 Aug. 1947)

Ec47. Hrenikoff, A.

This paper contains the description of a method for analyzing statically indeterminate flexural structures loaded beyond the elastic limit or structures of materials that do not obey Hooke's law. Contents are as follows: Stress-strain relations in I-beam, channel beams: deflections; shearing stresses in beams: elastic range, plastic range: effect of shear stresses; stress recession: computation of shape constants of an I-beam: deflections, strains, stresses, and moments under capacity loading; deformation data: limit design: yielding points, critical sections.

Ec47. Panilillo, F.


Ec45. Richardson, John M.

Ec44. Beskin, L.

Margin of safety against failure by fracture depends upon plastic behavior of materials rather than elastic action commonly assumed in calculating working stresses; using simplifying assumption, author develops equations and charts for predicting ultimate failure loads of parts subjected to bending and to eccentric loading. (Discussion confined essentially to failure of small metal machine parts.)
Design of military structures should be based on a dynamic analysis, and analysis should be in terms of ultimate loads. For impulsive loading, the important quantity normally is not the maximum force applied but rather the amount of energy the structure can absorb before collapse. In a typical structure (a simple reinforced concrete beam) the energy at the elastic limit is found by both calc and exp to be about 1/100 of the energy absorbed before failure. This points to the desirability of considering the plastic state in analysis. It is not proposed that smaller safety factors be used, but that if true safety factors are known, more consistent and therefore safer designs are possible with no increase in cost. Article gives tables, diagrams and graphs.

Peterson, F.G.E.

Theory of limit design explained, typical problems, steps involved in applying limit design to a simple rigid frame.

Goodrich, C.M.

General discussion giving philosophy of limit design and urging use of limit design in practice.

Leibnitz, Maier
"Experiments with Clamped and Simple Beams of I. Shape made of Steel St. 37," (In German) Bautechnik 7 p. 319, 1939. Also: Stahlbau 9, 1936.
Failure of Buildings---Static Tests

Johnson, Carl B.

Peterson, Charles

Green, N.B., and Horner, A.C.

Tests to determine diaphragm action of the single diagonally sheathed wood structure toward its use on buildings to effectively resist lateral seismic and wind forces. Truss and diaphragm action, limitations in practice, conclusions, applications, recommendations; analysis of the tests in accordance with beam theory; relationship of the shear stress modulus of the model panel to that of the prototype; deflection of, and load at proportional limit for, a full size wood diaphragm; application to design of roof panels.

Owen, J.B.B.

Techniques for testing structures to destruction are reviewed principally as they apply to British practice. Loading and strain measurements, etc. An acoustic gage is discussed which may offer some improvement in stability over resistance gages.


17 trusses, 37 joints of structural frames, 3 15-ft. struts, and 103 laboratory specimens tested to failure.


Engineering analysis and tests of small frame structures to determine the relative resistance of different types of frame wall construction to longitudinal thrust. Also
a study of each integral part of the frame building, such as the lintels, floor system, roof system and stair well, with an effort to give a better understanding and appreciation of the principles involved in wall construction.

Fa35. Green, N.B.
"The Lateral Resistance of Bearing Wall Buildings,"

Fa35. Green, N.B., Horner, A.C.; and Combs, Theodore C.

A summary of recent full size and quarter scale model tests, including working formulas and values for design. 22pp.

Fa34. LaBarre, and Converse, F.J.
"Lateral Load Research to Determine the Strength and Rigidity of Wood Floors as Diaphragms and of Brick Walls and Piers,"

A three-story, wood-joint, unreinforced brick bearing wall building with a central corridor having brick walls and concrete floors was tested. Purpose was to obtain fundamental information on the behavior of wood floors as distributing diaphragms for lateral loads, such as those produced by earthquake or wind, and to investigate the behavior of existing brick masonry when subjected to such loads. Qualitative and quantitative results. The school was 10 years old and appeared to represent approximately the average design and construction practice at the time of its erection. The effect of lateral forces apparently was not considered in the design of the building. Elastic load-deflection curves; photos; tables of test results.


Stanford tests. Points up necessity for adequate connections between structural elements of a building to provide resistance to earthquake forces.
FAILURE OF BUILDINGS—HIGH EXPLOSIVE BOMBS

See also: Ec43 Baker


Data made available by War Dept. as to resistance of various types of construction under actual bombing. Published by Office of Civilian Defense, Washington, D.C.


Fb41. Bondy, O.


London report on structural damage from bombing; oblique hits on walls are more common than vertical hits on roofs; damage even from same size bombs is extremely variable; fireproofing of steelwork is particularly important; bearing wall buildings are especially vulnerable; material thicknesses required for bomb protection.


FAILURE OF BUILDINGS—ATOMIC BOMBS


Bibliography.

Fe50. Bowman, Harry Lake


Photos of Japan A-Bomb damage. Chart of "Percent of Damage" vs list from ground zero for various types of construction.

Fe50. U.S. Department of Defense and Atomic Energy Commission


Comprehensive summary of state of knowledge (as of 1950) of physical and biological effects.

Fe48. Tester, A.C.


Study of effects of atomic bombing on stone due to heat, abrasion, etc.

Fe47. U.S. Strategic Bombing Survey, Physical Damage Division


Vol. I: Classification of buildings according to type for purpose of presenting damage in table form. 1200 pp. (All damage listed in Vols. I-III is designated either as superficial or structural. Superficial damage is defined as damage such as surface burns, etc., which does not reduce the load-carrying capacity of the structure. Structural damage is that which reduces the load-carrying capacity of the structure.)

Vol. II: Types of damage, fire cause and extent, damage to buildings.

Vol. III: Pictorial and graphical data are presented in an attempt to analyze the extent of damage to machine tools and bridges. Photos show extent of damaged buildings with characteristic patterns of failure of several types of structures and the effect on machinery contained within, caused by building collapse or flying debris.
U.S. Strategic Bombing Survey, Physical Damage Division.


Vol. I: Classification of buildings according to type for purpose of presenting damage in table form. (All damage listed in Vols. I-III is designated either as superficial or structural. See Hiroshima report F047.)
Part 2. Effects of Atomic Bomb on industrial structures.

Vol. II: Building type-damage tables.
Part 4. Effects of A bomb on public utilities.

Vol. III: Building type-damage tables.
Part 5. Effects of A bomb on machinery, equipment and plant utilities.
Part 6. Effects of A bomb on bridges and transportation systems.
Part 7. Fire damage effects of A bombs.

Both of the above Strategic Bombing Survey reports give exhaustive damage analyses—a great many photographs are included; detailed reports on damage to individual buildings. Condensation available from Documents Div., U.S. Govt. Printing Off., Washington, D.C.


Abstract of report written by scientist sent by British Govt. to study effects of atomic bombs exploded over Japan; illustrations reveal damage on buildings of brick, reinforced concrete and steel.

Praeger, E.H.


"The destruction wrought by atomic bombing of the Japanese cities, Hiroshima and Nagasaki, August, 1945, is outlined, with an analysis of typical damage within areas with respect to 'zero point.' The paper discusses principles and procedures of design necessary to resist attacks by these special new weapons."
See also: Da34 Greskoff

Fd31. Alford, J.L., and Housner, G.W.
"A Dynamic Test of a Four Story Reinforced Concrete Building," Publication of Earthquake Engineering Research Inst.
Aug. 1951.

Forced vibrations with measurements of deflections and accelerations of amplitudes approaching those experienced during strong-motion earthquakes. Results on damping: total is small; increases with displacement; independent of frequency.

Fd51. Birkenhauer, H.F.

Comprehensive summary of work in Japan and USA. Criteria of earthquake damage. Extensive bibliography should be consulted for significant references.

Fd48. Robertson, R.G.
"Earthquake-resistant Structures; Seismic Factors and Use of Reinforced Brickwork in Quetta Civil Reconstruction,"

Damages to structures caused by earthquakes in Quetta, Baluchistan, British India, in 1923, 1935 and 1941; measures to make buildings earthquake resistant. Gives seismic factors for different parts and types of structures. Formula for acceleration at top of independent-wall-type structure.

"Earthquake Investigations in California, 1934-35,"

Methods and results of intensive program. Includes vibration tests on many buildings. Also detailed analysis of damage to ordinary masonry buildings (exterior masonry bearing walls with interior load-bearing construction of wood, steel, or masonry; partitions, roof, and floor framing may be wood.)

Fd35. Green, Norman B., Horner, A.C., and Combs, Theodore, C.

A summary of recent full-size and quarter-scale model tests of wood floors considered as diaphragms in masonry wall buildings.
Freeman, John R.

Structural lessons and losses from the San Francisco and Charleston quakes; textbook on earthquake-resisting structural design, design of earthquake resistant buildings; stress in structures determined by period and amplitude; studies of engineering data for earthquake-resistant construction.

Dowell, Henry D.

Contains chapter on "Building Against Earthquake and Shock." A critical analysis of construction defects in existing buildings with relation to earthquake damage and resistance.
G. DESIGN FOR IMPULSIVE LOADING

See also: R51 Birkenhauer, Da51 Whitney, Ec48 Baker, Ec44 White, Da50 Newman Af45 "Steellyd Reinforced---," Da50 Penzien, Eb42 Whitney

G51. Neal, Bernard George, and Symonds, Paul S.

The determination of the critical value of the load parameter for any framed structure which, if exceeded, would cause failure by incremental collapse. It is essentially an elastic-plastic problem which can not be solved without considering the elastic behavior of the frame.


Abstracts of material from "Effects of Atomic Weapons" with recommendations on construction of protective structures.

G49. Swindlehurst, J.E.

Defense against explosives; explosions on surface, within building or below ground level; effect of atomic bomb; fully framed structures, whether of steel or of reinforced concrete, possess resisting properties superior in every way to those constructed with load bearing walls.

G48. Berling, G.

G48. Himperis, H.E.

Methods of active defense discussed.

G47. Turner, B.T.

Outline of methods used in designing such a cantilever for radar equipment, which may provide a basis for similar structures in aircraft.
Tests indicate that in the design of typical fortifications, an amount of plastic deformation consistent with a reasonable factor of safety against important damage, be permitted under the controlling design loads. In this report a study is made of the test data given in "Impact Tests of Reinforced Concrete Beams, II," by Newmark and Richert (OSRD 1751) wherein the testing under varying impact loads of 104 reinforced concrete beams of varying reinforcement is described. Results of analysis given in tables. It was found that the "fictitious elastic strength" (using dynamic elastic analysis) of the beams in bending and shear failure, under dynamic loads, was ten times the static ultimate strength. The total energy applied to a beam to produce failure should be of the same order of magnitude. This hypothesis was correlated with energy considerations, and for design purposes he recommends that factors of safety of 3 and 4 be applied to the fictitious ultimate stresses for bending and shear.

Wilbur, John B.

Wessman, H.E., and Rose, W.A.

Detailed discussion on those measures which should be taken to make building construction resistant to effects of bombing. Characteristics of bombs, design procedures, present construction practice and proposed modifications, design of specific types of buildings, analysis of building requirements. Fairly comprehensive summary of status of knowledge as of 1942.