TIMBER CONSTRUCTION MANUAL

THIRD EDITION
1985

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION

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AMERICAN INSTITUTE OF TIMBER CONSTRUCTION
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PREFACE

This Third Edition has been prepared to update the AITC Timber Construction Manual to reflect current timber design methods. Part I of the manual contains general design data and construction information. Part II contains information on loads and the design of structural elements and their fastenings. Part III contains reference information and AITC recommended standards and specifications for engineered timber construction.

The work of the preparation of the *Timber Construction Manual* was guided by the AITC Technical Advisory Committee and was carried out by AITC staff engineers and by engineers and technical representatives of AITC member firms.

Suggestions for the improvement of this manual will be welcomed and will receive consideration in the preparation of future editions.

The *Timber Construction Manual* has been adopted by the American Institute of Timber Construction as its official recommendation.

The American Institute of Timber Construction has developed this *Timber Construction Manual* for convenient reference by architects, engineers, contractors, teachers, and the laminating and fabricating industry, and all others having need for up-to-date technical data and recommendations on engineered timber construction.

While these data have been prepared in accordance with recognized engineering principles and are based on the most accurate and reliable technical data available, they should not be used or relied upon for any general or specific application without competent professional examination and verification of their accuracy, suitability, and applicability by a licensed professional engineer, designer, or architect. By the publication of this manual, AITC intends no representation or warranty, expressed or implied, that the information contained herein is suitable for any general or specific use or is free from infringement of any patent or copyright. Any user of this information assumes all risk and liability arising from such use.

PREFACE TO SECOND EDITION

The first edition of the AITC *Timber Construction Manual* was published in 1966. Changes in the wood products industry and technological advances and improvements in the structural timber fabricating industry have necessitated this revised edition of the *Manual*.

New lumber sizes and revisions in grading requirements for lumber and glued laminated timber are reflected in this second edition. Improved and refined design procedures are also incorporated.

The *Timber Construction Manual* was prepared by the AITC engineering staff with the guidance of the Institute's Technical Advisory Committee. The valuable assistance provided from many sources in developing technical data for the *Manual* is gratefully acknowledged.

PREFACE TO FIRST EDITION

In recent years, technical developments and the establishment of an engineered timber fabricating and laminating industry have had a profound effect on construction. Long clear spans of timber trusses, girders, arches, and decking are now commonplace. Engineered timber is widely used in such diversified construction as schools, churches, commercial buildings, industrial buildings, residences and farm buildings, highway and railway bridges, towers, theater screens, ships, and military and marine installations.

Modern practices combine engineering, quality control, and careful grading with the use of proper working stresses, dependable adhesives, and efficient mechanical fastenings to produce reliable construction. Laminating with strong, durable adhesives permits the manufacture of curved and variable shaped members and thus increases the versatility of timber construction.

The American Institute of Timber Construction is a nonprofit, technical, industrial association of manufacturers and fabricators who may design, plant-laminate, fabricate, assemble, and erect load-carrying sawn and glued timber framing and decking for roofs and other structural parts of schools, churches, commercial, industrial, and other buildings, and for other structures such as bridges, towers, and marine installations.

The American Institute of Timber Construction has developed this *Timber Construction Manual* for convenient reference by architects, engineers, contractors, teachers, the laminating and fabricating industry, and all others having a need for reliable, up-to-date technical data and recommendations on engineered timber construction. The information and the recommendations herein are based on the most reliable technical data available and reflect the commercial practices found to be most practical. Their application results in structurally sound construction.

The *Manual* has been arranged primarily for convenient use by designers, detailers, and fabricators of engineered timber construction. To avoid repetition, material which pertains to more than one area will be found in only one section. Suitable cross references are made in the other pertinent sections.

Information of an engineering textbook nature, such as derivations of formulae, is not included, since the purpose of the *Manual* is to present data for design and construction application by those familiar with engineering procedures.

Part I of the *Manual* contains design data and construction information. Part II contains AITC recommended standards and specifications which will aid the designer in preparing plans and specifications for engineered timber construction.

Material has been compiled from many sources. Where it has been possible to identify the author of the material reproduced, it is used with the author's permission.

Every precaution has been taken to assure that all the data and information included are as accurate as possible. However, the Institute cannot assume responsibility for errors or omissions resulting from the use of this *Manual* in the preparation of plans or specifications. The Institute does not prepare engineering plans.

The work of the preparation of the *Timber Construction Manual* was guided by the AITC Technical Advisory Committee and was carried out by AITC staff engineers and by engineers and technical representatives of AITC member firms.

Suggestions for the improvement of this *Manual* will be welcomed and will receive consideration in the preparation of future editions.

The *Timber Construction Manual* has been adopted by the American Institute of Timber Construction as its official recommendation.

GENERAL NOMENCLATURE

The following abbreviations and symbols are in general use throughout this manual. Deviations from these notations are indicated where they occur.

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AREA	American Railway Engineers Association
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute
APA	American Plywood Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWPA	American Wood-Preservers' Association
Btu	British thermal unit
DL	Dead load (psf)
EL	Earthquake load (psf)
EMC	Equilibrium moisture content (%)
FPL	Forest Products Laboratory, U.S. Forest Service
ft, ft^2, ft^3	feet, square feet, cubic feet
G	Specific gravity
hr	Hour
in., $in.^2$, $in.^3$, $in.^4$...	inches, square inches, cubic inches, inches to the fourth power
in.-lb	Inch-pounds
k	Kip (one thousand pounds)
KD	Kiln dried
lb	Pound
LL	Live Load (psf)
MC	Moisture content (%)
min	Minimum
MSR	Machine stress rated

NA	Neutral axis
NDS	*National Design Specification for Wood Construction*
o.c.	On centers
°F	Degrees Fahrenheit
pcf	Pounds per cubic foot
plf	Pounds per lineal foot
psf	Pounds per square foot
psi	Pounds per square inch
SL	Snow load (psf)
TL	Total load (psf)
USDA	United States Department of Agriculture
WL	Wind Load (psf)

SYMBOLS

A	Area of cross section (in.^{2})
A_1	In fastener group analysis, cross-sectional area of main wood member(s) before boring and grooving (in.^{2})
A_2	In fastener group analysis, sum of cross-sectional areas of wood or metal side member(s) before boring or drilling (in.^{2})
a	Dimension of member (in.)
a	Distance to load for bracket columns (in.)
A_c	Area of concrete footing in pole design (ft^2)
A_s	Area of steel member (in.^{2})
b	Breadth (width) of rectangular member (in.)
b	Smaller side of beam or column before exposure to fire (in.)
b	Width of column flange (in.)
C	Compressive force (lb)
C	Pole circumference at point of maximum moment (in.)
C	Thermal conductance (Btu/hr ft^2 °F)
c	Distance from neutral axis to outer surface of beam (in.)
C_C	Curvature factor
C_{co}	Seasoning conditioning modification factor for poles
C_{cs}	Critical section modification factor for poles
C_D	Duration-of-load factor
C_d	Depth-of-embedment factor
C_{dt}	Constant for tapered beam deflection
C_e	Fastener edge distance factor

C_f	Form factor
C_F	Size factor
C_g	Group action factor
C_I	Interaction stress factor
C_k	For bending members, largest value of C_s at which intermediate-beam formula applies
C_L	Lateral stability-of-beams factor
C_{lb}	Lag bolt modifying factor
C_M	Moisture content factor
C_M	Steel stress coefficient for bridge dowel design (psi)
C_n	Fastener end distance factor
C_P	Lateral stability-of-columns factor
C_p	Ponding magnification factor
C_R	Fire-retardant treatment factor
C_R	Steel stress coefficient for bridge dowel design (psi)
C_r	Reduction factor for double-tapered curved beams
C_s	Fastener spacing factor
C_s	Slenderness factor for beam stability
C_{SF}	Modifier for safety factor for poles
C_{st}	Fastener steel side plate factor
C_t	Temperature factor
C_x	Spaced column fixity factor
C_y	Factor for tapered beam deflection
D	Diameter (in.)
d	Bridge dowel diameter (in.)
d	Depth of rectangular member (in.)
d	Least dimension of compression member (in.)
d	Larger side of beam or column before exposure to fire (in.)
d_b	Arch depth at base (in.)
d_c	Depth of cross section at centerline (in.)
d_{cb}	Approximate centerline depth for double-tapered curved beams (in.)
d_{crt}	Minimum centerline depth due to radial tension for double-tapered curved beams (in.)
d_{eb}	Factor for calculating depth of double-tapered curved beams (in.)
d_{eff}	Approximate effective centerline deflection for double-tapered curved beams (in.)
D_H	Diameter of hole for pole design (ft)

d_t	Depth of tangent point (in.)
E	Modulus of elasticity (psi)
e	Eccentricity of load (in.)
f	Dimensionless factor from Figure 1.2
F_b	Design value in bending (psi)
f_b	Bending stress (psi)
F_c	Design value in compression parallel to grain (psi)
f_c	Compression parallel to grain stress (psi)
$F_{c\perp}$	Design value in compression perpendicular to grain (psi)
$f_{c\perp}$	Compression perpendicular to grain stress (psi)
f_{cr}	Ultimate column buckling strength (psi)
F_g	Design value for end grain in bearing (psi)
f_0	Reference stress for double-tapered curved beams (psi)
f_r	Radial stress (psi)
F_{rt}	Design value in radial tension (psi)
f_{rt}	Radial tension stress (psi)
f_s	Torsional stress (psi)
F_t	Design value in tension parallel to grain (psi)
f_t	Tension parallel to grain stress (psi)
F_v	Design value in horizontal shear (psi)
f_v	Horizontal shear stress (psi)
G	Shear modulus (modulus of rigidity) (psi)
h	Height of crown of arch (ft)
h_a	Height of apex for double-tapered curved beams (in.)
h_s	Height of soffit at midspan for double-tapered curved beams (in.)
I	Initial moisture content (below 30%) (%)
I	Moment of inertia (in.^{4})
I_K/I_G	Ratio of moment of inertia of knots to moment of inertia of gross cross section
J_x, J_y	Factor for column stability check
K	Constant for bridge deck design
K	Factor for intermediate columns
K	Bending stress factor for double-tapered curved beams
k	Change in member thickness for arch deflection (%)
k	Thermal conductivity (Btu in./hr ft^2 °F)
K_e	Effective buckling length factor
K_R	Factor for round columns
K_r	Radial stress factor

K_1, K_2	Coefficients for truss deflection
L	Span (ft)
l	Span length of beam or unsupported length of column (in.)
l/d	Span-to-depth ratio
L_c	Length between tangent points for double-tapered curved beams (ft)
L_e	Effective length for shear (ft)
l_e	Unsupported column length (in.)
l_e	Effective length of beam (in.)
l_t	Length of tapered leg for double-tapered curved beams (in.)
l_u	Unsupported beam length (in.)
M	Moment capacity (in. lb)
m	Final moisture content (below 30) (%)
M_D	Moment capacities for dowel bridge design (in. lb)
M_s	Bending moment due to unit load (in. lb)
M_y	Total secondary moment for dowel bridge design (in. lb)
N	Fastener value for angle with direction of grain (lb)
n	Number of dowels for bridge deck design
P	Axial load (lb)
P	Design wheel load for bridge design (lb)
p	Allowable passive soil pressure for poles (psf)
p	Fastener value for load acting parallel to grain (lb)
Q	Fastener value for load acting perpendicular to grain (lb)
Q	Statical moment of area (in.^{3})
R	Radius of curvature of inside face of lamination (in.)
r	Radius of gyration (in.)
R_D	Shear capacities for dowel bridge design (lb)
R_H	Horizontal reaction (lb)
R_m	Radius of curvature of centerline of curved member (in.)
R_T, R_1, R_2, ...	Thermal resistance (hr ft^2 °F/Btu)
R_v	Vertical reaction (lb)
R_y	Total secondary shear for dowel bridge design (lb)
S	Section modulus (in.^{3})
s	Effective bridge deck span (in.)
s	Length of arch segment (in.)

S_B	Allowable soil-bearing capacity for poles (psf)
S_m	Shrinkage from initial moisture condition to final moisture content *m* (%)
S_n	Section modulus times size factor (in.^{3})
S_0	Total shrinkage from Table 2.3 (%)
S_0, S_1, S_3, S_4	Allowable lateral soil-bearing pressure for poles (psf)
T	Applied torque (in. lb)
T	Tensile force (lb)
t	Bridge deck thickness (in.)
t	Fire resistance rating (min)
t	Thickness of column flange (in.)
t	Thickness of lamination (in.)
U	Overall heat transfer coefficient (Btu/hr ft^2 °F)
u	Force in truss member caused by unit load (lb)
V	Vertical shear force (lb)
W	Total uniform load (lb)
w	Uniform load (pounds per unit length)
W'	Total load of 1 in. of water (lb/in.)
X	Distance (ft)
x	Distance (in.)
x	Horizontal location (ft)
y	Vertical location (ft)
y	Wall height of arch (ft)
α	Angle measure (degrees)
α_r	Radial coefficient of thermal expansion
α_t	Tangental coefficient of thermal expansion
Δ_H	Horizontal movement (in.)
Δ	Deflection (in.)
Δ_c	Centerline deflection (in.)
θ	Angle measure (degrees)
π	Pi
σ_{PL}	Proportional limit stress for bridge dowel design (psi)
ϕ	Angle measure (degrees)
Ω	Coefficient of variation

CONTENTS

Part II DESIGN

Part I

GENERAL