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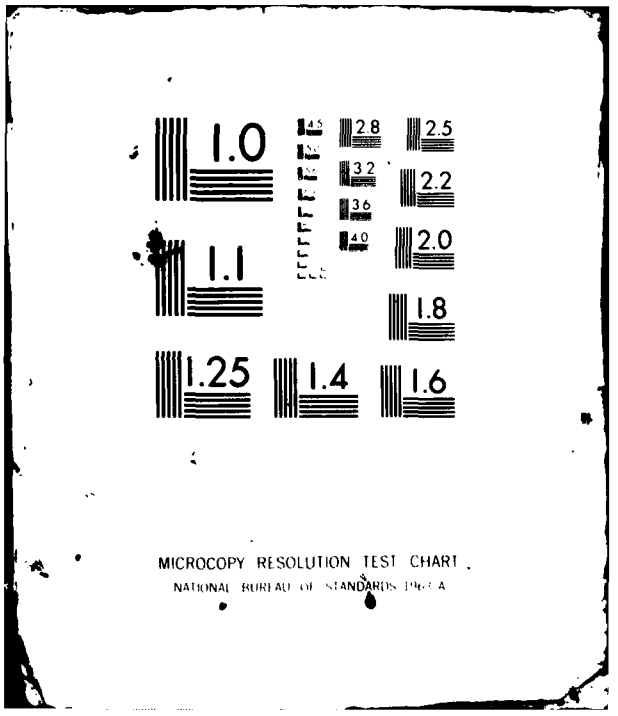
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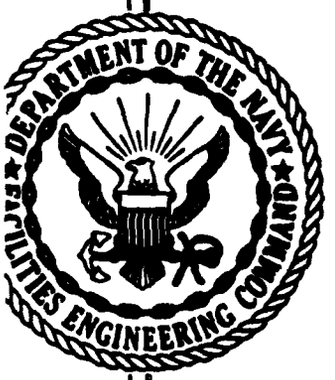

STRUCTURAL ENGINEERING

GENERAL REQUIREMENTS

DESIGN MANUAL 2.1

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ABSTRACT

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FOREWORD

This design manual is one of a series developed from an evaluation of facilities in the shore establishment, from surveys of the availability of new materials and construction methods, and from selection of the best design practices of the Naval Facilities Engineering Command, other Government agencies, and the private sector. This manual uses to the maximum extent feasible, national professional society, association, and institute standards in accordance with NAVFACENGCOM policy. Deviations from these criteria should not be made without prior approval of NAVFACENGCOM Headquarters (Code 04).

Design cannot remain static any more than can the naval functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged from within the Navy and from the private sector and should be furnished to NAVFACENGCOM Headquarters, Code 04. As the design manuals are revised, they are being restructured. A chapter or a combination of chapters will be issued as a separate design manual for ready reference to specific criteria.

This publication is certified as an official publication of the Naval Facilities Engineering Command and has been reviewed and approved in accordance with SECNAVINST 5600.16.

D. G. Iselin

D. G. Iselin
Rear Admiral, CEC, U.S. Navy
Commander
Naval Facilities Engineering Command

STRUCTURAL ENGINEERING DESIGN MANUALS

New DM Number	Superseded Chapter in Basic DM	Subject
2.1	-	General Requirements
2.2	1	Loads
2.3	2	Steel Structures
2.4	3	Concrete Structures
2.5	4	Timber Structures
2.6	5, 6, 7, 8	Aluminum Structures Masonry Structures Composite Structures Other Structural Materials
2.7	-	Snow Loads (Tri-Service)

CONTENTS

GENERAL REQUIREMENTS

2.1 GENERAL REQUIREMENTS

1. SCOPE. The provisions of NAVFAC DM's 2.1 through 2.6 provide guidance for the design of "structural elements" of Civil Engineering facilities. "Structural elements" shall include all elements of both foundation and superstructure which, in engineering practice, are proportioned on the basis of calculated stress. An element shall be considered as a "structural element" if in its proposed use: 1) for working stress design, the materials are stressed in excess of one-third of the allowable stress values (without increase for infrequent loading conditions), or 2) for load factor design, the sum of the actual loads is in excess of one-third of the sum of the factored loads.

a. Structural Materials. Criteria are provided only for those materials for which generally accepted standards of design have been developed. Use of other materials (nonstress grade lumber, metallic alloys other than those listed herein, and ungraded masonry units are examples) shall be limited to nonstructural elements, except as permitted by paragraph 3.

b. Machinery and Equipment. The provisions of NAVFAC DM's 2.1 through 2.6 do not apply to the design of machinery and equipment (ships and aircraft, for example) except for their foundations and supports.

2. POLICY. Although the Navy is not obligated to conform to local building codes, it is NAVFACENGCOM policy to avoid infringement of the regulations and standards of such codes.

3. EQUIVALENT SYSTEMS OF DESIGN. Nothing in this manual shall be construed to prohibit the use of any system of design or any materials of construction alternate to those indicated, provided that it shall be demonstrated to the satisfaction of NAVFACENGCOM that such design will provide: 1) a factor of safety against structural failure consistent with the requirements of paragraphs 3 through 10; 2) fire safety in consonance with the requirements of NAVFAC DM-8; and 3) such other characteristics pertinent to the safety of life, health, and property as prescribed in this manual or as may be required by NAVFACENGCOM.

4. RELATED CRITERIA. Certain criteria related to the subject matter of this manual appear in other publications, as follows:

Subject	Source
Fire Protection Engineering . . . . . Fire Protection Requirements	NAVFAC DM-8
Soil Mechanics Foundations and Earth Structures . . . . . Stability Requirements for Foundations Allowable Settlements	NAVFAC DM-7
Building Code Requirements for Reinforced Concrete . . . . . Crack Control	ACI-318

Subject	Source
Seismic Design for Buildings (Tri-Service)	NAVFAC P-355
Recommended Lateral Force Requirements	Structural Engineers Assoc. of California

5. SERVICE CLASSIFICATIONS. Structures shall be classified as follows. Where specific direction is not given, the classification shall be determined by the designer, subject to review and approval by NAVFACENGCOM.

a. Class A. Class A structures are those to which standard specifications for bridge type structures are applicable. Included are bridges, trestles, viaducts, and their components. The basis for classification as a Class A structure is the type of loading applied. This type of loading consists of groups or trains of wheels moving on the structure with impact effect. In addition, the wheels and tires are presumed to be within a size range and range of inflation pressure (generally less than 100 psig) corresponding to those of wheels and tires for passenger car and truck usage. Class A includes structures carrying automobile and truck traffic, railroad traffic, certain types of materials-handling equipment such as forklift trucks (other than those having solid tires), and straddle carriers. Class A does not include supports for overhead traveling cranes (Class B), mobile cranes or types of heavy-lift cranes generally used for waterfront work (Class C), pedestrian bridges (Class B), or structures carrying heavy earthmoving equipment or other equipment operating on tracks or oversize tires or fork-lift trucks having solid tires (Class C). In general, supports for machinery are to be considered under Class B, with due consideration for impact and resonant response.

b. Class B. Class B structures are those to which standard specifications for building-type structures are applicable. Portions of waterfront structures (piers and wharves) which are designed for uniform live load are included in Class B.

c. Class C. Class C covers special structures not readily classified in either of the above two categories. These include storage tanks, cable guyed structures, floating structures, structures supporting heavy-lift cranes and heavy earthmoving equipment, airport runways, catapults, and aircraft operating adjuncts, and others designated as special structures for which criteria are not specifically provided. Special codes or other information available in technical literature and manufacturers' publications shall be considered in establishing standards for design.

d. Combinations of Classes. Where a structure, or a portion thereof, falls into two or more classes (for example, a pier deck which is to be designed for a uniformly distributed load plus the moving loads of a crane), the design shall be proportioned for the most critical condition, considering both loading and class.

6. USE OF USED AND UNIDENTIFIED MATERIALS. The utilization of used materials and unidentified or ungraded materials shall be limited to nonstructural elements, except:

a. Stress Levels. Such materials (or elements) may be reused, or continued in use, at stress levels to which the material or elements were subjected in the previous construction, or at load capacity as demonstrated by load test procedures.

b. Grading by Test. Unidentified materials may be graded by the recovery and test of representative samples, or by other means satisfactory to the Field Division representative in charge.

c. Grading by Documentation. Used materials shall be considered to be graded where the grade is clearly indicated on the approved plans for the existing construction and they may be used at the allowable stress levels for that grade of like materials as established in the design standard operative at the time of making the evaluation, i.e., the current design standard. However, in-place dimensions and as-built conditions shall be checked visually and at least "spot checks" made to confirm that the materials specified actually were used.

7. STABILITY. Stability, as considered herein, relates to sliding, overturning, buoyancy, and other sources of gross displacement and not to stability as related to buckling. Except as provided in NAVFAC DM-7 with regard to foundation elements, a structure or any element thereof shall be proportioned to provide a minimum factor of safety of 1.50 against failure by sliding, overturning, or uplift. The required stability shall be provided solely by the dead load plus any permanent anchorages which may be provided. In the design standards, load combinations are specified wherein, in order to maximize potential uplift conditions, the specified load factor on dead load is less than 1.0 (usually 0.9). Such load factors shall be used for stability calculations.

8. SERVICE LIFE. Nothing in the following criteria shall be deemed to supersede the dictates of experience or of standard practice. Rather, the criteria are intended for guidance in special cases not covered by the reference standards, such as design and protection of tiedowns and tiebacks, required coating systems for steel, and intervals of recurrence of design loading conditions (flood, for example).

a. Normal Service Life. Unless specifically intended for a limited service life, or unless otherwise stipulated in job-specific criteria, structures shall be designed for a service life of 25 years.

b. Limited Life Structures. Where a service life of 1 year or less is intended, design may be predicated on an overall load factor of 1.25 for dead plus live load; an overall load factor of 1.15 for dead plus live load combined with any other single load; or 1.10 when combined with two or more other loads. Load factors for designs intended for limited service life intermediate between 1 year and 25 years may be interpolated between the values indicated in this paragraph and those for full service life designs.

9. BRACING. Unless otherwise specified, members used to brace compression members shall be proportioned to resist an axial load of at least 2 percent of the total compressive design load in the member braced, plus any transverse shear.

10. PROGRESSIVE FAILURE. Structural systems shall be designed to minimize the probability that an initial local failure of a structural element, caused by an abnormal event or severe overload, will spread to other structural members and precipitate the collapse of a disproportionately large portion of the structure.

11. EXCEPTIONS FOR MINOR STRUCTURES.

a. One- and Two-Family Houses.

(1) Traditional empirical provisions related to the structural design of wood framing shall apply. Nonstress grade lumber may be used for partitions, nonload bearing walls, and walls which do not resist lateral loads.

(2) For requirements relating to soil exploration and soil bearing capacity, see NAVFAC DM-7.

(3) Masonry foundation walls may be of hollow units except that the top course shall be filled.

b. Storage Sheds, Kiosks, Pump Houses. These and other structures which are intended to house minor equipment or stores and which are: 1) not intended for occupancy by humans or animals, or 2) would not be expected to be so occupied during storm conditions, or 3) which are open-sided or otherwise permit ready evacuation in the event of evidence of imminent distress, may be designed on the basis of the 10-year expectancy of occurrence of design conditions. In the absence of other data, this may be taken to mean that design climatic conditions (wind and snow load) are 70 percent of the intensities specified in NAVFAC DM-2.1. Provisions relating to increase in allowable stress (decreased load factors) for various load combinations shall apply. Nonstress grade materials may be used. The provisions of this paragraph shall not be deemed to apply in areas subject to typhoon or hurricane, or elsewhere, if in the event of failure, the structure could become a source of flying debris or otherwise become a palpable hazard to other structures.

c. Other.

(1) For foundation requirements for mobile or portable buildings, see NAVFAC DM-7.

(2) Buildings not more than one story high (two stories for residences and other lightly loaded usages) may be supported on poles embedded in the ground. Wood poles shall be given a preservative treatment suitable for the exposure. Embedded portions of steel poles shall be encased in concrete.

12. SEISMIC DESIGN. Loadings for seismic design shall be established as described in NAVFAC DM-2.2. In addition, details of design must be tailored to provide necessary ductility and continuity. Where no guidance exists in the cited reference standards, follow the general criteria and intent of:

1) Seismic Design for Building (Tri-Service) - NAVFAC P-355.

2) "Recommended Lateral Force Requirements," published by the Structural Engineers Association of California.

3) ACI-318 "Building Code Requirements for Reinforced Concrete."

S. I. Conversion Units

The following metric equivalences were developed in accordance with ASTM E 621 and are listed in the sequence as they appear in the text. All equivalences are approximate.

100 psi g	=	700 kPa

REFERENCES

AASHTO standards. American Association of State Highway and Transportation Officials, Washington, D.C. 20004
Standard Specifications for Highway Bridges

ACI Standards and Publications. American Concrete Institute, Detroit, Michigan 48219
ACI-318. Building Code Requirements for Reinforced Concrete

AREA publications. American Railway Engineering Association, Chicago, Illinois 60605
AREA Manual for Railway Engineering

ASTM publications. American Society for Testing and Materials, Philadelphia, Pennsylvania 19103
ASTM E380. Standard Metric Practice Guide

NAVFAC Documents and Standards. Government agencies may obtain documents from the U.S. Naval Publications and Forms Center, Philadelphia, Pennsylvania 19120. Telephone: AUTOVON-442-3321; commercial: 215-697-3321. Non-government agencies may obtain documents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

NAVFAC DM-2.2	Loads. Structural Engineering
NAVFAC DM-7	Soil Mechanics, Foundations and Earth Structures
NAVFAC DM-8	Fire Protection Engineering
NAVFAC DM-25.1	Piers and Wharves
NAVFAC P-355	Seismic Design for Building (Tri-Service)

Structural Engineers Association of California. Recommended Lateral Force Requirements


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