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MAY 1980

MILITARY HANDBOOK

STRUCTURAL ENGINEERING

GENERAL REQUIREMENTS

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ABSTRACT

This handbook provides basic design guidance relating to the design of structural elements and systems. It has been developed from extensive re-evaluation of facilities. It is intended for use by experienced architects and engineers. This handbook covers topics such as service classifications for various types of structures and uses, required service life for structures, grading and evaluation of existing materials, minimum forces used in the design of bracing, provisions relating to prevention of progressive failure, variances to conventional design standards permitted when designing minor structures, and general references for seismic design.

FOREWORD

This handbook has been 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 (NAVFACENGCOM), other Government agencies, and the private sector. This handbook was prepared using, to the maximum extent feasible, national professional society, association, and institute standards. Deviations from this criteria, in the planning, engineering, design, and construction of Naval shore facilities, cannot be made without prior approval of NAVFACENGCOM HQ Code 04.

Design cannot remain static any more than can the functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished to the Commander, Headquarters, Code 04B, Naval Facilities Engineering Command, 200 Stovall St., Alexandria, VA 22332-2300; telephone (703) 325-0450.

THIS HANDBOOK SHALL NOT BE USED AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGN (FINAL PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

STRUCTURAL ENGINEERING CRITERIA MANUALS

Criteria Manual	Title	PA
MIL-HDBK-1002/1	Structural Engineering, General Requirements	HDQTRS
DM-2.02	Structural Engineering, Loads	HDQTRS
MIL-HDBK-1002/3	Steel Structures	NORTHDIV
DM-2.04	Structural Engineering, Concrete Structures	LANTDIV
MIL-HDBK-1002/5	Timber Structures	NORTHDIV
MIL-HDBK-1002/6	Aluminum Structures, Composite Structures, Other Structural Materials	NORTHDIV
MIL-HDBK-1002/7	Seismic Site Response Spectra (Proposed)	HDQTRS
DM-2.08	Blast Resistant Structures	NORTHDIV
DM-2.9	Masonry Structural Design for Buildings	HDQTRS/ARMY

NOTE: Design manuals, when revised, will be converted to military handbooks and listed in the military handbook section of NAVFAC P-34.

This handbook is issued to provide immediate guidance to the user. However, it may or may not conform to format requirements of MIL-HDBK-1006/3 and will be corrected on the next update.

GENERAL REQUIREMENTS

CONTENTS

Section 1: INTRODUCTION

1.1 Scope. The provisions of NAVFAC DM-2 Series, Structural Engineering, provide guidance for the design of "structural elements" of civil engineering facilities. "Structural elements" include all elements of both foundation and superstructure which, in engieering practice, are proportioned on the basis of calculated stress. Consider an element as a "structural element" if, in its proposed use:

a) 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

b) for load factor design, the sum of the actual loads is in excess of one-third of the sum of the factored loads.

1.2 Cancellations. This handbook cancels and supersedes NAVFAC DM-2.1, May 1980.

1.3 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 where their provisions exceed the requirements of NAVFAC criteria.

1.4 Equivalent Systems of Design. Nothing in this handbook shall be construed as prohibiting the use of any system of design or any materials of construction alternate to those indicated, provided that it is demonstrated to the satisfaction of NAVFACENGCOM that such design will provide:

a) a factor of safety against structural failure consistent with the requirements of paras. 1.4 and 2.4 through 2.9,

b) fire safety in consonance with the requirements of MIL-HDBK-1008, Fire Protection For Facilities Engineering Design and Construction, and,

c) such other characteristics pertinent to the safety of life, health, and property as prescribed in this manual or as may be required by NAVFACENGCOM.

Section 2: GENERAL REQUIREMENTS

2.1 Scope. This section defines the general requirements for the design of structural elements of civil engineering facilities.

2.2 Structural Materials. Criteria are provided only for those materials for which generally accepted standards of design have been developed. Limit the use of other materials (nonstress grade lumber, metallic alloys other than those listed herein, and ungraded masonry units are examples) to nonstructural elements, except as permitted by para. 1.4.

2.3 Machinery and Equipment. The provisions of NAVFAC DM Series do not apply to the design of machinery and equipment unrelated to facilities (ships and aircraft, for example) except for their foundations and supports.

2.4 Service Classifications. Classify structures as indicated in paras. 2.4.1 through 2.4.4. Where specific direction is not given, the classification shall be determined by the designer, subject to review and approval by NAVFACENGCOM.

2.4.1 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 (689.4 kPa), 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 earth-moving equipment or other equipment operating on tracks or oversize tires or forklift trucks having solid tires (Class C). In general, consider supports for machinery under Class B, with due consideration for impact and resonant response.

2.4.2 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 (refer to MIL-HDBK-1025/1, Piers and Wharves).

2.4.3 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 earth-moving equipment, airport runways, catapults, and aircraft operating adjuncts, and others designed as special structures for which criteria are not specifically provided. Consider special codes or other information available in technical literature and manufacturers' publications in establishing standards for design.

2.4.4 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), proportion the design for the most critical condition, considering both loading and class.

2.5 Use of Used and Unidentified Materials. Limit the use of used materials and unidentified or ungraded materials to nonstructural elements, except as provided in paras. 2.5.1 through 2.5.3.

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

2.5.2 Grading by Test. Unidentified materials may be graded by the recovery and test of representative samples, or by other means satisfactory to the Engineering Field Division representative-at-large.

2.5.3 Grading by Documentation. Consider used materials to be graded where the grade is clearly indicated on the approved plans for the existing construction. The materials 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, check in-place dimensions and as-built conditions visually and make "spot checks" to confirm that the materials specified actually were used.

2.6 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-7.02 Foundations and Earth Structures, with regard to foundation elements, proportion a structure or any element thereof 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). Use such load factors for stability calculations.

2.7 Service Life. Any conflict between the following criteria and referenced standards should be referred to NAVFAC HQ Code 04.

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

2.7.2 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 are intended for limited service life.

2.8 Bracing. Unless otherwise specified, proportion members used to brace compression members to resist an axial load of at least 2 percent of the

2. Check fuel supply (oil). Note level of oil

total compressive design load in the member braced, plus any transverse shear.

2.9 Progressive Failure. Design structural systems 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.

2.10 Exceptions for Minor Structures

2.10.1 Family Housing. Criteria for family housing is provided in NAVFAC DM-35, Family Housing. For requirements relating to soil exploration and soil bearing capacity, refer to NAVFAC DM-7 Series, Soils and Foundations. Masonry foundation walls may be of hollow units except that the top course shall be filled with grout.

2.10.2 Storage Sheds, Kiosks, Pump Houses. These and other structures which are intended to house minor equipment or stores and which are:

a) not intended for occupancy by humans or animals, or

b) would not be expected to be so occupied during storm conditions, or

c) 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 this manual. Provisions relating to increase in allowable stress (decreased load factors) for various load combinations apply. Nonstress grade materials may be used. The provisions of this paragraph do not 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. The provisions of this paragraph do not apply to earthquake design in Seismic Zones 3 and 4.

2.10.3 Mobile or Portable Buildings. For foundation requirements for mobile or portable buildings, refer to NAVFAC DM-7.02, Foundations and Earth Structures. 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. Treat wood poles with a preservative suitable for the exposure. Encase embedded portions of steel poles in concrete.

2.11. Seismic Design. Establish loadings for seismic design as described in NAVFAC P-355, Seismic Design for Buildings, NAVFAC P-355.1, Seismic Design Guidelines for Essential Buildings, and NAVFAC P-355.2, Seismic Design Guidelines for Existing Buildings. The procedures in NAVFAC P-355.1 use site response spectra. Such spectra were developed for most sites in seismic zones 3 and 4. Spectra are summarized in NCEL TM 53-85-17, Compilation of Seismic Response Spectra, and will be provided in MIL-HDBK-1002/7, Seismic Site Response Spectra, when published. Use these spectra for all applicable projects in connection with NAVFAC P-355.1.

BIBLIOGRAPHY

AASHTO Standards. American Association of State Highway and Transportation Officials, 444 North Capitol St., NW, Suite 115, Washington, DC 20004.

Standard Specifications for Highway Bridges.

ACI Standards and Publications, available from American Concrete Institute, p.o. Box 19150, Redford Station, Detroit, MI 48219.

Building Code Requirements for Reinforced Concrete, ACI-318,

AREA Publications. American Railway Engineering Association, 200 L St., NW, Washington, D.C. 20036.

AREA Manual for Railway Engineering,

Structural Engineers Association of California. Recommended Lateral Force Requirements.

REFERENCES

Compilation of Seismic Response Spectra, Naval Civil Engineering Laboratory Technical Memorandum (TM) NO. 53-85-17. Available from Naval Civil Engineering Laboratory, Port Hueneme, CA 93403.

NAVFACENGCOM Design Manuals and P-Publications Department of Defense activities may obtain copies of Design Manuals and P-Publications from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. Department of Defense activities must use the Military Standard Requisitioning and Issue Procedure (MILSTRIP), using the stock control number obtained from NAVSUP Publication 2002.

Other Government Agencies and commercial organizations may procure Design Manuals and P-Publications from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

DM-2 Series	Structural Engineering
DM-7 Series	Soils and Foundations
MIL-HDBK-1008	Fire Protection for Facilities Engineering, Design, and Construction
MIL-HDBK-1025/1	Piers and Wharves
DM-35	Family Housing
P-355	Seismic Design for Buildings
P-355.1	Seismic Design Guidelines for Essential Buildings
P-355.2	Seismic Design Guidelines for Existing Buildings

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