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MILITARY HANDBOOK

MATERIALS AND BUILDING COMPONENTS

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ABSTRACT

General criteria for materials and building components selection and usage for all naval shore facilities are presented for use by experienced designers. Emphasis is placed on usage based on compliance with NAVFAC standards and project requirements for function, maintenance, and cost. Criteria for appearance, performance, and energy conservation effects on material selections are discussed.

FOREWORD

This military 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 uses, 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 NAVFACENGCOMHQ 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 Commander, Atlantic Division, Naval Facilities Engineering Command, Code 04A4, Norfolk, Virginia 23311-6287; telephone (804) 444-9970.

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.

ARCHITECTURAL CRITERIA MANUALS

Document Number	Title	Preparing Activity
DM-1.01	Basic Architectural Requirements and Design Considerations	LANTDIV
MIL-HDBK-1001/2	Materials and Building Components	LANTDIV
DM-1.03	Architectural Acoustics	LANTDIV
DM-1.04	Earth-Sheltered Buildings	NORTHDIV
*MIL-HDBK-1001/5	Roofing and Waterproofing	CHESDIV
*MIL-HDBK-1001/6	Building Thermal Mass Effects	WESTDIV

* To be issued.

NOTE: NAVFAC design manuals (DM), when revised, will be converted to military handbooks (MIL-HDBK).

MATERIALS AND BUILDING COMPONENTS

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Section 1: INTRODUCTION

1.1 Scope. This handbook contains basic criteria for building components and materials for all Navy architectural and design projects. The information is to be used in conjunction with applicable Naval Facilities Engineering Command (NAVFACENGCOM) and Department of Defense (DOD) criteria, as well as specific project user requirements, to form the basis of materials selection and usage.

1.2 Cancellation. This issue of MIL-HDBK-1001/2, Materials and Building Components, supersedes NAVFAC DM-1.02, Materials and Building Components, dated April 1986.

1.3 Related Criteria. Criteria in other publications related to materials and components and referenced in this manual are listed in REFERENCES. Refer to Federal Acquisition Regulations, Part 10, Specifications, Standards, and Other Purchase Descriptions, for information concerning preparation and use of specifications as related to material acquisition procedures and regulations.

Section 2: GENERAL CRITERIA

2.1 Approach. Major factors affecting materials selection include life cycle costs, appearance, and performance characteristics of the product. Projected life span of the building, flexibility and expansion requirements, availability of the material, and the energy impact of the product must be considered. A minimum number of different materials should be used to minimize labor costs and to create a unified building appearance.

2.2 Product Appearance.

2.2.1 Design. Products must represent current proven design standards and proven state-of-the-art technologies. Materials should require a minimum of applied finishes. Products with highly decorative or simulated finishes can appear substandard and should not be used.

2.2.2 Context. While it is not the intent to copy or repeat materials and components of existing adjacent buildings, products selected for new buildings must be compatible with existing structures. Base Exterior Architectural Plans (BEAP) should be reviewed for applicable criteria-establishing materials selection and used for a specific base.

2.2.3 Restoration. Restoration work in historic or architecturally significant buildings of any age requires careful product selection. Components and materials must provide a quality, aesthetic, and durable environment that responds to updated engineering technologies while not altering the basic architectural character and design integrity of the building.

2.3 Product Performance. Products must be strong and durable, not easily marred, discolored, or vandalized, and capable of withstanding regular cleaning. Factory-finished products or materials requiring only an initial finish application are desirable. Materials requiring new finishes or frequent replacement should be avoided. The variety of materials and finishes should be limited to minimize the number and types of different cleaning equipment and processes required.

2.4 Cost. Products must be economical and cost-effective. A minimum initial cost is always desirable, but life cycle costs must be considered. Materials with low initial costs that require frequent maintenance, care, cleaning, and replacement will not prove to be cost-effective in the long term.

2.5 Types of Construction. The projected life span of a building helps determine the durability and detailing requirements of materials and components.

2.5.1 Permanent Construction. Buildings and facilities designed and constructed to serve a specific purpose over a life expectancy of more than 25 years should be energy efficient and fire resistive or noncombustible. Select finishes, materials, and systems for low maintenance and life cycle costs based on 25 years.

2.5.2 Semipermanent Construction. Buildings and facilities designed and constructed to serve a specific purpose over a life expectancy of more than 5 years but less than 25 years should be energy efficient and noncombustible. Select finishes, materials, and systems for reasonable maintenance and life cycle costs based on 15 years.

2.5.3 Temporary Construction. It is defined as buildings and facilities designed and constructed to serve a specific purpose over a life expectancy of 5 years. Select ordinary construction, finishes, materials, and systems without maintenance costs being the primary factor.

2.5.4 Mobilization Construction. Buildings and facilities, designed and constructed to serve a specific purpose for a life expectancy of 5 years or less under mobilization conditions, should be suitable for rapid erection utilizing conventional or industrialized construction techniques or both. Select austere finishes, materials, and systems without regard to maintenance costs.

2.6 Miscellaneous Selection Criteria.

2.6.1 Geographical Factors. Local and indigenous materials and elements may offer choices for creative uses of products. The level of local construction technology must also be considered. Complicated industrialized curtain wall glazing systems would not be appropriate, for instance, in areas where construction technology is not advanced.

2.6.2 Availability. Products must be easily and quickly obtainable for initial construction. In addition, the future availability of the product for maintenance and replacement should be considered. Stock items should be used in lieu of special items where possible.

2.6.3 Energy Conservation. Energy conservation measures designed for the project will be a key influence on materials selection. Exterior wall and roof systems and materials must be chosen to maximize insulation values.

2.6.4 Acoustical Control. NAVFAC DM-1.03, Architectural Acoustics, contains specific criteria for acoustical control through materials usage. It should be reviewed in the initial planning and design stages to aid in the selection of materials with the most effective acoustical properties.

2.6.5 Expansion. Building components and materials should accommodate expansion. Systems and materials should be easily added to, enlarged, and readily available and reproducible.

2.6.6 Flexibility. Similar materials and finishes throughout a building will permit various functions to occur in different rooms. Where undefined future functions or flexible usage is required, temporary or nonpermanent materials and construction should be considered.

2.7 Metric System. Projects in certain locations may be required to be completed in or with metric (SI) equivalents. Refer to NAVFAC Instruction 4120.10, Use of the Metric System of Measurement in the Acquisition of Facilities and Related Equipment. American Society for Testing and Materials (ASTM) publications E380, Metric Practice; E621-78, Recommended Practice for the Use of Metric Units (SI) in Building Design and Construction; and American National Metric Council (ANMC) publication 85-1, Metric Editorial Guide, contain additional information. DM-6.02, Guide Specifications Manual, states that project specifications will be written using metric (SI) units if the products specified are readily available in SI units.

2.8 New Materials. The use of new materials is encouraged, but specific policies and procedures must be followed to ensure that the standards and qualities of the Department of the Navy are maintained and enhanced.

2.8.1 NAVFAC Policy. It is NAVFAC policy to specify materials, equipment, and construction methods that will provide maximum overall economy consistent with functional and aesthetic requirements, reasonable comfort, and sound architectural and engineering practice. Materials, equipment, and methods used should result in low costs consistent with economical maintenance for the required use and life expectancy of the facility. NAVFAC recognizes the need to keep pace with technological developments in the construction industry, but new materials, equipment, and methods must be adequately tested and proven by actual performance before adoption. Newly developed materials, equipment, and methods not included in NAVFAC guide specifications may be used in limited applications with prior approval by the NAVFACENGCOM Engineering Field Division. Such newly developed materials, equipment, or methods should not be used extensively until the quality and durability are proven and appropriate requirements have been included in NAVFAC guide specifications.

2.8.2 NAVFAC Procedures. New materials, equipment, or methods proposed to NAVFAC must meet the following prerequisites:

a) The item must equal or exceed minimum standards for quality and performance currently included in other criteria.

b) The in-place cost of the item must compete with other acceptable products, or the premium cost of the item must result in long term savings in maintenance or operation costs.

c) The item must be readily available in quantity and in wide geographical areas.

d) The merits of the item must have approved laboratory certification or evidence of satisfactory use under conditions similar to the proposed application.

e) Quality control of manufacturing processes and installation techniques must be guaranteed.

f) Proposed item must be nonrestrictive enough to admit other available and equally acceptable competition.

Section 3: BUILDING COMPONENTS

3.1 Approach. Major building systems and components must efficiently and economically accommodate the functional requirements of a building. Select systems on the basis of function, cost, and impact on architectural design. Manufactured (pre-engineered) and other systems building may be considered for specific projects where time, cost, or unique functional criteria require a nonstandard design approach.

3.2 Construction Systems.

3.2.1 Structural Systems. The NAVFAC criteria manual series on Structural Engineering, including DM-2.01, Structural Engineering General Requirements; and DM-2.02, Structural Engineering Loads; as well as NAVFAC P-355, Seismic Design for Buildings; contain specific criteria for structural systems design and selection.

3.2.1.1 System Types. Individual project requirements and limitations preclude setting rigid guidelines for structural system selection, although general criteria can be established for various system types.

a) Wood Frame. Wood frame systems are generally not recommended for major or permanent construction projects, although laminated or other structural wood systems can be used for certain building types, such as religious facilities. Refer to MIL-HDBK-1002/5, Timber Structures.

b) Masonry. Load-bearing masonry systems can be used for low-rise housing or general use building types. Limitations include cost, availability of materials, and local construction restrictions. DM-2.09, Masonry Structural Design for Buildings, contains specific criteria for masonry structures.

c) Concrete. Concrete structural systems are stable, offer inherent fire protection characteristics, and can be exposed for enhancement of the architectural character. More economical precast concrete structures can be used in low-to-mid-rise buildings where repetitive layouts occur. Refer to DM-2.04, Structural Engineering Concrete Structures, for specific criteria.

d) Steel. Steel structures are generally the best solution for high-rise buildings and facilities covering large areas such as maintenance, industrial, and training facilities. Specific design criteria is described in DM-2.03, Structural Engineering Steel Structures.

e) Pre-engineered. Pre-engineered structures should be considered where economy and fast erection time are major requirements. A variety of available comparable systems will result in competitive construction costs. Pre-engineered structures are also appropriate for buildings requiring high clear spans. Review the criteria established in NFGS-13121, Pre-engineered Metal Buildings (Rigid Frame). Also comply with requirements of Metal Building Manufacturers Association (MBMA), Metal Building Systems Manual and Recommended Design Practices Manual.

f) Miscellaneous Systems. Unique systems such as air supported, tensile, or other membrane structures may be appropriate solutions for special projects. Advantages include the ability to admit natural light into large portions of the building, ability to cover large spans and areas, and substantial energy savings as a result of reduced artificial lighting. Life cycle costs must be favorable, however, if these structures are to be considered. Earth-sheltered buildings provide excellent insulation, acoustical, and explosion-resistant properties, but have inherent cost, ventilation, and leakage problems. Refer to DM-1.04, Earth-Sheltered Buildings.

3.2.1.2 Fire Protection. Fire protection requirements are a major consideration in structural systems selection. The system should give required protection ratings with a minimum of additional costs. Specific protection criteria are described in MIL-HDBK-1008, Fire Protection for Facilities Engineering, Design, and Construction.

3.2.2 Floor Systems. Floor systems are directly related to the type of structural system selected. Refer to the NAVFAC criteria manual series on Structural Engineering.

3.2.2.1 Crawl Space. Although the most economical and standard construction for ground floors is slab-on-grade, the use of a crawl space under the ground floor should be considered in special circumstances. Energy conservation can be enhanced in tropical and humid regions by using a first floor crawl space for natural ventilation and cooling. In addition, existing underground utilities or under floor utilities distribution requirements may require the use of a ground floor crawl space. These benefits may be offset, however, by extra costs associated with the additional height resulting from a crawl space. The use of crawl spaces must also comply with DOD policy for termite protection and crawl spaces. These requirements are described in NAVFAC DM-1.01, Basic Architectural Requirements and Design Considerations.

3.2.2.2 Access Floors. Unusual utility requirements demand that access floors be used in most computer rooms. Refer to NFGS-10270, Access Flooring, for additional information.

3.2.3 Exterior Skin System. The exterior skin of a building must be appropriate to the structural system and to the building's function. The contextual environment, material of adjacent structures, and indigenous materials must be considered.

3.2.3.1 Walls.

a) Wood. Exterior walls of wood are not permitted for most major or permanent building types. While relatively economical and easily installed, exterior wood siding walls require constant maintenance, deteriorate rapidly, and offer little fire protection or additional insulation value. Consider wood siding only for small temporary buildings, additions to existing buildings, and single-family housing units.

b) Masonry. Brick, stone, and other masonry materials are appropriate for most building types, although the scale and function of the project must be considered. Limestone, granite, and other stone materials are of a more monumental scale and, although relatively expensive, are especially appropriate as exterior walls for major administrative, headquarters, religious, educational, health, and similar facilities.

c) Concrete. Concrete walls are appropriate for low-to-mid-rise buildings where function and scale require strength, durability, and security. Concrete walls are expensive, and proper installation and finishing may not be possible in some regions. The detailing and finishing of poured-in-place walls must be clean, simple, and economical. Precast concrete panels are less expensive, can be erected faster, and allow better quality control. Decorative finishes and large exposed aggregates in concrete walls should be used judiciously. Criteria on precast concrete wall panels are described in NFGS-03411, Precast Concrete Wall Panels.

d) Metal. Exterior metal walls, such as corrugated metal siding or ribbed metal panels, should be considered for temporary buildings, industrial buildings, or where economy and speed of erection are important criteria. The use of these materials must be carefully controlled since they are easily damaged and are usually perceived as industrial or temporary finishes. Prefabricated insulated metal panels provide an economical, easily installed exterior wall with high insulation values. More expensive porcelain or smooth aluminum panels can be used where a higher degree of finish is desired. Fabrication time of porcelain panels can be lengthy, however, and reordering materials to replace defective panels can cause delays, especially for projects that have limited construction schedules. Refer to NFGS-07410, Preformed Metal (Roofing) (and) (Siding).

e) Curtain Walls. Fabricated curtain wall systems provide a lightweight, attractive, unified, and quickly erected exterior skin. These systems are relatively expensive, however, and have inherent problems of moisture infiltration, air leakage, thermal conduction and convection, and complicated assemblies. Glass curtain wall systems are especially appropriate for mid-to-high-rise buildings and wherever functional requirements necessitate expansive areas of glazing. Curtain walls are also advantageous where expansion and wall modifications are programmed. NFGS-08900, Glazed Curtain Wall System, contains additional criteria.

f) Exterior Wall Insulation and Finish System. Exterior skin systems of applied insulation and finish offer economical and attractive options. These systems are especially appropriate for renovation and energy retrofit projects for existing buildings.

3.2.3.2 Glazing Systems. Select glazing components that can be easily installed in the wall construction with simple detailing. Exterior glazing systems must accommodate insulated glass where required and should preferably be operable. Framing material should generally be aluminum with a factory-applied duranodic finish. Where wood frames are used, the system should be sheathed in vinyl or aluminum for maximum durability and low maintenance.

3.2.4 Roof Systems. See DM-1.05, Roofing and Waterproofing.

3.2.5 Interior Partitions. Interior partition systems should be as consistent as possible throughout a building and appropriate for the building function. Refer to NAVFAC guide specifications for specific criteria on materials and installation.

3.2.5.1 Fixed Partitions. Fixed partition systems should be used where functional requirements are not likely to change within a reasonable period of time.

a) Wood Stud. Wood studs should be used only in housing or temporary facilities.

b) Metal Stud. Metal stud partitions can be used in a variety of building types. Metal stud walls are easily erected, offer some degree of flexibility, and can easily facilitate utilities distribution through the walls. Refer to NFGS-09100, Metal Support Systems.

c) Masonry. Masonry partitions are durable, require low maintenance, and are more permanent than stud partitions. These walls require additional cost for reinforcing and lintels and make utilities distribution more difficult. Consider masonry walls for maintenance, barracks, medical, utility, and other facilities where durability, permanence, strength, and low maintenance are required.

3.2.5.2 Special Partitions.

a) Movable and Folding. Select movable and folding partitions on the basis of quality of construction, appearance, acoustical properties, flexibility, and ease of dismantling and relocation. Folding partitions can be beneficial in increasing the flexibility of large areas. Additional criteria are available in NFGS-10655, Accordion Folding Partitions.

b) Security. Wire mesh security partitions can be used for storage areas, tool rooms, supply issue areas, or similar functions. The system must be durable, strong, and of a convenient modular size.

3.3 Systems Buildings. Systems buildings refer to buildings composed of prefabricated or manufactured components or systems. The entire building can be a wholly manufactured systems building, or separate parts, such as curtain walls, structural systems, or roofing components which can be prefabricated components. Factors to consider when determining if a systems approach should be used include:

a) Repetitiveness of building layout;
b) Simplicity of building layout;
c) Simplification and standardization of details;
d) The need for fast erection time; and
e) Availability of systems suppliers and contractors in the area.

3.3.1 Use of Systems Buildings. Systems buildings can be used for permanent building types, such as industrial, maintenance, and housing facilities, as well as small scale buildings in general. Temporary buildings and relocatable structures are also conducive to a systems building approach. Large scale and unique permanent structures are generally not considered appropriate for systems buildings since the economic advantages of modularity would be reduced.

3.3.2 Design Approach. The basic approach of designing systems buildings or components is simplicity and repetitiveness. Industry standard layout modules, details, and guidelines must be adhered to for the specific type of systems building. Avoid irregular building shapes, unusual detailing, and special conditions. The application of unconventional, nonstandard, or inappropriate finishes to a systems building should be avoided. Systems buildings must comply with the BEAP.

3.3.3 Manufactured Wood Buildings. Manufactured wood frame buildings can be considered for housing facilities and temporary structures. Efficient factory production of components and simplicity of field assembly can result in significant economies. A 4- by 4-foot (1200 by 1200 mm) planning grid and a 4- by 8-foot (1200 by 2400 mm) vertical grid should be used to comply with industry standard material sizes. Standard and modular components such as window and door units should also be used. The plan should be arranged for utilities economy; for example, group rooms with plumbing requirements should be arranged back-to-back.

3.3.4 Manufactured Metal Buildings. Pre-engineered and manufactured metal buildings can be used for a variety of building types, such as maintenance, storage, and training facilities, where large, open, repetitive areas with clear spans are desired. To decrease total erection time while maximizing cost efficiency, manufacturer's standard factory-finished metal wall and roof systems should be considered for buildings where pre-engineered metal structural systems are to be used. Manufacturer's standard window, door, and other components can also be considered, but their appearance must be appropriate and reflect state-of-the-art design. Refer to NFGS-13121 and MBMA guidelines.

3.3.5 Manufactured Concrete Buildings. Manufactured concrete building components can be effectively used in any combination to minimize construction costs and erection time. Manufactured concrete components also ensure a standardization of quality while enhancing permanency and lowering maintenance factors. Precast concrete structural systems, wall panels, and slab decking units can be used individually or in combination. Entire prefabricated modules or units have not generally proven to be as economical or flexible as originally desired and should be considered only after thorough investigation.

3.3.6 Mobilization Construction. Mobilization construction includes planning for rapid expansion of facilities or rapid construction of new facilities when necessitated by emergency conditions. The use of manufactured or systems buildings are especially appropriate for mobilization construction.

3.4 Miscellaneous Components.

3.4.1 Circulation Components. Circulation components must comply with life safety criteria.

3.4.1.1 Ramps. Building layouts should be configured to minimize the need for ramps. Where ramps are required, they must comply with physically handicapped access requirements for length, width, rise, slope, and materials. Exterior ramps must be integral parts of the building design rather than appendages.

3.4.1.2 Stairs. Stairs must comply with all exit and fire protection requirements. Closed risers with abrasive treads are recommended, although open risers may be considered for industrial type facilities. Buildings over one story in height must have stair, access stair, or ladder access to the roof.

3.4.1.3 Elevators. Elevator cab size shall be based on functional need. They must conform to physically handicapped access criteria unless it can be shown by supporting data that the facility will only be used by able-bodied military personnel. Speeds and capacities should be industry standard recommendations based on facility type and occupant load. Hydraulic elevators should generally be used for buildings up to four or five stories, and electric elevators generally should be used for all others. NAVFAC guide specifications NFGS-14200, Electric (Passenger)(Freight) Elevator, and NFGS-14214, Hydraulic (Passenger)(Freight) Elevator, and DM-3.09, Elevators, Escalators, Dumbwaiters, Access Lifts, and Pneumatic Tube Systems contain additional criteria.

3.4.1.4 Escalators. Escalators are convenient yet expensive components and should be used only where specifically required by program.

3.4.2 Exterior Penetrations.

3.4.2.1 Wall Penetrations. Louvers, grilles, vents, and other wall penetrations must be sized and grouped to create an unobtrusive appearance. Unless these elements can be successfully grouped and organized into positive design elements appropriate for accent colors or finishes, they should be painted to match adjacent wall surfaces. These items should be minimized and should generally be factory finished. Refer also to NFGS-10201, Metal (Wall) (and) (Door) Louvers.

3.4.2.2 Roof Penetrations. Roof penetrations should be minimized or eliminated to preclude potential leakage. Where penetrations are necessary, curbs and equipment supports must be properly secured and flashed.

Section 4: MATERIALS AND FINISHES

4.1 Concrete. All phases of concrete design and construction require experience and rigid quality controls that may not be available in some localities. Specific design criteria for concrete is described in NAVFAC DM-2.04. See Section 3 of this manual for a discussion of concrete for structures, walls, exterior skin, and other building components.

4.1.1 Cast-in-Place. Strict quality control measures are required for cast-in-place concrete. Refer to NAVFAC guide specifications NFGS-03300, Cast-in-Place Concrete, and NFGS-03302, Cast-in-Place Concrete (Minor Building Construction), for additional criteria.

4.1.2 Precast. Quality control measures can be more effective with precast concrete. NFGS-03410, Precast Structural Concrete (Non-Prestressed), NFGS-03411, and NFGS-03412, Precast Prestressed Concrete, should be reviewed.

4.2 Masonry. Refer to NAVFAC DM-2.06, Aluminum Structures, Masonry Structures, Composite Structures, Other Structural Materials, and NAVFAC DM-2.09 for specific structural criteria relating to masonry. See Section 3 of this manual for information on the use of masonry for structures and walls.

4.2.1 Concrete Masonry Units. Strength, durability, and low maintenance features make concrete masonry units an appropriate choice for many permanent service facilities. Since concrete masonry units are highly susceptible to water penetration by absorption and capillary action, the designer should take care in providing all required exterior coatings and flashings both above and below grade. See NFGS-04200, Unit Masonry, and NFGS-04230, Reinforced Masonry, for additional criteria.

4.2.2 Brick. Brick walls and brick veneer can be used as an exterior material for a variety of building types. Due to cost factors, the use of brick as an interior material should be limited.

4.2.3 Structural Clay Tile Units. Availability and cost factors will generally limit the use of structural clay tile units. Refer to NFGS-04250, Ceramic Glazed Structural Clay Facing Tile and Prefaced Concrete Masonry Units.

4.2.4 Natural Masonry. Natural masonry materials, such as limestone, granite, and marble, should be judiciously used due to high initial cost. Selective use for major buildings accessible to the public, such as command headquarters, medical, or religious facilities, could be considered appropriate.

4.3 Metals.

4.3.1 Structural. Specific criteria for structural steel is contained in NAVFAC DM-2.03. The American Institute of Steel Construction (AISC) Manual of Steel Construction and American Iron and Steel Institute (AISI) Specification for the Design of Cold-Formed Steel Structural Members provide other criteria and requirements. Also refer to NFGS-05120, Structural Steel; NFGS-05210, Steel Joists; NFGS-05311, Steel Roof Decking; and NFGS-05321, Steel Floor Decks. Section 3 of this manual contains additional information on metal structural and skin systems.

4.3.2 Miscellaneous Metals. Roofing accessories such as flashing, gutters, downspouts, and other miscellaneous metal items shall conform to standards and criteria established in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) Architectural Sheet Metal Manual. See also NFGS-05500, Metal Fabrications, and NFGS-07600, Flashing and Sheet Metal.

4.3.3 Ferrous Metals. NAVFAC DM-2.03 contains specific criteria for corrosion and wear protection for metal structural members. Fire protection requirements for ferrous metal structures are described in MIL-HDBK-1008.

4.3.4 Nonferrous Metals. Industry standard coatings and finishes for aluminum are listed in The Aluminum Association Designation Systems for Aluminum Finishes and Standards for Anodized Architectural Aluminum.

4.4 Wood and Plastics.

4.4.1 Wood. Structural systems of wood are discussed in Section 3 of this manual. While industry standard quality controls and availability permit general unrestrained use of wood in the continental United States, caution should be exercised when considering wood materials for overseas projects. NFGS-06100, Rough Carpentry, and NFGS-06200, Finish Carpentry, contain criteria for preservation, fire, and termite control treatment of wood.

4.4.2 Architectural Woodwork. Built-in shelves, counters, cabinets, casework, reception desks, and other architectural woodwork items shall generally conform to the Architectural Woodwork Institute (AWI) Quality Standards, Custom Grade. Simple, clean forms, standard detailing, and simple, sturdy hardware shall be used. Refer also to NFGS-06200; NFGS-11701, Casework, Metal and Wood (Medical and Dental); NFGS-12331, Vanities, Prefabricated; NFGS-12332, Wardrobe Storage Cabinet; and NFGS-12391, Kitchen Cabinets (and Vanity Cabinets).

4.4.3 Plastic Laminate. The use of plastic architectural finish materials should be limited to plastic laminate finishes for architectural woodwork items and shall conform to AWI and National Electrical Manufacturers Association (NEMA) standards. Material shall be high-pressure laminate applied by "forming" or "postforming" standards of AWI and NEMA for horizontal and vertical surfaces.

4.5 Insulation and Moisture Protection. Selection of insulation types, materials, and installation methods should be based on heating and cooling requirements and the thermal insulating properties of the construction systems and materials. Specific criteria for heating and cooling is available in NAVFAC DM-3.03, Heating, Ventilating, Air Conditioning, and Dehumidifying Systems, as well as DOD 4270.1-M, Construction Criteria Manual. Selection of insulating materials should take into account fire protection requirements, as described in MIL-HDBK-1008, moisture, rodent, and insect resistance, as well as available space for insulation. Certain types of insulation may not be permissible in all geographical locations. The designer should determine if individual activities have specific requirements for the types of insulation that can be used. In addition, recent discoveries concerning potential fire hazards of certain types of reflective insulation require that only reflective insulation with kraft paper conforming to the National Bureau of Standards (NBS) Voluntary Product Safety Standard P546 for Flame-Resistant Paper and Paperboard be used, as well as nonflammable or noncombustible adhesive. The designer should be aware in renovation projects that existing nonconforming reflective insulation may be present and may have to be replaced. NFGS guide specifications and other publications are available for a variety of insulation and moisture protection materials and are listed in NAVFAC P-34, Engineering and Design Criteria for Navy Facilities, and NAVFAC DM-50, NAVFAC Index to Engineering and Design Criteria.

4.5.1 Unacceptable Insulation Types.

4.5.1.1 Reflective. Recent discoveries concerning potential fire hazards of certain types of reflective insulation require that only reflective insulation with kraft paper conforming to NBS Voluntary Product Safety Standard P546 for Flame-Resistant Paper and Paperboard be used, as well as nonflammable or noncombustible adhesive. The designer should be aware in renovation projects that existing nonconforming reflective insulation may be present and may have to be replaced.

4.5.1.2 Urea-Formaldehyde (UF) Foam. Because of the possibility that a health hazard could occur, it is NAVFACENGCOM Policy to prohibit the further installation of UF foam insulation in Navy shore facilities. Based on complaints reported during a Consumer Product Safety Commission (CPSC) investigation, the installation of UF insulation in buildings may release formaldehyde gas, a strong irritant, into occupied spaces.

Individuals who suffered illnesses after installation of UF foam reported symptoms such as eye, nose, and throat irritation; coughing; shortness of breath; nausea and vomiting; skin rashes; headaches and dizziness; and nosebleeds. The CPSC investigation concluded that removal of UF insulation in existing buildings is not necessary, unless adverse health conditions have been experienced. If health problems have been experienced by individuals occupying buildings insulated with UF foam, medical advice and monitoring should be obtained from the local Naval Medical Command industrial hygienist.

4.5.2 Acceptable Insulation Types.

4.5.2.1 References. NFGS guide specifications and other publications are available for a variety of insulation and moisture protection materials. They are listed in NAVFAC P-34, Engineering an Design Criteria for Navy Facilities, and NAVFAC DM-50, NAVFAC Index to Engineering and Design Criteria.

4.5.2.2 Exterior Wall Insulation and Finish Systems. These systems provide a complete insulation and finish package with excellent thermal values and initial labor savings. These systems are especially beneficial in retrofit projects where existing exterior wall conditions preclude the addition of insulation within the wall or on the interior surface.

4.6 Doors and Windows.

4.6.1 Doors and Frames. Available NAVFAC guide specifications and other publications containing criteria for doors and frames are listed in NAVFAC P-34 and NAVFAC DM-50.

4.6.1.1 Metal. Metal doors and frames are recommended for general use in Navy buildings. Refer to NFGS-08110, Steel Doors and Frames, and NFGS-08320, Metal-Clad (Kalamein) Doors and Frames.

4.6.1.2 Wood. Wood doors and frames are considered appropriate for housing construction, to match existing conditions, or in administrative areas where appearance is important. Refer to NFGS-08210, Wood Doors.

4.6.1.3 Entrances. Entrance doors, windows, and frames should be weather and stain resistant, protected from weather, and of sufficient strength to resist constant usage. Aluminum doors and frames or storefront systems are generally recommended for entrances. Monumental wood entrance doors could be considered for religious facilities and other special applications. Entrances should be of simple, clean design without frivolous details. Refer to NFGS-08120, Aluminum Doors and Frames, for additional criteria.

4.6.1.4 Service Doors. Exterior service doors in buildings with heating, ventilating, and air-conditioning (HVAC) systems should be insulated. Type of operation will be determined by frequency of use and maintenance requirements. Where these doors are located in a fire separation wall, they shall be provided with a device for automatic closing upon fire detection. Service doors should generally be placed away from public entrances. Sliding doors can be considered for interior application but are generally discouraged for exterior use. Additional criteria are described in NFGS-08310, Sliding Fire Doors; NFGS-08331, Overhead Coiling Doors; NFGS-08360, Sectional Overhead Doors; and NFGS-08367, Vertical Lift Metal Doors.

4.6.1.5 Special Doors. Aircraft hangar doors, doors for cold storage rooms, and other special purpose doors are discussed in design manuals for specific building types and in publications listed in NAVFAC P-34, NAVFAC DM-50, and NAVFAC P-272, Definitive Designs for Naval Shore Facilities.

4.6.2 Windows and Frames. Exterior windows, with the exception of storefront entrances, should generally be operable. Exterior windows should have insulating glass where required for thermal or solar protection.

4.6.2.1 Metal. Aluminum-framed windows are recommended for most applications. Steel-framed windows should generally be limited to industrial type facilities. Factory-applied finishes are recommended. Refer to NFGS-08510, Steel Windows; NFGS-08520, Aluminum Windows; and NFGS-08529, Aluminum Storm Windows.

4.6.2.2 Wood. Wood windows should be limited to new housing facilities, renovation, or retrofit projects due to the high degree of maintenance required. To reduce maintenance costs, factory-applied vinyl or aluminum finishes are recommended. Refer to NFGS-08610, Wood Windows.

4.6.2.3 Curtain Walls. Curtain walls as an exterior skin are discussed in Section 3 of this manual. In addition, refer to NFGS-08900.

4.6.2.4 Replacement Windows. Replacement windows should reflect the character of the existing building. Where due to existing conditions replacement windows must be wood frame, an aluminum or vinyl panning system to cover existing wood trim should be considered.

4.6.3 Glass and Glazing. The use of reflective or mirror glass should be limited due to possible deterioration of coatings, condensation problems, and general undesirable appearance. Tinted glass for solar reflection is preferred. Comply with the requirements of DOD 4270.1-M for glass shading and reflectivity. Insulated glass block can be an alternative for exterior glazing areas in some projects. Excellent thermal-resistant value, appearance, and creative design options are advantages of glass block, although availability and cost factors require selected usage. Glass block can also be effectively used in interior treatments where light transmission is desired but privacy and acoustical control is required. Refer to NFGS-08800, Glazing, for general criteria; NAVFAC DM-37.04, Brigs and Detention Facilities, for criteria on security glazing; and NAVFAC DM-37.06, Chapels and Religious Educational Facilities, for criteria on colored glass.

4.6.4 Hardware. NFGS-08710, Finish Hardware, Door and Hardware Institute (DHI) standards, and American National Standards Institute (ANSI) standards should be used for selecting builders' hardware.

4.7 Finishes. Interior design criteria applicable to selection of finishes are described in NAVFAC DM-1.01, as well as in DM-14.01, Interior Design Guide. Acoustical properties of finishes shall meet applicable criteria established in NAVFAC DM-1.03. Refer also to NAVFAC guide specifications, design manuals, standard drawings, and publications listed in NAVFAC P-34 and NAVFAC DM-50. Design manuals and standard drawings for specific building types are listed in NAVFAC P-272 and establish specific criteria for these building types. Interior finishes shall also comply with guidelines established in DOD 4270.1-M.

4.7.1 Floors.

4.7.1.1 Concrete. Exposed concrete floors in most habitable spaces should be sealed. Unfinished concrete floors are appropriate for mechanical rooms or storage rooms.

4.7.1.2 Masonry. Brick, limestone, or other masonry pavers may be appropriate for exterior use on projects having high command interest and large volumes of pedestrian traffic. Engineering Field Division (EFD) points of contact should be consulted for local policies or restrictions on using pavers on grade. If pavers are used, the designer should ensure proper detailing of a recessed slab to avoid trapping water between pavers and slab by using two-level plaza drains or weeping in channels to a drain field of gravel. This type of exterior paving system is costly when compared to more conventional systems, such as exposed concrete slabs, and should therefore be used judiciously. Interior masonry floors should be limited to selected public spaces in major buildings.

4.7.1.3 Quarry Tile. Use quarry tile for heavy-duty-use-floors, such as institutional kitchens. Avoid organic adhesives. Refer to NFGS-09331, Chemical-Resistant Quarry Tile Flooring.

4.7.1.4 Ceramic Tile. Use nonslip ceramic mosaic tile in wet areas such as toilets, showers, and locker rooms. Coordinate floor tile size with size of ceramic tile used on walls. Comply with the requirements of NFGS-09310, Ceramic Tile, Quarry Tile, and Paver Tile.

4.7.1.5 Terrazzo. Terrazzo provides a durable, low maintenance floor appropriate for use in heavy traffic areas. High initial costs, acoustical problems, and cold appearance are disadvantages. Refer to NFGS-09411, Terrazzo, Bonded to Concrete.

4.7.1.6 Resilient Flooring. A standard 12- by 12-inch (300 by 300 mm) vinyl composition tile is recommended for most general use areas. Sheet vinyl or fluid-applied resilient flooring should be used only in special use situations as directed. Refer to NFGS-09650, Resilient Flooring; NFGS-09661, Vinyl Composition Tile on Concrete; NFGS-09666, Institutional Sheet Vinyl Flooring; and NFGS-09670, Fluid Applied Resilient (Resinous) Flooring.

4.7.1.7 Carpet. Carpet provides an aesthetic solution where appearance and acoustical control are important. Special considerations include durability, maintainability, static control, and flammability. Carpet tile costs more than broadloom, but offers advantages in applications, such as open plan offices, where rearrangement is expected and in areas where access to underfloor power/communication systems is required. Refer to NAVFAC DM-14.02, Carpet Selection Guide; NFGS-09680, Carpet; and NFGS-09690, Carpet Tile, for additional criteria.

4.7.1.8 Wood. Wood floors are generally recommended only for new housing construction or for renovation or restoration projects. See NFGS-09570, Wood Parquet Flooring, and NFGS-09595, Wood Block Industrial Flooring.

4.7.1.9 Recreational Flooring. Options for flooring for gymnasiums, sports courts, or other recreational facilities include wood, sports carpeting, and applied resilient floors. Wood floors are expensive and require continual maintenance. See NFGS-09561, Gymnasium-Type Hardwood Strip Flooring Systems. Applied resilient and sports carpet floors are attractive alternatives for recreational flooring. Sports carpet does require additional maintenance, however, and can limit or prohibit certain activities.

4.7.2 Partitions. Additional criteria for interior partitions are discussed in Section 3 of this manual.

4.7.2.1 Masonry. Exposed concrete block partitions are appropriate in areas where image is not a prime consideration and where a low degree of maintenance is required. Masonry partitions should not be used if flexibility or expansion is a requirement.

4.7.2.2 Gypsum Wallboard. Gypsum wallboard partitions provide the most economical solution for most applications while allowing some degree of flexibility. Gypsum wallboard should not be used in locations where severe physical abuse or vandalism can be anticipated. Refer to NFGS-09250, Gypsum Board.

4.7.2.3 Plaster. The use of plaster partitions is generally discouraged due to initial costs, maintenance factors, and inflexibility. See NFGS-09215, Veneer Plaster.

4.7.2.4 Ceramic Tile. See NFGS-09310, Ceramic Tile, Quarry Tile, and Power Tile.

4.7.2.5 Vinyl. Vinyl wall covering provides a surface requiring lower maintenance than exposed gypsum wallboard or plaster. However, additional costs and resultant permanent color must be considered. A simple pebble or fabric textured design is recommended. Figured, highly patterned, or other decorative designs should not be used. Refer to NFGS-09955, Vinyl-Coated Fabric Wall Covering.

4.7.3 Ceilings.

4.7.3.1 Lay-In. Suspended acoustical tile ceilings are an economical solution with excellent acoustical properties and are recommended for most finished ceiling applications. Concealed spline ceilings are somewhat more expensive but are more attractive than acoustical tile ceilings with exposed support systems. Refer to NFGS-09500, Acoustical Treatment. If required for additional thermal or acoustical properties, insulation can be added above these ceilings, although conflicts with ceiling-mounted fixtures and fire hazards must be resolved.

4.7.3.2 Gypsum Wallboard. Gypsum wallboard ceilings are relatively expensive and offer no acoustical benefits. They do create an aesthetic appearance, however, and can be considered for special prominent spaces.

4.7.3.3 Exposed. Ceilings exposed to the structure above are most appropriate for maintenance, service, or utility facilities, and in areas such as mechanical or equipment rooms. Exposed ceilings can also be creative, effective solutions for facilities with large open areas or with the need for maximum flexibility.

4.7.4 Paint. NFGS-09910, Painting of Buildings (Field Painting), contains specific criteria for interior and exterior painting systems for buildings. In addition, NAVFAC P-34 and NAVFAC DM-50 list other applicable publications pertaining to paints and coatings. Refer also to NAVFAC P-309, Color for Naval Shore Facilities.

REFERENCES

Aluminum Association (AA), 818 Connecticut Avenue, NW, Washington, DC 20006.

Designation System for Aluminum Finishes

Standards for Anodized Architectural Aluminum

American National Standards Institute Inc. (ANSI), General Standards, 1430 Broadway, New York, NY 10018.

American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

ASTM E380	Metric Practice
ASTM E621-78	Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction

Architectural Sheet Metal Manual, Sheet Metal and Air Conditioning Contractors' National Association, Inc., 8224 Old Court House Road, Tysons Corner, Vienna, VA 22180.

Construction Criteria Manual, Department of Defense, DOD 4270.1-M. Copies can be obtained from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

Door and Hardwood Institute, Standards, 7711 Old Springhouse Road, McLean, VA 22102-3474.

Federal Acquisition Regulations, Part 10, Specifications, Standards and other Purchase Descriptions. Copies can be obtained from the U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

Manual of Steel Construction, American Institute of Steel Construction, 1221 Avenue of the Americas, New York, NY 10020.

Metal Building Manufacturers' Association (MBMA), 1230 Keith Building, Cleveland, OH 44115.

Metal Building Systems Manual

Recommended Design Practices Manual

Metric Editorial Guide ANMC 85-1, American National Metric Council, 1010 Vermont Avenue, Suite 320, Washington, DC 20005.

National Electric Manufacturers Association (NEMA), General Standards, 2101 L Street, NW, Washington, DC 20037.

Naval Facilities Engineering Command (NAVFAC), Design Manuals (DM), Military Handbooks (MIL-HDBK), Instructions (NAVFACINST), Publications (P) and Guide Specifications (NFGS). Copies can be obtained from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

DM-1.01	Basic Architectural Requirements and Design Considerations
DM-1.03	Architectural Acoustics
DM-1.04	Earth-Sheltered Buildings
*MIL-HDBK-1001/5	Roofing and Waterproofing
*MIL-HDBK-1001/6	Building Thermal Mass Effects
DM-2.01	Structural Engineering General Requirements
DM-2.02	Structural Engineering Loads
*MIL-HDBK-1002/3	Structural Engineering Steel Structures
DM-2.04	Structural Engineering Concrete Structures
MIL-HDBK-1002/5	Structural Engineering Timber Structures
MIL-HDBK-1002/6	Aluminum Structures, Masonry Structures, Composite Structures, Other Structural Materials
DM-2.09	Masonry Structural Design for Buildings
DM-3.03	Heating, Ventilating, Air Conditioning, and Dehumidifying Systems
DM-3.09	Elevators, Escalators, Dumbwaiters, Access Lifts, and Pneumatic Tube Systems
DM-6.02	Guide Specification Manual
DM-14.01	Interior Design Guide
DM-14.02	Carpet Selection Guide
DM-37.04	Brigs and Detention Facilities (Interim Criteria)
DM-37.06	Chapels and Religious Educational Facilities
DM-50	NAVFAC Index to Engineering and Design Criteria

* To be issued.

MIL-HDBK-1008	Fire Protection For Facilities Engineering, Design, and Construction
NAVFACINST 4120.10	Use of the Metric System of Measurement in the Acquisition of Facilities and Related Equipment
P-34	Engineering and Design Criteria for Navy Facilities
P-272	Definitive Designs for Naval Shore Facilities
P-309	Color for Naval Shore Facilities
P-355	Seismic Design for Buildings
NFGS-03300	Cast-in-Place Contrete
NFGS-03302	Cast-in-Place Concrete (Minor Building Construction)
NFGS-03410	Precast Structural Concrete (Non-Prestressed)
NFGS-03411	Precast Concrete Wall Panels
NFGS-03412	Precast Prestressed Concrete
NFGS-04200	Unit Masonry
NFGS-04230	Reinforced Masonry
NFGS-04250	Ceramic Glazed Structural Clay Facing Tile and Prefaced Concrete Masonry Units
NFGS-05120	Structural Steel
NFGS-05210	Steel Joists
NFGS-05311	Steel Roof Decking
NFGS-05321	Steel Floor Decks
NFGS-05500	Metal Fabrications
NFGS-06100	Rough Carpentry
NFGS-06200	Finish Carpentry
NFGS-07410	Preformed Metal (Roofing) (and) (Siding)
NFGS-07600	Flashing and Sheet Metal
NFGS-08110	Steel Doors and Frames

NFGS-08120	Aluminum Doors and Frames
NFGS-08210	Wood Doors
NFGS-08310	Sliding Fire Doors
NFGS-08320	Metal-Clad (Kalamein) Doors and Frames
NFGS-08331	Overhead Coiling Doors
NFGS-08360	Sectional Overhead Doors
NFGS-08367	Vertical Lift Metal Doors
NFGS-08510	Steel Windows
NFGS-08520	Aluminum Windows
NFGS-08529	Aluminum Storm Windows
NFGS-08610	Wood Windows
NFGS-08710	Finish Hardware
NFGS-08800	Glazing
NFGS-08900	Glazed Curtain Wall System
NFGS-09100	Metal Support Systems
NFGS-09215	Veneer Plaster
NFGS-09250	Gypsum Board
NFGS-09310	Ceramic Tile, Quarry Tile, and Paver Tile
NFGS-09331	Chemical-Resistant Quarry Tile Flooring
NFGS-09411	Terrazzo, Bonded to Concrete
NFGS-09500	Acoustical Treatment
NFGS-09561	Gymnasium-Type Hardwood Strip Flooring Systems
NFGS-09570	Wood Parquet Flooring
NFGS-09595	Wood Block Industrial Flooring
NFGS-09650	Resilient Flooring
NFGS-09661	Vinyl Composition Tile on Concrete

NFGS-09666	Institutional Sheet Vinyl Flooring
NFGS-09670	Fluid Applied Resilient (Resinous) Flooring
NFGS-09680	Carpet
NFGS-09690	Carpet Tile
NFGS-09910	Painting of Buildings (Field Painting)
NFGS-09955	Vinyl-Coated Fabric Wall Covering
NFGS-10201	Metal (Wall) (and) (Door) Louvers
NFGS-10270	Access Flooring
NFGS-10655	Accordion Folding Partitions
NFGS-11701	Casework, Metal and Wood (Medical and Dental)
NFGS-12331	Vanities, Prefabricated
NFGS-12332	Wardrobe Storage Cabinets
NFGS-12391	Kitchen Cabinets (and Vanity Cabinets)
NFGS-13121	Pre-engineered Metal Buildings (Rigid Frame)
NFGS-14200	Electric (Passenger)(Freight) Elevator
NFGS-14214	Hydraulic (Passenger)(Freight) Elevator

Quality Standards, Architectural Woodwork Institute, 2310 S. Walter Reed Drive, Arlington, VA 22206.

Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute (AISI), 1000 16th Street, NW, Washington, DC 20036.

Voluntary Product Safety Standard P546-71 for Flame-Resistant Paper and Paperboard, National Bureau of Standards, Gaithersburg, MD 20899.

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