UFC 3-320-04A
1 March 2005
with Change 2

UNIFIED FACILITIES CRITERIA (UFC)

METAL BUILDING SYSTEMS

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UNIFIED FACILITIES CRITERIA (UFC)

METAL BUILDING SYSTEMS

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location
2	Nov 2008	CEGS to UFGS

This UFC supersedes TI 809-30, dated 1 August 1998. The format of this UFC does not conform to UFC 1-300-01; however, the format will be adjusted to conform at the next revision. The body of this UFC is the previous TI 809-30, dated 1 August 1998.

FOREWORD

\1\
The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Support Agency (AFCESA) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

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TI 809-30
1 August 1998

US Army Corps
of Engineers®

Technical Instructions

METAL BUILDING SYSTEMS

Headquarters
U.S. Army Corps of Engineers
Engineering Division
Directorate of Military Programs
Washington, DC 20314-1000

TECHNICAL INSTRUCTIONS

METAL BUILDING SYSTEMS

Approved for public release; distribution is unlimited.

Record of Changes (changes indicated by \1\ ... /1/)

No.	Date	Pages
1	30 August 1999	Foreword, 1, 3 ,4, 5

FOREWORD

These technical instructions (TI) provide design and construction criteria and apply to all U.S. Army Corps of Engineers (USACE) commands having military construction responsibilities. TI will be used for all Army projects and for projects executed for other military services or work for other customers where appropriate.

TI are living documents and will be periodically reviewed, updated, and made available to users as part of the HQUSACE responsibility for technical criteria and policy for new military construction. \1\ CEMP-ED/1/ is responsible for administration of the TI system; technical content of TI is the responsibility of the HQUSACE element of the discipline involved. Recommended changes to TI, with rationale for the changes, should be sent to HQUSACE, ATTN: \1\ CEMP-ED/1/, 20 Massachusetts Ave., NW, Washington, DC 20314-1000.

TI are effective upon issuance. TI are distributed only in electronic media through the TECHINFO Internet site *http://www.hnd.usace.army.mil/techinfo/index.htm* and the Construction Criteria Base (CCB) system maintained by the National Institute of Building Sciences at Internet site *http://www.nibs.org/ccb/.* Hard copies of these instructions produced by the user from the electronic media should be checked against the current electronic version prior to use to assure that the latest instructions are used.

FOR THE DIRECTOR OF MILITARY PROGRAMS:

/s/

KISUK CHEUNG, P.E.
Chief, Engineering and Construction Division
Directorate of Military Programs

TECHNICAL INSTRUCTIONS

METAL BUILDING SYSTEMS

Table of Contents

INTRODUCTION

1. PURPOSE AND SCOPE. This document provides guidance on the sue of Metal Building Systems for Corps of Engineers projects. It applies primarily to the structural discipline, but close coordination with the architectural discipline is required during building procurement. The use of this type of construction should be considered where it will meet the quality, performance and functional requirements of the project, where it will be architecturally compatible with the environment in which it will be erected, and where such use is indicated by life cycle cost analysis to be economically justified.

2. APPLICABILITY. These instructions are applicable to all USACE elements involved with the design of buildings and other structures.

3. REFERENCES.

a. Government Publications

UFGS 13 34 19	Metal Building Systems
\1\ TI 809-01	Load Assumptions for Buildings /1/
TI 809-04	Seismic Design for Buildings

b. Nongovernment Publication

AISC S335	Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design
AISC S342L	Load and Resistance Factor Design Specification for Structural Steel Buildings
AISI SG-673	Cold-formed Steel Design Manual
ASCE 7	American Society of Civil Engineers-Minimum Design Loads for Buildings and Other Structures
MBMA	Metal Building Manufacturers Association 1996 Low Rise Buildings Systems Manual
ICBO-01	Uniform Building Code

4. General.

a. Definition. A Metal Building System is defined by MBMA as "a complete integrated set of mutually dependent components and assemblies that form a building. It includes the primary and secondary framing, covering, and accessories, all of which are manufactured to permit inspection on site prior to assembly or erection". In simpler terms, it is a steel frame building that typically consists of the following metal components:

Roof Sheeting
Wall Sheeting
Purlins
Girts
Frames (including side wall columns)
Columns
Endwall Beams and Columns
Flange Braces
Longitudinal Bracing
Connections
Screws and Bolts
Other non-structural parts

When assembled, all of the parts form the shell of a complete structure. All components are typically designed, fabricated, and furnished by a single manufacturer based on owner identified requirements. They are delivered to the job site where they are assembled by a structural steel erector. The general contractor, erection contractor, building supplier, or other agreed upon party may act as the erector. Erection normally uses field-bolted connections with little or no field welding. Primary components, such as columns, beams, and girders, are typically fabricated from plates, are shop welded, and are optimized for the specified loading conditions. Webs of beams and columns are normally tapered to conserve material in areas of low stress. While Metal Building Systems with tapered rigid frames are the most common, other types of framing are also in common use: single span self-framing (no frame), multiple-span beam and column frames, trussed column and girders, trussed rigid frames, continuous beam frames, columns with tapered girders, etc.

b. Pre-Engineered Buildings. Several years ago Metal Building Systems were commonly referred to as "Pre-engineered Buildings". The term is still popular in the building trades despite efforts by MBMA members to change the culture. "Pre-engineered Building" was an appropriate name because it described the procurement process in place at that time. Building manufacturers hired structural engineers to design a series of standard building modules for different wind loading. The modules differed in eave height, building width, and roof slope. The modules could then be joined to create buildings of practically any length. An owner would review the catalog, select a building with a footprint and interior height that most closely matched the requirements, and place the order with the supplier. The manufacturer would then fabricate the parts based on the standard design drawings on file and ship the building to the owner's site. Erection would be by a general contractor or by an erector that worked with or for the supplier. This approach is quite different from the modern process. Today, most manufacturers use proprietary computer programs for design and provide a custom designed order an entire building (frame, wall, and roof covering) or parts (frame and roof). Parts may be combined with other building materials (masonry, precast concrete, light gauge steel framing and siding, etc.) To provide a complete facility. Low cost and speed of fabrication/erection are the principal advantages to using a Metal Building System type structure. Manufacturers that specialize in this work have developed design and fabrication techniques that make them very competitive. The perception that these buildings are inferior to other custom designed structures comes primarily from early industry reliance on a separate building code (MBMA Low Rise Building Systems Manual), which at one time did promote the use of wind and live load pressures that were less than those traditionally used. (It should be noted that the MBMA supported their criteria with tests indicating that traditional criteria was too conservative for low rise single story structures.) Recent changes sin both the MBMA design guidelines and the traditional codes have rought the two closer together so that today, the differences are small. Owners who express a concern for structural suitability should be counseled on the specific differences, if any. Persistent concerns can be resolved by requiring the manufacturer to design to the higher code requirement since almost any reasonable requirement can be accommodated by the manufacturer.

d. Corps Guide Specifications. Metal Building Systems are obtained by the Corps of Engineers using either of two performance specifications: UFGS 13 34 19, Metal Building Systems. Projects that include buildings supplied under both specs should specify which specification applies to which building. \1\The first specification is used for medium to large structures./1/ UFGS 13 34 19 should be used for most COD projects where an occupied structure is proposed. The specifying engineer will edit the specification and define the owner's requirements to include the design codes to be used. Do not leave both options in the specification or mix options since this complicates the design. \1\/1/

e. Foundations. Metal Building System manufacturers do not design foundations; foundation investigation and design is performed by the contractor. The manufacturer provides column reactions for the specified loading, and the building contractor obtains the services of a professional engineer to design the site-specific foundations for the delivered structure using the reactions and a foundation report. On Corps of Engineers projects, using UFGS 13 34 19, the Corps performs a preliminary design for the foundations based on the data obtained from in-house or AE-prepared engineering analysis of a typical structure, or from the Metal Building manufacturer based on its analysis of the proposed structure. The resulting foundation design is shown on the drawings as both a basis for bid by the contractor, and to identify foundation type and typical details required for the final foundation design. The final design is performed by a registered professional engineer hired by the contractor. The soils data used for the design is included in the Corps specification. Final column reactions are supplied by the Metal Building manufacturer who will provide the building.

f. Other Foundations (Non-metal Building Systems Manufacturer Supplied Items). Foundations for all Non-metal Building System supplied items, such as masonry wall and equipment foundations, should be designed by the project structural engineer and shown on the contract drawings. Design responsibility should not be transferred to the contractor or to his (or her) foundations engineer.

g. Design Criteria. As previously discussed, MBMA publishes a design manual, "Low Rise Building Systems Manual," that establishes standard design and commercial practices for metal buildings. Compliance with this manual (code) is voluntary, but most commercial structures provided by MBMA members follow this guidance. Manufacturers can, and do, design to other national and local codes when requested by the owner. Metal Buildings were first used for farm, warehouse, and other utilitarian type structures and grained wide acceptance in the Corps for warehouses, pump houses, guard houses, and POL storage houses. In the early 1980's the metal building industry began marketing these buildings for larger and more complicated structures including everything from corporate headquarters buildings to aircraft hangars. Their efforts were well accepted in the commercial arena due to their significant cost advantage. The Corps met with representatives from MBMA and several of the leading manufacturers at their request to review the use of metal buildings in the Corps. Following this meeting, the Corps agreed to revise their guidance and allow a broader use of these structures, but only if they were designed to the same level of quality as current Corps custom designed buildings. (Prior to that meeting metal buildings could only be used for utilitarian structures.) In the early 90's there were significant differences between Corps criteria (based on National Codes herein referred to an traditional criteria), and MBMA criteria. Differences were primarily in the magnitudes of wind loads, live loads (roof), snow loads, and building drift. To accommodate this broader usage, the Corps developed two specifications — Special Purpose Metal Buildings (long span, high eave height, expensive contents) that used traditional design codes and Standard Metal Buildings (typical spans and eave heights) that used MBMA codes. Over the years the differences between MBMA and traditional criteria have become fewer and with the publication of the 1996 edition of the Metal Building Manufacturers Association Low Rise Buildings Systems Manual, have become almost nonexistent. Recognizing this change, Corps' specifications were modified in 1998. UFGS 13 34 19, Metal Building Systems, is now used for all buildings previously covered by both of the earlier specifications. \1\ text deleted /1/

h. Advantage. Metal Building Systems provide economical usable structures and are a good choice if the metal building appearance is acceptable to the user. The appearance can be enhanced by the use of other cladding materials such as precast panels and reinforced masonry, but in these cases, the cost advantages diminish. The extensive use of computers for everything from design to fabrication has resulted in a low cost alternative that is material efficient, quickly fabricated, and easily erected.

5. Specification Issues.

a. Quality Certification. Metal building will be the product of a recognized steel building systems manufacturer who has been in the practice of manufacturing steel building systems for a period not less than 5 years. The manufacturer will be chiefly engaged in the practice of designing and fabricating steel building systems. Manufacturer's furnishing buildings under UFGS 13 34 19 will be certified under the American Institute of Steel Construction Metal Building Systems (MB) Certification Program, AISC FCD-90. Structural framing and covering will be designed by a licensed Professional Engineer experienced in design of this work. The AISC Quality Certification Program can act as a pre-qualification system for structural steel fabricators. The purpose of the AISC Quality Certification Program is to confirm to the construction industry that a certified structural steel fabricating plant has the personnel, organization, experience, procedures, knowledge, equipment, capability, and commitment to produce fabricated steel of the required quality for a steel building.

b. Building Configuration. Buildings can be furnished in virtually any size requested by the owner. Single-space or multiple-span tapered plate beam and column designs are most prevalent. The specification should be edited to delete any unacceptable framing choices. (The selection of a single framing system greatly simplifies foundation design.) Drawings should clearly indicate required footprint dimensions as well as any other critical or controlling dimensional criteria (such as minimal overhead or sidewall working space clearances). This is especially true for shop buildings that enclose the work space for vehicles or aircraft. Pay particular attention to clearances required to shop sidewalls where long span rigid frame "knees" can significantly impose on the working area. Interior columns, if compatible with building use, can significantly reduce total building frame costs.

c. Drawings. Control drawings are an extension of the performance specification and should be used to illustrate project requirements not completely identified or illustrated in the specification. Excessive detailing should be avoided since the advantage of using a Metal Building System is lost if the manufacturer is forced to use details other than those which have made standard for its product. Architectural drawings should provide basic floor plans and building elevations. Roof slopes, door and window openings, and areas that must remain devoid of bracing must also be indicated. Structural drawings should include a foundation plan (based on a preliminary design), a floor slab plan (showing joint layout), and structural elevations where unusual bracing requirements exist. Working clearances discussed earlier can be shown on architectural or structural drawings as appropriate, but should not be shown on both.

d. Design Requirements. The designer/specifier must be familiar with all referenced design standards and codes, especially when specifying large complicated structures, so that the specification contains the appropriate choice for the structure being procured. \1\ text deleted/1/ These decisions should receive special attention during the Independent Technical Review process.

(1) Collateral loads are an estimate of the miscellaneous loading, expressed as a uniform load applied to the entire structure, that account for small miscellaneous items such as lights, ducts, etc., that are hung from the structural frame or secondary framing members. Collateral loads should not be increased to account for heavy items, i.e., those with a mass more than 25 kg (55 lb.) Hanging from the framing, since that would impose a significant penalty on members that do not support the heavy loads. Instead, large equipment should be shown on the contract drawings and tabulated on the structural drawings with descriptions, estimated weights (to be verified by the contractor), plan dimensions, drawing references for locations, and any unusual access requirements. Secondary members should be increased appropriately in size or number to support the heavier loads.

(2) Wind loads are frequently subject to miscalculation even by experienced engineers and an error, if undetected, could result in costly redesign and resubmittal. Relying on code references alone and allowing the manufacturer to calculate pressures may be safe for small uncomplicated structures, but it is preferable to calculate pressures and illustrate the limits of these pressures on the control drawings for large complicated structures. The use of tables and isometric drawings to illustrate all significant design pressures, the extent of all high pressure areas, and the pressures for parts and portions of the structure along with their tributary area limitations is recommended.

(3) Seismic loads rarely control the design of lightweight flexible steel structures. These loads become more of a concern if rigid masonry or precast elements are attached to the structure as cladding./1/ text deleted/1/

(4) The foundations paragraph in the guide specifications contains written criteria the contractor will use to design the building foundation. Additional supporting criteria, to include required details of construction, should be shown on the structural plates of the contract drawings. Examples include: details of integral slab footings, details of separate wall or column footings, minimum thickness of

slabs at edges, dimensions of turn-down portion of slabs, details of hair pins or tie rods for lateral thrust resistance, etc.

(5) If Structural Standing Seam Metal Roofing is to be used on the structure, then purlin spacing of 750 mm (30 inches) maximum at corner, edge, and ridge zones and at 1500 mm (5 foot) maximum for the remainder of the roof are required and must be clearly shown on the drawings, or in the specification.

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(3) Seismic loads rarely control the design of lightweight flexible steel structures. These loads become more of a concern if rigid masonry or precast elements are attached to the structure as cladding. ICBO-01 was chosen as the specification reference for seismic loads since this commercial criteria is readily available to the manufacturers and closely approximates the design guidance in TI 809-04.

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(5) If Structural Standing Seam Metal Roofing is to be used on the structure, then purlin spacing of 750 mm (30 inches) maximum at corner, edge, and ridge zones and at 1500 mm (5 foot) maximum for the remainder of the roof are required and must be clearly shown on the drawings, or in the specification.

(6) Acceptable methods for resisting lateral loads include cross-bracing (X-bracing), diagonal bracing, rigid frames, and wind columns. Metal shear wall bracing should only be allowed for self-supporting structures procured under specification section UFGS 13 34 19. Bracing conflicts with doorways and other openings can be a problem. Bays and roof/wall openings that must remain free of bracing should be shown on the architectural drawings.

(7) Metal Buildings are flexible structures that move under the application of wind, seismic, and crane loading. Appendix A6 of the 1996 Low Rise Building Systems Manual provides guidance and should be considered when specifying allowable drift in the specification. The specifications engineer and design engineer must insure that the maximum allowable frame drift is suitable for the proposed structure considering all details of

construction. Masonry walls are particularly susceptible to damage if not properly integrated into the design. They may be supported, or isolated, but it is important to insure that movement of the building structure does not overstress the masonry. Similarly, when separate support columns are used for top running cranes, they must be supported so that differential movement between the crane columns and building columns, due to differences in stiffness, does not overstress either column and result in local column buckling. Drift limitations are an area of contention among structural engineers and significant engineering judgment is required when limitations are established. Application of a requirement that is too stringent can significantly impact the cost of a structure. Requirements that are too lax can lead to damage of rigidly connected components. This is an area of special interest for the Independent Technical Review.

e. Design Analysis. A complete building design analysis consists of at least 2 parts, the building design and the foundation design. Computer designs are prevalent in the industry and may be difficult to review and UFGS 13 34 19 includes provisions designed to assist in this regard. Since all computer design analyses are certified by a licensed Professional Engineer, it is generally sufficient for the project structural engineer to limit his/her review to the input/output portion of the analysis. Verify that the specified loadings have been properly applied, the wind loads have been properly calculated, and that the output results are properly reflected on the shop drawings. Hand calculations to verify the assumptions and the method of analysis for arriving at the final results should only be requested in unusual cases. Foundation design analyses should be reviewed following established Architect-Engineer review procedures.

f. Submittals. Design analyses and erection procedures should be reviewed by Engineering as an extension of design.

g. Erection Plan. Obtaining an acceptable site-specific erection plan is sometimes difficult. The building manufacturer frequently requires the erector or another third party provide the plan. Caution should be exercised when long span structures or other structures requiring unique design solutions are procured. Separately contracted erectors may not appreciate the need for additional bracing during construction and problems could result. Several Corps structures have collapsed during construction due to inadequate bracing/erection plans. The requirement for a site specific erection plan should be strictly enforced with the contractor. A review by the building manufacturer may be warranted when plans are prepared by a separate erector for a complicated structure.

h. Warranties. Specified warranties obtained from the Metal Building System manufacturer only apply to manufacturer supplied items. If masonry walls are used in lieu of metal siding, any problems with the walls are covered under the general contractor's warranty, not under the Metal Building System warranty.

i. Welding. If UFGS 13 34 19 is used for large hanger type buildings or where more critical welding is involved, the manufacturer must have proper quality control of shop welds. If the metal building manufacturer is not AISC MB certified, then a separate specification on welding requirements should be added to the contract (UFGS 05 05 23, Welding, Structural).

j. Base Plate Bearing. Standard practice for the Metal Building System industry does not require base plates to be shimmed with nonshrink grout to fill the void to assure good bearing. This is probably a holdover from the days when most of these structures were bolted to finished slabs or integral footings. If the standard MBMA building practice is not acceptable to the engineer, then additional editing of the specification, or the design of a custom metal building, is required.

APPENDIX

SAMPLE METAL BUILDING SYSTEM FOUNDATION NOTES

Metal Building System buildings are procured using Guide Specification UFGS 13 34 19. The structural drawings should include a foundation plan that indicates an estimate of the foundation requirements for a building that will meet the specified requirements. (Masonry wall foundations, where masonry is used, will be completely detailed and shown on the contract drawings). The foundation plan should be consistent with the requirements of the foundation report. As a minimum, the following notes should be considered.

1. Building (specify building by name & number) will be procured as a Metal Building System as specified in specification section (UFGS 13 34 19).

2. The metal building foundations shown on this sheet are estimates for the building and are to be used as a guide for the building supplied. The contractor will redesign the metal building foundations for the actual building loads provided by the Metal Building Manufacturer. Foundations for items other than the metal building will be constructed as shown.

3. The contractor will not vary from the basic criteria shown by this drawing, such as slab thickness, control joint spacing and location, capillary water barrier, vapor barrier, minimum depth of footing, and column thrust resisting system.

4. Building footings will be sized for an allowable soil bearing value, minimum bottom of footing depth, and safety factor as indicated in the specifications. The minimum footing width will be _______.

5. Foundation design will be performed by a Registered Professional Engineer as specified and will be submitted for approval as part of the Metal Building System design analysis.